B.TECH. ECE PROGRAMME SCHEME

DEPARTMENT OF ELECTRONICS ANDCOMMUNICATION ENGINEERING

NATIONAL INSTITUTE OFTECHNOLOGY KURUKSHETRA

B.Tech. in Electronics& Communication Engineering Programme Scheme

For Academic Year 2026-27 onwards

The Course Structure for B. Tech. Programme shall have the following categories of courses:

Sr. No.	Category
1	Institute Core (IC)
2	Non-Conventional Institute Core (NC)
3	Program Core (PC)
4	Program Elective (PE)
5	Open Elective (OE)

Course category explanation

Course category	Explanation
IC	Basic Sciences
	Engineering Arts and Sciences
	Humanities and Social Sciences
PC	Courses specific to the relevant discipline
PE	Elective Courses specific to the relevant discipline
OE	Elective Courses from any domain
NC	Courses only qualifying in nature

Course category summery sheet:

Course Category	SEMESTER								Total Courses
	I	II	III	IV	V	VI	VII	VIII	
IC	**06**	**05**	**01**	**01**	**-**	**-**	**01**	**-**	**14**
PC	**00**	**01**	**05**	**05**	**02**	**03**	**02**	**1**	**19**
PE	**-**	**-**	**-**	**-**	**2**	**2**	**2**	**2**	**08**
OE	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**1**	**04**
NC	**1**	**3**	**-**	**2**	**-**	**2**	**-**	**-**	**04**
Total Credits	**20**	**22**	**22**	**22**	**20**	**23**	**23**	**18**	**49 170**

B.TECH. ECE PROGRAMME SCHEME

SEMESTER – I

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T@	P	
1	IC	Economics for Engineers (OR) Business Studies	HSIC 102	3	0	0	3#
			HSIC 104	3	0	0	
2		Differential Calculus and Differential Equations	MAIC 101	3	0	0	3
3		Engineering Physics	PHIC 101	2	0	2	3
4		Engineering Practice	MEIC 102	1	0	3	2
5		Problems Solving and Programming using C	CSIC 103	3	0	2	4
6		Energy and Environment Science	CHIC 101	2	0	2	3
7	NC	Indian Knowledge Systems	HSNC 106	2	0	0	2#
		Teachings of Gita	HSNC 107				
		French Language Skills	HSNC 108				
		German Language Skills	HSNC 109				
		Japanese Language Skills	HSNC 110				
		Thought Lab and Practices	HSNC 111				
8		Sports	SANC 101	0	0	4	2*
		Yoga	SANC 102				
		NCC	SANC 103				
9		Club	SANC 104				
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
	Total						**20**

* Evaluation of these courses will be carried out at the end of each academic year i.e in 2nd semester.

Minimum number of students required to register for the subject to be offered is 50 and maximum number is 80 in one lecture group, limited to only 2 lecture groups for any subject.

@ In lieu of tutorial, wherever necessary, assignments and interactions with the students may be conducted at their own convenience by the faculty concerned.

B.TECH. ECE PROGRAMME SCHEME

SEMESTER – II

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1.	IC	Communication Skills in English (OR) Financial Education	HSIC 101	2	0	2	3#
			HSIC 103	3	0	0	
2.		Integral Calculus and Difference Equations	MAIC 102	3	0	0	3
3.		Advanced Engineering Physics	PHIC 103	2	0	2	3
4.		Engineering Graphics (Web Design)^	CSIC 102	1	0	3	2
5.		Chemistry	CHIC 103	2	0	2	3
6.	NC	Human Values and Social Responsibility	HSNC 101	2	0	0	2#
		Sanskrit Language Skills	HSNC 102				
		Hindi Language Skills	HSNC 103				
		Telugu Language Skills	HSNC 104				
		Constitution of India	HSNC 105				
		Vedic Mathematics	MANC 101				
7.		Sports	SANC 101	0	0	4	2
		Yoga	SANC 102				
		NCC	SANC 103				
8.		Club	SANC 104				
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
9.	PC	Circuit Theory (Theory & Lab)	ECPC 101	3	0	2	4
	Total						**22**

^Treated as a practical course (not integrated), evaluation will be as per practical course.

Minimum number of students required to register for the subject to be offered is 50 and maximum number is 80 in one lecture group, limited to only 2 lecture groups for any subject.

@ In lieu of tutorial, wherever necessary, assignments and interactions with the students may be conducted at their own convenience by the faculty concerned.

B.TECH. ECE PROGRAMME SCHEME

SEMESTER – III

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1	IC	Machine Learning & Data Analytics	CSIC 221	3	0	2	4
2	PC	Electronic Devices and Circuits	ECPC 201	3	0	0	3
3		Digital Design	ECPC 202	3	0	0	3
4		Signals, Systems &Random Variables	ECPC 203	3	0	0	3
5		Fields and waves	ECPC 204	3	0	0	3
6		Communication Engineering	ECPC 205	3	0	0	3
7		Electronics-I Lab	ECPC 206	0	0	2	1
8		Digital Design Lab	ECPC 207	0	0	2	1
9		Programming with MATLAB Lab	ECPC 208	0	0	2	1
10	NC	Sports	SANC 101	0	0	4	2*
		Yoga	SANC 102				
		NCC	SANC 103				
11	NC	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
Total							**22**

* Evaluation of these courses will be carried out at the end of each academic year i.e in, 4th semester.

B.TECH. ECE PROGRAMME SCHEME

SEMESTER – IV

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1	IC	Applied Linear Algebra	MAIC 204	3	0	0	3
2	PC	Analog Electronics	ECPC 209	3	0	0	3
3		Digital Communication	ECPC 210	3	0	0	3
4		Computer Architecture	ECPC 211	3	0	0	3
5		Information Theory and Coding	ECPC 212	3	0	0	3
6		Electronics-IILab	ECPC 213	0	0	2	1
7		Communication EngineeringLab (Comm. Lab -I)	ECPC 214	0	0	2	1
8		Digital Communication Lab (Comm. Lab -II)	ECPC 215	0	0	2	1
9		Object Oriented Programming Lab	ECPC 216	1	0	2	2
10	NC	Sports	SANC 101	0	0	4	2
		Yoga	SANC 102				
		NCC	SANC 103				
11	NC	Club	SANC 104				
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
Total							**22**
#Six-week internship during summer vacation Mandatory and it is to be evaluated in the V-Sem.							

B.TECH. ECE PROGRAMME SCHEME

SEMESTER – V

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1	PC	Digital Signal Processing	ECPC 301	3	0	0	3
2		Antenna &Wave Propagation	ECPC 302	3	0	0	3
3	PE	Program Elective-I	ECPE xxx	3	0	0	3
4		Program Elective -II	ECPE xxx	3	0	0	3
5	OE	Open Elective-I	ECOE xxx	3	0	0	3
6	PC	DSP Lab	ECPC303	0	0	2	1
7		HDL Lab	ECPC304	0	0	2	1
8		Transmission Lines& Antenna Lab (Comm. Lab -III)	ECPC305	0	0	2	1
9		Seminar	ECPC306	0	0	1	1
10		#Summer Training	ECPC307	Six Weeks			1
11	NC	Sports	SANC 101	0	0	4	2*
		Yoga	SANC 102				
		NCC	SANC 103				
12	NC	Club	SANC 104				
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
Total							**20**

* Evaluation of these courses will be carried out at the end of each academic year i.e in 6th semester.

Six-week internship after IV Sem in the summer vacation mandatory, and it is to be evaluated in the V-Sem.

Sr.No	Course Title	Course Code
LIST OF PROGRAM ELECTIVES		
1	Control System Engineering	ECPE 301
2	Memory Testing	ECPE 302
3	Multicarrier Communication	ECPE 303
4	MEMS	ECPE 304
5	Wireless Technologies	ECPE 305
6	Neuro- Fuzzy Systems	ECPE 306
7	IoT & Applications	ECPE 307
8	Sensors	ECPE 308
9	Analog IC Design	ECPE 309
10	Advanced MOS Devices	ECPE 310
11	Semiconductor Photonic Devices	ECPE 311
12	Verilog HDL	ECPE 312
13	Biomedical Electronics	ECPE 313
OPEN ELECTIVE-I		
1	Communication Systems	ECOE 301
2	Microprocessors	ECOE 302

B.TECH. ECE PROGRAMME SCHEME
SEMESTER – VI

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1	PC	Computer Networks	ECPC308	3	0	0	3
2		Processor Design	ECPC309	3	0	0	3
3		Microwave Theory & Devices	ECPC310	3	0	0	3
4	PE	Program Elective –III	ECPE xxx	3	0	0	3
5		Program Elective –IV	ECPE xxx	3	0	0	3
6	OE	Open Elective-II	ECOE xxx	3	0	0	3
7	PC	Processors Lab	ECPC311	0	0	2	1
8		Embedded System Lab	ECPC312	0	0	2	1
9		Machine Learning Lab	ECPC313	0	0	2	1
10	NC	Sports	SANC 101	0	0	4	**2**
		Yoga	SANC 102				
		NCC	SANC 103				
11	NC	Club	SANC 104				
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
Total							**23**
#Six-week internship during summer vacation Mandatory and it is to be evaluated in the VII-Sem.							

Sr.No	Course Title	Course Code
LIST OF PROGRAM ELECTIVES		
1	Image Processing	ECPE 314
2	Statistical Signal Processing	ECPE 315
3	Adaptive Signal Processing	ECPE 316
4	OFDM Systems	ECPE 317
5	Estimation & Detection	ECPE 318
6	Cyber Physical Systems	ECPE 319
7	Computational Electromagnetics and its Applications	ECPE 320
8	Mathematics for Machine Learning	ECPE 321
9	Embedded System Fundamentals	ECPE 322
10	Wireless Sensor Networks	ECPE 323
11	Advanced Microcontroller Architecture	ECPE 324
12	Digital IC Design	ECPE 325
13	ASICs & FPGAs	ECPE 326
14	Cryptography	ECPE 327
15	Data Science	ECPE 328
16	DSP Architecture	ECPE 329
17	Microstrip Antennas	ECPE 330
18	Data Structures	ECPE 331
LIST OF OPEN ELECTIVE-II		
1	Wireless Communications	ECOE 303
2	Logic Design and Analysis using Verilog	ECOE 304
3	Image Processing Applications	ECOE 305

B.TECH. ECE PROGRAMME SCHEME

SEMESTER – VII

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1	IC	Entrepreneurship & Start Ups	XXIC XXX	3	0	0	3
2	PC	Microelectronics & VLSI Design	ECPC 401	3	0	0	3
3		Wireless & Mobile Communication	ECPC 402	3	0	0	3
4	PE	Program Elective –V	ECPE xxx	3	0	0	3
5		Program Elective –VI	ECPE xxx	3	0	0	3
6	OE	Open Elective-III	ECOE xxx	3	0	0	3
7	PC	Project-I	ECPC 403	0	0	6	3
8		Microwave Lab	ECPC 404	0	0	2	1
9		#Summer Training	ECPC 405	Six Weeks			1
Total							**23**

Six-week internship after VI Sem in the summer vacation mandatory, and it is to be evaluated in the VII-Sem.

Sr.No	Course Title	Course Code
LIST OF PROGRAM ELECTIVES		
1	Deep Learning	ECPE 401
2	Image Forensic	ECPE 402
3	Biomedical Signal Processing	ECPE 403
4	Cognitive Radio	ECPE 404
5	Speech Processing	ECPE 405
6	Mathematical Aspects of Biomedical System Design	ECPE 406
7	Optical Communication Networks	ECPE 407
8	Advanced Mobile Communication	ECPE 408
9	Multiple Access Technologies	ECPE 409
10	Optical Wireless Communication	ECPE 410
11	Bio-Sensors	ECPE 411
12	VLSI Testing and Verification	ECPE 412
13	RF Microelectronics	ECPE 413
14	Analog & Mixed Signal Design	ECPE 414
15	Nano Electronics	ECPE 415
16	Advanced Computer Networks	ECPE 416
17	Quantum Communication	ECPE 417
18	Optical Communication	ECPE 418
OPEN ELECTIVE-III		
1	Sensors	ECOE 401
2	FSM Controller Design	ECOE 402

B.TECH. ECE PROGRAMME SCHEME
SEMESTER – VIII (Project & Course Work)

The students will not proceed for the full semester internship, will study according to the following course structure.

Sr.No	Course Category	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T	P	
1	PC	Data Security	ECPC 406	3	0	0	3
2	PE	Program Elective –VII	ECPE xxx	3	0	0	3
3		Program Elective –VIII	ECPE xxx	3	0	0	3
4	OE	Open Elective-IV	ECOE xxx	3	0	0	3
5	PC	Project –II	ECPC 407	0	0	12	6
Total							**18**

Sr.No	Course Title	Course Code
LIST OF PROGRAM ELECTIVES		
1	Television & RADAR Engineering	ECPE 419
2	Sonar System/Under water Communication	ECPE 420
3	Array Signal Processing	ECPE 421
4	Optical Signal Processing	ECPE 422
5	MIMO Systems	ECPE 423
6	Optical Wireless Techniques for IoT & 5G/6G systems	ECPE 424
7	Deep Learning for Advanced Communication Systems	ECPE 425
8	Space Time Coding	ECPE 426
9	Optical Networking and Switching	ECPE 427
10	Wavelets	ECPE 428
11	Satellite Communication	ECPE 429
12	Pattern Recognition	ECPE 430
13	Wireless Network Security	ECPE 431
14	Embedded System Security	ECPE 432
15	Cyber Security	ECPE 433
16	Satellite Image Processing	ECPE 434
17	Quantum Computing	ECPE 435
18	6G Net Works	ECPE 436
19	Cloud Computing	ECPE 437
20	Soft Computing & Expert Systems	ECPE 438
21	Computer Vision	ECPE 439
LIST OF OPEN ELECTIVE-IV		
1	Internet of Things	ECOE 403
2	Computer Networks and Information Security	ECOE 404

B.TECH. ECE PROGRAMME SCHEME
Internship*
SEMESTER – VIII (Internship & Course Work)

The students who will be permitted to go for the full semester internship must earn 18 credits through one of the following two modes:

(i)Mode-I: The students will obtain 9 credits for internship and 9 credits from the three NPTEL Courses as listed below:

S.No	Course Title	Course code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
			L	T@	P	
1	NPTEL Course-1	ECOC-XXX				3
2	NPTEL Course-2	ECOC-XXX				3
3	NPTEL Course-3	ECOC-XXX				3
4	Internship	ECPC-408				9
Total						18

LIST OF NPTEL COURSES

Sr.No	Course Code	Course Title
1	ECOC 401	NPTEL Course-1
2	ECOC 402	NPTEL Course-2
3	ECOC 403	NPTEL Course-3
4	ECOC 404	NPTEL Course-4
5	ECOC 405	NPTEL Course-5
6	ECOC 406	NPTEL Course-6
7	ECOC 407	NPTEL Course-7

The list of NPTEL courses will be decided by the DAC based on the availability of courses on the NPTEL platform in that current semester.

OR

(ii) Mode-II: The students will obtain 9 credits for internship and 9 credits from the three courses (one PC and two PE's) offered by the department in the current semester on self-study mode. They have to appear for the end semester examination for these courses as per the examination schedule of the Institute.

Semester – II

ECPC-101 CIRCUIT THEORY (INT)

Pre-requisite: Mathematics (MAIC-101)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The aim of this course is to make students competent in analyzing electrical circuits, apply Kirchhoff's current and voltage laws to circuits in order to determine voltage, current and power in branches of any circuits excited by DC voltages and current sources.

Course Content:

UNIT I **10 hrs.**

Basic Circuits & Network Theorems: Ohm's Law , Kirchhoff's laws , DC and AC Circuits, Resistors in series and parallel circuits ,Mesh current and node voltage method of analysis for D.C and A.C. circuits , Initial conditions. Network reduction: voltage and current division, source transformation , star delta conversion. Theorems: Thevenin's and Norton's, Superposition, Maximum power transfer, Substitution, and Reciprocity Theorems.

UNIT II **10 hrs.**

RL, RC and RLC Circuits & Resonance: Series and parallel resonance : their frequency response, Quality factor and Bandwidth, Self and mutual inductance, Coefficient of coupling, Tuned circuits, Single tuned circuits, Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and A.C. with sinusoidal input , Bandwidth and High Q circuits.

UNIT III **10 hrs.**

S-Domain Analysis of Circuits: Complex Frequency , Definition of the Laplace Transform, Laplace Transforms of Simple Time Functions, Inverse Transform Techniques, Basic Theorems for the Laplace Transform, The Initial-Value and Final-Value Theorems, Z(s) & Y(s) , Nodal and Mesh Analysis in s-Domain, Additional Circuit Analysis Techniques, Poles, Zeros, and Transfer Functions, Convolution Transfer Function.

UNIT IV **10 hrs.**

Two-Port Networks: One-Port Networks, Admittance Parameters, Some Equivalent Networks , Impedance Parameters, Hybrid Parameters , Transmission Parameters.

Text Book(s) / Reference(s):

[1] William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill publishers, 6th edition, New Delhi, 2003.

[2] Joseph A. Edminister, Mahmood Nahri, "Electric circuits", Schaum's series, Tata McGrawHill, New Delhi, 2001. 4th Ed

[3] M.E. Van Valkenburg, Ahmed Rumel, "Network Analysis", Prentice-Hall of India Pvt.Ltd.; 3rd edition

Course Outcomes:

On completion of this course, studentswill be able to:

CO1: Apply KCL and KVL in electrical circuits to calculate currents, voltages and powersin typical linear electric circuits

CO2: Apply circuit theorems and reduce more complicated circuits into the Thevenin's and Norton's equivalent circuits.

CO3: Analyze AC and DC Circuits.

CO4: Describe circuit elements in phasor domain and perform steady-state analysis using phasors.

CO5: Analyze resonance circuits and to develop transfer functions.

CO6: To understand Two-Port networks and its parameters.

Current Laws to circuits in order to determine voltage, current and power in branches of any circuits excited by DC voltage and current sources.

S.No	Experiment	Objectives
1	DC Measurement	(i) To understand the basics of DC (direct current) circuits. (ii) To use a digital multimeter (DMM) to measure DC voltage, current and resistance. (iii) To understand the valid measurement condition for a digital multimeter.
2	Network Analysis Methods	(i) To analyze a resistive circuit using node or mesh analysis. (ii) To understand Thevenin's and Norton's theorems. (iii) To verify the superposition principle.
3	AC Measurement	(i) To understand the basics of AC (alternating current) circuits. (ii) To use an oscilloscope to display and record a waveform. (iii) To use an oscilloscope to measure frequency, period, voltage (magnitude, peak-to-peak, maximum, minimum, etc), DC offset, etc, of the waveform. (iv) To use an oscilloscope to measure frequency, period, voltage (magnitude, peak-to-peak, maximum, minimum, etc), DC offset, etc, of the waveform.

Circuit Theory Lab

Pre-requisite: Mathematics (MAIC-101)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description about the course:

The aim of course is to make students competent in analyzing electrical circuits, apply Kirchhoff's	First order & Second order circuits	(i) To study the step response of first order circuits. (ii) To understand the concept of the time constant. (iii) To study the step response of second order circuits. (iv) To understand the difference between overdamped, critically damped and underdamped responses. (v) To determine theoretically and experimentally the damped natural frequency in

Voltage and 4		the under-damped case.
5	Sinusoidal Steady State	(i) To understand and calculate the power factor of a passive circuit. (ii) To verify that resistive components dissipate power while reactive components do not.
6	Transfer Functions	(i) To Study the transfer function of a circuit. (ii) To use the transfer function to find the specified frequency specified in the different cases.
7	Series and Parallel Resonance	(i) To study the behavior of series and parallel LC circuits at resonance. (ii) To understand the resonance frequency, cut-off frequency, bandwidth and quality factor of a resonance circuit. (iii) To determine if the circuit is inductive or capacitive. (iv) To understand the circuit behavior at resonance.

Course Outcomes:

At the end of the course, the students will be able to:

- **CO1:** Apply KVL and KCL in electrical circuits to calculate current, voltage and power in typical linear electrical circuits.
- **CO2:** Apply circuit theorems.
- **CO3:** Analyze AC and DC circuits.
- **CO4:** Reduce more complex circuits into Thevenin's and Norton's equivalent circuits.
- **CO5:** Describe circuit elements in phasor domain and perform steady state analysis using phasors.
- **CO6:** Analyze resonance circuits.

Semester – III

ECPC-201 ELECTRONIC DEVICES AND CIRCUITS

Pre-requisite: Engineering Physics (PHIC-101) and Advanced Engineering Physics (PHIC-103)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
To enable the students to understand the working principle of diodes and transistors for circuit applications.

Course Content:

UNIT I **10 hrs.**

Review of P-N Junctions: abrupt and linearly graded junctions. V-I characteristic, C-V characteristic, Zener and Avalanche Breakdown. Diode circuit model. P-N junction applications: Rectifiers, Clipping and Clamping Circuits, Voltage Regulator.

UNIT II **10 hrs.**

BJT: Ideal and Real transistor, I-V Characteristics, Small signal equivalent circuits, High frequency and Switching Transistors, BJT as an amplifier – Biasing, small Signal analysis. Frequency response. BJT equivalent circuit models- DC model, h-parameter model, re model and hybrid-π model. Power transistors.

UNIT III **10 hrs.**

Theory of field effect transistors: Static characteristics of JFETs and MOSFETs; Analysis of MOS structure, MOS capacitor C-V and concept of accumulation, depletion and inversion; Threshold Voltage, MOSFET I-V and C-V characteristics and small signal models, Body bias. Short channel effects: SS, DIBL, GIDL, surface mobility, CLM.

UNIT IV **10 hrs.**

JFET and MOSFET single-stage amplifiers: Biasing, Small signal analysis, Frequency Response. Feedback Amplifiers and Oscillators. Case study: Electronic waste management, IKS-based solutions.

Text Book(s) / Reference(s):

[1] J. Millman and C. Halkias, Integrated Electronics, McGraw Hill, 2nd Edition, 2009.

[2] Behzad Razavi, Design of analog CMOS Integrated circuits, McGraw Hill, 2002.

[3] Tyagi M.S., "Introduction to Semiconductor Materials and Devices", John Wiley & Sons, 1993.

[4] Streetman B.G., Banerjee, S.K, "Solid State Electronic Devices", Pearson Education, 6th Edition 2006.

[5] Y. Taur and T. K. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press
[6] A. Sedra and C. Smith, Microelectronic Circuits: Theory and Applications, Oxford University Press, 6th Edition, 2013.

Course Outcomes:

At the end of the course, the students will be able to

CO1: Understand the working principle of the P-N junction diode, BJT, JFET, and MOSFET.

CO2: Understand the short-channel effects in MOS devices.

CO3: Understand BJT, JFET, and MOSFET's small signal analysis and circuit applications.

CO4: Design and analysis of feedback and oscillator circuits.

ECPC-202 DIGITAL DESIGN

Pre-requisite: Advanced Engineering Physics (PHIC-103)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
This course will enable students to Learn Boolean equation-based design of digital and sequential circuits, Understand the importance of logic families and design transistor-based gates and circuits and to implement digital circuits on FPGAs and evaluate their power and performance.

Course Content:

UNIT I **10 hrs.**

Number Systems and Codes: Binary, octal, and hexadecimal number systems, Conversion between number systems, Complements of binary numbers, BCD codes, gray codes, and ASCII codes.

Boolean Algebra and Logic Gates: Boolean algebra: Boolean laws, De Morgan's theorem, Boolean functions, Karnaugh maps, QM Method, Basic logic gates: AND, OR, NOT gates and their truth tables, Universal gates: NAND, NOR, XOR, and XNOR gates, Logic gate circuits and their applications. TTL, CMOS, ECL logic families, fan in, fanout.

UNIT II **12 hrs.**

Combinational Circuits: Adders and subtractors: Half adder, full adder, ripple carry adder, carry look-ahead adder, subtractor circuits, Multiplexers and demultiplexers, Encoders and decoders, Comparators and magnitude comparators, Parity generators and checkers

Sequential Circuits: Latches and flip-flops: SR flip-flop, D flip-flop, JK flip-flop, T flip-flop, Registers: shift registers, parallel in/serial out (PISO) registers, serial in/parallel out (SIPO) registers, and parallel in/parallel out (PIPO) registers, Counters: ripple counter, synchronous counter, and Johnson counter.

UNIT III **10 hrs.**

Memory Elements: SRAM, DRAM, and ROM, Finite State Machines (FSMs): Mealy and Moore models, state diagrams, state tables, and state reduction techniques.

Digital System Design: Digital system design flow and design methodology, Timing analysis and timing constraints, Clock domains and clock distribution, Synchronous and asynchronous design techniques

UNIT IV **8 hrs.**

Introduction to FPGA Architecture and Programming: FPGA based design flow. Two real time Case Studies. Power optimization techniques: Dynamic and Static Power Dissipation, Power gating, clock gating, data gating.

Text Book(s) / Reference(s):

[1] M. Morris Mano and Michael Ciletti, Digital Design.
[2] Thomas L. Floyd and R. Brockwell, Digital Fundamentals.
[3] Stephen Brown and Zvonko Vranesic, Fundamentals of Digital Logic with Verilog Design
[4] Giuliano Donzellini and Luca Oneto, Introduction to Digital Systems Design
[5] Guy Even and Moti Medina, Digital Logic Design: A Rigorous Approach

Course Outcomes:

At the end of the course, the students will be able to:

CO1: Understand how to write Boolean equations and simplify them
CO2: Design digital circuits and develop applications
CO3: Design sequential circuits, FSMs, state reductions and develop optimized circuits and applications
CO4: Understand programmable devices, their applications, design flow.
CO5: Understand power consumption of circuits, its pros and cons and reduction techniques.

ECPC-203 SIGNALS, SYSTEMS AND RANDOM VARIABLES

Pre-requisite: Differential Calculus and Differential Equations (MAIC-101) and, Integral Calculus and Difference Equations (MAIC-102)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course on signals, systems and random variables provides a foundation for the design and analysis of various engineering and behavioral science systems. It contains descriptions of various discrete time and continuous signals, convolution integral and convolution sum, LTI systems, Fourier series and Fourier Transform and their important properties. Random variables and processes are dealt with in detail. Several important distribution functions applicable to different engineering fields are included. The students shall be able to apply the knowledge to various science and engineering fields.

Course Learning Objectives:
To understand LTI systems, analysis of periodic signals, analysis of aperiodic signals, random variables and random processes.

Course Content:

UNIT I **10 hrs.**

LTI Systems: Continuous time and discrete time signals, Even and Odd signals. Elementary continuous time and discrete time signals. Classification of signals, causality; stability, time invariance, linearity. Continuous time and Discrete time LTI Systems, convolution Integral and convolution sum, Properties of LTI Systems. Differential and Difference equations. Singularity functions.

UNIT II **10 hrs.**

Fourier Analysis of Signals: Fourier series representation of continuous time and discrete time periodic signals. Fourier series and LTI Systems. Laplace Transform and concept of ROC. Continuous Time Fourier Transform (CTFT). Properties of CTFT. Discrete time Fourier Transform (DTFT). Properties of DTFT. Systems characterized by Linear constant co-efficient differential equations and difference equations. Magnitude and phase spectrum, group delay.

UNIT III **12 hrs.**

Random Variables: Probability, Conditional Probability, definition of random variables, cumulative distribution function, probability density function, discrete random variables, continuous random variables, mathematical expectation, moments of

random variables. Chebyshev inequality. Some important distribution functions: uniform, rectangular, Gaussian, Bernoulli, binomial, Poisson, Exponential, Rayleigh, Rice, lognormal, and chi square. Sum of random variables, Functions of random variables. Joint distribution, marginal and conditional distributions, statistical independence, Central Limit Theorem, moments and Characteristic Functions.

UNIT IV **8 hrs.**

Random Processes: Definition and description of Random Processes, Classification of random processes, statistical characterization, mean, correlation and covariance functions, Stationary random processes, Ergodicity, Power Spectral density, Weiner-khintchine theorem, Response of memory-less and linear systems to random inputs, discrete time stochastic processes, Cyclostationary processes, Gaussian, Poisson, Markov processes.

Text Book(s) / Reference(s):

[1] Oppenheim Willsky and Nawab, Signals and Systems, PHI. 4th Ed
[2] Simon Haykin, Signals and Systems, John Wiley 4th Ed
[3] Taub and Schilling, Principles of Communication Systems, TMH. 4th Ed
[4] Papoulis, A. Probability, Random Variables and Stochastic Processes, MGH, 3rd Ed.
[5] Gray, R.M. Davission, L.D, Introduction to Statistical Signal Processing- Web Edition-1999.
[6] Sundarapandian, V. Probability, Statistics and Queueing Theory, PHI Learning Private Limited, 3rd Ed.

Course Outcomes:

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

CO1: Utilize the concepts of Discrete time and Continuous time signals and their transformations.
CO2: Analyze the Fourier series of periodic and Fourier transforms of non-periodic discrete time and continuous time signals.
CO3: Understand and apply the concepts of Fourier series and Fourier transform.
CO4: Characterize probability models and function of random variables based on single & multiples random variables.
CO5: Evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits.
CO6: Understand the concept of random processes and determine covariance and spectral density of stationary random processes.

ECPC-204 FIELDS & WAVES

Pre-requisite: Differential Calculus and Differential Equations (MAIC-101)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
Fields and Waves (FW) is a highly abstract and complex subject that examines how exerting a force on charged particles is affected by the presence and motion of adjacent particles. The interdependence of the time varying electric and magnetic fields—one producing the other, and vice versa—has allowed the students to consider them as a single coherent entity: the electromagnetic field. Under this umbrella, students can learn about numerous and varied topics ranging from the basics of steady electric and magnetic fields to transmission lines including waveguides along with their real-life applications.

Course Content:

UNIT I **10 hrs.**

Overview of electromagnetic fields and wave phenomena, Historical background and key concepts. Electrostatic Fields: Coulomb's law and electric field intensity, Electric potential and potential gradient, method of images, Gauss's law and its applications, Conductors, dielectrics and their boundary conditions, Poisson's and Laplace's equations, uniqueness theorem. Magnetostatic Fields: Biot-Savart law and magnetic field intensity, Ampere's law and its applications, magnetic vector potentials, Magnetic materials and boundary conditions, magnetic circuits, Inductance and magnetic energy

UNIT II **10 hrs.**

Faraday's law of electromagnetic induction, Maxwell's equations in point form and integral form, Maxwell's equations for sinusoidal variations, retarded potentials. Plane waves and their characteristics, Wave propagation in lossless and lossy media, Boundary conditions for electromagnetic fields, Poynting vector and power considerations, Reflection, transmission, and refraction of waves, SWR, Wave polarization and polarization transformations

UNIT III **10 hrs.**

Transmission line equations, graphical methods, Smith chart, Impedance Matching, Rectangular and cylindrical waveguides, Modes of propagation, Resonant cavities and cavity resonators, power flow in wave guides, excitation of wave guides, dielectric waveguides.

UNIT IV **10 hrs.**

Applications of Fields and Waves in various sustainable technologies, case studies from the Indian knowledge system.

Text Book(s) / Reference(s):

[1] E. C. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, PHI, 3rd Ed.
[2] David & Chang, Field and Wave Electromagnetics, Addison Wesley, 3rd Ed.
[3] W. H. Hayt, Engineering Electromagnetics, JR. Tata Mc-Graw Hill Edition, Fifth edition.
[4] Sadiku, Matthew NO, and Shrikrishna V. Kulkarni. Principles of electromagnetics. Vol. 6. New Delhi, India: OxfordUniversity Press, 2015.

Course Outcomes:

At the end of the course, the students will be able to

CO1: Review the basics of electromagnetic theory
CO2: Comprehend the effects of sinusoidal time variation in both electric and magnetic fields using Maxwell equations and retarded potentials.
CO3: Understand the propagation of electromagnetic waves through different media and apply the above knowledge to understand working of transmission lines and waveguides.
CO4: Practice the use of Field and Waves in various real-life applications.

ECPC-205 COMMUNICATION ENGINEERING

Pre-requisite: Signals, Systems & Random Variables (ECPC-203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course will provide the fundamentals and basic concepts of different modulation and demodulation schemes. The effect of AWG noise on these systems.

Course Content:

UNIT I **8 hrs.**

Introduction: Analog and digital signals/sources and systems, deterministic and random signals, frequency allocations, block diagram of a communication system. Modulation, need for modulation. Sampling theorem, Analog-to-digital conversion schemes: PCM, MD, ADM etc.

UNIT II **12 hrs.**

Amplitude Modulation and Angle Modulation Systems: Frequency translation, a method of frequency translation, recovery of base-band signal. Amplitude modulation (AM), Representation of band pass signals, Generation and Demodulation of different AM waves. Comparison among AM, DSBSC, and SSBSC. Phase modulation (PM) and Frequency Modulation (FM), Relationship between FM and PM, Single tone frequency modulation, Spectrum Analysis of Sinusoidal FM Wave, Narrow band FM, Wide band FM, Transmission bandwidth of FM Wave - Generation of FM Waves, Detection of FM, Balanced Frequency discriminator, Zero crossing detector, Phase locked loop, Comparison of FM and AM.

UNIT III **12 hrs.**

Pulse Modulation & Receivers: Pulse analog modulations, PAM, PWM, PPM. Generation and demodulation of pulse modulated signals. Radio Receivers: Tuned radio frequency receiver (TRF), Super-heterodyne receiver (SRF), AFC and AGC. FM Receivers, Comparison of AM & FM Receivers

UNIT IV **8 hrs.**

Noise: Introduction to noise. Performance analysis of AM and FM receivers under AWGN. Threshold effect in Angle Modulation System, Pre-emphasis and de-emphasis. Detection of faults in AM and FM receivers. Recent applications of AM and FM. Medical image analysis using AM-FM model as a case study.

Text Book(s) / Reference(s):

[1] Simon Haykins, Communication Systems, Wiley & Sons, 4th Edition.
[2] Herbert Taub, and Donald L. Schilling, Principles of Communication Systems, McGraw-Hill.
[3] B.P. Lathi, Modern Digital and Analog Communications, Oxford.
[4] George Kennedy and Bernard Davis, Electronics & Communication Systems.
[5] Kyriacos P Constantinou, et. al., Medical Image Analysis Using AM-FM Models and Methods, IEEE Reviews in Biomedical Engineering, 2020.

Course Outcomes:

At the end of the course, the students will be able to:

CO1: Understand different modulation and demodulation schemes.
CO2: Analyze power requirement of different waveforms of modulated signals.
CO3: Analyze different characteristics of the receiver.
CO4: Compute the effect of noise by computing SNR in AM and FM receivers.

ECPC-206 ELECTRONICS-I LAB

Pre-requisite: Engineering Physics (PHIC-101) , Advanced Engineering Physics (PHIC-103) and Electronic Devices and Circuits (ECPC-201)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description of the Course:
This course is designed to apply knowledge of analog electronics to hands-on laboratory experience. To design and analyze various electronic circuits using p-n junction diode, Zener diode, BJT, JFET and MOSFET, assemble and make performance measurements on analog circuits, perform hand-worked analytical analysis of these circuits, and write formal laboratory reports summarizing the results obtained, and discussing the correlation between the analytical predictions and the observed behaviors.

List of Experiments:

1. PN Junction diode characteristics. A. Forward bias, B. Reverse bias.
2. Zener diode characteristics and voltage regulator.
3. Half wave Rectifier with and without filter.
4. Full wave Rectifier with and without filter.
5. Transistor CB characteristics (Input and Output).
6. Transistor CE characteristics (Input and Output).
7. Frequency response of CE Amplifier.
8. Frequency response of CC Amplifier (Emitter Follower).
9. FET Characteristics
10. Frequency Response of single stage RC coupled Amplifier.
11. Frequency Response of double stage RC coupled Amplifier.

Course Outcomes:
At the end of the course the students will be able to

CO1: To familiarize students with measuring instruments.
CO2: To demonstrate students the working and input-output characteristics of p-n junction diode, Zener diode, BJT, JFET and MOSFET.
CO3: To demonstrate students Halfwave & Full wave Rectifier with and without filter.
CO4: To demonstrate students the working of single stage amplifiers using BJT and MOSFETs.

ECPC-207 DIGITAL DESIGN LAB

Pre-requisite: Advanced Engineering Physics (PHIC-103), Digital Design (ECPC-202)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description of the Course:
This course is designed to apply knowledge of digital electronics to hands-on laboratory experience. To familiarize students with the working of ICs of logic gates, MUXs, Encoder, Decoder, Flip-Flops etc. To demonstrate students, the realization of MUXs/De-MUX, Encoder, Decoder, Flip-Flops etc. with the help of basic ICs. To enable students to realize one Flip-Flop with the help of other Flip Flops. To enable the students to design counters, shift registers, adder, subtractor etc. with the help of basic ICs.

List of Experiments:

1. Introduction to Digital Design Lab- Nomenclature of Digital ICs, Specifications, Study of the Data Sheet, Concept of Vcc and Ground, Verification of the Truth Tables of Logic Gates using TTL ICs.
2. Study and Verify (a) Demorgan's Theorem for 2 variables. (b) The sum-of product and product-of-sum expressions using universal gates.
3. Design and implementation of (a) Full Adder using basic logic gates. (b) Full subtractor using basic logic gates.
4. Implementation and Verification of Decoder/De-Multiplexer and Encoder using Logic Gates.
5. Realization of the following flip-flops using NAND Gates. (a) Clocked SR Flip-Flop (b) JK Flip-Flop.
6. Realisation of 2-bit comparator using gates and study of four-bit comparator.
7. Realization of following shift registers using IC7474 (a) SISO (b) SIPO (c) PISO (d) PIPO.
8. Design and implementation of MOD-12 up and down counter.
9. Design and study of BCD to 7-segment converter.
10. Design of a 3-input NAND gate and its simulation using a suitable logic simulator.
11. Design of a 3-input NOR gate and its simulation using a suitable logic simulator.

Course Outcomes:

At the end of the course, the students will be able to:

CO1: Construct digital circuit to examine Boolean algebra, truth table of different logic gates.

CO2: Design various combinational and sequential circuits after analysing their timing properties.

CO3: Understand the use of digital ICs of different logic functions.

CO4: Design different types of counters, shift registers, adder, subtractor with the help of ICs.

ECPC-208 PROGRAMMING WITH MATLAB

Pre-requisite: Differential Calculus and Differential Equations (MAIC-101)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description:
This lab aims to familiarize the students about numerical computing in various fields. MATLAB allows matrix manipulations, plotting the function by using polar & contour3 commands, implementation of algorithms & creation of user interfaces. It calculates their design, waveforms, graphs, circles, circular helix and solves various integral and differential equations. Using MATLAB symbolic math toolbox, determine the Laplace transform. Further in this lab students will attain the knowledge about convolution and cross correlation between two sequences.

List of Experiments:

1. To study Basic MATLAB arithmetic Commands.
2. For an electrical circuit with an inductance L=0.01 mH and resistance R=100Ω, write a program to calculate the damped natural frequency for different values of C varying from 0.1 to 1 in step of 0.01.
3. Write a MATLAB program to define and operate on vectors u=<1,2,3,4> and v=<2,3,4,5>: scalar multiplication 5v, power operations u^5 and v^5, element-wise multiplication u.*v, and u.*v^t.
4. Write a MATLAB program to calculate summations: sum of k from 0 to 100, sum of k^2 from 0 to 100, sum of 1/k from 1 to 100, sum of 1/k^2 from 1 to 100.
5. Write a MATLAB program to break a function f(x) into odd and even parts using fodd(x)=(f(x)-f(-x))/2 and feven(x)=(f(x)+f(-x))/2, applied to f(x)=e^x using symbolic math.
6. Write a MATLAB program to generate different waveforms: square wave, sine wave, triangle wave, exponential wave, unit step function, unit impulse function, rectangular pulse of width 2, and unit ramp function.
7. Draw graphs of specified mathematical functions using MATLAB.
8. Draw the circle of radius r=5 using MATLAB.
9. Write a function in MATLAB for factorial to compute n! for n=50.
10. Write a MATLAB program to compute the sum of all powers of 2 below 50 using the while command.
11. Write a MATLAB program to solve a system of three linear equations in x, y, z.
12. Write a MATLAB program for Fibonacci series.

13. Write a MATLAB program for the calculation of the alternating harmonic series 1-1/2+1/3-1/4+...
14. Write a MATLAB program to compute and generalize s(N)=sum(1/k^2) for N from 20 to 100.
15. Write a Matlab function that accepts sides a, b, c of a triangle and returns its area using Heron's formula.
16. Write a MATLAB program to compute and display even powers of 2 less than or equal to a given positive number.
17. Use the command plot3(x,y,z) to plot the circular helix x(t)=sin(t), y(t)=cos(t), z(t)=t for 0≤t≤20.
18. Plot the surface defined by f(x,y)=(x-3)^2+(y-2)^2 for 2≤x≤4, 1≤y≤3 using MATLAB.
19. Find the solution of first order ODE: x'=2x+5sin(t), x(0)=1.
20. Plot r^2=2sin(5t) for 0≤t≤2π using polar command in Matlab.
21. Plot z=-5/(1+x^2+y^2) for |x|≤3, |y|≤3 using the contour3 command in Matlab.
22. Compute a double integral and the Laplace transform of x(t)=[sin(at)+cos(bt)]u(t).
23. Compute the first order differential equation dy/dx=x+t with initial condition x(0)=0.
24. Compute the transcendental equation sin(x)=e^x-5 with initial value x0=1 using MATLAB.
25. Determine the convolution of x(t)=1/(1+t^2) with itself.
26. Compute the cross correlation between X(n)={1,2,-1,3} and h(n)={3,-2,1,4}.
27. Let x(n)=u(n)-u(n-10). Decompose x(n) into even and odd components.
28. Let x(t)=e^(-1000|t|). Sample x(t) at fs=5000 samples/sec and reconstruct x(t) from samples.
29. Using MATLAB symbolic math toolbox, determine the Laplace Transform of x(t)=t*e^(-at)*u(t).

Course Outcomes:

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

CO1: Learn various aspects of MATLAB such as interface, syntax, debugging and execution.

CO2: Understand how various MATLAB scripts are created, saved and executed.

CO3: Apply above knowledge in writing simple programs.

CO4: Learn basic concepts of simulation using SIMULINK and write complex programs.

Semester – IV

ECPC-209 ANALOG ELECTRONICS

Pre-requisite: Engineering Physics (PHIC-101) , Advanced Engineering Physics (PHIC-103) and Electronic Devices and Circuits (ECPC-201)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
To enable the students to design single and multistage amplifiers, oscillators and Op-Amp-based linear and non-linear circuits.

Course Content:

UNIT I **10 hrs.**

Analysis and design of the single-stage amplifier using MOS devices, estimation of voltage gain, input resistance, output resistance etc., Classification of amplifiers, Direct coupled amplifiers, Multistage amplifiers, and the Frequency response of amplifiers. Current Mirrors, Differential Amplifiers.

UNIT II **10 hrs.**

Introduction to OP-AMP, ideal OP-AMP, equivalent circuit, transfer characteristics, Op-Amp with negative feedback, inverting and non-inverting amplifiers, frequency response, compensating network, circuit stability, and slew rate.

UNIT III **10 hrs.**

OP-AMP applications: integrator and differentiator, summing amplifier, precision rectifier, Schmitt trigger and its applications. Operational Transconductance Amplifier, Active filters: Low pass, high pass, band pass and band stop, design guidelines.

UNIT IV **10 hrs.**

Digital-to-analog converters (DAC), Analog-to-digital converters (ADC), Oscillators: Review the basic concept, Barkhausen criterion, RC oscillators, LC oscillators. Real-life applications: A case study.

Text Book(s) / Reference(s):

[1] A. Sedra and C. Smith, Microelectronic Circuits: Theory and Applications, Oxford University Press, 6th Edition, 2013.
[2] J. Millman and C. Halkias, Integrated Electronics, McGraw Hill, 2nd Edition, 2009.
[3] Behzad Razavi, Design of analog CMOS Integrated circuits, McGraw Hill, 2002.
[4] R. A. Gayakwaed, OP-amps and Linear Integrated circuits, Prentice Hall India Learning Private Limited, 4th Edition 2002.
[5] K. R. Botkar, Integrated circuits, Khanna Publishers, 2004.

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

CO1: Design single and multistage amplifiers and current mirrors
CO2: Understand the characteristics of op-amps and circuit design based on op-amps.
CO3: Understand the use of op-amps in different types of applications.
CO4: Design ADC and DAC.

ECPC-210 DIGITAL COMMUNICATION

Pre-requisite: Communication Engineering (ECPC-205), Signals, Systems and Random Variables (ECPC-203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course on digital communication provides a foundation for design and analysis of various digital communication techniques. It contains the methods of baseband communication, their challenges and the techniques to overcome them. Various digital modulation techniques such as BPSK, DPSK, QPSK, MPSK, QAM, FSK, MFSK, MSK are introduced and their performance is analyzed. Some more recent techniques such as spread spectrum systems and multicarrier systems are introduced along with their applications in real world systems. The students will learn the concept of pulse shaping, methods of equalization, signal space representation, along with different passband digital communication techniques, their analysis and implementation.

Course Objectives:
To understand the key modules of digital communication systems with emphasis on digital modulation techniques; various aspects such as the effect of Inter Symbol Interference, BER for different modulation techniques and bandwidth efficiency, and practical applications.

Course Content:

UNIT I **12 hrs.**

Base Band Pulse Transmission: Matched filter and its properties average probability of symbol error in binary encoded PCM receiver, inter symbol interference, Nyquist criterion for distortion less base band binary transmission, ideal Nyquist channel raised cosine spectrum, correlative level coding Duo binary signaling, tapped delay line equalization, adaptive equalization, LMS algorithm, Eye pattern.

UNIT II **10 hrs.**

Signal Space Analysis & Optimum Receiver: Pass band transmission model; gram Schmidt orthogonalization procedure, geometric Interpretation of signals, Response of bank of correlators to noise input, detection of known signal in AWGN. Likelihood function, coherent detection of signals, maximum likelihood decoding, correlation receiver, matched filter receiver.

UNIT III **10 hrs.**

Digital Modulation Techniques: BPSK, DPSK, QPSK, MPSK, QAM, FSK, MFSK, MSK, modulation and demodulation schemes and their performance analysis, comparison of modulation schemes on the basis of probability of error and bandwidth efficiency, signal space diagram and spectra of the above modulation schemes.

UNIT IV **8 hrs.**

Spread Spectrum and Multicarrier Communications: Pseudonoise sequence, principle of spread spectrum, direct sequence spread spectrum with coherent BPSK, signal, space dimensionality & processing gain, probability of error, frequency hopped spread spectrum, CDMA, Principles of OFDM, Cyclic prefix redundancy in OFDM, OFDM equalization, DMT system, applications of OFDM and DMT.

Text Book(s) / Reference(s):

[1] Simon Haykins, Communication Systems, Wiley & Sons, 4th Edition.
[2] Taub & Schilling, Principles of Communication Systems, TMH.
[3] B.P. Lathi, Modern Digital and Analog Communications, Oxford.
[4] Proakis, Digital Communication.

Course Outcomes:

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

CO1: Understand the baseband binary data transmission system and the process of equalization
CO2: Obtain the signal space representation for signals and analyse them.
CO3: Understand and analyse various detection criteria for detection of signals
CO4: Understand the principle of various digital modulation techniques
CO5: Analyze the BER performance of digital modulation techniques.
CO6: Understand principles of spread spectrum systems
CO7: Understand the principles of DMT and OFDM systems and their practical applications.

ECPC-211 COMPUTER ARCHITECTURE

Pre-requisite: Digital Design (ECPC-202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the course:
This course aims to provide a strong foundation for students to understand the modern eras of computer architecture (i.e., the single-core era, multi-core era, and accelerator era) and to apply these insights and principles to future computer designs.

Course Content:

UNIT I **8 hrs.**

Introduction to Computer Hardware and Software: Functional Units, Historical perspective, Performance of computer, Register transfer and micro-operations, Information representation, Instruction format, Instruction types, Addressing modes, Instruction set architectures- CISC and RISC, Super-scaler architecture, Fixed point and floating point operations.

UNIT II **12 hrs.**

Basic Processing Unit & Memory Organization: Fundamental concepts, ALU, Control unit, Multiple bus organization, Hardwired control, Micro programmed control, Semiconductor RAM memories, Read-Only Memories, Speed, Size and Cost, Cache Memories, Performance considerations, Cache Coherency in Multiprocessor, Virtual Memories, Memory Management Requirements, Secondary Storage devices.

UNIT III **12 hrs.**

Pipeline and Vector Processing: Parallel processing, Pipelining, Hazards, CISC & RISC pipeline, Vector processing. Array processing.

I/O Organization: Accessing I/O Devices, Programmed I/O, Interrupt-driven I/O, Direct Memory Access, Buses, Interface Circuits: Serial port, Parallel port, PCI Bus, SCSI Bus, USB, The External Interface-FireWire and InfiniBand.

UNIT IV **8 hrs.**

Advanced Computer Architecture: Study of instruction set design, parallel processing, bit, instruction, and data level parallelism, distributed computing, virtualization architecture, AI/ML applications and cloud and mobile architecture. Case Study: MIPS processor architecture. Computer architecture for sustainable computer systems. Future Trends in Computer Architecture Research.

Text Book(s) / Reference(s):

[1] C. Hamacher, Z. Vranesic and S. Zaky, Computer Organization, McGraw-Hill, 5th ed., 2002.
[2] W. Stallings, Computer Organization and Architecture - Designing for Performance, Pearson, 7th ed., 2006.
[3] M.M. Mano, Computer System Architecture, PHI.
[4] J. P. Hayes, Computer Architecture and Organization, McGraw-Hill.
[5] John L. Hennessy, David A. Patterson, Computer Architecture - A Quantitative Approach, 5th edition.

Course Outcomes:

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

CO1: Comprehend the basic knowledge of functional components of computer systems.

CO2: Analyze concept of various addressing modes including design instruction set architecture. Identify the function of building blocks within the CPU of a computer system.

CO3: Explain memory system design including Cache and Virtual-memory systems. Familiarize with the basic knowledge of I/O devices and interface circuits.

CO4: Identify problems and understand parallel programming models of multicore processors, multiprocessors.

ECPC-212 INFORMATION THEORY AND CODING

Pre-requisite: Communication Engineering (ECPC-205), Signals, Systems and Random Variables (ECPC-203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Information theory and coding deals with the concept of information content in a digital message and techniques to efficiently represent them by using source coding methods. The channel coding techniques aim at providing reliable digital communication of message signals over noisy channels. The course contains Shannon's fundamental theorems on coding, necessary mathematical background for various error correction codes, construction and detection of linear block codes, cyclic codes, and convolutional codes. The students will learn how to use the source coding techniques to remove the redundancy from the message and then design suitable channel codes for use at transmitter and decode them at the receiver to ensure error free transmission of message signals.

Course Learning Objectives:
To understand elements of information theory and source coding, Linear block codes, Cyclic codes, Convolutional codes and their applications.

Course Content:

UNIT I **12 hrs.**

Elements of Information Theory and Source Coding: Introduction, information as a measure of uncertainty, Entropy & its properties, Entropy of continuous sources, Discrete memoryless channels, Mutual information & its properties, BSC, BEC. Channel capacity, Shannon's theorem on coding for memoryless noisy channels, Shannon's three fundamental theorems. Separable binary codes, Shannon-Fano encoding, Noiseless coding, Theorem of decodability, Average length of encoded message, Shannon's binary encoding, Fundamental theorem of discrete noiseless coding, Huffman's minimum redundancy codes, capacity of colored noise source, water filling algorithms.

UNIT II **12 hrs.**

Linear Block Codes: Groups & fields, Galois fields & its construction, Minimal polynomial, Vector spaces, Dual spaces, Linear block codes, Syndrome & error detections, Minimum distance, Error detecting and correcting capabilities of a block code, Standard array & Syndrome decoding, Hamming code.

UNIT III **8 hrs.**

Cyclic Codes: Description of cyclic codes, Polynomial representation, Minimum degree code polynomial, Generator polynomial, Generator matrix, Systematic form, Parity check matrices, cyclic codes encoders, Syndrome computation and error detection, Cyclic Hamming codes, Decoding of cyclic codes.

UNIT IV **8 hrs.**

Convolutional Codes: Encoding of Convolution codes, Structural properties of Convolution codes, State diagram, Code tree, Trellis diagram, Free distance, Coding gain, Viterbi decoding, distance properties of binary convolutional codes, Burst error correcting convolutional codes. Implementation of error control codes in real systems and case studies.

Text Book(s) / Reference(s):

[1] F. M. Reza, Information Theory, McGraw Hill, 1st Ed.
[2] Das, Mullick and Chatterjee, Digital Communication, Wiley Eastern Ltd, 3rd Ed.
[3] Shu Lin and J. Costello, Error Control Coding, Prentice Hall, 3rd Ed.

Course Outcomes:

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

CO1: Understand the concepts of Random variables and stochastic processes and their applications in communication engineering.
CO2: To be able to perform the time and frequency domain analysis of the signals in a digital communication system.
CO3: Understand and apply the Entropy function, source coding and the three Shannon's fundamental theorems.
CO4: Design the linear block codes and cyclic codes.
CO5: Understand and apply the convolutions codes, state diagrams, code tree and trellis diagrams, decoding algorithms.
CO6: Understand and evaluate the channel performance using Information theory.

ECPC-213 ELECTRONICS-II LAB

Pre-requisite: Electronic Devices and Circuits (ECPC-201) and Analog Electronics (ECPC-209)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description about the course:
The purpose of this course is to familiarize the students about the practical implementation of single and multistage amplifiers, oscillators and Op-Amp-based linear and non-linear circuits. The basic objective is to familiarize students with the working principle of single stage and multistage amplifiers and their frequency response, & to demonstrate students with the designing of basic current mirrors, differential amplifiers and Op-amp using MOSFETs.

List of Experiments:

1. Design a single stage RC Coupled Amplifier and plot its gain frequency response.
2. Design a double stage RC Coupled Amplifier and Plot its gain frequency response.
3. Design a RC phase shift oscillator using IC-741.
4. Design a Wein Bridge oscillator using IC-741.
5. Design a Voltage to Current Converter and Current to Voltage Converter using IC-741.
6. To study various Wave Shaping circuits (clipper, clamper) using IC-741.
7. To design and test the performance of integrator and differentiator circuits using op-amp (IC-741).
8. To design first order Active Low Pass and High Pass filters using OP-Amp IC-741 for a given cut off frequency.
9. Introduction to LT-Spice design software and Study of MOSFET Characteristics using LT-Spice.
10. Design and Analysis of single stage common source amplifiers in LT-Spice.

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

CO1: To Design & analyze a single stage, double stage for RC Coupled Amplifier and plot its gain frequency response.
CO2: To Design & analyze oscillators using IC-741.

CO3: To Design & analyze various Wave Shaping circuits (clipper, clamper) using IC-741.
CO4: To design and test the performance of integrator and differentiator circuits using op-amp (IC-741).
CO5: To design first order Active Low Pass and High Pass filters using OP-Amp IC-741 for a given cut off frequency

ECPC-214 COMMUNICATION ENGINEERING LAB

Pre-requisite: Communication Engineering (ECPC-205)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description about the course:
The purpose of this course is to familiarize the students about the practical implementation of modulation and demodulation of analog communication schemes, pulse modulation and the waveforms associated.

List of Experiments:

1. To generate an Amplitude Modulated waveform with a given modulation index and perform Demodulation.
2. To generate a Frequency Modulated waveform and study its modulation index and perform Demodulation.
3. To study Delta Modulation and Demodulation.
4. To study Adaptive Delta Modulation and Demodulation.
5. To study Pulse Amplitude Modulation and Demodulation.
6. To study Pulse Width Modulation and Demodulation.
7. To study Pulse Position Modulation and Demodulation.
8. To study Diode Detector.
9. To study AGC.
10. To study the selectivity of Superheterodyne Receiver

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

CO1: Understand the basic hardware components used for modulation and demodulation schemes of analog communication.
CO2: Design and Implementation of the different types of modulation schemes.
CO3: Understand the waveforms associated with the different types of modulation schemes.
CO4: Learn about the use of Superheterodyne receiver.

ECPC-215 DIGITAL COMMUNICATION LAB

Pre-requisite: Communication Engineering (ECPC-205), Digital Communication (ECPC-210)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description about the course:
The purpose of this course is to familiarize the students about the modulation and demodulation schemes of digital communication and understand the types of waveforms associated.

List of Experiments:

1. Verification of sampling theorem.
2. To study PSK modulation and demodulation.
3. To study FSK modulation and demodulation.
4. To study ASK modulation and demodulation.
5. To study PCM modulation and demodulation.
6. To study DPSK modulation and demodulation.
7. To study DQPSK modulation and demodulation.
8. To study TDM amplitude modulation and demodulation.
9. To study BPSK using Simulink
10. To study QPSK and its constellation diagram in MATLAB

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

CO1: Understand the sampling theorem.
CO2: Understand the basic hardware components used for digital modulation schemes
CO3: Learn the modulation and demodulation of different types of digital communication schemes.
CO4: Understand the waveforms associated with the different types of digital modulation schemes.
CO5: Learn about the constellation diagram of QPSK and other digital modulation schemes in MATLAB.

ECPC-216 OBJECT ORIENTED PROGRAMMING LAB

Pre-requisite: Problems Solving and Programming using C (CSIC-103)

L	T	P	Credits	Total contact hours
1	0	2	2	24

Brief Description about the course:
This lab aims to get understanding of the basic concepts in object-oriented programming including encapsulation, abstraction, inheritance, and polymorphism. The student will design, implement, test, and debug programs to solve real-world problems in object-oriented programming languages (C++ and Java). Further, this course is dedicated to enhance the programming skills of the students by giving practical assignments and also requisite knowledge about Object Oriented Programming through C++ and Java to develop Applications/Projects.

List of Experiments:
1. To understand the programming using structure.
2. To study the object and classes in object-oriented programming.
3. To understand the concept of array of objects.
4. To study the concepts of friend functions, inline functions, and function overloading.
5. To study different types of constructors with destructors.
6. To study Stack, Queue, Array, and Operator overloading.
7. To study dynamic memory allocation based on new and delete operators.
8. To study inheritance.
9. Implement the concepts of abstract class and virtual functions in C++.
10. To study exception handling and file handling in C++.
11. To study Java programs.
12. To design a graphical user interface (GUI) in Java.

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

CO1: Gain knowledge and understanding of object-oriented programming concepts.
CO2: Analyze and apply the generic classes concepts in programming problems.
CO3: Apply the object-oriented programming concepts as and when required in the application development.
CO4: Implement patterns involving dynamic binding and utilization of polymorphism.
CO5: Understanding of Java packages for GUI development.

Semester – V

ECPC-301 DIGITAL SIGNAL PROCESSING

Pre-requisite: Signals, Systems & Random Variables(ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
To understand Discrete transforms, implementation of discrete time systems, design of FIR filters, design of IIR filters.

Course Content:

UNIT I **10 hrs.**

The Z-Transforms: Z-transform and its properties, poles and zeros, Inversion of Z-transform, One sided Z-transform and solution of differential equations. Analysis of LTI systems in Z-domain, causality, stability, Relationship between Z-transform and Fourier transform. Frequency selective filters; all pass filters, minimum-phase, maximum-phase and mixed-phase systems.

UNIT II **10 hrs.**

DFT and FFT: Frequency domain sampling and DFT, Linear transformation, relationship to other transforms, properties of DFT, Linear filtering using DFT, Frequency analysis of signals using DFT, radix 2 & radix-4 FFT algorithms, Goertzel algorithm, Applications of FFT algorithm, computation of DFT of real sequences.

UNIT III **10 hrs.**

Implementation of Discrete Time Systems: Direct form, cascade form, frequency sampling and lattice structures for FIR systems. Direct forms, transposed form, cascade form, parallel form. Lattice and lattice ladder structures for IIR systems. State space structures.

UNIT IV **10 hrs.**

Design of Filters: Characteristics of practical frequency selective filters. Filters design specifications peak pass band ripple, minimum stop band attenuation. Four types of FIR filters Design of FIR filters using windows. Kaiser window method comparison of design methods for FIR filters Gibbs phenomenon, design of FIR filters by frequency sampling method, design of optimum equiripple FIR filters, alternation theorem. Design of IIR filters from analog filters, Design by approximation of derivatives, Impulse invariance method bilinear transformation method characteristics of Butterworth, Chebyshev, and Elliptical analog filters and design of IIR filters, Frequency transformation.

Text Book(s) / Reference(s):

[1] John G. Proakis, Digital Signal Processing, PHI
[2] S. K. Mitra, Digital Signal Processing, TMH
[3] Rabiner and Gold, Digital Signal Processing, PHI
[4] Salivahan, Digital Signal Processing, TMH

Course Outcomes:

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

CO1: Understand discrete-time sequences and Z-transform.
CO2: Compute DFT and FFT of discrete time signals.
CO3: Design FIR and IIR filters using different techniques.
CO4: Design frequency selective filters.
CO5: Learn the DSP programming tools and use them for applications
CO6: Design and implement signal processing modules in DSPs

ECPC-302 ANTENNA AND WAVE PROPAGATION

Pre-requisite: Fields and waves (ECPC 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
Antenna and Wave propagation is the gateway for understanding all kinds of wireless communication for different applications. The evolution and basics of Antenna and Wave propagation technology followed by ability to identify antenna parameters of Linear wire antennas, Aperture type antennas, Antenna Arrays, Narrowband, Broadband and Frequency independent antennas forms the syllabus.

Course Content:

UNIT I **10 hrs.**

Retarded vector and scalar potentials. Radiation and induction fields, Radiation from elementary and half wave dipole with different current distributions, Antenna parameters and definitions, Radiation pattern and gain, Antenna arrays and beamforming, Antenna impedance and matching

UNIT II **10 hrs.**

Monopole and Dipole antennas, Biconical Antennas, Loop antennas, Helical Antennas, Principle of pattern multiplication, Broadside arrays, End fire arrays, Array pattern synthesis, Uniform Array, Binomial Array, Chebyshev Array, Yagi-Uda and Turnstile Antennas, Radiation from rectangular aperture, Horn antennas, Parabolic reflector antennas, Microstrip antennas, Printed antennas, Slot antennas

UNIT III **10 hrs.**

Broadband Antennas. The frequency independent concept: Rumsey's principle, Frequency independent planar log spiral antenna, Frequency independent conical spiral antenna and Log periodic antenna. Different modes of propagation, Ground waves, Space waves, Surface waves and Tropospheric waves, Ionosphere, Wave propagation in the ionosphere, Critical frequency, Maximum Usable Frequency (MUF), Skip distance, Virtual height, Radio noise of terrestrial and extra terrestrial origin. Multipath fading of radio waves.

UNIT IV **10 hrs.**

MIMO (Multiple-Input Multiple-Output) systems, Smart antennas, Metamaterial antennas, 5G and beyond: Antennas for next-generation wireless systems. Applications of Antenna and Wave Propagation in various sustainable technologies, case studies from the Indian knowledge system.

Text Book(s) / Reference(s):

[1] John D. Kraus, Antennas, McGraw Hill. 4th Ed. 2010, Mc Graw Hill
[2] C. A Balanis Antenna Theory Analysis & Design 3rd Ed. 2005, Wiley & Sons
[3] E. C. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, PHI

Course Outcomes:

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

CO1: Develop an understanding of various Antenna Types and their families
CO2: Quantify the fields radiated by various types of antenna.
CO3: Understand the fundamentals and modes of wave propagation
CO4: Practicing various antennas for real-life applications.

ECPC-303 DSP LAB

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description:

1. (a) Generate square wave of frequency (input from keyboard); from its harmonics of sinusoidal components. (b) Use the pause function from MATLAB to demonstrate the effect of addition of harmonics to its fundamental frequency.
2. Find the inverse Z-transform. (a) Compute Circular convolution of x(n)= {1,2,1,0,2,1}; n >=0 and y(n)= {2,4,0,1,1,0}; n>=0. (b) A signal sequence x(n) = {1, 1, 1} is applied to a system with an unknown impulse response h(n). The observed output is y(n)= {1,4,8,10,8,4,1}. Write a program to find h(n).
3. A linear phase, bandpass FIR filter is required to meet the following specification: Passband 12-16 kHz, Transition width 2 kHz, Passband ripple 1 dB, Stopband attenuation 45 dB, Sampling Frequency 50 kHz. Estimate the filter length and use the optimal method to determine the filter coefficient and hence plot the magnitude-frequency response. Compare the passband stopband ripples of the filter with the specified values.
4. Design an IIR filter with following specifications: Lower passband 0-50 Hz, Upper passband 450-500 Hz, Stop band 200-300 Hz, Passband ripple 3 dB, Stopband attenuation 20 dB, Sampling frequency 1 kHz.
5. Implement the above filters using SIMULINK and verify the performance.
6. Implement an FIR filter on the DSP kit by using the FDA tool and code composer studio.
7. Implement an IIR filter on the DSP kit by using the FDA tool and code composer studio.

Course Outcomes:

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

CO1: Generate and analyse periodic signals by synthesising waveforms from their sinusoidal harmonic components using MATLAB, demonstrating the effect of harmonic addition on the resultant waveform.

CO2: Implement Z-transform inversion and circular convolution operations programmatically, and determine unknown system impulse responses from observed input-output signal pairs.

CO3: Design and evaluate FIR filters meeting given specifications for passband, stopband attenuation, and transition width using optimal design methods, and verify frequency response characteristics against specified values.
CO4: Design IIR filters for given passband and stopband specifications and compare their performance with equivalent FIR designs in terms of filter order and ripple characteristics.
CO5: Simulate and verify FIR and IIR filter implementations using MATLAB Simulink, analysing the performance of designed filters under various input conditions.
CO6: Implement FIR and IIR filters on a real-time DSP hardware kit using the FDA tool and Code Composer Studio, validating practical performance against simulation results.

ECPC-304 HDL LAB

Pre-requisite: Digital Design (ECPC 202) and Digital Design Lab (ECPC 207)

L	T	P	Credits	Total contact hours
0	0	2	1	24

List of Experiments:

1. Write a program to implement a 3:8 decoder.
2. Write a program to implement an 8:1 multiplexer and 1:8 demultiplexer.
3. Write a program to implement 4-bit addition/subtraction.
4. Write a program to implement a 4-bit comparator.
5. Write Verilog code for SR, D, JK, and T Flip flops.
6. Write a program to generate Mod-10 up counter.
7. Write a program to generate the 1010 sequence detector. The overlapping patterns are allowed.
8. Write a program to perform serial to parallel and parallel to serial transfer of 4 bit binary number.
9. Write a program to design a 2-bit ALU containing 4 arithmetic & 4 logic operations.
10. Write a Verilog code to design a clock divider circuit that generates 1/2, 1/3rd and 1/4th clock from a given input clock. Port the design to FPGA and validate the functionality.

Course Outcomes:

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

CO1: Write the Verilog programs to simulate Combinational circuits in Dataflow, Behavioral and Structural modelling.
CO2: Describe sequential circuits like flip flops and counters in Behavioral description and validate simulation waveforms.
CO3: Debug and identify the errors in codes.
CO4: Synthesize Combinational and Sequential circuits on FPGA and test the hardware.

ECPC-305 TRANSMISSION LINES & ANTENNA LAB

Pre-requisite: Fields and waves (ECPC 204)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description:
This laboratory course provides hands-on experience with transmission line characteristics and antenna radiation patterns. Students investigate the behaviour of simulated and actual transmission lines under various input conditions, measuring parameters such as attenuation, delay, input impedance, and frequency response, including fault localization techniques. The antenna experiments cover radiation pattern measurement for dipole (half-wave and quarter-wave), folded dipole, Yagi-Uda (3, 5, and 7 element), and helical antenna configurations, reinforcing theoretical concepts from the co-requisite course ECPC-204 (Fields and Waves).

List of Experiments:

1. To Study Attenuation in a Simulated Transmission Line.
2. To Study Delay using a pulse input Simulated Transmission Line.
3. To Study and measure the Actual Transmission Line characteristics.
4. To Study & measure the attenuation of Actual Transmission Line.
5. To Study and measure the input impedance of Actual Transmission Line.
6. To Study & measure the frequency characteristics of Actual Transmission Line.
7. To Study the fault localization in Actual Transmission Line.
8. To Study and measure the radiation patterns of dipole antennas.
9. Study of simple dipole (λ/2) antenna.
10. Study of simple dipole (λ/4) antenna.
11. Study of Folded dipole (λ/2) antenna.
12. To Study and measure the radiation patterns of Yagi-Uda antennas.
13. Study of Yagi-Uda 3 element antenna.
14. Study of Yagi-Uda 5 element antenna.
15. Study of Yagi-Uda 7 element antenna.
16. To Study and measure the radiation patterns of helical antenna.

Course Outcomes:

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

CO1: Demonstrate the behaviour of simulated transmission lines by measuring attenuation and signal delay characteristics under pulse and steady-state inputs.

CO2: Measure and analyse the key parameters of actual transmission lines including attenuation, input impedance, and frequency response using standard laboratory instruments.

CO3: Identify and localise faults in transmission lines using appropriate measurement techniques.

CO4: Measure and compare the radiation patterns of half-wave, quarter-wave, and folded dipole antennas, correlating experimental results with theoretical predictions.

CO5: Evaluate the effect of the number of elements on the radiation pattern, directivity, and gain of Yagi-Uda antenna arrays through experimental observation.

CO6: Characterise the radiation pattern of a helical antenna and distinguish its performance from linear and array antenna configurations studied in the course.

ECPC-306 SEMINAR (SEMESTER V)

L	T	P	Credits	Total contact hours
0	0	1	1	-

Brief Description about the course:
The Program Core Seminar is a structured activity in which students explore an emerging or applied topic in the ECE domain, conduct a focused literature survey, and present their findings to peers and faculty. The seminar develops independent research habits, technical communication skills, and awareness of current trends in ECE and related fields.

Course Outcomes:

CO1: Identify and articulate a relevant technical topic in the ECE domain.
CO2: Survey existing literature and synthesise key ideas from multiple sources.
CO3: Prepare a concise written report following standard technical writing conventions.
CO4: Deliver a clear oral presentation and respond to questions from the audience.

ECPC-307 SUMMER TRAINING (SEMESTER V)

L	T	P	Credits	Total contact hours
0	0	0	1	Six Weeks

Course Objectives:
The internship is aimed at developing the undergraduate education program in Electronics and Communication Engineering to include a practical training in a professional engineering set up (a company, top educational institution, research institute etc.) hereafter referred to as host "organization" as deemed appropriate. The participating organizations are selected that are either already visiting NIT Kurukshetra for placement or are forming new relationships of mutual benefit. The internship gives the student the opportunity to translate engineering theory into practice in a professional engineering environment. The technical activity in the project should be related to both the student's engineering studies and to the host organization's activities and it should constitute a significant body of engineering work at the appropriate level. It should involve tasks and methods that are more appropriately completed in a professional engineering environment and should, where possible, make use of human and technology resources provided by the organization. It consolidates the student's prior learning and provides a context for later research studies. The student remains a full time registered student at the institute during the project semester and this activity is therefore wholly distinct from any industrial interactions which may occur over vacation periods.

Assessment Details:
Each student is assigned a faculty supervisor who is responsible for managing and assessment of the internship semester. The faculty supervisor monitors the student's progress in a semester and interacts with the industry mentor during his/her visit to the host organization twice. This includes a Reflective Diary which is updated throughout the project semester, an Interim internship Report, a Final Report with Learning Agreement/Outcomes and a Final Presentation & Viva which involves the faculty Supervisor and some other members from the department. The mentor from the host organization is asked to provide his assessment on the designated form. The faculty supervisor is responsible for managing and performing the assessment of the project semester experience.

Course Outcomes:
Upon completion of internship, the students will be able to:
CO1: Acquire knowledge and experience of software and hardware practices in the area of project.
CO2: Carry out design calculations and implementations in the area of the project.

CO3: Associate with the implementation of the internship requiring individual and teamwork skills.
CO4: Communicate their work effectively through writing and presentation.
CO5: Demonstrate the knowledge of professional responsibilities and respect for ethics.
Note: Six-week internship after IV Sem in the summer vacation mandatory, and it is to be evaluated in the V-Sem.

ECPE-301 CONTROL SYSTEM ENGINEERING

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The purpose of this course is to make the students understand control systems and its components, mathematical modelling, time response analysis, the root locus technique, frequency response analysis, stability and state variable analysis.

Course Content:

UNIT I **10 hrs.**

Introduction to Control Systems, Basic Control System Components, Concept of Feedback and its Impact on the Performance, Differential Equations of Physical Systems, Laplace Transforms, Transfer Function, Mathematical Modelling of Electrical, Mechanical, and Electro-mechanical Systems, Block Diagrams, Block Diagram Reduction Techniques, Signal Flow Graph, Mason's Gain Formula.

UNIT II **10 hrs.**

Standard test signals, Time Response Analysis of First and Second Order Systems, Steady State Analysis, Steady State Error, Static Error Constants, Stability, Routh-Hurwitz Theorem, Relative Stability Criteria. Root Locus Technique for Stability, Root Contours

UNIT III **10 hrs.**

Frequency Response Analysis of First and Second Order Systems, Polar plot, Gain Margin, Phase Margin, Nyquist Stability Criteria, Bode Plot, Determining Transfer Function from Bode Plot, Design of Compensators: Lead, Lag, Lead-lag

UNIT IV **10 hrs.**

Controllers: Proportional, Derivative, Integral, PI, PD and PID. State Space Analysis, State Variables, State Transition Matrix, Free Response, Forced Response, Concept of Controllability and Observability, Pole placement by state feedback. Applications: Home Automation, Transportation Systems, Automobiles and Consumer Electronics

Text Book(s) / Reference(s):

[1] 'Modern Control Systems' by R. C. Dorf, R. H. Bishop, Prentice Hall.
[2] 'Modern Control Engineering' by Katsuhiko Ogata, Prentice Hall
[3] 'Control Systems, Principles and Design' by M. Gopal, McGraw Hill Education

Course Outcomes:

CO1: Understand the control system and its components
CO2: Develop mathematical model of basic electrical mechanical systems
CO3: Determine the stability in time and frequency domain using various methods
CO4: Understand the impact of feedback on the performance of the control system.

ECPE-302 MEMORY TESTING

Pre-requisite: Digital Design (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
To understand the basics of memory testing, memory fault models and challenges associated with memory testing.

Course Content:

UNIT I **10 hrs.**

Introduction to Memory Testing: Memory architecture and organization, Memory faults and defects, Memory testing methodologies, Memory test equipment and software

UNIT II **10 hrs.**

Memory Test Algorithms: March algorithms, Checkerboard algorithms, Walking 1's and 0's algorithms, Random access algorithms, March-C algorithms, BIST algorithms

UNIT III **10 hrs.**

Memory Fault Models: Stuck-at faults, Transition faults, Bridging faults, Coupling faults, Cell faults, Address decoder faults

UNIT IV **10 hrs.**

Memory Test Modes: Functional testing, Parametric testing, Diagnosis testing, Burn-in testing, Screening testing, Reliability testing. Memory Repair and Redundancy: Memory repair techniques, Memory redundancy techniques, Memory yield analysis

Text Book(s) / Reference(s):

[1] Memory Fault Diagnosis and Tolerance: Techniques and Applications by Bhavani Shankar, Dhiraj Pradhan, and Nur A. Touba.
[2] Memory Systems: Cache, DRAM, Disk by Bruce Jacob, Spencer Ng, and David Wang.
[3] Memory Controllers for Real-Time Embedded Systems: Predictable and Composable Real-Time Systems by Benny Akesson and Kees Goossens.
[4] Testing and Reliable Design of CMOS Circuits by David M. Harris and Mike Bushnell.
[5] Defect-Oriented Testing for CMOS Analog and Digital Circuits by Xiaoqing Wen and Chun-Huat Heng

Course Outcomes:

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

CO1: Learn memory architecture and organization

CO2: Understand memory test algorithms.

CO3: Learn memory fault models.

CO4: Understand the memory reliability and role of memory testing.

ECPE-303 MULTICARRIER COMMUNICATION

Pre-requisite: Signals, Systems & Random Variables (ECPC 203), and Antenna &Wave Propagation (ECPC 302)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Description:
This course covers the principles and applications of multicarrier communication systems. Topics include discrete Fourier transform (DFT), fast Fourier transform (FFT), orthogonal frequency-division multiplexing (OFDM), multicarrier modulation (MCM), and their applications in wireless and wired communication systems.

Course Content:

UNIT 1 **10 hrs.**

Introduction to Multicarrier Communication, Historical background and motivation for multicarrier communication, Overview of multicarrier communication systems, Discrete Fourier Transform (DFT) and its properties, Fourier Transform and Fast Fourier Transform (FFT), Fast Fourier Transform (FFT) algorithms and their implementation

UNIT 2 **10 hrs.**

Orthogonal Frequency-Division Multiplexing (OFDM), Principles of OFDM, OFDM system model and block diagram, Implementation of OFDM transceiver, Guard interval and cyclic prefix, Frequency and time synchronization in OFDM

UNIT 3 **10 hrs.**

Principles of MCM and its properties, Multi-Carrier FDMA, Multi-Carrier TDMA, Single carrier versus multi carrier system. Applications of Multicarrier Communication, Multicarrier techniques in wireless communication systems (e.g., LTE, WiMAX), Multicarrier techniques in wired communication systems (e.g., DSL). Advanced Topics in Multicarrier Communication, Multiuser MCM techniques (e.g., OFDMA), Carrier aggregation and its applications.

UNIT 4 **10 hrs.**

MIMO techniques in multicarrier communication systems, Performance Analysis of Multicarrier Communication Systems, Error analysis and performance metrics, Interference analysis and mitigation techniques. Future Directions in Multicarrier Communication, 5G and beyond, Emerging trends in multicarrier communication research

Text Book(s) / Reference(s):

[1] John Proakis, Massoud Salehi, Digital Communications, McGraw Hill, (2008).
[2] "Orthogonal Frequency Division Multiplexing for Wireless Communications" by Jianhua Zhang and Hsiao-Hwa Chen
[3] "Multicarrier Techniques for 4G Mobile Communications" by E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, and H. V. Poor
[4] "Digital Communications: Fundamentals and Applications" by Bernard Sklar
[5] Simon Haykin, Digital Communication Systems, Wiley, (2013).
[6] B.P Lathi, Zhi Ding, Modern Digital & Analog Communication Systems, Oxford Publication, (2011).

Course Outcomes:

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

CO1: Understand the basic concepts of Multicarrier Communication
CO2: Understand the concepts of OFDM
CO3: Understand Multicarrier techniques in wired communication systems.
CO4: Analyze performance of Multicarrier Communication.

ECPE-304 MEMS

Pre-requisite: Electronic Devices and Circuits (ECPC 201)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Research and development of MEMS builds on advances in silicon processing infrastructure for creating micron-scale machines. Unlike conventional ICs, MEMS devices have many functions, such as communication, sensing and actuation. This course will cover a wide range of topics including MEMS design and layout, bulk and surface micromachining, fabrication processes and applications, for example biosensors in medical applications, inertial transducers for navigation.

Course Content:

UNIT I **10 hrs.**

Introduction to MEMS and Micro fabrication: MEMS Roadmap, MEMS markets, Benefits of Miniaturization, Benefits of Scaling. Micro fabrication: Basic Fabrication Processes, Oxidation, Film Deposition, Lithography, Etching, Ion Implantation, Diffusion. Micro ElectroMechanical Systems.

UNIT II **10 hrs.**

MEMS Devices: Pressure sensors, RF MEMS Switch, Temperature sensors, Humidity sensors. Microactuators: Electromagnetic and Thermal micro actuation. Physical Microsensors: Classification of physical sensors. Sensor Principles. Examples: Thermal sensors, Electrical Sensors, Chemical Sensors and Biosensors.

UNIT III **10 hrs.**

Mechanics of MEMS Materials: Stress-strain-material properties. Measurement and characterization of mechanical parameters. Microstructural Elements: bending moment and strain-flexural rigidity.

UNIT IV **10 hrs.**

Mechanical miniature devices. Electromagnetic actuators and sensors. RF/Electronics devices. Optical/Photonic devices. Medical devices e.g., DNA-chip, micro-arrays. Case study: BioMEMS. Case study: Emerging MEMS technologies.

Text Book(s) / Reference(s):

[1] Chang Liu, "Foundations of MEMS", Second Edition, Prentice-Hall, 2012.
[2] Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill, 2017.

[3] D. K. Bhattacharya and B. K. Kaushik, "Microelectromechanical Systems", Cengage, ISBN: 9788131525883, 2015.
[4] S. D. Senturia, "Microsystem Design", Springer, 2000.
[5] M. J. Madou, "Fundamental of Microfabrication", Second Edition CRC Press, 2002.
[6] N. Maluf, "An Introduction to Microelectromechanical Systems Engineering", vol. 13, no. 2, IOP Publishing Ltd, 2002.
[7] Md. Gad-el-Hak, "MEMS Handbook", Applied Mechanics Reviews, vol. 55, no. 6, 2002.

Course Outcomes:

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

CO1: Understand fundamental principles of sensing and actuation in MEMS.

CO2: Understand the principle, design, and fabrication techniques of recent devices in the MEMs industry.

CO3: Understand the basic principles and applications of micro-fabrication processes, such as photolithography, ion implantation, diffusion, oxidation, CVD, PVD, and etching.

CO4: Students will be able to consider recent advancements in the field of MEMS and devices.

ECPE-305 WIRELESS TECHNOLOGIES

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course provides the basic understanding of wireless LAN standards, 5G and 6G wireless networks. Key enabling technologies of 5G and 6G wireless networks are analyzed. New applications and services are explored.

Course Contents:

UNIT **10 hrs.**

Wireless Communication: Evolution- 1G to 5G, overview of wireless channel, cellular concept, 4G, LTE, LTE-LTE-A, Architecture, 3GPP specifications, Capabilities.

UNIT I **10 hrs.**

Wireless LAN fundamentals, IBSS, BSS, ESS, IEEE 802.11 standards, CSMA/CA, PCF, WLAN design considerations Bluetooth, RFID-types, UWB, and their applications Security and privacy in WLANS

UNIT III **10 hrs.**

5G networks: New Radio (NR), SA, NSA, NOMA, 5G Technologies- small cells, massive MIMO, beam formation, mmWaves, 5G applications- eMBB, URLLC, mMTC, D2D communications, V2X communications; Use cases in IoT

UNIT IV **10 hrs.**

6G- network architecture, basic building blocks, 6G research activities, visible light communication, energy harvesting, intelligent reflecting surface, wireless powered communication networks, Time Switching, Applications in IoT services

Text Book(s) / Reference(s):

[1] R. Vannithamby and S. Talwar, Towards 5G: Applications, Requirements and Candidate Technologies, John Willey & Sons, West Sussex, 2017.
[2] Martin Maier, Amin Ebrahim Zadeh, "Towards 6G: A New Era of Convergence", Wiley-IEEE Press
[3] Paulo Sergio Rufino Henrique, Ramjee Prasad, 6G: The Road to the Future Wireless Technologies 2030, River Publishers Series.
[4] Theodore S. Rappaport, Wireless Communications: Principles and Practice, Pearson

Course Outcomes:

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

CO1: Understand the basics of WLANS, 5G, and 6G wireless networks

CO2: To evaluate the performance of wireless technologies in varied channel conditions

CO3: To design the 5G and 6G networks

CO4: To develop 5G and 6G powered applications and services

ECPE-306 NEURO-FUZZY SYSTEMS

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
To learn about neural network structures and learning strategies; understand the concept of fuzzy systems and design them for practical applications.

Course Contents:

UNIT I **10 hrs.**

Introduction to Neural Networks: Introduction: The Human Brain and Biological Neuron, Artificial Neuron Models, Types of Neuron Activation Function, ANN Architectures Characteristics of ANN, Mc Culloch-Pitts Model, Historical Developments, Potential Applications of ANN.

UNIT II **10 hrs.**

Essentials of Artificial Neural Networks: Classification Taxonomy of ANN – Connectivity, Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules. Back Propagation Algorithm Feed Forward Neural Networks: Single Layer and Multilayer. Radial Basis function networks (RBFN), Self-organizing feature map.

UNIT III **10 hrs.**

Introduction to Fuzzy Systems: Introduction: Fuzzy and Neurofuzzy system and their merits. Introduction to Architecture of a fuzzy system. Fuzzification Rule Base, Inference engine, Defuzzification. Fuzzy Mathematics: Fuzzy sets & operation of fuzzy sets. Properties of fuzzy sets. Fuzzy relations. Fuzzy graphs & Fuzzy Arithmetic.

UNIT IV **10 hrs.**

Architecture & Design Issues: Fuzzification. Fuzzy Rule based Models. Implication process, Defuzzification Techniques. Fuzzy Logic in Control Applications: Selection of Design Methodology, Technical Design objectives, Mamdani & Sugeno-Takagi Architectures. Adaptive Neuro Fuzzy Interference Systems (ANFIS), Functional equivalence between RBFN and FIS

Text Book(s) / Reference(s):

[1] Simon Haykin, "Neural Networks- A comprehensive foundation", Pearson Education, 2001.
[2] Jang, Sun, Mizutani, "Neuro-Fuzzy and soft computing", Pearson, 1997.
[3] KLIR & YAUN: Fuzzy Sets and Fuzzy Logic, Prentice Hall of India
[4] T.J.Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill.

Course Outcomes:

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

CO1: Understand the basic principles of neural networks

CO2: Apply the supervised and unsupervised methods for training of neural networks

CO3: Use neural networks for practical applications

CO4: Understand the elements of fuzzy systems

CO5: Design fuzzy systems based on Mamdani and Sugeno-Takagi models

CO6: Use the concept of adaptive neuro fuzzy systems (ANFIS) for practical applications

ECPE-307 IOT & ITS APPLICATIONS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course will be focused on introducing students to new trends, applications, system architecture and challenges involved in developing/deploying internet of things systems using real industrial use cases. A number of systems are getting connected to the internet, where the sensor data is analyzed to monitor and control the systems. Correctly analyzing data coming from multiple sensors, choosing the right hardware given the power and performance tradeoff, hardware heterogeneity and security are some of the challenges involved in developing IoT applications. The course will cover the real-world use cases of IoT applications and hands-on projects related to those based on the concepts learned in the class.

Course Contents:

UNIT I **8 hrs.**

Overview of IoT systems: New trends, applications and challenges. IoT system architecture Edge devices, sensors, actuators, gateway, data storage and historical analysis in the cloud.

UNIT II **10 hrs.**

Sensor networks: Wireless sensor networks (WSN), localization, node mobility, energy efficiency in WSN. Communication: MQTT, wifi, Bluetooth, RFID, LoRa, LoRaWAN, communication security.

UNIT III **12 hrs.**

IoT system optimization: Low power devices, energy harvesting, performance trade-off, choosing the right hardware. Applications of deep learning in IoT: Introduction to deep learning, camera-based IoT applications in healthcare, retail and agriculture.

UNIT IV **10 hrs.**

Smart and connected devices: Raspberry-pi, Google home mini, Alexa, Echo show Industrial use cases: smart home and agriculture. Case studies: Smart cities, transportation, manufacturing, automobile.

Text Book(s) / Reference(s):

[1] Peter Waher "Learning Internet of Things"
[2] S. Misra, C. Roy, and A. Mukherjee, 2020 "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press.

[3] Simone Cirani, Gianluigi Ferrari, Marco Picone, and Luca Veltri, "Internet of Things: Architectures, Protocols and Standards" WILEY.
[4] Andrew Minteer, "Analytics for the Internet of Things (IoT): Intelligent analytics for your intelligent devices".

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the IoT system and its applications.
CO2: Understand IoT system optimization and communication.
CO3: Analyze the applications of deep learning in IoT.
CO4: Apply the IoT knowledge in smart cities, transportation and manufacturing.

ECPE-308 SENSORS

Pre-requisite: Digital Design (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
In recent years, technological advances have resulted in the rapid development of a new and exciting research direction – the interdisciplinary use of sensors for data collection, systems analysis, and monitoring. These highly calibrated sensors require precision engineering techniques that play an important role in analyzing and integrating large datasets. Sensor networks in particular represent a very active area of research, including work on problems such as sensor network localization and network design. Application areas for sensors and sensor networks include environmental monitoring, military surveillance, computational neuroscience, seismic detection, and a great deal more. The fundamental problems of utilizing the collected data for efficient system operation and decision making encompasses multiple research areas, including applied mathematics, optimization, signal/image processing, as well as emerging areas that require interdisciplinary techniques from several fields of research.

Course Contents:

UNIT I **10 hrs.**

Introduction to Sensors, Definition of sensors and their importance, Basic concepts and terminology related to sensors, Classification of sensors based on various criteria. Sensor Principles and Working Mechanisms, Overview of different types of sensors (e.g., temperature, pressure, motion, light), Explanation of underlying physical and electrical principles, Sensor characteristics and specifications (accuracy, resolution, linearity, etc.)

UNIT II **10 hrs.**

Sensor Technologies and Transducers, Review of common sensor technologies (e.g., resistive, capacitive, inductive, optical), Transducers and signal conditioning circuits, Sensor packaging and integration techniques. Sensor Interfaces and Data Acquisition, Introduction to analog-to-digital conversion, Sensor interface circuits (amplifiers, filters, multiplexers), Data acquisition systems and protocols (e.g., ADC, SPI, I2C)

UNIT III **10 hrs.**

Sensor Applications and Systems, Sensors in various industries (automotive, aerospace, healthcare, etc.), Sensor networks and wireless sensor systems, Sensor fusion and integration with other technologies (e.g., IoT, AI). Sensor Calibration and Testing,

Importance of sensor calibration, Calibration techniques and standards, Sensor testing methodologies (accuracy, repeatability, drift)

UNIT IV **10 hrs.**

Emerging Trends in Sensors, Overview of recent advancements in sensor technology, Nanosensors and MEMS (Micro-Electro-Mechanical Systems), Wearable and flexible sensors, Sensors for ADAS. Application to various sustainable technologies, case studies from the Indian knowledge system.

Text Book(s) / Reference(s):

[1] Sensors and Actuators, D. Patranabis, 2nd Ed., PHI, 2013.
[2] Make sensors: Terokarvinen, kemo, karvinen and villey valtokari, 1st edition, maker media, 2014.
[3] Sensors handbook- Sabrie soloman, 2nd Ed. TMH, 2009
[4] Handbook of Modern Sensors, J. Fraden, Fourth Edition, Springer

Course Outcomes:

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

CO1: Explain the fundamental principles, classification, and characteristics of various types of sensors and transducers used in engineering applications.

CO2: Analyze sensor interface circuits, signal conditioning techniques, and data acquisition systems including analog-to-digital conversion and communication protocols such as SPI and I2C.

CO3: Apply sensor technologies in real-world systems across domains such as automotive, healthcare, aerospace, and IoT by evaluating calibration techniques and testing methodologies for accuracy and reliability.

CO4: Assess emerging trends in sensor technology including MEMS, nanosensors, wearable sensors, and ADAS applications, and relate them to sustainable technologies and the Indian knowledge system.

ECPE-309 ANALOG IC DESIGN

Pre-requisite: Analog Electronics (ECPC 209)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
Course objectives: (1) To learn the basics of CMOS amplifier design (2) To develop the skills to design an analog VLSI circuit for a given specification.

Course Content:

UNIT I **10 hrs.**

Basic MOS Device Physics: General Considerations, MOS I/V Characteristics, Second Order effects, MOS small signal Model, NMOS versus PMOS devices, single stage amplifiers-common source amplifiers with different types of loads, source follower, common gate amplifiers.

UNIT II **10 hrs.**

Cascode stage, choice of device models, Differential amplifiers-analysis of single-ended and differential output amplifiers, common mode response, differential pair with MOS load, gilbert cells, Frequency response of amplifiers

UNIT III **10 hrs.**

Current Mirrors: Current sources and sinks, basic current mirrors, cascode current mirror, analysis of current mirrors, CMOS bandgap references: Supply independent biasing, temperature independent references, PTAT and CTAT current generation, constant Gm biasing, speed and noise issues.

UNIT IV **10 hrs.**

CMOS Operational Amplifiers: Performance parameters, one-stage and two-stage Op Amps, gain boosting, input range limitations, slew rate, Stability and Frequency Compensation.

Text Book(s) / Reference(s):

[1] B. Razavi, Design of Analog CMOS Integrated Circuits, MH.
[2] P R Gray and R G Meyer, Analysis and Design of Analog Integrated Circuits, 5th Edition, Wiley, 2009.
[3] P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, Second Edition, OUP.

Course Outcomes:

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

CO1: Draw the small signal equivalent diagram of an analog circuit and analyze its performance.

CO2: Design basic amplifiers, current mirrors, differential amplifiers, bandgap reference and op-amp circuits for a given specification.

CO3: Analyse the frequency response of the different configurations of an amplifier.

CO4: Understand the feedback topologies involved in the amplifier design.

ECPE-310 ADVANCED MOS DEVICES

Pre-requisite: Digital Design (ECPC 202), and Analog Electronics (ECPC 209)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
To enable the students to understand the basics of advanced MOS Devices for high-performance and low-power analog & digital Applications.

Course Content:

UNIT I **10 hrs.**

MOSFETs: Review of MOS Characteristics, Short channel MOSFET, Subthreshold Characteristics, Equivalent Circuits, Short channel Effects. Models for Long Channel and Short Channel MOSFETs.

UNIT II **10 hrs.**

History of Multigate MOSFETs, Multigate MOSFET Physics, Classical physics, Natural length and short-channel effects, Current drive, Corner effect, Quantum effects. Nanoscale Devices.

UNIT III **10 hrs.**

High-speed semiconductor Devices: Basic concepts, Requirements for high-speed circuits, devices and materials, Classification and properties of semiconductor devices, Ternary compound semiconductors and their applications, MESFET, Hetero junctions and HEMT.

UNIT IV **10 hrs.**

BSIM CMG A Compact Model for Multi-Gate Transistors: BSIM CMG Model, Surface Potential Model, I-V Model, C-V Model, Modeling Physical Effects of Real Devices, Quantum Mechanical Effects (QME), Short-channel Effects (SCE).

Text Book(s) / Reference(s):

[1] Y. Taur and T. K. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press
[2] MS Tyagi, Introduction to Semiconductor Materials & Devices, John-Wiley
[3] B. G. Streetman, Solid state electronic Devices, Pearson India Education
[4] Jean-Pierre Colinge, FinFETs and Other Multi-Gate Transistors, Springer
[5] Simon M. Sze, High-Speed Semiconductor Devices, Wiley.

Course Outcomes:

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

CO1: Inculcate the in-depth knowledge of long and short channel MOS Devices

CO2: Understand the recent advancement in multigate and nanoscale devices that are in production.

CO3: Understand the basics of high speed and hetero junction devices

CO4: Understand generation of compact models for advance semiconductor devices.

ECPE-311 SEMICONDUCTOR PHOTONIC DEVICES

Pre-requisite: Engineering Physics (PHIC-101) and Advanced Engineering Physics (PHIC-103)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
To provide a detailed exposure to the physics, principle of operation, design, and characteristics of widely used semiconductor optoelectronic devices for applications in Optoelectronics, Optical Communication and Optical Signal Processing. Specific emphasis will be on semiconductor optical amplifiers, sources, detectors, and modulators, which also lead to the realization of Photonic Integrated Circuits.

Course Content:

UNIT I **10 hrs.**

Review of Semiconductor Physics for Photonics: The Band Structure; The Density of States $\rho(k)$ and $\rho(E)$; Density of States in a Quantum Well Structure; Carrier Concentration & Fermi Level; Quasi Fermi Levels. Semiconductor Optoelectronic Materials; Heterostructures, Strained-Layers, Bandgap Engineering; Heterostructure p-n junctions; Schottky Junctions & Ohmic Contact. Interaction of Photons with Electrons and Holes in a Semiconductor; Optical Joint Density of States, Probabilities of Emission and Absorption; Rates of Emission and Absorption; Absorption Spectrum of Semiconductors. Amplification by Stimulated Emission; The Semiconductor Optical Amplifier.

UNIT II **10 hrs.**

Absorption Spectrum of Quantum Well Structures; Quantum Confined Stark Effect and Franz-Keldysh Effect. Electro-absorption Modulator: Principle of Operation and Device Configuration. Injection Electroluminescence. Light Emitting Diode: Device Structure and Output Characteristics, Modulation Bandwidth, Materials for LED, and Applications. White light LEDs.

UNIT III **10 hrs.**

General Characteristics of Photodetectors, Impulse Response of Photodetectors. Photoconductors, Semiconductor Photo-Diodes, PIN diodes and APDs: Structure, Materials, Characteristics, and Device Performance. Photo-Transistors. Array Photodetectors: Quantum well infrared photodetectors (QWIP), CCD; Photomultiplier Tube, Thermal detectors, Solar cell.

UNIT IV **10 hrs.**

Laser Diodes: Device Structure and Output Characteristics, Single Frequency Lasers; DFB, DBR Lasers, VCSEL, Quantum Well Laser, Quantum Cascade Laser, Micro-cavity lasers. Modulation of Laser Diodes, Practical Laser Diodes & Handling Photonic Integrated Circuits - PICs; some examples and design issues.

Text Book(s) / Reference(s):

[1] Saleh, Bahaa EA, and Malvin Carl Teich. Fundamentals of photonics. John Wiley & sons, 2019.
[2] Ghione, Giovanni. Semiconductor devices for high-speed optoelectronics. Vol. 116. Cambridge: Cambridge University Press, 2009.
[3] Bhattacharya, Pallab. Semiconductor optoelectronic devices. Prentice-Hall, Inc., 1997.
[4] Singh, Jasprit. Semiconductor optoelectronics: physics and technology. Vol. 2. New York: McGraw-Hill, 1995.
[5] Keiser, Gerd. Optical fiber communications. Vol. 2. New York: McGraw-Hill, 2000.
[6] Yariv, Amnon, and Pochi Yeh. Photonics: optical electronics in modern communications. Oxford university press, 2007.

Course Outcomes:

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

CO1: Understand Interaction of Photons with Electrons and Holes in a Semiconductor; Rates of Emission and Absorption; Amplification by Stimulated Emission; The Semiconductor Optical Amplifier etc.

CO2: Learn fundamentals of Laser Diodes: Device Structure and Output Characteristics, Single Frequency Lasers; DFB, DBR Lasers, VCSEL, Quantum Well and Quantum Cascade Laser, Micro-cavity lasers.

CO3: Understand Modulation of Laser Diodes, Practical Laser Diodes & Handling.

CO4: Learn Photodetectors: General Characteristics of Photodetectors, Impulse Response, Photoconductors, PIN, APD, Array Detectors, CCD, Solar Cell. Photonic Integrated Circuits.

ECPE-312 VERILOG HDL

Pre-requisite: Digital Design **(**ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:
Learning Verilog HDL and using it to design basic digital circuits. Designing complex arithmetic circuits and sequential circuits. Implementation of Verilog Design on FPGAs and their analyses.

Course Content:

UNIT I **10 hrs.**

Introduction to Verilog HDL: Overview of Verilog HDL and its importance in digital circuit design, Basic syntax, data types, and operators in Verilog HDL, Verilog HDL design flow and simulation basics, Designing combinational circuits using Verilog HDL, Sequential Circuit Design using Verilog HDL.

Introduction to Sequential Circuits and Their Applications: Creating Flip-Flops and Latches using Verilog HDL, Designing Finite State Machines (FSMs) using Verilog HDL, Synthesis and optimization of sequential circuits using Verilog HDL

UNIT II **8 hrs.**

Modelling in Verilog HDL: Overview of Behavioral Modeling in Verilog HDL, Data flow and Structural Modelling, and Using Always block and conditional statements in Verilog HDL, Blocking and Non-Blocking Statements, Delay modeling and Timing Control, tasks and Functions, Creating testbenches for Verilog HDL design verification.

UNIT III **10 hrs.**

Advanced Topics in Verilog HDL: Hierarchical design and reusable modules, Parameterized Modules and Macros, Designing Memories and Arithmetic circuits in Verilog HDL, Designing Finite State Machines with Mealy and Moore Models, Verification process and types of simulation, Debugging and error tracing in Verilog HDL design

UNIT IV **12 hrs.**

Design Projects Using Verilog HDL: Applying the knowledge gained in the course to design digital circuits in Verilog HDL, designing Verilog project from scratch, FPGA architecture, verification, and implementation of projects on FPGA and demonstrations.

Text Book(s) / Reference(s):
[1] Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis.

[2] Frank Vahid and Roman Lysecky, Digital Design with RTL Design, Verilog and VHDL
[3] Blaine Readler, Verilog by Example: A Concise Introduction for FPGA Design.
[4] Pong P. Chu, FPGA Prototyping by Verilog Examples: Xilinx Spartan-3 Version.
[5] Zainalabedin Navabi, Verilog Digital System Design: Register Transfer Level Synthesis, Testbench, and Verification.

Course Outcomes:

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

CO1: Learn Verilog HDL and apply it for simple and complex designs
CO2: Design data path and controller for CPUs.
CO3: Understand various types of FPGAs, their architectures.
CO4: Use Vivado tool for Verilog designs and implement them on FPGA boards
CO5: Understand FPGA based design flow.

ECPE-313 BIOMEDICAL ELECTRONICS

Pre-requisite: Electronic Devices and Circuits (ECPC-201), Digital Design (ECPC-202), ElectronicsI Lab (ECPC-206), Signals, Systems and Random Variables (ECPC-203) andDigital Signal Processing (ECPC-301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Description:
The course deals with bioelectric signal basics, different types of transducers, biomedical recording systems, diagnostic and therapeutic equipment, and medical imaging system measurements. The main objective is to help students acquire knowledge on types of sensors and transducers, working principles, selection procedures, and applications of biomedical electronic systems.

Course Contents:

UNIT I **10 hrs.**

Physiological Systems and Signals: Biology of the heart, circulatory and respiratory systems, auditory systems, physiology of nerve and muscle cells, fundamental organization of brain and spinal cord. Biosignals: Origin of bioelectric signals, electrocardiogram (ECG), phonocardiogram (PCG), encephalogram (EEG) and electromyogram (EMG).

UNIT II **10 hrs.**

Physiological Transducers: Electrodes: silver-silver chloride electrodes, electrodes for ECG, EEG, EMG, Microelectrodes. Performance characteristics of transducers, classification of transducers based on Electrical principle involved: Resistive position transducer, resistive pressure transducer, inductive pressure transducer, capacitive pressure transducer; Self generating inductive transducer: linear variable differential transformer (LVDT), Piezoelectric Transducer.

UNIT III **10 hrs.**

Recording Systems: Preamplifier, Signal conditioning: Differential amplifier, current to voltage converter, instrumentation amplifier; biomedical filters: LPF, HPF, bandpass, band stop (Notch filter); source of noise in low level measurement, Recording systems for ECG, PCG, EEG and EMG.

UNIT IV **10 hrs.**

Diagnostic and Therapeutic Equipment: Blood pressure monitors – Electro-cardio scope – Pulse Oximeter – pH meter – Auto analyzer – Pacemakers – Defibrillator – Heart lung machine – Nerve and muscle stimulators – Dialysis machines – Surgical

diathermy equipment – Nebulizer; inhalator – Aspirator – Humidifier – Ventilator and spirometry.
Medical Imaging Systems: X-ray imaging, Computed tomography, ultrasonic imaging systems, Magnetic resonance imaging system, thermal imaging systems.

Text Book(s) / Reference(s):
[1] Principles of Biomedical Instrumentation and Measurements, Richard Aston, ISBN: 0-675-20943-9, Maxwell Macmillan International Publishing Company.
[2] Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment and Technology, 4th Edition. Upper Saddle River, New Jersey: Prentice-Hall, 2001.
[3] John G Webster, "Medical Instrumentation Applications and Design", John Wiley and Sons, New York, (3e), 2011.
[4] R S Khandpur, "Handbook of Biomedical Instrumentation", McGraw Hill, Delhi, (3e), 2014.
[5] L A Geddes, L E Baker, "Principles of Applied Medical Instrumentation", Wiley India, New Delhi, (3e), 2008.
[6] Richard Aston, "Principles of Biomedical Instrumentation and Measurement", Merrill, New York, 1991.
[7] Joseph J Carr, John M Brown, "Introduction to Biomedical Equipment technology", Prentice Hall, New Jersey, (4e), 2003.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Apply principles and concepts of electronics to analyze input and output signals in medical electronics
CO2: Apply principles and concepts of electronics to design filters for de-noising of medical measurements
CO3: Recognize different types of transducers, ongoing progress in improving their design, and their application in medical measurements
CO4: Apply principles and concepts of sensing and engineering to (i) design diagnostic devices for detection of markers in biofluids, and (ii) be able to evaluate quality of diagnostic devices

ECOE-301 COMMUNICATION SYSTEMS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course will provide the fundamental concepts of signals, Fourier Transform and Modulation and Demodulation schemes. The effect of noise on AM and FM receivers will also be discussed.

Course Content:

UNIT I **9 hrs.**

Introduction: Signals: Continuous Signals, Discrete Signals, Digital Signals, Random Signals. Fourier Transform, Properties of Fourier Transform, Fourier Transforms of signals used in communications.

UNIT II **10 hrs.**

Amplitude Modulation: Concept of Modulation, Amplitude modulation: Double-Sideband Suppressed Carrier, Double-Sideband Full Carrier, Single Sideband and vestigial sideband modulation; Demodulation: Carrier Recovery in AM, Coherent Demodulation, Envelope Detector, Square-Law Demodulator; Integrated Super Heterodyne Receiver.

UNIT III **12 hrs.**

Angle Modulation: Frequency Modulation, Phase Modulation, Narrow Band Angle Modulation, Wideband FM, Modulators, Demodulators. Sampling, Pulse amplitude modulation, Pulse width modulation, Pulse position modulation. Brief introduction about Digital modulation.

UNIT IV **9 hrs.**

Performance Analysis of Receivers under AWGN: Effects of Noise in Analog Modulation Systems. Case study of AM and FM Receivers. Analog and Digital Receiver performance in AWGN.

Text Book(s) / Reference(s):

[1] S. Haykin, "Communication Systems," John Wiley & Sons, 5th Ed., 2009.
[2] B.P. Lathi and Z. Ding, "Modern Digital and Analog Communication Systems," 4th Ed., Oxford University Press, 2009.
[3] Louis E. Frenzel, "Principles of Electronic Communication Systems," 3rd Ed., Tata McGraw-Hill, 2008.

[4] Dennis Roddy and John Coolen, "Electronic Communications," 4th Ed., Pearson, 2008.
[5] J. G. Proakis and M. Salehi, "Fundamentals of Communication Systems," Prentice Hall, 2004.
[6] Leon W. Couch, Digital and Analog Communication Systems, 4th Ed., Macmillan Coll Div., 1993.

Course Outcomes:

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

CO1: Understand the basics of signals and Fourier transforms.

CO2: Understand the basics of Amplitude and Frequency Modulation and demodulations.

CO3: Apply Fourier transform to get the spectrum of different modulated signals and decide the requirement of bandwidth.

CO4: Analyze the effect of noise in AM and FM receivers.

ECOE-302 MICROPROCESSORS

Pre-requisite: Digital Design **(**ECPC 202), and Computer Architecture (ECPC 211)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:
To learn the importance of microprocessors, understand architecture and programming of 8086 processor and advance processors, interfacing techniques like memory and I/O. Study new events in the fields of microprocessors and microprocessor interfacing.

Course Content:

UNIT I **8 hrs.**

Introduction to 8-Bit Microprocessor Architecture: Evolution of Microprocessor, Microprocessor Architecture and its operations, Memory, Buses, Input/Output devices, ALU, Timing and Control Unit, registers, Pin Configuration, Instruction Cycle, Timing Diagram.

Introduction to 16-Bit Microprocessor Architecture: 8086 Block diagram; description of data registers, address registers; pointer and index registers, PSW, Queue, BIU and EU, 8086 Pin diagram descriptions. 8086 minimum mode and maximum mode CPU module. 8086 CPU Read/Write timing diagrams in minimum mode and maximum mode.

UNIT II **10 hrs.**

8086 Instruction Set: Instruction formats, addressing modes, Data transfer instructions, string instructions, logical instructions, arithmetic instructions, transfer of control instructions; process control instructions; Assembler directives, Writing assembly Language programs for logical processing, arithmetic processing, timing delays; loops, data conversions, modular programming, Macros.

UNIT III **12 hrs.**

Interfacing and Programmable Devices: Basic interfacing concepts and address decoding techniques, Programmable interval timer, programmable peripheral interface 8255.

Interrupts and DMA: classification – internal and external, maskable and non-maskable, hardware and software. Interrupt Vector Table, interrupt cycle, interrupt service routine, and interrupt priorities. Programmable interrupt controller 8259, programmable DMA controller 8237. Relevance and features of 8087 co-processor.

UNIT IV **10 hrs.**

Advancement in Microprocessors: Block diagram of Advanced Microprocessor, Features and comparison of 80286, 80386, 80486, Pentium IV. Concept of core processor.

Introduction to Power PC, Features of Power PC601 and AMD Athlon Processor. Features and applications of Super SPARC Processor. Case study: Different Processor Technology for sustainable computing, Powering a microprocessor by photosynthesis.

Text Book(s) / Reference(s):

[1] D.V. Hall, Microprocessors and Interfacing, McGraw Hill 3rd Edition, 2017.
[2] A. K. Ray, K. M. Bhurchandi, Advanced Microprocessor & Peripherals, Tata McGraw Hill, 3rd Edition, 2017.
[3] J. Uffenbeck, The 8086/8088 family, PHI.
[4] Liu, Gibson, Microcomputer Systems – The 8086/8088 family, PHI, 2nd Edition.
[5] Triebel, Walter, Avatar Singh, The 8088 and 8086 microprocessors: programming, interfacing, software, hardware, and applications: including the 80286, 80386, 80486, and Pentium processors, Prentice Hall, 4th Edition, 2003.

Course Outcomes:

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

CO1: Develop the basic understanding of 16-bit microprocessor architecture. Program a microprocessor system using assembly language.

CO2: Understand and capable of interfacing the microprocessor to the I/O devices.

CO3: Explain the architecture of generic advanced microprocessor and features of advanced microprocessors

CO4: Interpret specifications for any microprocessor or peripheral chip.

Semester – VI

ECPC-308 COMPUTER NETWORKS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
The objective of this course is to provide an understanding of theoretical aspects of computer networks, including the protocols involved in the exchange of information between communicating devices

Course Content:

UNIT I **10 hrs.**
Computer Network Topologies, Network Hardware, Network Software, OSI Model and TCP/IP protocol stack, ATM, Data communication fundamentals, wired physical layer, Wireless physical layer, and Physical layer based on telephone line.

UNIT II **10 hrs.**
Data Link layer design issues, Error detection & correction, Elementary Data Link protocols, Sliding Window Protocols, Example Data Link Protocols, Aloha Protocols, Wired MAC layer, IEEE 802.2: Logical Link control, Wireless MAC layer.

UNIT III **10 hrs.**
Network layer services, Datagram and Virtual circuit services, Routing algorithms, Congestion control algorithms, Internetworking, Transport layer services, Elements of transport protocols, The Internet transport protocols: UDP & TCP.

UNIT IV **10 hrs.**
Domain Name System, World Wide Web and HTTP, Electronic mail system, File Transfer protocol, Network security, Attacks on different network layers and their countermeasures. Use cases

Text Book(s) / Reference(s):
[1] Tanenbaum A.S, "Computer Networks", Pearson, 4th ed., 2003.
[2] Forouzan B.A, "Data Communications and Networking", Tata McGraw Hill, 4th ed. 2006.
[3] Stallings W, "Data and Computer Communications", PHI, 9th ed., 2011.
[4] Kurose & Ross K. W., "Computer Networking: A Top-Down Approach featuring the Internet", Pearson, 5th edition, 2010.

Course Outcomes:

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

CO1: Understand the computer network hardware and software.

CO2: Compare the OSI and TCP/IP protocol stacks.

CO3: Examine the protocols operating at different layers of network architecture.

CO4: Categorize the services offered by all layers of the network's protocol stack.

CO5: Assess the cryptographic technique and Identify the sources of network security threats.

ECPC-309 PROCESSOR DESIGN

Pre-requisite: Digital Design (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:

To understand the architectures of popular processors and their area specific usage and advantages. To learn the fundamentals of processor design. To understand instruction level parallelism and multi-level pipelining. To analyze the impact of workload, the degree of instruction-level parallelism, hardware parallelism, power consumption and technology on the efficiency of processors.

Course Content:

UNIT I **8 hrs.**

CISC Processor Design: Defining microprocessor, hardware flowchart, implementing from flowchart, exception, control store, microcode design.

UNIT II **10 hrs.**

RISC Processor Design: Building datapath and controller, single cycle implementation, multi cycle implementation, pipelined implementation, exception and hazards handling. (Example: DLX Processor)

UNIT III **12 hrs.**

Superscalar Processors Design: Superscalar organization, superscalar pipeline overview, VLSI implementation of dynamic pipelines, register renaming, reservation station, re-ordering buffers, branch predictor, and dynamic instruction scheduler etc.; simultaneous multi-threading (SMT) design. (Example: Open SPARC T1)

UNIT IV **10 hrs.**

Memory System Design. Application specific instruction set processor (ASIP) design. Dynamic reconfigurable processors (DRP). Impact of physical technology, trends in power consumption, low power techniques, low voltage techniques, clock distribution.

Text Book(s) / Reference(s):

[1] Nick Tredennick, Microprocessor Logic Design, Digital Press, 1987

[2] D.A. Patterson and J.L. Hennessy, Computer Organization and Design, Morgan Kaufman Pub., N. Delhi, 2005

[3] JP Shen and MH Lipasti, Modern Processor Design, MC Graw Hill, Crowfordsville, 2005

[4] Mike Johnson, Superscalar Microprocessor Design, Prentice Hall, Englewood Cliffs, NJ, 1991
[5] J.L. Hennessy, and D.A. Patterson, Computer Architecture: A quantitative approach, Fifth Edition, Morgan Kaufman Publication, 2012
[6] A. Chandrakasan and W J Bowhill, and F. Fox, Design of High-Performance Microprocessor Circuits, IEEE Press, 2001

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Design basic processor and analyse the fundamentals of processor architecture
CO2: Choose application specific processor
CO3: Optimize parallelism and multi-level pipelining for performance and efficiency
CO4: Understand the design of instruction set, memory and reconfigurable processor

ECPC-310 MICROWAVE THEORY AND DEVICES

Pre-requisite: Electronic Devices and Circuits (ECPC 201), and Fields and Waves (ECPC 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The purpose of this course is to provide a comprehensive introduction to microwaves and principles of microwave devices. Course Learning Objectives are to acquaint graduating students with fundamentals, analytical methods, design principles and applications of active and passive microwave components and devices.

Course Content:

UNIT I **10 hrs.**

Microwave Tubes: Operating principle of multicavity and reflex klystron, magnetron, and traveling wave tube.

Waveguides: TE, TM, TEM modes solutions of Maxwell's equations, Rectangular and circular waveguides, micro strip and strip lines.

UNIT II **8 hrs.**

Microwave Devices: Gunn diode, IMPATT, PIN, Schottky barrier, microwave BJT, MESFET, HEMT, Applications.

UNIT III **12 hrs.**

Scattering matrix representation of microwave networks, Directional couplers, E-plane, H-Plane and Magic Tee, coupling of waveguides- probes, loops and apertures.

Resonators: basic principle, loaded, unloaded, and external Q, open and shorted TEM lines, microstrip and dielectric resonators. Ferrites- permeability tensor, plane wave propagation in ferrites, Faraday rotation, circulators, isolators, phase shifters, and microwave attenuators

UNIT IV **10 hrs.**

Introduction to Microwave Measurements: Slotted Line, Tunable Detector, VSWR Meter, Power Meter, Measurement of frequency, Power, Phase shift, VSWR and Impedance. Study of advanced microwave applications in industry and medical science: Microwave Imaging, Food Processing, Chemical Heating etc.

Text Book(s) / Reference(s):

[1] 'Microwave Engineering' by David M. Pozar, John Wiley & Sons
[2] 'Microwave Devices and Circuits' by Liao S.Y., Pearson Prentice Hall
[3] 'Foundations for Microwave Engineering' by Robert E. Collin, Wiley-IEEE Press

Course Outcomes:

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

CO1: Understand the basic concepts and applications of microwave systems.

CO2: Analyze, test and use various passive microwave components for different applications.

CO3: Understand the working of Klystron, TWT and Magnetron

CO4: Understand the principle of various microwave devices and their applications

ECPC-311 PROCESSORS LAB

Pre-requisite: Digital Design (ECPC 202), and Digital Design Lab (ECPC 207)

L	T	P	Credits	Total contact hours
0	0	2	1	24

List of Experiments:

1. Arranging an Array of Bytes in Ascending/Descending Order.
2. Logic operations - Shift and rotate - Converting packed BCD to unpacked BCD, BCD to ASCII conversion.
3. String operations - Move block, Reverse string, String comparison, Length of string.
4. Find the square root of a number & verify.
5. Generation of Sine, Triangular and Square wave using Interface with 8255 (PPI) and measurement of time period/frequency of sine, triangular and square wave.
6. Realize MOD-10 Up-Down Counter on 7-Segment display using Interface with 8255 (PPI).
7. Interface Stepper Motor and controlling its RPM and direction of rotation.
8. ON/OFF control of SSR (Solid State Relay) using interface with 8255.
9. Interfacing of LM35/RTD temperature sensor with 8086 and displaying the temp value on LCD.
10. To interface a traffic light system using 8086 & 8255.

Course Outcomes:

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

CO1: Write and execute 8086 assembly language programs for data manipulation operations including sorting, BCD/ASCII conversions, and string processing.
CO2: Implement arithmetic and logical operations in assembly language and verify results through simulation and hardware execution.
CO3: Interface the 8086 processor with peripheral devices such as the 8255 PPI to control output devices including 7-segment displays, stepper motors, SSRs, and traffic light systems. **CO4:** Design and test sensor-based interfacing systems using the 8086 processor with temperature sensors and LCD displays, analysing the input-output behaviour of the complete hardware-software system.

ECPC-312 EMBEDDED SYSTEM LAB

Pre-requisite: Computer Architecture (ECPC 211)

L	T	P	Credits	Total contact hours
0	0	2	1	24

List of Experiments:
8051:

ARM: LPC 2148 ARM 7 Processor
ARM programming in C language using KEIL IDE. Implement the lighting and winking LEDs of the ARM I/O port via programming. Changing ARM state mode by using MRS/MMSR instruction and specify a start address of the text segment by using the command line. To read analog voltage and display its digital equivalent on LCD using ARM.

PIC: (PIC 16F877)
Reading matrix keypad (DK) using PIC.

AVR:
Stepper Motor Control Using ATMEGA-16 Microcontroller. Temperature control using ATmega16.

Course Outcomes:
At the end of this course, students should be able to:
CO1: Identify the functionality of development boards to implement embedded applications.
CO2: Compile bug free assembly or C language programs for microcontrollers to a required task.
CO3: Design an electronic circuit for diverse I/O devices used in real time embedded applications.
CO4: Develop a product with all sub systems of functional requirements in optimal hardware and software components.

ECPC-313 MACHINE LEARNING LAB

Pre-requisite: Machine Learning & Data Analytics (CSIC 221)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description:
This lab is regarding the design and development of Machine learning algorithms for classification/recognition of the data. It is also for developing and modelling the real time software for classification/recognition of the data.

List of Experiments:
1. Development of k-nearest neighbor's algorithm for classification of image data.
2. Implementation of k-means clustering algorithm for binary and multi-class classification of image data.
3. Development of expectation maximization (EM) algorithm for binary classification of the data and find the probabilities, means and variances of the respective classes.
4. Implement principle component analysis (PCA) technique on 2-D data and determine the Eigen vectors. Plot PCA space of the first two PCs.
5. Implement linear discriminant analysis (LDA) technique for data classification.
6. Apply PCA and LDA techniques for dimensionality reduction of feature vectors.
7. Study of the SVM technique using MATLAB/C and apply this technique for data classification.
8. Study of the different deep learning techniques using MATLAB/C.
9. Design a feature map of a given data using convolution and pooling operation of convolutional neural network (CNN).
10. Minor project.

Text Book(s) / Reference(s):
[1] C. M. Bishop, Pattern Recognition and Machine Learning, Springer

Course Outcomes:
Upon successful completion of this laboratory course, the students will be able to:
CO1: Implement and evaluate supervised machine learning algorithms including k-nearest neighbours, Linear Discriminant Analysis, and Support Vector Machines for classification of real-world datasets.
CO2: Apply unsupervised learning techniques such as k-means clustering and the Expectation-Maximization algorithm to perform binary and multi-class data classification, interpreting the resulting probabilistic parameters.

CO3: Implement dimensionality reduction techniques — Principal Component Analysis and Linear Discriminant Analysis — on multi-dimensional feature vectors and visualise the transformed feature space.
CO4: Design and analyse deep learning architectures including Convolutional Neural Networks by implementing convolution and pooling operations, and develop a minor project integrating multiple machine learning techniques for a practical application.

ECPE-314 IMAGE PROCESSING

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Image processing is a rapidly growing field that deals with the use of digital images to various fields of life including medical, automation, etc. This course provides an in-depth introduction to the fundamental concepts, techniques, and tools used in image processing. The course covers the topics such as image acquisition, image processing, image compression, steganography, and digital watermarking. Students will learn how to apply these techniques to identify image tampering, detect forged images, and authenticate the origin of digital images.

Course Learning Objectives:
The student should be able to understand and apply the various concepts of Digital Image Processing.

Course Contents:

UNIT I **10 hrs.**

Introduction: The Origin of Digital Image Processing, Problems and Applications, Fundamental steps in image processing, Components of an image processing system. Transforms and their properties. Two Dimensional DFT, DCT. Hadamard, Slant, Haar and KL, Transforms and their properties. Image Perception: Image models, sampling & quantization, neighbors of a pixel, connectivity, labeling of connected components.

UNIT II **10 hrs.**

Intensity Transformation and Spatial Filtering: Basic intensity transformation functions, Histogram processing, spatial filters, homomorphic filtering, generation of spatial marks. Fuzzy techniques for Intensity Transformation and Spatial Filtering. Image Restoration and Reconstruction: Noise models, Restoration in the presence of Noise only, Frequency domain filtering, Inverse filtering, Wiener filtering, Geometric mean filtering. Image reconstruction from projections. Image Compression: Redundancy models, error free compression, Lossy compression, Some basic compression methods, Image compression standards.

UNIT III **10 hrs.**

Color Image Processing: Color Models, Pseudocolor Image Processing, Basics of full color image processing, color transformations, segmentation, smoothing and sharpening, Noise in color Images. VMF, VDF, etc. Morphological Image Processing:

Erosion, Dilation, Opening, Closing, Some basic morphological algorithms, Gray scale morphology.

UNIT IV **10 hrs.**

Image Segmentation: Detection of Discontinuity, Edge detection, Boundary detection, Thresholding, Regional oriented segmentation uses of motion in segmentation. Representation and Description: Representation, Regional descriptors, Boundary descriptors, Image analysis, Pattern and their classes, Decision theoretical methods, Structural methods, Interpretation. Copy paste attacks, its challenges and identification. Noise removal from images depending on its nature.

Text Book(s) / Reference(s):

[1] Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson, 3rd Edition, 2016.
[2] Anil K. Jain, Fundamentals of Digital Image Processing, Pearson 2002.
[3] Kenneth R. Castleman, Digital Image Processing, Pearson, 2006.
[4] Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, 'Digital Image Processing using MATLAB', Pearson Education, Inc., 2000.
[5] Hany Farid, 'Photo Forensics' The MIT Press, 2016.

Course Outcomes:

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

CO1: Understand and apply the Image filtering, Restoration, segmentation, etc.
CO2: Apply the vector approach to handle the color images.
CO3: Apply the 'Morphological operation' for various applications.
CO4: Develop the understanding about digital image forensics.

ECPE-315 STATISTICAL SIGNAL PROCESSING

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Content:

UNIT I **10 hrs.**

Problem Formulation and Objective of Signal Detection and Signal Parameter Estimation in Discrete-Time Domain, classification of estimation and detection problems, Applications: Radar, image processing, speech, communications.

UNIT II **8 hrs.**

Recap of calculus, linear algebra, Probability and stochastic processes, Review of Gaussian Variables and Processes spectral characteristics of signals and noise, Bias, Minimum Variance Unbiased Estimation (MVUE), Fisher Information Matrix, Cramer-Rao Lower Bound

UNIT III **12 hrs.**

Linear Models, Finding MVU estimators via linear models Generalized Minimum Variance Unbiased Estimation, Rao Blackwell and Lehman Scheffe theorem, Best Linear Unbiased Estimators (BLUE), Maximum Likelihood Estimation (MLE), Bayesian: Minimum mean square error (MMSE), Linear MMSE, Minimum absolute error, Minimum probability of error (MAP), Least Squares, Applications: image, radar, processing, speech, communications.

UNIT IV **10 hrs.**

Hypothesis Test, Likelihood Ratio Test, Neyman-Pearson Theorem, Receiver Operating Characteristics, Minimum Probability of Error, Bayes Risk, Multiple Hypothesis Testing, Detection of Deterministic Signals: Matched Filter, Generalized Matched Filter, Detection of Random Signals: Estimator-Correlator, Linear Model, General Gaussian Detection Statistical.

Text Book(s) / Reference(s):

[1] S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Vol-I, Prentice Hall PTR, 2009.

[2] H. V. Poor, An Introduction to Signal Detection and Estimation, Springer, 2/e, 1998.

[3] Harry L. Van Trees, Detection, Estimation and Modulation Theory (Detection, Estimation and Modulation Theory, Part-I), John Wiley & Sons, 2002.

Course Outcomes:

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

CO1: Understanding of signal detection and estimation problems.

CO2: Learning of the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators

CO3: Understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), the Neyman-Pearson and Bayesian detectors.

CO4: Possess fundamental grounding and sophistication needed to apply statistical signal processing to real world problems.

ECPE-316 ADAPTIVE SIGNAL PROCESSING

Pre-requisite: Signal , Systems and Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Content:

UNIT I **10 hrs.**

Linear Prediction: Direct form linear prediction filtering. Normal equations for linear prediction filtering. Levinson algorithm. Linear prediction lattice filtering.

UNIT II **10 hrs.**

Digital Wiener Filtering: Wiener smoothing and prediction filters. Application of Wiener smoothing to noise cancelling. Application of Wiener prediction filters. Constrained, linear MMSE filtering. Minimum variance beam forming.

Least Mean Squares Adaptive Filter: LMS adaptive algorithm. Properties of LMS adaptive filter. Normalized forms. Finite precision effects. Adaptive beam forming.

UNIT III **10 hrs.**

Orthogonalized Adaptive Filters: Frequency domain adaptive filters. Adaptive lattice filters.

Least Squares Adaptive Filters: Godard algorithm. Lattice.

UNIT IV **10 hrs.**

Other Adaptive Filtering Techniques: Neural networks and multi-layer perceptrons. Adaptive IIR filtering. The constant modulus algorithm.

Blind Adaptive Filtering: Cost functions. Higher-order statistics. Examples.

Text Book(s) / Reference(s):

[1] Adaptive Filter Theory, S. Haykin, Prentice-Hall, 4-th edition, 2001.
[2] Fundamentals of Adaptive Filtering, Ali H. Sayed, John Wiley, 2003.
[3] Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, D. Manolakis, V. Ingle, S. Kogan, McGraw Hill, 1999.
[4] Adaptive Signal Processing, B. Widrow, S. Stearns, Prentice-Hall, 1985.
[5] Theory and Design of Adaptive Filters, J. Triechler, C. Johnson Prentice-Hall, 1995.

Course Outcomes:

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

CO1: Understand the concept of linear prediction and its applications.

CO2: Understand the Weiner filtering methods and LMS adaptive filtering techniques and their applications
CO3: Understand the concept of frequency domain adaptive filtering.
CO4: Understand and analyze the higher statistics based filtering methods.
CO5: Analyze various adaptive filtering techniques and apply the appropriate technique suitable for a particular application.

ECPE-317 OFDM SYSTEMS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course will provide the fundamentals and basic concepts of fading channels, SISO and OFDM systems. The performance of these systems under AWGN and fading channels.

Course Content:

UNIT I **10 hrs.**

Introduction: Mobile communication systems: past, present, and future. Multicarrier techniques for 4G systems, Mobile channel modelling: path loss, excess delay, power delay profile, root-mean-squared (RMS) delay spread, coherence bandwidth, Doppler spread, and coherence time. Categorization of fading channels: frequency non-selective and slowly fading channels, frequency selective fading channels, time-selective fading channels, frequency and time-selective fading channels. Methods for channel fading mitigation.

UNIT II **10 hrs.**

Fundamentals of MCM/OFDM: Introduction to OFDM, origin of OFDM, use of discrete-time Fourier transform, insertion of cyclic prefix for current form of OFDM. OFDM system architecture, Discrete-time model of an OFDM system.

UNIT III **10 hrs.**

OFDM Characteristics: Bit-error rate in AWGN channel, Bit-error rate of CPSK-based OFDM system in Rayleigh fading channels, Bit-error rate of DPSK-based OFDM system in Rayleigh fading channels, Bit-error rate in frequency selective and time selective Rayleigh fading channels. Strengths and drawbacks of OFDM. Time and frequency synchronization, Time and frequency offset compensation.

UNIT IV **10 hrs.**

Peak to Average Power Ratio (PAPR) Reduction: PAPR definition, statistical properties of PAPR, different techniques to reduce PAPR in OFDM. Applications and case study of OFDM System. Future research directions: MIMO-OFDM, Optical-OFDM.

Text Book(s) / Reference(s):

[1] Man-On Pun, Michele Morelli, and C-C Jay Kuo; Multi-Carrier Techniques for Broadband Wireless Communications: A Signal Processing Perspective, Imperial College Press London.

[2] Shinsuke Hara, Ramjee Prasad; Multi-Carrier Techniques for 4G Mobile Communications, Artech House Boston London.
[3] Ahmad R. S. Bahai, Burton R. Saltzberg and Mustafa Ergen; Multi-Carrier Digital Communications: Theory and Applications of OFDM, Springer.
[4] Richard van Nee, Ramjee Prasad; OFDM for Wireless Multimedia Communications, Artech House Boston London.
[5] Marc Engels; Wireless OFDM Systems: How to make them work?, Kluwer Academic Publishers London.

Course Outcomes:

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

CO1: Understand the basics of multicarrier techniques and the effect of fading channels.

CO2: Apply discrete Fourier transform to design OFDM system and see the effect of cyclic prefix on it.

CO3: Analyze different characteristics of OFDM systems under different fading environments.

CO4: Apply different algorithms to compute PAPR analysis of OFDM systems.

ECPE-318 ESTIMATION AND DETECTION

Pre-requisite: Differential Calculus and Differential Equations (MAIC-101) and, Integral Calculus and Difference Equations (MAIC-102), Communication Engineering (ECPC 205), and Information Theory and Coding (ECPC 212)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
Estimation and detection are at the heart of most signal processing systems which are central in Information and Communication Technology (ICT) and also provide the foundation for data analytics in a broader context (e.g. finance, medicine, industry, earth science). This course gives an introduction to the basic techniques for estimation and detection with focus on signals processing aspects.

Course Content:

UNIT I **10 hrs.**

Overview of estimation and detection problems, Mathematical background and notation, Basic concepts and terminology Review of probability theory, Random variables and their properties, Probability density functions and cumulative distribution functions, Joint, conditional, and marginal distributions

UNIT II **10 hrs.**

Point estimation: maximum likelihood estimation, method of moments, Interval estimation: confidence intervals, hypothesis testing, Properties of estimators: bias, consistency, efficiency Least squares estimation, Bayesian estimation, Minimum mean square error (MMSE) estimation, Maximum a posteriori (MAP) estimation

UNIT III **10 hrs.**

Detection Theory: Binary hypothesis testing, Signal detection in noise, Receiver Operating Characteristic (ROC) curves, Neyman-Pearson criterion, Optimal detectors: matched filter, likelihood ratio test. Estimation and Detection in Gaussian Noise, Gaussian random variables and processes, Linear estimation: Wiener filter, linear regression, Optimal detection in Gaussian noise

UNIT IV **10 hrs.**

Introduction to Signal Processing Applications: Radar and sonar systems, Communications systems, Image and video processing, Sensor networks. Applications of Estimation and detection in various sustainable technologies, case studies from the Indian knowledge system.

Text Book(s) / Reference(s):

[1] S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory," Pearson.
[2] S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory," Pearson.
[3] H. V. Poor, "An Introduction to Signal Detection and Estimation," Springer.
[4] H. L. Van Trees, Detection, Estimation and Modulation Theory, Parts 1 and 2, John Wiley Inter-Science.
[5] E. L. Lehman, Testing Statistical Hypothesis, John Wiley.

Course Outcomes:

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

CO1: Analyze the estimator properties such as Bias, Efficiency, Linearity and CR bound.

CO2: Use classical estimation techniques such as MLE and LS for estimation of parameters.

CO3: Apply Bayesian estimation approaches in various applications.

CO4: Comprehend methods of detection of signals with known and unknown parameters and apply them to real engineering problems.

ECPE-319 CYBER PHYSICAL SYSTEMS

Pre-requisite: Digital Design (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
This course introduces students to the fundamental concepts, principles, and technologies underlying Cyber-Physical Systems, which integrate computation, communication, and control into physical systems. Students will learn about the design, modeling, and analysis of CPS and their practical applications.

Course Content:

UNIT I **10 hrs.**

Introduction to Cyber-Physical Systems: Definition and significance of CPS, Examples and applications of CPS.

Fundamental Concepts: Real-time computing and control, Sensors and actuators, Embedded systems.

Modeling and Simulation: Continuous and discrete-time modelling, State-space representation, Simulation tools (e.g., MATLAB/Simulink)

UNIT II **10 hrs.**

Control Systems in CPS: PID controllers, State feedback control, Model Predictive Control (MPC).

Communication in CPS: Wireless communication protocols, Networked control systems, Internet of Things (IoT).

Sensors and Sensing Techniques: Sensor types (e.g., accelerometers, gyroscopes), Data acquisition and processing, Sensor fusion

UNIT III **10 hrs.**

Safety and Security in CPS: Safety standards and regulations, Cybersecurity challenges, Risk assessment and mitigation.

Cyber-Physical System Design: Hardware and software co-design, System architecture, Case studies in CPS design

UNIT IV **10 hrs.**

Case Studies and Applications: Autonomous vehicles, Smart grid systems, Healthcare applications, Smart buildings, Examples from Indian Knowledge system

Text Book(s) / Reference(s):

[1] "Principles of Cyber-Physical Systems" by Rajeev Alur

[2] "Cyber-Physical Systems: Foundations, Principles and Applications" by Houbing Song, Danda B. Rawat, Sabina Jeschke, and Christian Brecher
[3] "Cyber-Physical Systems: From Theory to Practice" by Danda B. Rawat, Joel J.P.C. Rodrigues, and Ivan Stojmenovic
[4] "Embedded Systems: Cyber-Physical Systems" by Peter Marwedel
[5] "Cyber-Physical Systems: Architecture, Security and Applications" edited by Nizar Alsharif, Magdy Bayoumi, and Sherali Zeadally
[6] "Cyber-Physical Systems: Integrated Computing and Engineering Design" by Nigamanth Sridhar and Sandeep K. S. Gupta
[7] "Cyber-Physical Systems: Decision Making Mechanisms and Applications" by Hakima Chaouchi and Mohamed Aissani

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Review the basics of CPS
CO2: Comprehend its mechanisms and modelling
CO3: Understand the involved communications, computing and hardware components
CO4: Learn to design and appreciate its practical applications.

ECPE-320 COMPUTATIONAL ELECTROMAGNETICS AND ITS APPLICATIONS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course covers the mathematical formulation of the following methods: Integral Equations Methods (and their solution by the Method of Moments), the Finite Element Method, and the Finite Difference Time Domain method. These methods are illustrated by their use in solving scattering problems and antenna radiation/impedance calculation problems.

Course Content:

UNIT I **10 hrs.**

Review of vector calculus, electromagnetic fields, and an overview of computational electromagnetics.

UNIT II **10 hrs.**

Surface integral equations in 2D, Green's functions, solving surface integral equations by method of moments (MoM), Solving volume integral equations by method of moments.

Finite Difference Methods (FDM): Central/forward/backward differences, solving Poisson equations on a rectangular domain.

UNIT III **10 hrs.**

Finite Element Method (FEM): Introduction to finite element methods (FEM), Finite element method (FEM) in 1D, Finite element method (FEM) in 2D.

Finite Difference Time Domain Method (FDTD): Finite difference time domain (FDTD) method: introduction, materials and boundary conditions, perfectly matched layers.

UNIT IV **10 hrs.**

Applications of CEM: inverse problems and antenna radiation problems, antenna radiation problems and hybrid methods.

Text Book(s) / Reference(s):

[1] Peterson, Andrew F., Scott L. Ray, Raj Mittra, Computational methods for electromagnetics. Vol. 351. New York: IEEE press, 1998.

[2] Balanis, Constantine A. Advanced engineering electromagnetics. John Wiley & Sons, 2012.

[3] Chew, Weng Cho. Waves and fields in homogenous media. Vol. 16. John Wiley & Sons, 1999.
[4] Volakis, John Leonidas, John L. Volakis, Arindam Chatterjee, and Leo C. Kempel. Finite element method for electromagnetics. Universities Press, 1998.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand various methods used to solve complex electromagnetic engineering problems.
CO2: Learn fundamentals of Method of moments (MoM).
CO3: Understand basics of Finite element method (FEM) & Finite Difference method (FDM).
CO4: Understand basics of Finite difference time domain (FDTD) method.

ECPE-321 MATHEMATICS FOR MACHINE LEARNING

Pre-requisite: Applied Linear Algebra (MAIC -204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Machine learning is a growing field at the intersection of probability, statistics, optimization, and computer science, which aims to develop algorithms for making predictions based on data. This course is an introduction to key mathematical concepts at the heart of machine learning. This course will cover basic models and mathematics for machine learning, including statistical learning theory and neural networks.

Course Content:

UNIT I **10 hrs.**

Introduction: Vectors in machine learning, Vector space, Subspace, Basis and dimension, Norms and spaces, Features and models, Least squares, linear independence and orthogonality, Linear classifiers, Loss, risk.

UNIT II **10 hrs.**

Vector calculus (e.g., partial derivatives, chain rule, Jacobian), Basic probability distributions, Bayes' theorem, Model selection, Cross validation, Underfitting, Overfitting, and Regularization.

UNIT III **10 hrs.**

Dimensionality reduction, Principal component analysis, Linear discriminant Analysis, Singular value decomposition, Least square approximation, Linear and nonlinear regression, Bayesian linear regression, Logistic regression, Kernel methods, and Support vector machines

UNIT IV **10 hrs.**

Gradient Descent, Neural networks and backpropagation, Maximum likelihood estimation, Gaussian mixture models, Unsupervised learning and clustering, AdaBoost, Decision trees, Random forests, Applications: face recognition and recommender systems.

Text Book(s) / Reference(s):

[1] Christopher M. Bishop, Pattern recognition and machine learning, Springer, 2006.
[2] Stephen Boyd and Lieven Vandenberghe, Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares, Cambridge University Press.
[3] Lars Elden, Fundamentals of Algorithms Matrix Methods in Data Mining and Pattern Recognition, SIAM Publication Library

Course Outcomes:

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

CO1: Understanding the role of vectors and orthogonality principles in machine learning.

CO2: Demonstration of applicability of vector calculus in optimizing machine learning models.

CO3: In-depth analysis of dimensionality reduction techniques and linear and non-linear curve fitting methods.

CO4: Utilization of different machine learning models in a variety of applications.

ECPE-322 EMBEDDED SYSTEMS FUNDAMENTALS

Pre-requisite: Computer Architecture (ECPC 211)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course emphasizes on comprehensive treatment of embedded hardware and real time operating systems, in tune with the requirements of Industry. The objective of this course is to enable the students to understand embedded-system programming and apply that knowledge to design and develop embedded solutions.

Course Content:

UNIT 1 **10 hrs.**

Introduction to Embedded Systems: Embedded systems Overview. Processor in the System, Other Hardware Units. Software Embedded into a System. Embedded System – On-Chip (SOC). Processor and Memory Organization: Structural Units in a Processor, Processor Selection for an Embedded System, Memory Devices, Memory Selection for an Embedded Systems, Interfacing Processors, Memories and Input Output Devices

UNIT II **10 hrs.**

Introduction to ARM Processors: Introduction to ARM processors, Evolution of ARM processors, ARM Processor cores and CPU cores.

Device Drivers and Interrupts Servicing Mechanics: Device Drivers, Parallel Port and Serial Port Device Drives in a System, Device Drivers for Internal Programmable Timing Devices, Interrupt Servicing Mechanism.

UNIT III **10 hrs.**

Embedded Systems Interfacing: I/O Devices. Timer and Counting Devices. Serial Peripheral Interface (SPI), Inter-Integrated Circuit, RS-232, Universal Serial Bus, CAN, IrDA, Bluetooth, PCI and AMBA bus protocols. Computer Parallel Communication between the Networked I/O. Advanced I/O Buses

UNIT IV **10 hrs.**

Hardware-Software Co-Design in an Embedded System: Embedded System Project Management. Embedded System Design and Co-Design issues in System Development Process. Design Cycle in the Development Phase for an Embedded System: Use of Target Systems, Use of Software Tools for Development of an Embedded System, Hardware Tests, Issues in Embedded System Design. Applications: Flashing of LEDS using Shift Register, Interfacing stepper motor, Interfacing temperature sensor, Interfacing ADC.

Text Book(s) / Reference(s):

[1] Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications, Elsevier, Third Edition, 2014.
[2] Santanu Chattopadhya, Embedded System Design, Second Edition, PHI, 2013.
[3] T. Noergaard, "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers", Elsevier Pvt. Ltd. Publications, 2005.
[4] F. Vahid and T. D. Givargis, "Embedded system Design: A Unified Hardware/Software Introduction", John Wily & Sons Inc, 2002.
[5] P. Marwedel, "Embedded System Design", Science Publishers, 2007.
[6] Raj Kamal, "Embedded Systems: Architecture, Programming and Design", TMH.

Course Outcomes:

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

CO1: Understand the processor and memory organization.
CO2: Learn different types of I/O Devices, timer and counting devices.
CO3: Understand the exception, interrupts and interrupt handling schemes
CO4: Understand the importance of Hardware-Software Co-design in an Embedded System.

ECPE-323 WIRELESS SENSOR NETWORKS

Pre-requisite: Computer Networks (ECPC 308)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:
To understand the fundamentals of wireless sensor networks and their application to critical real-time scenarios. To study the various protocols at different layers and their differences from traditional protocols. To understand the issues pertaining to sensor networks and the challenges involved in managing a sensor network.

Course Content:

UNIT I **10 hrs.**

Introduction to ad-hoc/sensor networks: Key definitions of ad-hoc/sensor networks, unique constraints, and challenges, advantages of ad-hoc/sensor networks, driving applications, issues in ad-hoc wireless networks, issues in the design of sensor network, sensor network architecture, data dissemination, and gathering.

UNIT II **10 hrs.**

MAC Protocols: issues in designing MAC protocols for ad-hoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor networks, S-MAC.

Routing Protocols: issues in designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power-aware routing protocols.

UNIT III **10 hrs.**

Topology control, clustering, Time-synchronization: clocks and the synchronization problem, time synchronization in WSNs, Time synchronization protocols, Localization: Ranging techniques, Ranging-based localization, Event-driven localization.

UNIT IV **10 hrs.**

Power management: Local power management aspects, Dynamic power management. Security: challenges of security in WSNs, IEEE 802.15.4 Standard, and ZigBee.

Text Book(s) / Reference(s):

[1] C. Siva Ram Murthy, and B.S. Manoj, "Ad-hoc Wireless networks," Pearson publication, 2008.

[2] W. Dargie, and C. Poellabauer, "Fundamentals of wireless sensor networks: Theory and practice," John Wiley and Sons Ltd., 2010.

[3] I. F. Akylidiz, and M.C. Vuran, "Wireless sensor networks," John Wiley and Sons Ltd., 2010.
[4] Feng Zhao and Leonides Guibas, "Wireless sensor networks," Elsevier publication, 2004.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Technical knowledge in building a WSN network.
CO2: Analysis of various critical parameters in deploying a WSN.
CO3: Analysis of specific protocols related to medium access control, routing, and time-synchronization problems.
CO4: Comprehend the study of localization strategies, power management, and security aspects.

ECPE-324 ADVANCED MICROCONTROLLER ARCHITECTURE

Pre-requisite: Computer Architecture (ECPC-211), Processor Design (ECPC-309), Digital Design (ECPC-202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Provide an opportunity to the students to learn ARM architecture, instruction set and programming. ARM is very popular for portable applications because of its high performance with low power consumption. Students will learn architecture, assembly language and C programming for ARM microcontroller in this course.

Course Content:

UNIT I **10 hrs.**

ARM Introduction: Types of computer Architectures, ISA's and ARM, Difference between RISC and CISC, History of ARM microprocessor, ARM processor family.

ARM Architecture and Pipeline Structure: ARM Core data flow model, Architectural inheritance, The ARM7TDMI programmer's model: General purpose registers, ARM memory map, data format, ARM 3 stage Pipeline, ARM 5 stage Pipeline, Pipeline Hazards, condition codes. ARM7TDMI Interface signals.

UNIT II **10 hrs.**

ARM7TDMI Assembly Language Instructions and Programming: Different Types of Instructions, ARM Instruction set, data processing instructions. Shift Operations. Data processing Instructions. Addressing modes with examples. Instruction Timing, Swap Instructions. Program Control Flow, Control Flow Instructions. Interrupts and Exceptions, Reset Handling. Software Interrupt Instruction, undefined instruction exception. Interrupt Latency, Multiply Instructions, Thumb state, Thumb Programmers model, Thumb Instructions, Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers, Co-processor instructions.

UNIT III **10 hrs.**

Embedded C Programming for ARM: ARM Development Environment Embedded Software, Overview of C compiler and optimization, Basic C data types, C Looping structures, Register allocations, function calls, pointer aliasing, floating point, Inline functions and inline assembly, Portability issues. C programs for General purpose I/O, general purpose timer, PWM Modulator, UART, I2C Interface, SPI Interface, ADC, DAC.

Cache and Memory Management and Protection: Memory Technologies, memory Hierarchy. Cache Memory, Mapping Functions. Cache Design, Unified or split cache,

multiple level of caches, ARM cache features. Processes, Memory Map, Protected Systems, ARM systems with MPU, memory Protection Unit (MPU). Physical Vs Virtual Memory, Paging, Segmentation. MMU Advantage, Multitasking with MMU, Tightly coupled Memory (TCM).

UNIT IV **10 hrs.**

ARM Peripherals and Versions: AMBA Overview, Typical AMBA Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers, APB bridge. Overview of ARM Versions: ARMv5, ARMv6, ARM v7 (Cortex family R: Real time A: Application and M: Microcontroller), ARM big.LITTLE Technology, ARMv8.

Text Book(s) / Reference(s):

[1] M. A. Mazidi, ARM Assembly Language Programming & Architecture, 2nd Edition, 2016.
[2] William Hohl, Christopher Hinds, Arm Assembly Language, Fundamentals and Techniques, CRC Press, 2nd edition.
[3] Andrew N. Sloss, Dominic Symes, Chris Wright, Arm System Developer's Guide, Designing and Optimizing Software, Elsevier.
[4] Steve Furber, Arm System-on-chip Architecture, Pearson publication, 2nd Edition.
[5] Lyla Das, Embedded Systems, Pearson publication.
[6] Manuals and Technical Documents from the ARM Inc, website.

Course Outcomes:

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

CO1: Explain the architecture and programming model of ARM 7TDMI

CO2: Learn and analyze assembly language programs for ARM microcontroller

CO3: Develop an Embedded C language program for interfacing I/O devices with ARM microcontroller and use it

CO4: Exemplify the memory management system of ARM and different versions of ARM. Design an ARM-based system to solve real-life challenges.

ECPE-325 DIGITAL IC DESIGN

Pre-requisite: Engineering Physics (PHIC-101) , Advanced Engineering Physics (PHIC-103) , and Electronic Devices and Circuits (ECPC-201)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
To learn the digital integrated circuits design process. To understand CMOS logic, and circuits and overcome power, delay and timing issues in digital ICs.

Course Content:

UNIT I **10 hrs.**

Overview of Digital Circuits, The MOSFET Threshold Voltage, The MOSFET I-V model, Subthreshold Conduction, MOSFET DC Analysis, IC Fabrication, MOSFET Capacitances, Static Behavior of Inverter, Calculating Inverter Delay, Sizing Inverter for minimum delay, Sizing Inverter Chain for minimum delay, Inverter Power and Energy

UNIT II **10 hrs.**

Layout, Design Rules, CAD tools, CMOS Logic Schematic & Layouts. CMOS Logic VTC and Delay Calculations, CMOS Logic Energy and Power, Ratioed Logic, Pass-Transistor Logic, Domino Logic, Signal Integrity Issues in Dynamic Logic, Sizing Logic Networks for minimum delay - Logical Effort

UNIT III **10 hrs.**

Synchronous System Design, Static Latches and Registers - D, RS FF, CC, Dynamic Latches and Registers - PT, TSPC, pulse-based, Interconnect RLC and Delay Models, Minimizing Interconnect Delay - Buffer Insertion, Adder Design

UNIT IV **10 hrs.**

Semiconductor Memory Architectures, CMOS ROM, Non-volatile Memory - Flash Architecture 6T SRAM, Sense Amplifiers, Peripherals - Voltage references, Charge Pumps Peripherals - Address Decoders, DRAM, DRAM Sensing

Text Book(s) / Reference(s):

[1] J. M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Second Edition, Prentice Hall.
[2] D. Hodges, H. Jackson and R. Saleh, Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology, Third Edition, McGraw-Hill, 2004.
[3] S. Kang and Y. Leblebici, CMOS Digital Integrated Circuits, Third Edition, McGraw-Hill, 2003.
[4] K. Bernstein et al., High Speed CMOS Design Styles, Kluwer, 1998.

[5] N. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Ed., Addison Wesley, 1993.

Course Outcomes:

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

CO1: Have an idea about basic CMOS circuits in VLSI

CO2: Know the performance metrics of IC design.

CO3: Design integrated circuits using CMOS logic.

CO4: Be able to understand power, delay and timing issues in digital ICs.

ECPE-326 ASICs & FPGAs

Pre-requisite: Digital Design (ECPC 202), and Processor Design (ECPC 309)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:
This course enables students to gain practical design methodologies for developing applications for FPGAs and ASICs. Students will learn the fundamentals for FPGA and ASIC design through software coding techniques in VHDL, and develop the skills necessary to solve critical digital design problems efficiently. Using commercial CAD tools, students will learn how to implement RTL VHDL designs, verify their application through simulation, and optimize performance by exploiting parallelism in their architecture.

Course Content:

UNIT I **8 hrs.**

Overview of ASIC and PLD: Types of ASICs - Design flow – CAD tools used in ASIC Design – Programming Technologies: Antifuse – static RAM – EPROM and EEPROM technology, Programmable Logic Devices: ROMs and EPROMs – PLA – PAL. Gate Arrays – CPLDs and FPGAs

UNIT II **12 hrs.**

ASIC Physical Design: System partition - partitioning - partitioning methods – interconnect delay models and measurement of delay - floor planning - placement – Routing: global routing - detailed routing - special routing - circuit extraction – DRC

UNIT III **10 hrs.**

Logic Synthesis, Simulation and Testing: Design systems - Logic Synthesis - Half gate ASIC - Schematic entry - Low level design language - PLA tools - EDIF - CFI design representation. Verilog and logic synthesis - VHDL and logic synthesis - types of simulation - boundary scan test - fault simulation - automatic test pattern generation.

UNIT IV **10 hrs.**

FPGA: Field Programmable gate arrays - Logic blocks, routing architecture, Design flow technology - mapping for FPGAs, Xilinx XC4000 - ALTERA's FLEX 8000/10000, ACTEL's ACT-1,2,3 and their speed performance. Case studies: Altera MAX 5000 and 7000 - Altera MAX 9000 – Spartan II and Virtex II FPGAs - Apex and Cyclone FPGAs

SOC Design: Design Methodologies – Processes and Flows - Embedded software development for SOC – Techniques for SOC Testing – Configurable SOC – Hardware/Software codesign. Case studies: Digital camera, Bluetooth radio/modem,

SDRAM and USB. Case study: Advancement in FPGA, ASIC architectures towards sustainable computing.

Text Book(s) / Reference(s):

[1] M. J. S. Smith, Application Specific Integrated Circuits, Addison-Wesley Longman Inc., 1997
[2] S. Trimberger, Field Programmable Gate Array Technology, Kluwer Academic Publications, 1994.
[3] John V. Oldfield, Richard C Dore, Field Programmable Gate Arrays, Wiley Publications, 1995.
[4] P. K. Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall, 1994.
[5] Parag. K. Lala, Digital System Design using Programmable Logic Devices, BSP, 2003.
[6] S. Brown, R. Francis, J. Rose, Z. Vransic, Field Programmable Gate Array, Kluwer Pub, 1992.
[7] J. Old Field, R. Dorf, Field Programmable Gate Arrays, John Wiley & Sons, Newyork, 1995
[8] Farzad Nekoogar and Faranak Nekoogar, from ASICs to SOCs: A Practical Approach, Prentice Hall PTR, 2003.
[9] Wayne Wolf, FPGA-Based System Design, Prentice Hall PTR, 2004.
[10] R. Rajsuman, System-on-a-Chip Design, and Test. Santa Clara, CA: Artech House Publishers, 2000.
[11] F. Nekoogar, Timing Verification of Application-Specific Integrated Circuits (ASICs). Prentice Hall PTR, 1999.

Course Outcomes:

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

CO1: Understand the basic strategies for hardware design using VHDL and understand the building blocks that are available to digital designers.

CO2: Differentiate VHDL code for hardware simulation and synthesis, use commercial CAD tools to synthesize and simulate RTL VHDL designs.

CO3: Write RTL VHDL designs that exploit parallel processing architectures, apply design flow methodologies & optimization techniques for a given problem

CO4: Analyze and solve timing-related problems based on synthesis timing reports, demonstrate a working RTL design with all aspects in the projects

ECPE-327 CRYPTOGRAPHY

Pre-requisite: Differential Calculus and Differential Equations (MAIC-101), Integral Calculus and Difference Equations (MAIC-102), and Applied Linear Algebra (MAIC -204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
The objective of this course is to familiarize the students with cryptography and its applications. Topics will include historical cryptography, encryption, authentication, public key cryptography and key distribution.

Course Content:

UNIT I **10 hrs.**

Fundamental of Cryptography: Introduction to security, classification of security attacks, security mechanisms and services, Historical Ciphers, Shannon's perfect security, Symmetric key encryption: stream ciphers: RC4, Block ciphers: DES, 3DES, AES, IDEA, Modes of operation, Symmetric-Key Distribution, Public Key Encryption Algorithms: RSA, elliptic curve cryptography, Primality Testing and Factoring, Public key distribution, Public Key Infrastructure. Attacks on symmetric key and asymmetric key ciphers.

UNIT II **10 hrs.**

Authentication: Attacks on Public Key Schemes, Signature Scheme, MAC and Hash Functions, properties and requirements of digital signatures, MAC and HASH, Kerberos, Entity authentication: weak Authentication, Challenge-Response identification (strong authentication).

UNIT III **10 hrs.**

Key Distribution: Key management, D-H key exchange algorithm, attacks on D-H algorithm, Elliptic curve cryptography (ECC)

UNIT IV **10 hrs.**

Practical Applications: E-MAIL security, PKI, SSL/TLS, HTTPS, IPV6 and IPSEC, Proxies and Firewalls, Wireless network security, Overview of light weight cryptography, Case Studies on Cryptography and security: Single Sign On (SSO), Secure Inter-branch Payment Transactions, Secret Splitting, Secure Multiparty Calculation.

Text Book(s) / Reference(s):

[1] Douglas Stinson, "Cryptography Theory and Practice", 2nd Edition, Chapman & Hall/CRC.

[2] B. A. Forouzan, "Cryptography & Network Security", Tata Mc Graw Hill.
[3] W. Stallings, "Cryptography and Network Security", Pearson Education.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the concept and need of cryptography.
CO2: Implement and design symmetric and asymmetric key algorithms.
CO3: Implement various key distribution and authentication techniques.
CO4: Comprehend and analyze cryptographic primitives in real time applications.
CO5: Analyze security challenges in wireless networks and its preventive measures.

ECPE-328 DATA SCIENCE

Pre-requisite: Applied Linear Algebra (MAIC 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Introduce R/python as a programming language. Introduce the mathematical foundations required for data science. Introduce the first level data science algorithms. Introduce a data analytics problem solving framework.

Course Content:

UNIT I **10 hrs.**

Course philosophy and introduction to R and python. Linear algebra for data science: Algebraic view and Geometric view - vectors, matrices, product of matrix & vector, rank, null space, distance, projections, eigenvalue decomposition

UNIT II **10 hrs.**

Statistics: descriptive statistics, notion of probability, distributions, mean, variance, covariance, covariance matrix, understanding univariate and multivariate normal distributions, introduction to hypothesis testing, confidence interval for estimates, Optimization

UNIT III **10 hrs.**

Simple linear regression and verifying assumptions used in linear regression. Multivariate linear regression, model assessment, assessing importance of different variables, subset selection

UNIT IV **10 hrs.**

Classification using logistic regression, Classification using KNN and k-means clustering. Application in biometric systems, digit recognition, character recognition, biomedical images etc.

Text Book(s) / Reference(s):

[1] Data science from scratch - First principles with Python, Joel Grus, O'Reilly, 2015
[2] Machine Learning, Tom Mitchell, McGrawhill, 1997
[3] Machine Learning Refined: Foundations, Algorithms, and Applications, Jeremy Watt, Reza Borhani, Aggelos K. Katsaggelos, Cambridge University Press, 2nd Edition, 2020

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Describe a flow process for data science problems
CO2: Develop R codes for data science solutions
CO3: Correlate results to the solution approach followed
CO4: Assess the solution approach and construct use cases to validate the approach and identify modifications required.

ECPE-329 DSP ARCHITECTURE

Pre-requisite: Signals, Systems & Random Variables (ECPC- 203), Digital Signal Processing (ECPC -301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:
The objective of this course is to enable the students to impart the knowledge of basic DSP concepts and number systems to be used, different types of A/D, D/A conversion errors. Learn the architectural differences between DSP and General purpose processor. Learn about interfacing of serial & parallel communication devices to the processor. Implement the DSP & FFT algorithms.

Course Contents:

UNIT I **8 hrs.**

Architectures for Programmable Digital Signal-Processing Devices: Introduction, Basic Architectural Features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External Interfacing.

UNIT II **12 hrs.**

Programmable Digital Signal Processors: Introduction, Commercial Digital Signal-processing Devices, Data Addressing Modes of TMS32OC54XX, Memory Space of TMS32OC54xx Processors, Program Control. Detailed Study of TMS320C54X & 54xx Instructions and Programming, On-Chip Peripherals, Interrupts of TMS32OC54XX Processors, Pipeline Operation of TMS32OC54xx Processor.

UNIT III **10 hrs.**

Implementation of Basic DSP Algorithms: Introduction, The Q-notation, FIR Filters, IIR Filters, Interpolation and Decimation Filters (one example in each case). Implementation of FFT Algorithms: Introduction, An FFT Algorithm for DFT Computation, Overflow and Scaling, Bit-Reversed Index. Generation & Implementation on the TMS32OC54xx.

UNIT IV **10 hrs.**

Interfacing Memory and Parallel I/O Peripherals to Programmable DSP Devices: Introduction, Memory Space Organization, External Bus Interfacing Signals. Memory Interface, Parallel I/O Interface, Programmed I/O, Interrupts and I/O Direct Memory Access (DMA).

Interfacing and Applications of DSP Processors: Introduction, Synchronous Serial Interface, A CODEC Interface Circuit, DSP Based Bio-telemetry Receiver, A Speech

Processing System, An Image Processing System. Case study: Advance architectures for sustainable computing, issues, & performance consideration.

Text Book(s) / Reference(s):

[1] Avatar Singh and S. Srinivasan, Digital Signal Processing, Thomson Learning, 2004.
[2] Ifeachor E. C., Jervis B. W, Digital Signal Processing: A practical approach, Pearson-Education, PHI, 2002.
[3] B Venkataramani and M Bhaskar, Digital Signal Processors, TMH, 2nd, 2010.
[4] Peter Pirsch, Architectures for Digital Signal Processing, John Weily, 2008.

Course Outcomes:

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

CO1: Comprehend the knowledge and concepts of digital signal processing techniques.

CO2: Apply the knowledge of DSP computational building blocks to achieve speed in DSP architecture or processor.

CO3: Apply knowledge of various types of addressing modes, interrupts, peripherals and pipelining structure of TMS320C54xx processor. Develop basic DSP algorithms using DSP processors.

CO4: Discuss about synchronous serial interface and multichannel buffered serial port (McBSP) of DSP device. Demonstrate the programming of CODEC interfacing.

ECPE-330 MICROSTRIP ANTENNAS

Pre-requisite: Fields and waves (ECPC 204), Microwave Theory & Devices (ECPC 310)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This can be termed a middle-level course in the electronic communication engineering domain. The course deals with microstrip antenna basics, different types of microstrip antennas, some design features, and microstrip antenna arrays. The main objective is to enable the students to understand the working principles of microstrip antenna analysis and design.

Course Content:

UNIT I **10 hrs.**

Microstrip Antennas: The origin of microstrip radiators, Microstrip analysis methods, Microstrip antenna advantages and disadvantages, Microstrip antenna applications.
Circular Microstrip Antennas: properties, Directivity, Input resistance and impedance bandwidth, Gain, radiation pattern, and efficiency, Circular microstrip antenna radiation modes, Circular microstrip antenna cross-polarization, Annular microstrip antenna, Shorted annular microstrip antenna

UNIT II **10 hrs.**

Rectangular Microstrip Antennas: The transmission line model, The cavity model, radiation pattern of linear rectangular patch, Quarter-wave microstrip antenna, Efficiency, Design of microstrip antenna with dielectric cover, Design guidelines for rectangular microstrip antenna, Electromagnetically coupled rectangular microstrip antenna, Ultra-wide rectangular microstrip antennas

UNIT III **10 hrs.**

Micro Strip Arrays: Introduction, Planer array theory, Rectangular microstrip antenna array modeled with slots, Aperture excitation distribution, Microstrip array feeding methods, Mutual coupling.

UNIT IV **10 hrs.**

Computer-Aided Design of Rectangular Microstrip Antennas: CAD Model for Rectangular Patch Antenna, CAD Formulas for Resonance Frequency, Q Factors Bandwidth, CAD Formula for Bandwidth Radiation Efficiency, Input Resistance, Probe Reactance Directivity, Results for Input Impedance, Radiation Patterns.

Text Book(s) / Reference(s):

[1] Lee, Kai Fong, and Wei Chen, eds. Advances in microstrip and printed antennas. New York: Wiley, 1997.
[2] Liao, Samuel Y. Microwave devices and circuits. Pearson Education India, 1990.
[3] Pozar, David M. Microwave engineering. John wiley & sons, 2011.
[4] Bancroft, Randy. Microstrip and printed antenna design. Institution of Engineering and Technology, 2019.
[5] James, James R., Peter S. Hall, and Colin Wood. Microstrip antenna: theory and design. Vol. 12. Iet, 1986

Course Outcomes:

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

CO1: Understand various types of Microstrip Antennas

CO2: Learn various types of analysis and design techniques for Microstrip Antennas and Microstrip Arrays

CO3: Understand fundamentals of Computer-Aided Design of Rectangular Microstrip Antennas.

ECPE-331 DATA STRUCTURES

Pre-requisite: Problems Solving and Programming using C (CSIC 103)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:
To learn the efficient storage mechanisms of data for an easy access and implementation of various basic and advanced data structures. Also, understand the various techniques for representation of the data in the real world with the concepts of protection and management of data.

Course Content:

UNIT I **8 hrs.**

Introduction: Understanding pointers, usage of pointers, arithmetic on pointers, memory allocation, memory management functions and operators, debugging pointers dangling pointers, memory leaks, etc. The Concept of data type, definition and brief description of various data structures, data structures versus data types, operations on data structures, algorithm complexity, Big O notation.

UNIT II **12 hrs.**

Linked List, Stacks and Queues: Linear and multi-dimensional arrays and their representation, operations on arrays, sparse matrices and their storage. Linear linked list, operations on linear linked list, doubly linked list, operations on doubly linked list, application of linked lists. Sequential and linked representations, operations on stacks, application of stacks such as parenthesis checker, evaluation of postfix expressions, conversion from infix to postfix representation, implementing recursive functions. Sequential representation of queue, linear queue, circular queue, operations on linear and circular queue, linked representation of a queue and operations on it, deque, priority queue, applications of queues.

UNIT III **12 hrs.**

Tree and Heap: Basic terminology, sequential and linked representations of trees, traversing a binary tree using recursive and non-recursive procedures, inserting a node, deleting a node, brief introduction to threaded binary trees, AVL trees and B-trees. Representing a heap in memory, operations on heaps, application of heap in implementing priority queue and heap sort algorithm.

UNIT IV **8 hrs.**

Graphs, Sorting and Searching: Basic terminology of Graphs, representation of graphs (adjacency matrix, adjacency list), traversal of a graph (breadth-first search and depth-first search), and applications of graphs. Comparing direct address tables with hash

tables, hash functions, concept of collision and its resolution using open addressing and separate chaining, double hashing, rehashing. Searching an element using linear search and binary search techniques, Sorting arrays using bubble sort, selection sort, insertion sort, quick sort, merge sort, heap sort, shell sort and radix sort, complexities of searching & sorting algorithms. Case study: Advance data structure, Dynamic Graphs, Dynamic Optimality, including geometric data structures, like a map, and temporal data structures, as in storage that happens over a time series.

Text Book(s) / Reference(s):

[1] Sartaj Sahni, Data Structures, Algorithms and Applications in C++, Tata McGraw Hill.
[2] Tenenbaum, Augenstein, & Langsam, Data Structures using C and C++, Prentice Hall of India.
[3] R. S. Salaria, Data Structures & Algorithms Using C++, Khanna Book Publishing Co. (P) Ltd.
[4] Seymour Lipschutz, Data Structures, Schaum's Outline Series, Tata McGraw Hill
[5] Kruse, Data Structures & Program Design, Prentice Hall of India.
[6] R. S. Salaria, Test Your Skills in Data Structures

Course Outcomes:

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

CO1: Understand the efficient storage mechanisms of data for easy access. Design and implementation of various basic and advanced data structures.
CO2: Comprehend various techniques for representation of the data in the real world.
CO3: Develop applications using data structures. Understand the concept of protection and management of data.
CO4: Implement various techniques for efficient storage and access of data.

ECOE-303 WIRELESS COMMUNICATIONS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

About the Course:
This course provides fundamental aspects of digital communication and ideas of frequency reuse in cellular networks. Wireless networks being deployed in real-life scenarios are introduced. Emphasis is given to understand how to build applications and services using 4G and 5G standards for digital transformation.

Course Contents:

UNIT I **10 hrs.**
Information in binary format, information transfer, introduction to and history of cellular communication, cellular concept, frequency reuse

UNIT II **10 hrs.**
Wireless channel-models, path loss, shadowing, diversity in wireless communication, channel capacity, mechanism of high-rate data transmission, interference management and system capacity, outage, scheduling, and its effect on capacity, link budget

UNIT III **10 hrs.**
Wireless LANs, IEEE 802.11 standards, Bluetooth, RFID, ZigBee. Cellular networks and its services, 4G, LTE standards, Delivery of multimedia services.

UNIT IV **10 hrs.**
5G wireless networks, applications and services, role of 5G in digital transformation and IIoT. Deployment of 5G networks in India. Environmental impact of 5G networks, 5G networks and sustainability, 5G enabled sustainability networks.

Text Book(s) / Reference(s):
[1] Wireless Communications: Principles and Practice by Theodore S. Rappaport, Pub: Pearson
[2] Erik Dahlman, "4G, LTE-Advanced Pro and The Road to 5G"

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the basic cellular concept and frequency reuse of mobile cellular, challenges of wireless channel
CO2: Analyze the system capacity
CO3: To evaluate sustainability issues
CO4: To develop sustainable solutions for digital transformation

ECOE-304 LOGIC DESIGN AND ANALYSIS USING VERILOG

Pre-requisite: Digital Design (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Objectives:

This course aims to provide students with the understanding of the different technologies related to HDLs, construct, compile and execute Verilog HDL programs using provided software tools. Design digital components and circuits that are testable, reusable, and synthesizable. Students are provided with access to the CAD tools to use hardware description language to model, analyze and design various digital circuits/systems.

Course Contents:

UNIT I **8 hrs.**

Introduction to HDL (Verilog): Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis, Functional Verification, System Tasks, Programming Language Interface, Module, Simulation and Synthesis Tools, Test Bench. Language Constructs and conventions: Introduction, Keywords, Identifiers, White Space Characters, Comments, Numbers, Strings, Logic Values, Strengths, Data Types, Scalars and Vectors, Parameters, Memory, Operators, System Tasks.

UNIT II **12 hrs.**

Gate Level Modelling: Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tri-State Gates, Array of Instances of Primitives, Additional Examples, Design of Flipflops with Gate Primitives, Delays, Strengths and Contention Resolution, Net Types, Design of Basic Circuits.

Behavioural Modelling: Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, Examples, Assignments with Delays, Wait construct, Multiple Always Blocks, Designs at Behavioural Level, Blocking and Non-blocking Assignments, The case statement, Simulation Flow. If and if-else constructs, assign-design construct, repeat construct, for loop, the "disable" construct, while loop, forever loop, parallel blocks, force-release construct, Event.

UNIT III **10 hrs.**

Modelling at Dataflow Level: Introduction, Continuous Assignment Structures, Delays and Continuous Assignments, Assignment to Vectors, Operators.

Switch Level Modelling: Introduction, Basic Transistor Switches, CMOS Switch, Bi-directional Gates, Time Delays with Switch Primitives, Instantiations with Strengths and Delays, Strength Contention with Tri-reg Nets

Functions, Tasks, User-Defined Primitives: Introduction, Function, Tasks, User-Defined Primitives (UDP), FSM Design (Moore and Mealy Machines). System Tasks, Functions and Compiler Directives: Introduction, Parameters, Path Delays, Module Parameters, System Tasks and Functions, File-Based Tasks and Functions, Compiler Directives, Hierarchical Access.

UNIT IV **10 hrs.**

Synthesis of Digital Logic Circuit Design: Introduction to Synthesis, Synthesis of combinational logic, Synthesis of sequential logic with latches and flip-flops, Synthesis of Explicit and Implicit State Machines. Describing Clock driven Finite-State Machines, Asynchronous driven Finite State Machines, Switch level modeling. HDL modeling of DSS; CORDIC. System Design using ASM Chart, Design and Synthesis of Datapath Controllers. Clocked Sequential Finite State Machines, Asynchronous Sequential Finite State Machines, Sequential Design using LSI & MSI circuits. Case study: Understand the role of electronics in sustainable development. Design & analysis of digital system towards sustainable computing.

Text Book(s) / Reference(s):

[1] T. R. Padmanabhan, B. Bala Tripura Sundari, Design Through Verilog HDL, John Wiley & Sons, INC., Publication, 2004.
[2] Michael, D. Ciletti, Advanced digital design with the Verilog HDL, Pearson Education India, 2002
[3] Samir Palnitkar, Verilog HDL Pearson Education, 2nd Edition, 2009.
[4] J. Basker, A Verilog HDL Primer, Star Galaxy Publishing, 3rd Edition.
[5] Zainalabdien Navabi, Verilog Digital System Design, TMH, 2nd Edition.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: Explain different design constraints in Verilog HDL
CO2: Categorize different modelling styles
CO3: Model the combinational and sequential circuits using Verilog HDL
CO4: Illustrate the Synthesis of Digital Logic Circuit Design

ECOE-305 IMAGE PROCESSING APPLICATIONS

Pre-requisite: Signals, Systems & Random Variables (ECPC 203), Applied Linear Algebra (MAIC - 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Image processing is a rapidly growing field that deals with the use of digital images to various fields of life including medical, automation, etc. This course helps to understand and apply the various concepts of image processing into different fields.

Course Contents:

UNIT I 10 hrs.
Introduction, Components of an image processing system, different image formats, Image Perception: Image models, sampling & quantization, neighbors of a pixel, connectivity, labeling of connected components.

UNIT II 10 hrs.
Intensity Transformation and its applications, image improvement and modifications using Histogram processing. Use of Image Restoration and Reconstruction: Noise models, Restoration in the presence of Noise only, Frequency domain filtering, Inverse filtering, Wiener filtering, Geometric mean filtering. Image reconstruction from projections. Lossy and lossless compression for some real life applications, Some basic compression methods, Image compression standards.

UNIT III8 hrs.
Color Image Processing: Color Models, Pseudocolor Image Processing, Basics of full color image processing, color transformations, segmentation, smoothing and sharpening, Noise in color Images. VMF, VDF, etc. Morphological Image Processing for image identification, boundary extraction, etc.

UNIT IV 14 hrs.
Image steganography, Watermarking, Super-resolution, Copy paste attack on images. A small project on real life application depending upon the branch of the student.

Text Book(s) / Reference(s):
[1] Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson, 3rd Edition, 2016.
[2] Anil K. Jain, Fundamentals of Digital Image Processing, Pearson 2002.
[3] Kenneth R. Castleman, Digital Image Processing, Pearson, 2006.

[4] Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, 'Digital Image Processing using MATLAB', Pearson Education, Inc., 2000.
[5] Hany Farid, 'Photo Forensics' The MIT Press, 2016.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand and apply the Image filtering, Restoration, segmentation, etc.
CO2: Apply the vector approach to handle the color images.
CO3: Apply the 'Morphological operation' for various applications.
CO4: Will be able to apply the image processing concepts in his/her respective branch of Enggineering.

Semester – VII

ECPC-401 MICROELECTRONICS AND VLSI DESIGN

Pre-requisite: Electronics Device and Circuits (ECPC-201) and Analog Electronics (ECPC-209)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
Enable the students to understand the fabrication process sequence of silicon semiconductor devices and IC's.

Course Content:

UNIT I **8 hrs.**

Crystal Growth: MGS, EGS, Czochralspi crystal Puller, Silicon shaping, Wafer Preparation.
Epitaxy, Oxidation, Litho Graphy and Reactive Plasma Etching

UNIT II **12 hrs.**

Di-electric and Poly-Silicon Film Deposition, Diffusion, Ion Implantation and Metallization, Assembly & Packaging, Isolation Techniques, N-MOS IC fabrication Process Sequence.

UNIT III **8 hrs.**

MOS Design Process: Stick Diagram & Design rules. Physical design of IC's Layout rules & circuit abstractor, Cell generation, Layout environments, Layout methodologies.

UNIT IV **12 hrs.**

Basic Circuit Concepts: Sheet resistance concept, Area Capacitances, Inverter Delays, cascaded inverters as drivers, Propagation Delays.
Scaling of MOS Devices: Scaling Factors, Limitations of scaling.
Subsystem design and layout: switch logic, gate logic, Two-input nMOS and CMOS gates.

Text Book(s) / Reference(s):
[1] S. M. Sze, VLSI Technology, Mc Graw Hill.
[2] S. K. Ghandhi, VLSI Fabrication Principles.
[3] Pucknell DA & Eshraghian K, Basic VLSI Design, PHI.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the Crystal Growth, Oxidation and LithoGraphy techniques in silicon device.

CO2: Understand Deposition techniques and fabrication process silicon ICs.
CO3: Understand various design process, rules and layout methodologies of ICs.
CO4: Understand the basic circuit concepts, scaling issues and subsystem design of various logics.

ECPC-402 WIRELESS AND MOBILE COMMUNICATION

Pre-requisite: Communications Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
The course will provide an in-depth understanding of the principles, performance and evolution of wireless communication standards (2G to 6G).

Course Content:

UNIT I **10 hrs.**

Cellular Communications: Introduction to Cellular Communications, Frequency reuse, Multiple Access, Technologies, Cellular Processes, GSM (SS7), Call Setup, Handover etc., Teletraffic Theory

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

UNIT II **10 hrs.**

Broadband Wireless Channel Modeling: WSSUS Channel Modeling, RMS Delay Spread, Doppler Fading, Jakes Model, Autocorrelation, Jakes Spectrum, Impact of Doppler Fading

CDMA: Introduction to CDMA, Walsh codes, Variable tree OVSF, PN Sequences, Multipath diversity, RAKE Receiver, CDMA Receiver Synchronization.

UNIT III **10 hrs.**

OFDM: Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix, Channel model and SNR performance, OFDM Issues – PAPR, Frequency and Timing Offset Issues

MIMO: Introduction to MIMO, MIMO Channel Capacity, SVD and Eigen modes of the MIMO Channel, MIMO Spatial Multiplexing – BLAST, MIMO Diversity – Alamouti, OSTBC, MRT, MIMO-OFDM.

UNIT IV **10 hrs.**

UWB (Ultrawide Band): UWB Definition and Features, UWB Wireless Channels, UWB Data Modulation, Uniform Pulse Train, Bit Error Rate Performance of UWB

Evolution of Wireless Standards (2G-6G): GPRS, WCDMA, LTE/WiMAX, Cognitive Radios, IEEE wireless standards. Spectrum Sharing Framework for 6G-enabled IoT. Case studies from the Indian knowledge system.

Text Book(s) / Reference(s):

[1] Andrea Goldsmith, Wireless Communications: Cambridge University Press.
[2] Theodore Rappaport, Wireless Communications: Principles and Practice, Prentice Hall.
[3] Ezio Biglieri, MIMO Wireless Communications – Cambridge University Press.
[4] Aditya K. Jagannatham, Principles of Modern Wireless Communication Systems: Mc GrawHill Education

Course Outcomes:

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

CO1: Synthesis and analyze wireless and mobile cellular communication systems over different stochastic fading channels

CO2: Understand advanced multiple access techniques

CO3: Learn diversity reception techniques

CO4: Explore the need of MIMO/OFDM as the pivoting technology for capacity maximization

CO5: Analyse the evolution of different wireless standards (2G TO 5G stds.) And the need

CO6: Contribute and meet the dynamic requirements of telecom companies

ECPC 403 Project-I

L	T	P	Credits	Total contact hours
0	0	6	3	-

Brief Description:
Project-I is a supervised engineering project undertaken in the seventh semester. Students identify a problem in the ECE domain, review relevant literature, propose a solution, and build a working prototype or simulation by the end of the semester.

Course Outcomes:
CO1: Identify and formulate a problem in the ECE domain with a clear objective.
CO2: Conduct a literature survey and propose a technically sound solution.
CO3: Design, implement, and test a prototype or simulation.
CO4: Document and present the work clearly and professionally.

ECPC 404 Microwave Lab

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
0	0	2	1	24

Brief Description:
This lab aims to familiarize the students about the various microwave components, the characteristics of reflex Klystron tube and Gunn diode and communication antennas used in microwave range. It includes their design, gain, directivity, polar pattern, VSWR and various other characteristics. Further in this lab students will attain the knowledge about operation of various Plane-Tee and designing of Microstrip Patch Antenna.

List of Experiments:
1. To study the microwave components.
2. To study the characteristics of the reflex Klystron tube and to determine its electronic tuning range.
3. To determine the frequency and wavelength in a rectangular waveguide working in TE 10 mode.
4. To determine the standing wave ratio and reflection coefficient.
5. To study the I-V characteristics of Gunn diode.
6. To study the magic tee, isolator and attenuator.
7. To measure the coupling coefficient and directivity of a wave guide directional coupler
8. To measure the polar pattern and the gain of a waveguide horn antenna.
9. Design of Rectangular Microstrip Patch Antenna with Coaxial Probe using HFSS.
10. Design of Rectangular Microstrip Patch Antenna using Stripline Feed using HFSS.

Course Outcomes:
Upon successful completion of this laboratory course, the students will be able to
CO1: Gain knowledge and understanding of microwave analysis methods.
CO2: Be able to apply analysis methods to determine circuit properties of passive/active microwave devices.
CO3: Know how to model and determine the performance characteristics of a microwave circuit or system using computer aided design methods.
CO4: Have knowledge of basic communication link design; signal power budget, noise evaluation and link carrier to noise ratio.
CO5: Have knowledge of how transmission and waveguide structures and designing of Microstrip Patch Antenna.

ECPC 405 Summer Training

L	T	P	Credits	Total contact hours
-	-	-	1	Six weeks

Course Objectives:
The internship is aimed at developing the undergraduate education program in Electronics and Communication Engineering to include a practical training in a professional engineering set up (a company, top educational institution, research institute etc.) hereafter referred to as host "organization" as deemed appropriate. The participating organizations are selected that are either already visiting NIT Kurukshetra for placement or are forming new relationships of mutual benefit. The internship gives the student the opportunity to translate engineering theory into practice in a professional engineering environment. The technical activity in the project should be related to both the student's engineering studies and to the host organization's activities and it should constitute a significant body of engineering work at the appropriate level.

Assessment Details:
Each student is assigned a faculty supervisor who is responsible for managing and assessment of the internship semester. The faculty supervisor monitors the student's progress in a semester and interacts with the industry mentor during his/her visit to the host organization twice. This includes a Reflective Diary which is updated throughout the project semester, an Interim internship Report, a Final Report with Learning Agreement/Outcomes and a Final Presentation & Viva. The mentor from the host organization is asked to provide his assessment on the designated form.

Course Outcomes (COs):
Upon successful completion of internship, the students will be able to:
CO1: Acquire knowledge and experience of software and hardware practices in the area of project.
CO2: Carry out design calculations and implementations in the area of the project.
CO3: Associate with the implementation of the internship requiring individual and teamwork skills.
CO4: Communicate their work effectively through writing and presentation.
CO5: Demonstrate the knowledge of professional responsibilities and respect for ethics.

ECPE-401 DEEP LEARNING

Pre-requisite: Applied Linear Algebra (MAIC - 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The course focuses on fundamental principles, underlying mathematics, and implementation details of deep learning techniques. This includes the concepts and methods used to optimize these highly parameterized models (gradient descent and backpropagation, and more generally computation graphs), the modules that make them up (linear, convolution, and pooling layers, activation functions, etc.), and common neural network architectures (convolutional neural networks, recurrent neural networks, etc.). Applications ranging from computer vision to natural language processing and decision-making (reinforcement learning) are included.

Course Content:

UNIT I **8 hrs.**

Introduction to Deep Learning, Deep Feedforward Networks, Decision Surfaces, Gradient Based learning - Hidden Units - Back-propagation, and other Differential Algorithms, Regularization for Deep Learning, Optimization for training Deep Models, Batch Optimization.

UNIT II **12 hrs.**

Convolution operation - Motivation - Pooling - Convolution and Pooling as strong prior, Efficient convolution algorithms, Unsupervised features, Adam Effective training in Deep Net - early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization, Residual Network, Skip Connection Network, Fully Connected CNN.

UNIT III **12 hrs.**

Sequence Modeling: Recurrent and Recursive Nets, LSTM Networks, Autoencoders, Regularized Auto encoders, Semantic Segmentation, Greedy Layer-wise Unsupervised Pre-Training - Transfer learning and Domain Adaptation, Deep Generative Models. Applications: Image Denoising and Object Detection

UNIT IV **8 hrs.**

Introduction to Keras and Tensorflow – Deep Learning for computer vision, Deep Learning for Text and Sequences, Generative Deep Learning – Text Generation with LSTM, Generating images with variational autoencoders – Generative Adversarial Networks (GAN)

Text Book(s) / Reference(s):

[1] Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep Learning", The MIT Press.
[2] Francois Chollet, "Deep Learning with Python", Manning Publications.
[3] Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", First Edition, O'Reilly Media, 2017.

Course Outcomes:

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

CO1: Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains.
CO2: Incorporate transfer of knowledge in machine learning algorithms.
CO3: Implement deep learning algorithms and solve real-world problems.
CO4: Implementation of Deep Learning techniques using Python.

ECPE-402 IMAGE FORENSICS

Pre-requisite: Digital Signal Processing (ECPC 301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Image forensics is a rapidly growing field that deals with the analysis of digital images to determine their authenticity, integrity, and origin. This course provides an in-depth introduction to the fundamental concepts, techniques, and tools used in image forensics. The course covers the topics such as image acquisition, image processing, image compression, steganography, and digital watermarking. Students will learn how to apply these techniques to identify image tampering, detect forged images, and authenticate the origin of digital images.

Course Contents:

UNIT I **10 hrs.**

Introduction: Overview of image forensics, History of image forensics, Applications of image forensics. Image Acquisition: Types of digital images, Image formation and properties, Image acquisition devices, Image file formats.

UNIT II **10 hrs.**

Image Processing Techniques: Image enhancement and restoration, Noise reduction, Image segmentation, Feature extraction, Image analysis. Image Compression Techniques: Lossless and lossy compression, Image compression algorithms, Evaluation of compression quality, Impact of compression on image forensics.

UNIT III **10 hrs.**

Image Tampering and Forgery Detection: Types of image tampering and forgery, Image forensics tools and techniques for detection, Analysis of compression artifacts and inconsistencies, Detection of splicing and copy-paste operations. Steganography: Principles of steganography, Steganography techniques and tools, Detection of hidden information in digital images.

UNIT IV **10 hrs.**

Digital Watermarking: Principles of digital watermarking, Types of digital watermarks, Watermark embedding and extraction, Authentication of digital images. Evaluation of Image Forensics Techniques: Metrics for evaluating image forensics techniques, Benchmark datasets, Performance evaluation of image forensics tools. Case Studies and Applications: Real-world applications of image forensics, Case studies of image tampering and forgery detection, Analysis of recent image forensics research.

Text Book(s) / Reference(s):

[1] "Introduction to Digital Forensics" by Brian Carrier (2014)
[2] "Digital Forensics for Legal Professionals: Understanding Digital Evidence From The Warrant To The Courtroom" by Lars Daniel (2017)
[3] "Handbook of Digital Forensics and Investigation" by Eoghan Casey (2010)
[4] "Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods (2018)
[5] "Image Processing and Analysis: Variational, PDE, Wavelet, and Stochastic Methods" by Tony F. Chan and Jianhong (Jackie) Shen (2005)
[6] "Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab" by Chris Solomon and Toby Breckon (2011)
[7] "Digital Watermarking and Steganography" by Ingemar J. Cox, Matthew L. Miller, and Jeffrey A. Bloom (2007)
[8] "Practical Handbook on Image Processing for Scientific and Technical Applications" by Bernd Jahne (2004)
[9] "Image Analysis, Classification and Change Detection in Remote Sensing: With Algorithms for ENVI/IDL and Python" by Morton J. Canty (2018)
[10] "Forensic Science: An Introduction to Scientific and Investigative Techniques, Fifth Edition" by Stuart H. James, Jon J. Nordby, and Suzanne Bell (2013)
[11] "Digital Image Forensics: There is More to a Picture than Meets the Eye" by Springer (2012).

Course Outcomes:

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

CO1: Understand the fundamental concepts and principles of image forensics.
CO2: Analyze and detect image tampering and forgeries.
CO3: Implement steganography techniques to hide information in digital images.
CO4: Evaluate the effectiveness of image forensics techniques.

ECPE-403 BIO-MEDICAL SIGNAL PROCESSING

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Description:
The course deals with biomedical signal basics, different types of biomedical signals, and biomedical recording system applications. The main objective is to help students acquire knowledge on different types of biomedical signal characteristics and analysis.

Course Contents:

UNIT I **10 hrs.**

Signal processing: Review of Discrete time signals and systems – LTI systems – Response of LTI systems – Convolution – Difference equation representation of discrete systems Z transform – Transform analysis of LTI system – DFT. STFT – Introduction to wavelets – CWT and DWT with Haar wavelet.

UNIT II **10 hrs.**

Introduction to Biomedical Signals: The nature of Biomedical Signals, Examples of Biomedical Signals, Objectives and difficulties in Biomedical analysis, Biomedical signals – The Brain and its potentials. Electrophysiological origin of brain waves. Electroencephalogram (EEG), signal and its characteristics, Electrocardiogram (ECG) signal origin and characteristics and Electromyogram (EMG) signal and its characteristics. ECG lead system, ECG signal characteristics; Non-Stationarities in ECG signal, EEG lead system, EEG signal characteristics. Types of noise in bio signals.

UNIT III **10 hrs.**

Biomedical Signal Processing – Neurological Signal Processing: EEG analysis – Parametric modelling – Linear prediction theory; Autoregressive (AR) method; Recursive estimation of AR parameters.

Cardiological signal processing: ECG parameters and their estimation – Arrhythmia analysis monitoring – ECG data reduction techniques.

UNIT IV **10 hrs.**

Biomedical Signal Processing Methods and Applications: Adaptive interference/Noise cancellation: Types of noise in biomedical signals; Digital filters – IIR and FIR – Notch filters – Optimal and adaptive filters. Weiner filters – steepest descent algorithm – LMS adaptive algorithm – Adaptive noise canceller – cancellation of 50 Hz signal in ECG – Cancellation of maternal ECG in fetal electrocardiography.

Text Book(s) / Reference(s):

[1] D. C Reddy, "Biomedical Signal Processing, Principles and Techniques", Tata McGraw Hill Publishing Company Limited, First Edition, 2005
[2] Willis J Tompkins, "Biomedical Digital Signal Processing", Prentice Hall India Private Limited, First Edition, 2006.
[3] Rangaraj M Rangayyan "Biomedical Signal Analysis – A case study approach" IEEE press series in biomedical engineering, First Edition, 2002.
[4] John G Proakis, Dimitris and G. Manolakis, "Digital Signal Processing Principles algorithms, applications" PHI Third Edition. 2006
[5] Myer Kutz, "Biomedical Engineering and Design Handbook, Volume I", McGraw Hill, 2009.
[6] Katarzyn J. Blinowska, Jaroslaw Zygierewicz, "Practical Biomedical Signal Analysis Using MATLAB", 1st Edition, CRC Press, 2011
[7] https://nptel.ac.in/courses/108/105/108105101

Course Outcomes:

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

CO1: Understand and analyze the dynamic characteristics of biomedical systems and modelling.

CO2: Apply specific mathematical techniques and solve problems in ECG signals.

CO3: Implement various signal processing techniques to model EEG signals.

CO4: Design and develop biomedical signal processing techniques for real time biomedical signals.

ECPE-404 COGNITIVE RADIO

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
Cognitive Radio is a new paradigm in wireless communication systems to alleviate the problem of spectrum underutilization. The course focuses on software-defined radio, cognitive radio, its functions, spectrum sensing techniques and advanced topics in cognitive radio.

Course Contents:

UNIT I **10 hrs.**

Introduction to Wireless Communication: Wireless Channels, Path Loss, Shadowing, Fading, Delay Spread, Doppler Spread

Introduction to CR: Software Defined Radio, Cognitive Radio and its functions, Dynamic Spectrum Access, Underlay, Overlay and Interweave model, Concept of Primary and Secondary Users.

UNIT II **8 hrs.**

Detection Theory: Hypothesis Testing, Neyman-Pearson Criteria, Likelihood Ratio Test, Receiver-Operator Characteristics (ROC), Probability of Error, Monte-Carlo Simulations.

UNIT III **12 hrs.**

Spectrum Sensing: Primary User Detection Techniques, Energy Detection, Coherent Detection, Cyclostationary Feature Detection, Autocorrelation based Detection Effects of Imperfect knowledge of Noise Power, Cooperative Spectrum Sensing: OR, AND and MAJORITY rule.

UNIT IV **10 hrs.**

Overview of IEEE 802.22 standard, security issues in cognitive radios, emerging applications of Cognitive radio, Cognitive Radio for Internet of Things, Smart Grid Networks, Public Safety Networks

Text Book(s) / Reference(s):

[1] Fundamentals of Statistical Processing, Volume 2: Detection Theory by Steven M Kay, Pearson Education India

[2] Principles of Cognitive Radio by H. Vincent Poor, et.al, Cambridge University Press

[3] Fundamentals of Cognitive Radio by Peyman Setoodeh and Simon Haykin, John Wiley & Sons

Course Outcomes:

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

CO1: Understand the fundamentals of cognitive radio networks

CO2: Understand basic principles used in detection of primary users

CO3: Analyze various spectrum sensing algorithms

CO4: Understand emerging applications of cognitive radio

ECPE-405 SPEECH PROCESSING

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
The aim of this course is to introduce the students with models for speech signal in Time-domain and Frequency-domain. Students will also be familiarized with the Homomorphic Speech processing system.

Course Contents:

UNIT I **10 hrs.**

Digital models for speech signals: Mechanism of speech production & acoustic phonetics, the acoustic theory of speech production, lossless tube models, and digital models for speech signals.

UNIT II **10 hrs.**

Time Domain Models and Digital Representation of Speech: Time dependent processing of speech, short time energy and average magnitude, short time average zero crossing rate, discrimination between speech & silence, pitch period estimation using parallel processing, short time autocorrelation function & AMDF, pitch period estimation using autocorrelation function, Median Smoothing and Speech Processing. Sampling speech signals, Review of the statistical model for speech, Instantaneous Quantization, Adaptive Quantization, General Theory of Differential Quantization, DPCM, Direct Digital Code Conversion.

UNIT III **10 hrs.**

Short Time Fourier analysis of Speech Signal: Definition and properties, Design of digital filter banks, Implementation of filter bank summation method using FFT, Spectrographic displays, Pitch detection, Analysis by synthesis, Analysis-Synthesis systems.

UNIT IV **10 hrs.**

Homomorphic Speech processing and Linear Predictive Coding of Speech: Homomorphic systems for convolution, Complex cepstrum of speech, Pitch detection, Formant estimation, The Homomorphic vocoder, Basic principles of linear predictive analysis, Computation of the gain for the model, Solution of LPC equations, Comparisons between the methods of solution of the LPC analysis equations, The prediction error signal, Frequency domain interpretation of linear predictive analysis, relation of linear predictive analysis to lossless tube models, Relations between the

various speech parameters, Synthesis of speech from linear predictive parameters, application of LPC parameters.

Text Book(s) / Reference(s):

[1] Digital Processing of Speech Signals by L.R. Rabiner and R.W. Schafer, Pearson
[2] Discrete-Time Speech Signal Processing Principles and Practices by Thomas F. Quatieri, Pearson
[3] Chris Rowden: Speech Processing McGraw Hill.

Course Outcomes:

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

CO1: Qualitatively describe the mechanisms of human speech production and how the articulation mode of different classes of speech sounds determines their acoustic characteristics.

CO2: Apply MatLab tools to analyse speech signals in the time and frequency domains, and in terms of the parameters of a source-filter production model.

CO3: Solve given problems regarding parameter estimation in source-filter production models and regarding speech analysis and synthesis using these models.

CO4: Describe and implement methods and systems for efficient quantization and coding of speech signals, and solve given problems regarding these methods.

CO5: Describe and implement methods for speech enhancement, and solve given problems regarding these methods.

ECPE-406 MATHEMATICAL ASPECTS OF BIOMEDICAL SYSTEM DESIGN

Pre-requisite: Signals, Systems & Random Variables (ECPC 203)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
This course focuses on the mathematical modeling of biological systems and signals, covering topics such as signals and systems, action potential generation, and electrical equivalent circuit models for biological tissues. It also explores microfabrication basics for biomedical systems and signal conditioning circuits for modern biomedical devices.

Course Content:

UNIT I **12 hrs.**

Signals and Systems: Introduction to Signals and Systems, Signal Types and Moving Average System, Fourier Series, Continuous Time Fourier Transform, Discrete Time Fourier Transform and Sampling. Introduction to Biomedical Signals: Action Potential and Its Generation, Origin and Waveform Characteristics of Basic Biomedical Signals Like: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis.

UNIT II **12 hrs.**

Biomedical Systems and Microfabrication: Microfabrication Basics for Biomedical Systems, Fluid Flow in Body Lumen, Introduction to Electrical Equivalent Circuit Models for Biological Systems, Percolation Theory and Applications in Biological Tissues

UNIT III **8 hrs.**

Mathematical Foundations and Modeling: Linear Algebra, Introduction to Probability, Probability: Random Variables and CDF, Probability: Important Measures and Generating Functions, Common Random Variables, Joint and Marginal Probability Distribution

UNIT IV **8 hrs.**

Biomedical Electronics and Instrumentation: Introduction to Biomedical Optics, Optical Properties of Tissues and Mathematical Modelling, Introduction to Signal Conditioning Circuits for Biomedical Devices, Recent Trends in Biomedical Electronic System Design

Text Book(s) / Reference(s):

[1] Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons.
[2] Reddy, D.C., 2005. Biomedical signal processing: principles and techniques. McGraw-Hill
[3] Tompkins, W.J., 1993. Biomedical digital signal processing. Editorial Prentice Hall.

Course Outcomes:

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

CO1: Explain the origin, waveform characteristics, and analysis objectives of fundamental biomedical signals such as ECG, EEG, EMG, and ENG, applying Fourier series and transform techniques for their representation.

CO2: Analyse electrical equivalent circuit models for biological tissues and apply percolation theory and fluid flow concepts to model biomedical systems, including microfabrication basics for biomedical device design.

CO3: Apply concepts of linear algebra, probability theory, random variables, and joint probability distributions to formulate and solve mathematical models of biological systems.

CO4: Evaluate signal conditioning circuits and optical modelling techniques for biomedical devices, and assess recent trends in biomedical electronic system design for practical diagnostic applications.

ECPE-407 OPTICAL COMMUNICATION NETWORKS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
In this course, students will learn optical fiber sources and transmission techniques, the idea of optical fiber networks algorithms such as SONET/SDH and optical CDMA. Further students will explore trends of optical fiber measurement systems.

Course Contents:

UNIT I **10 hrs.**

Introduction to Optical Fibers: Evolution of fiber optic system, Element of an Optical Fiber Transmission link, Total internal reflection, Acceptance angle, Numerical aperture, Skew rays, Ray Optics, Optical Fiber Modes and Configurations, Mode theory of Circular Wave guides, Overview of Modes, Key Modal concepts, Linearly Polarized Modes, Single Mode Fibers, Graded Index fiber structure.

Signal Degradation in Optical Fibers: Attenuation, Absorption losses, Scattering losses, Bending Losses, Core and Cladding losses, Signal Distortion in Optical Wave guides, Information Capacity determination, Group Delay, Material Dispersion, Wave guide Dispersion, Signal distortion in SM fibers, Polarization Mode dispersion, Intermodal dispersion, Pulse Broadening in GI fibers, Mode Coupling, Design Optimization of SM fibers, RI profile and cut-off wavelength.

UNIT II **10 hrs.**

Fiber Optical Sources and Coupling: Direct and indirect Band gap materials, LED structures, Light source materials, Quantum efficiency and LED power, Modulation of a LED, lasers Diodes, Modes and Threshold condition, Rate equations, External Quantum efficiency, Resonant frequencies, Laser Diodes, Temperature effects, Introduction to Quantum laser, Fiber amplifiers, Power Launching and coupling, Lensing schemes, Fiber-to-Fiber joints, Fiber splicing, Signal to Noise ratio, Detector response time.

UNIT III **10 hrs.**

Fiber-Optic Receiver and Measurements: Fundamental receiver operation, Pre amplifiers, Error sources, Receiver Configuration, Probability of Error, Quantum limit, Fiber Attenuation measurements, Dispersion measurements, Fiber Refractive index profile measurements, Fiber cut-off Wavelength Measurements, Fiber Numerical Aperture Measurements, Fiber diameter measurements.

UNIT IV **10 hrs.**

Optical Networks and System Transmission: Basic Networks, SONET/SDH, Broadcast, and select WDM Networks, Wavelength Routed Networks, Non-linear effects on Network performance, Link Power budget, Rise time budget, Noise Effects on System Performance, Operational Principles of WDM Performance of WDM + EDFA system Solutions, Optical CDMA, Ultra High Capacity Networks.

Text Book(s) / Reference(s):

[1] Keiser, Gerd. Optical fiber communications. Vol. 2. New York: McGraw-Hill, 2000.
[2] John, M. Senior. Optical Fiber Communication-Principle and Practice. Prentice Hall, 2009.
[3] Ramaswami, Rajiv, Kumar Sivarajan, and Galen Sasaki. Optical networks: a practical perspective. Morgan Kaufmann, 2009.
[4] J.Gower. Optical Communication System. Prentice Hall of India, 2001.

Course Outcomes:

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

CO1: Discuss the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.

CO2: Explain the various optical sources and optical detectors and their use in the optical communication system.

CO3: Understand basics of Fiber-Optic Receiver and Measurements.

CO4: Analyze the digital transmission and its associated parameters on system performance

ECPE-408 ADVANCED MOBILE COMMUNICATION

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Description:
This course covers advanced topics in mobile communication systems. Topics include wireless channel modeling, advanced multiple access techniques, advanced topics in mobile communication, and their applications in 4G, 5G and beyond systems.

Course Contents:

UNIT I **10 hrs.**

Overview of mobile communication systems, Evolution of mobile communication systems, Review of wireless channels, Background and quick review of wireless channels: propagation losses, multipath propagation, time-variant channels, 4G and 5G system architecture and protocols.

UNIT II **10 hrs.**

Non Orthogonal Multiple Access: Introduction to NOMA, Performance analysis of NOMA in uplink and downlink, imperfectness in NOMA, spectral efficiency and energy efficiency, state of the art in NOMA. Advantages and disadvantages of NOMA, MIMO-NOMA, Cooperative NOMA

UNIT III **10 hrs.**

D2D Communication: Introduction of D2D communication, state of the art, Limitations and research issues in D2D Communication, Different applications of D2D communication in 5G

UNIT IV **10 hrs.**

Millimeter and THz wave communication: Introduction, state of the art, security issues, Standardization, Limitations and research issues in mm and THz wave communication.

Text Book(s) / Reference(s):

[1] Theodore S Rappaport, "Wireless Communications- Principles And Practice" (Review of wireless propagation models).
[2] Lingyang Song, Dusit Niyato, Zhu Han, Ekram Hossain, "Wireless Device-to-Device Communications and Networks", Cambridge University Press.
[3] Chen Xu, Lingyang Song, and Zhu Han, "Resource Management for Device-to-Device Underlay Communication", Springer Publishing Company.

[4] Kao-Cheng Huang Zhaocheng Wang, "Millimeter Wave Communication Systems", John Wiley & Sons.

Course Outcomes:

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

CO1: Understand the 5G and 4G architecture and protocols

CO2: Evaluate the performance of NOMA systems.

CO3: Find research issues in D2D communication.

CO4: Find the research issues in Millimeter and THz wave communication.

ECPE-409 MULTIPLE ACCESS TECHNOLOGIES

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Description:
This course covers the principles and applications of multiple access techniques in wireless communication systems. Topics include frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), orthogonal frequency-division multiple access (OFDMA), Non-orthogonal frequency-division multiple access (NOMA), Rate split multiple access (RSMA) and their applications in wireless communication systems.

Course Contents:

UNIT I **10 hrs.**

Introduction to Multiple Access Techniques, Historical background and motivation for multiple access techniques, Overview of multiple access techniques, Frequency Division Multiple Access (FDMA), Principles of FDMA and its properties, Design of FDMA systems, Time Division Multiple Access (TDMA), Principles of TDMA and its properties, Design of TDMA systems

UNIT II **10 hrs.**

Spread spectrum modulation, Code Division Multiple Access (CDMA), Principles of CDMA and its properties, Design of CDMA systems, Advantages of CDMA, CDMA Near Far Problem and power control, Performance of CDMA uplink and downlink scenario with multiple users, Asynchronous CDMA.

UNIT III **10 hrs.**

Introduction of Orthogonal Frequency-Division Multiple Access (OFDMA), Multicarrier transmission, cyclic prefix in OFDM, BER for OFDM, Effect of frequency offset in OFDM, OFDM- Peak to Average Power Ratio (PAPR), SC-FDMA, Design of OFDMA systems

UNIT IV **10 hrs.**

Advanced Topics in Multiple Access Techniques, Non-orthogonal multiple access (NOMA) techniques, SNR in uplink and downlink NOMA, spectral efficiency and power efficiency in NOMA, Interference analysis and mitigation techniques, cooperative NOMA, MIMO NOMA, Rate split multiple access (RSMA), 5G and beyond Emerging trends in multiple access techniques research

Text Book(s) / Reference(s):

[1] "Wireless Communications: Principles and Practice" by Theodore S. Rappaport
[2] "CDMA: Principles of Spread Spectrum Communication" by Andrew J. Viterbi and Jim K. Omura
[3] "Multiple Access Communications: Foundations for Emerging Technologies" by David J. Goodman

Course Outcomes:

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

CO1: Evaluate the performance of FDMA and TDMA
CO2: Evaluate the performance of CDMA systems.
CO3: Evaluate the performance of OFDMA systems.
CO4: Find the research issues in multiple access techniques in 5G and beyond wireless networks.

ECPE-410 OPTICAL WIRELESS COMMUNICATION

Pre-requisite: Communication Engineering (ECPC - 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:

It is envisaged that the course will provide the fundamentals and basic concepts of wireless channels and their effect on the wireless optical system (WOC) performance. The fundamental limitation of wireless optical communication systems arises from the environment through which light signal propagates. The modulation and demodulation techniques used in WOC systems are quite different from those used in optical fiber systems. In this course, the students would be exposed to atmospheric/free-space channel characterization, transmitter and receiver design and link feasibility.

Course Content:

UNIT - I **8 hrs.**

Introduction to optical wireless communication systems Wireless access schemes, brief history of OWC, OWC/Radio Comparison, OWC Application Areas, OWC Challenges. Optical sources and detectors.

UNIT – II **12 hrs.**

Channel modelling Indoor Optical Wireless Communication Channel: LOS Propagation Model, Non-LOS Propagation Model, Ceiling Bounce Model, Hayasaka–Ito Model, Model. Artificial Light Interference, Incandescent Lamp, Fluorescent Lamp Driven by Conventional Ballast, Fluorescent Lamp Model. Outdoor Channel: Atmospheric Channel Loss, Fog and Visibility, Beam Divergence, Optical and Window Loss, Pointing Loss. The Atmospheric Turbulence Models: Log-Normal Turbulence Model, Spatial Coherence in Weak Turbulence, Limit of Log-Normal Turbulence Model, the Gamma–Gamma Turbulence Model, the Negative Exponential Turbulence Model.

UNIT - III **8 hrs.**

Modulation techniques Analogue Intensity Modulation, Digital Baseband Modulation Techniques, Pulse Position Modulation, Pulse Interval Modulation (PIM), Dual-Header PIM, Multilevel DPIM, Subcarrier Intensity Modulation, Orthogonal Frequency Division Multiplexing.

UNIT – IV **12 hrs.**

Detection techniques: Photon counter, PIN/APD, PMT, coherent techniques viz., homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, concept of adaptive threshold.Role of OWC in 5G technology based systems.

Text Books / Reference:

[1] L. C. Andrews, R. L. Phillips, Laser Beam Propagation through Random Media, SPIE Press, USA, 2005.

[2] J. H. Franz, V. K. Jain, Optical Communications: Components and Systems, Narosa Publishing House, 2000.

[3] D. Chadha, Terrestrial Wireless Optical Communication, Tata McGraw-Hill, 2012.

[4] Z. Ghassemlooy, W. Popoola, S. Rajbhandari, Optical Wireless Communications, CRC Press,2013.

Course Outcomes:

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

CO1: Understand the basics of wireless optical communications, optical sources and optical detectors.

CO2: Understand different modulation techniques and channel modelling techniques for OWC systems.

CO3: Apply different channel modelling techniques to observe their effect on OWC system performance.

CO4: Apply different channel modelling techniques to observe their effect on OWC system performance.

ECPE-411 BIO SENSORS

Pre-requisite: Chemistry (CHIC 103)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
To familiarize students with biosensor technology and their application area.

Course Contents:

UNIT I **10 hrs.**

Description of biosensor and its general principles, Biomolecules used in biosensors and immobilization methods, immobilization of biological materials, support materials, their types and properties.

UNIT II **10 hrs.**

The properties and characteristics of biosensors, performance factors in biosensors, enzymatic biosensors, immune-biosensors.

UNIT III **10 hrs.**

DNA biosensors, Cell basis biosensors, Electrochemical biosensors, Optical biosensors.

UNIT IV **10 hrs.**

Other measurements methods, Biosensors in food analysis, Biosensors in environmental analysis. Futuristic technologies and challenges related to Bio-sensing.

Text Book(s) / Reference(s):

[1] A.Mulchandani, K.R. Rogers, 1998. "Enzyme and Microbial Biosensors Techniques and Protocols", Humana Press, Totowa, New Jersey.
[2] J.Cooper, T.Cass, Biosensors, Oxford university press, second edition, 2004.
[3] Chen Jianrong, Miao Yuqing, He Nongyue, Wu Xiaohua, Li Sijiao, Nanotechnology and biosensors, Biotechnology Advances, Volume 22, Issue 7, September 2004, Pages 505-518.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: Acquire knowledge about the biosensors.
CO2: Understand various biomolecules used in biosensors and immobilization methods
CO3: Design a biosensor.
CO4: Acquire knowledge about advantages of biosensors.
CO5: Understand DNA biosensors, Cell basis biosensors and Electrochemical biosensors
CO6: Understanding the use of Biosensors in environmental analysis.

ECPE-412 VLSI TESTING AND VERIFICATION

Pre-requisite: Digital Design (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
Students learn the essential concepts of the digital VLSI design flow, including high-level synthesis, RTL design, and logic optimization. The curriculum covers physical fault modeling, fault simulation algorithms (such as serial and parallel), and advanced testing techniques like Automatic Test Pattern Generation (ATPG) and Built-In Self-Test (BIST) architectures.

Course Learning Objective:
To learn the concepts of Digital VLSI design flow specification, VLSI testing and verification.

Course Contents:

UNIT I **10 hrs.**

Introduction: Introduction to Digital VLSI Design Flow Specification, Brief of High-level Synthesis, RTL Design, Logic Optimization, Verification and Test Planning, Design Representation, Hardware Specific Transformations. Functional vs. Structural Testing, Physical faults and their modelling, Fault equivalence and dominance; fault collapsing and Checkpoint Theorem.

UNIT II **10 hrs.**

Fault Simulation and Testability Measures: Circuit Modeling and Algorithms for Fault Simulation, (Serial Fault Simulation, Parallel Fault Simulation, Deductive Fault Simulation, Concurrent Fault Simulation), Combinational SCOAP Measures and Sequential SCOAP Measures.

UNIT III **10 hrs.**

Combinational Circuit Test Pattern Generation: Introduction to Automatic Test Pattern Generation (ATPG) and ATPG Algebras, Standard ATPG Algorithms, D-Calculus and D-Algorithm, Basics of PODEM and FAN.

UNIT IV **10 hrs.**

Scan Chains based Sequential Circuit Testing, Introduction to BIST architecture, BIST Test Pattern Generation, Response Compaction and Response Analysis, Memory BIST.

Text Book(s) / Reference(s):

[1] D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design, Springer, 1st edition.
[2] S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall, 2nd edition.
[3] G. De Micheli. Synthesis and optimization of digital circuits, 1st edition.
[4] M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition.
[5] Bushnell and Agrawal, Essentials of Electronic Testing for Digital, Memory & Mixed-Signal Circuits, Kluwer Academic Publishers.

Course Outcomes:

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

CO1: Understand the difference between Design, Verification and Test.
CO2: Understand the Physical faults and their modelling
CO3: Understand Fault Simulation and Testability Measures.
CO4: Identify the design for testability methods for combinational & sequential CMOS circuits.

ECPE-413 RF MICROELECTRONICS

Pre-requisite : Electronics Device and Circuits (ECPC-201) and Analog Electronics (ECPC-206) Analog IC Design (ECPE -309)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
This course introduces the design and analysis of Radio Frequency (RF) integrated circuits, focusing on components like low-noise amplifiers (LNAs), mixers, and oscillators. It emphasizes RF engineering fundamentals, including impedance matching, noise, and linearity, to prepare students for designing wireless communication transceivers.

Course Contents:

UNIT I **10 hrs.**

Active RF Components and their characteristic parameters: RF diodes, BJT, FET, HEMT.

RF Filter Design: Filter configurations, resonators, filter realizations – Butterworth, Chebychev.

UNIT II **10 hrs.**

High-Frequency Amplifier Design: Zeros as bandwidth enhancer, shunt series amplifier, bandwidth enhancement with fT doublers, voltage references and biasing, tuned and cascaded amplifiers, RF Power Amplifier Design.

UNIT III **10 hrs.**

Noise in RF Circuits: types of noise, two port noise theory, Low-Noise Amplifier (LNA) – intrinsic MOSFET two port noise parameters, LNA topologies, design example, LNA Design example.

UNIT IV **10 hrs.**

Phase-Locked Loops: PLL models, noise properties, sequential phase detectors, loop filters and charge pumps.

RF Oscillators: tuned and negative resistance oscillators.

Mixers: non-linear systems as mixers, multiplier based mixers.

RF amplifier design – a case study

Text Book(s) / Reference(s):

[1] T. H. Lee, The Design of CMOS Radio Frequency Integrated Circuits, CUP.
[2] R. Ludwig and P. Bretchko, RF Circuit Design, Pearson.
[3] B. Razavi, RF Microelectronics, PH.
[4] B. Leung, VLSI for Wireless Communication, PH.
[5] B. Razavi, Phase-Locking in High-Performance Systems, Wiley/IEEE.
[6] B. Razavi, Monolithic Phase-Locked Loops and Clock Recovery Circuits, IEEE Press.
[7] R. E. Best, Phase-Locked Loops: Design, Simulation and Applications, Fifth Edition, MH.

Course Outcomes:

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

CO1: Understand the active RF components and their performance metrics.
CO2: Analyse the design of high frequency amplifiers.
CO3: Understand the LNA, PLL, Oscillator design techniques.
CO4: Distinguish between different types of mixers.

ECPE-414 ANALOG AND MIXED SIGNAL DESIGN

Pre-requisite: Electronics Device and Circuits (ECPC-201) and Analog Electronics (ECPC-206) Analog IC Design (ECPE -309)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
This course deals with the design of integrated circuits that handle both analog and digital signals, specifically focusing on advanced MOS device modeling and operational amplifier design. Key topics include the analysis and implementation of data converters (ADCs and DACs) and Phase-Locked Loops (PLLs).

Course Contents:

UNIT I **8 hrs.**

Data Converters: Introduction, Characteristic Parameters, Basic DAC and ADC Architectures. Sampling and Aliasing, SPICE models for DACs and ADCs, Quantization Noise

UNIT II **10 hrs.**

Data Converter SNR: Clock Jitter, Improving SNR using Averaging, decimating filters for ADC's, Interpolating filters for DAC's, Band pass and high pass Sinc filters, using feedback to improve SNR.

UNIT III **12 hrs.**

Noise Shaping data converters: First order noise shaping, Digital first order NS Modulators, Modulation Noise, Decimating and filtering the output of a NS Modulator, Integrator & Forward modulator gain, op-amp gain, Second order Noise Shaping, Noise shaping Topologies.

UNIT IV **10 hrs.**

Implementing data converters: R-2R topologies for DAC's – Current mode, voltage mode, wide swing current mode DAC, topologies without an op-amp, effects of op-amp parameters, Implementing ADC's-Implementing S/H, Cyclic ADC, Pipeline ADC - using 1.5 bits per stage, capacitor error averaging, comparator placement, clock generation, offsets and alternative topologies, Layout of Pipelined ADC's.

Text Book(s) / Reference(s):

[1] R. J. Baker, CMOS Mixed Signal Circuit Design, Wiley-IEEE Press; 2nd edition, 2008.
[2] A. Handkiewicz, "Mixed-Signal Systems: A Guide to CMOS Circuit Design," Wiley-IEEE, 2002.

[3] B. Razavi, "Principles of Data Conversion System Design," Wiley-IEEE Press, 1995.
[4] E. Sanchez-Sinencio and A. G. Andreou, "Low-Voltage/Low-Power Integrated Circuits and Systems: Low-Voltage Mixed-Signal Circuits," Wiley-IEEE Press; 1st edition, 1999.
[5] Y. Tsividis, "Mixed Analog-Digital VLSI Devices and Technology," World Scientific Pub Co Inc., 2002.

Course Outcomes:

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

CO1: Appreciate the fundamentals of data converters and also optimize their performances.
CO2: Understand the SPICE models for ADC and DAC architecture.
CO3: Understand how to design the filters for DAC.
CO4: Design the CMOS digital circuits and implement its layout.
CO5: Analyze and design the different structures of ADC & DAC.

ECPE-415 NANO ELECTRONICS

Pre-requisite: Electronic Devices and Circuits (ECPC-201)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the course:
The objective of this course is to familiarize students with nanoelectronics and nanoscale structures and electron transport phenomena in semiconductors and nanostructures. The course also covers introduction to 2D materials & 2D based nano devices and their applications in current scenarios.

Course Content:

UNIT I: 10hrs.
Introduction to nanoelectronics: From classical electronics to nanoelectronics. Electrons in traditional low-dimensional structures: Electrons in quantum wells, Electrons in quantum wires, Electrons in quantum dots. Materials for nanoelectronics: semiconductors, carbon nanomaterials, nanotubes. Introduction to particles and waves, Classical particles, Classical waves, Wave-particle duality.

UNIT II: 10hrs.
Electrons in low-dimensional structures: electrons in quantum wells, electrons in quantum wires, electrons in quantum dots. Introduction to Wave mechanics, Schrodinger wave equation, Atoms and atomic orbitals, Crystal lattices: Bonding in crystals, Electron energy bands, Semiconductor heterostructures, Inorganic-organic heterostructures, Carbon nanomaterials: nanotubes and fullerenes.

UNIT III: 10hrs.
Introduction to growth and fabrication of nanostructures: Nanolithography, etching. Techniques for characterization of nanostructures. Spontaneous formation and ordering of nanostructures. Electron transport in semiconductors and nanostructures. Time and length scales of the electrons in solids. Density of states of electrons in nanostructures. Electron transport in nanostructures.

UNIT IV: 10hrs.
Nanoelectronic devices. Resonant-tunnelling diodes. Field-effect transistors. Single-electron-transfer devices. Quantum- dot cellular automata. Recent 2D materials-based nano-devices (CNTFET, MTJs, SPINFET etc.) and their applications.

Text Books/ References:

[1] S. Datta, "Lessons from Nanoelectronics: A New Perspective on Transport (Lessons from Nanoscience: A Lecture Notes Series)", World Scientific, 2012.

[2] V. Mitin, V. Kochelap, and M. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press, 2008.
[3] C. P. Poole and F. J. Owens, "Introduction to nanotechnology", John Wiley & Sons, 2003.
[4] C. Dupas, P. Houdy, M. Lahmani Nanoscience: Nanotechnologies and Nanophysics, Springer, 2004.
[5] Akhlesh Lakhtakia, Nanometer structures: theory, Modelling, and simulation, ASME Press, 2004.
[6] S. E. Lyshevski, Nano- and micro-electromechanical systems fundamentals of nano and microengineering, 2nd Edition, CRC Press, 2004.
[7] http://idol.union.edu/~malekis/ESC24/ESC24MainPage/NanoMainPage.htm
[8] http://mrsec.wisc.edu/edetc/index.html
[9] www.nanohub.org (Supriyo Datta and Mark Ludstrom lectures)

Course Outcomes:

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

CO1: Acquire fundamental knowledge of nanoelectronics.

CO2: Learn about different fabrication techniques for nanostructures.

CO3: Gain knowledge on different nanoelectronic devices and their applications.

CO4: Discover different 2D materials based nanodevices (MTJs, CNTFETs, SPINFET, etc.) and their applications.

ECPE-416 ADVANCED COMPUTER NETWORKS

Pre-requisite: Computer Networks (ECPC 308)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
This course covers advanced networking concepts beyond basics, including high-speed network architectures, congestion control, and Quality of Service (QoS) management. It also explores modern paradigms such as Software Defined Networking (SDN) and Network Function Virtualization (NFV).

Course Objectives:
To understand the advanced networking concepts for next-generation network architecture and design. To study the various protocols at different layers and their differences from traditional protocols. To understand the issues pertaining to sensor networks and the challenges involved in managing a sensor network.

Course Contents:

UNIT I **10 hrs.**

Packet-Switched Networks: OSI and IP Models, Ethernet, Token Ring, FDDI, DQDB, Frame Relay. The Internet and TCP/IP Networks: The Internet, Internet Protocol, TCP, and UDP, Performance of TCP/IP Networks.

UNIT II **10 hrs.**

Circuit-Switched Networks: Performance of Circuit-Switched Networks, SONET, Dense Wave-Division Multiplexing, Fiber to the Home, Digital Subscriber Line, Intelligent Networks, CATV, Asynchronous Transfer Mode: Main features, Addressing, Signaling and Routing, ATM Header Structure, ATM Adaptation Layer, Management and Control, BISDN, Internetworking with ATM.

UNIT III **10 hrs.**

Wireless Networks: Introduction, The Wireless Channel, Link Level Design, Channel Access, Network Design, Wireless Networks Today, Future Systems, and Standards.

UNIT IV **10 hrs.**

Networks of Queues: closed networks, open networks, estimating parameters and distributions, Computational methods for queueing network solutions, and Security issues in the Internet architecture.

Text Book(s) / Reference(s):

[1] J. Walrand, and P. Varaiya, "High-performance Communication Networks," Elsevier publication, 2nd edition, 2005.
[2] Dimitri Bertsekas, and Robert Gallager, "Data Network," Pearson publication, 2nd edition, 2015.
[3] A. Leon-Garcia, and Indra Widjaja, "Communication Networks," Mc Graw Hill, 2004
[4] James Kurose and Keith Ross, "Computer Networking-a Top-Down Approach", 7th Ed. Pearson, 2017.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: Understand advanced concepts in high-performance communication networks.
CO2: Comprehend the study of major communication networks.
CO3: Analyze specific protocols and control mechanisms that operate these networks.
CO4: Analyze some of the new principles that are evolving for future networks.

ECPE-417 QUANTUM COMMUNICATION

Pre-requisite: Communication Engineering (ECPC 205), Applied Linear Algebra (MAIC 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
This course provides a comprehensive overview of quantum communication. The objective is to make the students understand fundamental concepts of quantum communication.

Course Contents:

UNIT I **8 hrs.**
Introduction: Classical networks, overview, Maxwell's equations revisited. Applications of polarization in Quantum Networks.

UNIT II **10 hrs.**
Photon Polarization, General Quantum Variables and Qubits, Applications of quantum variables in Quantum Networks. Composite Quantum Systems – Applications of quantum systems in Quantum Networks. Quantum Entanglement, its importance for Quantum Communications.

UNIT III **10 hrs.**
Experimental Quantum Teleportation of Qubits, engineering sources of Entangled Photons, The No Cloning Theorem.

UNIT IV **12 hrs.**
Quantum Cryptography, The Benett–Brassard Protocol for Quantum key distribution. Eckert's Protocol for Quantum key distribution using entanglement. Quantum Teleportation – An Application of composite qubits and entanglement.

Text Book(s) / Reference(s):
[1] Michael Nielson, Isaac Chuang, "Quantum Computation and Quantum Information"
[2] Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory"

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand quantum communication
CO2: Analyse quantum cryptography
CO3: Evaluate the performance of quantum communication
CO4: Application of quantum teleportation

ECPE-418 OPTICAL COMMUNICATIONS

Pre-requisite: Communication Engineering (ECPC 205), Fields and Waves (ECPC 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
It is envisaged that the course will provide the fundamentals and basic concepts of wireless channels and their effect on the wireless optical system (WOC) performance. The fundamental limitation of wireless optical communication systems arises from the environment through which light signal propagates. The modulation and demodulation techniques used in WOC systems are quite different from those used in optical fiber systems. In this course, the students would be exposed to atmospheric/free-space channel characterization, transmitter and receiver design and link feasibility.

Course Content:

UNIT I **10 hrs.**

Introduction: Propagation within the fiber, Numerical aperture of fiber, diffraction, step index and graded index fiber, Modes of propagation in the fiber, Single mode and multi-mode fibers. Splices and connectors.

UNIT II **10 hrs.**

Losses in Optical Fiber: Rayleigh Scattering Losses, Absorption Losses, Leaky modes, mode coupling losses, Bending Losses, Combined Losses in the fiber.

Dispersion Effect: Effect of dispersion on the pulse transmission Intermodal dispersion, Material dispersion, Wave guide dispersion, Total dispersion, Transmission rate.

UNIT III **10 hrs.**

Light Sources: LEDS, Laser Action in semiconductor Lasers, Semiconductor Lasers for optical communication – Laser modes, Spectral Characteristics, Power Voltage Characteristics, Frequency response.

Detectors: P-I-N Photodiode, APD Noise Analysis in detectors, Coherent and non-coherent detection, The fiber-optic Communication System.

UNIT IV **10 hrs.**

Optical Networks: Optical coupler, space switches, linear divider-combiners, wavelength division multiplexer and demultiplexer, optical amplifier, optical link network-single hop, multi-hop, hybrid and photonic networks.

Text Book(s) / Reference(s):

[1] John Power, An Introduction to Fiber optic systems, McGraw Hill International.
[2] John Gowar, Optical communication Systems.
[3] R. Ramaswamy, Optical Networks, Narosa Publication

Course Outcomes:

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

CO1: Understand the basics of optical sources and optical detectors.

CO2: Understand different modulation techniques for OC systems.

CO3: Understand the basics of optical Light sources & detectors.

CO4: Understand the basics of optical networks.

ECOE-401 SENSORS

Pre-requisite: Electronic Devices and Circuits (ECPC 201)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
In recent years, technological advances have resulted in the rapid development of a new and exciting research direction – the interdisciplinary use of sensors for data collection, systems analysis, and monitoring. These highly calibrated sensors require precision engineering techniques that play an important role in analyzing and integrating large datasets. Sensor networks in particular represent a very active area of research, including work on problems such as sensor network localization and network design. Application areas for sensors and sensor networks include environmental monitoring, military surveillance, computational neuroscience, seismic detection, and a great deal more. The fundamental problems of utilizing the collected data for efficient system operation and decision making encompasses multiple research areas, including applied mathematics, optimization, signal/image processing, as well as emerging areas that require interdisciplinary techniques from several fields of research.

Course Contents:

UNIT I **10 hrs.**

Introduction to Sensors, Definition and types of sensors, Sensor characteristics: sensitivity, accuracy, resolution, range, and linearity. Transducers: conversion of physical quantities to electrical signals, Passive and active sensors, Analog and digital sensors, Classification of Sensors based on measurement principles: Temperature sensors, Pressure sensors, Proximity sensors, Motion sensors, Force and load sensors, Humidity sensors, Light sensors, Gas sensors, Chemical sensors, Biosensors

UNIT II **10 hrs.**

Sensor Signal Conditioning, Signal conditioning techniques: amplification, filtering, and linearization, Noise reduction and interference rejection, Calibration and sensor characterization, Sensor Interfaces and Data Acquisition, Analog-to-digital conversion, Serial and parallel interfaces, Microcontrollers and microprocessors for sensor integration, Data acquisition systems and software

UNIT III **10 hrs.**

Sensor Applications in Different Engineering Streams. Sensors in mechanical engineering: Accelerometers, Strain gauges, Position and displacement sensors, Vibration sensors, Flow sensors. Sensors in electrical engineering: Current and voltage sensors, Magnetic field sensors, Hall effect sensors, Power sensors, Radiation sensors.

Sensors in civil engineering: Structural health monitoring sensors, Geotechnical sensors, Environmental sensors. Sensors in biomedical engineering: ECG and EEG sensors, Blood pressure sensors, Oxygen sensors, Glucose sensors, Prosthetic sensors

UNIT IV **10 hrs.**

Sensor Integration and IoT Applications, Wireless sensor networks, Internet of Things (IoT) and sensor integration, Sensor fusion and data integration techniques. Emerging Sensor Technologies and Trends, Nanosensors, MEMS sensors, Wearable sensors, Energy harvesting sensors, Sensor networks for smart cities. Application to various sustainable technologies, case studies from the Indian knowledge system.

Text Book(s) / Reference(s):

[1] Sensors and Actuators, D. Patranabis, 2nd Ed., PHI, 2013.
[2] Make sensors: Terokarvinen, kemo, karvinen and villey valtokari, 1st edition, maker media, 2014.
[3] Sensors handbook- Sabrie soloman, 2nd Ed. TMH, 2009
[4] Handbook of Modern Sensors, J. Fraden, Fourth Edition, Springer
[5] Instrument transducers, H. K. P. Neubert, OUP
[6] Measurement systems: application & design, E. A. Doebelin, Mc Graw Hill

Course Outcomes:

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

CO1: Classify and describe various types of sensors and transducers based on their working principles, characteristics, and measurement parameters including sensitivity, accuracy, resolution, and linearity.

CO2: Apply signal conditioning techniques such as amplification, filtering, linearization, and analog-to-digital conversion to design sensor interface circuits and data acquisition systems for real-world measurements.

CO3: Analyse the selection and application of appropriate sensors across mechanical, electrical, civil, and biomedical engineering domains, evaluating their suitability for specific measurement requirements.

CO4: Evaluate emerging sensor technologies including MEMS, nanosensors, wearable sensors, and wireless sensor networks, and assess their integration with IoT platforms and sustainable technology applications with reference to the Indian knowledge system.

ECOE-402 FSM CONTROLLER DESIGN

Pre-requisite: Computer Organization and Architecture (ECPC 202)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
This elective focuses on the design and implementation of Finite State Machines (FSMs) for digital controllers using hardware description languages like Verilog or VHDL. It covers state reduction, state assignment, and the realization of complex control logic for various digital systems.

Course Contents:

UNIT I **10 hrs.**

Introduction to FSMs: Definition of FSMs and their role in digital system design, Types of FSMs (Moore and Mealy), Examples of FSMs in real-world applications, State Diagrams and State Tables: Representing FSMs using state diagrams and state tables, Determining the number of states required for a given problem, State encoding and state assignment

UNIT II **10 hrs.**

Logic Design for FSMs: Designing combinational logic for next-state and output functions, Karnaugh maps and Boolean algebra for logic minimization, Implementing FSMs using logic gates and multiplexers, Sequential Circuit Design for FSMs: Designing sequential circuits for state storage and transition detection, Flip-flops and latches for state storage, Timing considerations for sequential circuits.

UNIT III **12 hrs.**

FSM Optimization: Optimization techniques for reducing the number of states and transitions in an FSM, State minimization algorithms (e.g., state reduction, state merging, partitioning) Code generation and optimization for FSM-based designs, FSM Design Using HDL: introduction to Verilog and FSM design, FSM coding styles (e.g., behavioral, RTL, gate-level), Simulation and synthesis of FSMs using HDL tools.

UNIT IV **8 hrs.**

Applications of FSMs: FSMs for digital control systems (e.g., PID controllers), FSMs for protocol design (e.g., communication protocols, state machines), FSMs for digital signal processing (e.g., filters, FFT), Case studies: Design of Elevator, ATM FSMs.

Text Book(s) / Reference(s):

[1] David Harris and Sarah Harris, Digital Design and Computer Architecture
[2] Volnei A. Pedroni, Finite State Machines in Hardware: Theory and Design

[3] David J. Comer, Design of Sequential and State Machines.
[4] Mark Zwolinski, Digital System Design with VHDL.
[5] Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis.

Course Outcomes:

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

CO1: Understand FSM, importance and their design
CO2: Understand FSM architecture, Design fundamentals
CO3: Impact of states on power consumption, state reduction techniques,
CO4: Design and implementation of real time FSMs

Semester – VIII

ECPC-406 DATA SECURITY

Pre-requisite: Computer Networks (ECPC 310)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The objective of this course is to familiarize the students with cryptography and its applications. Topics will include historical cryptography, encryption, authentication, public key cryptography and key distribution.

Course Content:

UNIT I **10 hrs.**

Fundamental of Data Security: Introduction to security, classification of security attacks, security mechanisms and services, Historical Ciphers, Shannon's perfect security, Symmetric key encryption: stream ciphers: RC4, Block ciphers: DES, 3DES, AES, IDEA, Modes of operation, Symmetric-Key Distribution, Public Key Encryption Algorithms: RSA, elliptic curve cryptography, Primality Testing and Factoring, Public key distribution, Public Key Infrastructure. Attacks on symmetric key and asymmetric key ciphers.

UNIT II **10 hrs.**

Authentication: Attacks on Public Key Schemes, Signature Scheme, MAC and Hash Functions, properties and requirements of digital signatures, MAC and HASH, Kerberos, Entity authentication: weak Authentication, Challenge-Response identification (strong authentication), and Zero knowledge proofs.

UNIT III **10 hrs.**

Key Distribution: Key management, D-H key exchange algorithm, attacks on D-H algorithm, Key redistribution, MIT key agreement protocol, Key Agreement using self-certifying keys.

UNIT IV **10 hrs.**

Practical Applications: E-MAIL security PKI, CA. X509 certificates, SSL/TLS, HTTPS, IPV6 and IPSEC, Proxies and Firewalls, Wireless network security.

Text Book(s) / Reference(s):

[1] Douglas Stinson, "Cryptography Theory and Practice", 2nd Edition, Chapman & Hall/CRC.
[2] B. A. Forouzan, "Cryptography & Network Security", Tata Mc Graw Hill.
[3] W. Stallings, "Cryptography and Network Security", Pearson Education.

Course Outcomes:

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

CO1: Understand the concept and need of cryptography.

CO2: Implement and design symmetric and asymmetric key algorithms.

CO3: Implement various key distribution and authentication techniques.

CO4: Comprehend and analyze cryptographic primitives in real time applications.

CO5: Understand and analyze various network security protocols.

CO6: Analyze security challenges in wireless networks and its preventive measures

ECPC 407 Project –II/ Internship

L	T	P	Credits	Total contact hours
0	0	12	6	-

Brief Description:
This is a full-semester supervised major project/internship undertaken in the eighth semester, building upon the work initiated in previous semesters or independent work. Students extend their prototype into a complete, tested, and documented ECE based system, culminating in a final thesis submission and viva voce examination.

Course Outcomes:
CO1: Define a well-scoped ECE based problem and establish clear research or design objectives.
CO2: Review existing literature and identify gaps addressed by the proposed solution.
CO3: Design and implement a complete, integrated ECE based system or application.
CO4: Evaluate system performance against defined objectives through testing and analysis.
CO5 well-structured thesis and deliver a pro**:** Produce a professional oral presentation.

ECPC 408 Internship

L	T	P	Credits	Total contact hours
			9	-

ECPE-419 TELEVISION & RADAR ENGINEERING

Pre-requisite: Communication Engineering (ECPC-205), Digital Communication (ECPC-210)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Television (TV) and Radar Engineering is a subject which has been designed to meet the requirements of Modern Technology on 'Television Engineering' for Electrical and Electronics Engineering students at the Degree level. It will also meet the needs of a comprehensive course on TV and Radar. This course introduces the basic concepts of Television and Radar.

Course Content:

UNIT I **10 hrs.**

Introduction: Elements of TV System, Analysis and Synthesis of TV Pictures, composite Video, VSB Signal transmission and channel BW.

Monochrome Signal Transmission and Reception: Block diagram of Monochrome Signal Transmitter and Receiver, Explanation of different sections, Transmitting and receiving antennas.

Elements of Colour TV: Introduction, compatibility considerations, Interleaving process, three color theory, Chrominance Signal, composite color signal, comparison of NTSC, PAL and SECAM Systems.

UNIT II **10 hrs.**

Advanced Topics in TV Engineering: Introduction, & working and block diagram of the Projector TV, 3D-TV, HDTV, Digital TV, Camcorders.

UNIT III **10 hrs.**

Introduction to RADAR: Fundamentals, the Radar equations, CW and Frequency-Modulated Radar, MTI and Pulse Doppler Radar.

UNIT IV **10 hrs.**

Radar Systems: Tracking Radar, Radar Transmitters & Antennas, case studies in Other Radar Topics.

Text Book(s) / Reference(s):

[1] AM Dhake, Monochrome and Colour TV, TMH.
[2] R.R.Gulati, Colour TV.Engg. Wiley Eastern Ltd.
[3] SP Bali, Colour TV theory & practice, TMH
[4] Merrill I. Skolnik, Introduction to Radar Systems, TMH

Course Outcomes:

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

CO1: Understand the basic concepts and applications of television systems.

CO2: Understand the basic concepts, analyze, test and use various components for transmission and reception television systems.

CO3: Understand the working of RADAR.

CO4: Understand the principle of various RADAR systems and their applications

ECPE-420 SONAR SYSTEM / UNDER WATER COMMUNICATION

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course provides an outline about sonar systems, its types and their applications. The course will provide an overview of signal processing and filtering options for output received from sonar systems and acoustic modems. It will discuss acoustic modems and underwater sensor networks.

Course Contents:

UNIT I **10 hrs.**

Types of sonar systems: active and passive, sonar equations, propagation characteristics of the medium, transmission loss and spreading effects, beam forming and steering, detection threshold, square law detector, cross-correlation detector, Ambient noise: sources of ambient noise, shallow water ambient noise, effect of depth, directional characteristics of deep water ambient noise, electrical noise, machinery noise, flow noise, propeller noise, self-noise and radiated noise.

UNIT II **10 hrs.**

Correlation receivers and matched filters: Advanced Sonar Signal Processing functions, adaptive beam forming, synthetic aperture arrays, automated decision making.

Orthogonal Frequency division multiplexing: Key features, characteristics and principle of operation of OFDM, Channel coding and interleaving System model, Enhancement of spectral efficiencies, Transmission/Reception of OFTD - OFDM Simulations.

UNIT III **10 hrs.**

Acoustic Modem: Underwater Wireless Modem, Sweep spread carrier signal, transmission characteristics in shallow water channel, separation of time varying multipath arrivals, Typical acoustics modems, characteristics and specifications, Applications, Acoustic Releases, Real time wireless current monitoring system.

UNIT IV **10 hrs.**

Underwater Sensor Network: Underwater Networking, Ocean Sampling Networks, Pollution Monitoring, Environmental Monitoring and Tactical surveillance systems, Major challenges in design of Underwater Sensor Networks, Factors that affect the UWSN, Sensor Node Architecture, GIBS, VRAP, DABSRAPT. etc.

Text Book(s) / Reference(s):

[1] Urick, Robert J. Principles of underwater sound. McGraw Hill Book Company, New York (1975).
[2] Waite, Ashley D. Sonar for practising engineers. Wiley, 2002.
[3] Marple Jr, S. Lawrence, and William M. Carey. Digital spectral analysis with applications. Prentice Hall. Signal Processing Series 1989.
[4] Oppenheim, Alan V. Applications of digital signal processing. Prentice Hall, Englewood Cliffs (1978).
[5] Antoniou, Andreas. Digital filters: analysis, design, and signal processing applications. McGraw-Hill Education, 2018.
[6] Vogel, Michael, et al. "Real-time deepwater current profiling system." In MTS/IEEE Oceans 2001, vol. 1, pp. 269-274. IEEE, 2001.
[7] Akyildiz, Ian F., Dario Pompili, and Tommaso Melodia. "Underwater acoustic sensor networks: research challenges." Ad hoc networks 3, no. 3 (2005): 257-279.
[8] Vasilescu, Iuliu, et al. "Data collection, storage, and retrieval with an underwater sensor network." In Proceedings of the 3rd international conference on Embedded networked sensor systems, pp. 154-165. 2005.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: Understand basics of transducers and array systems used for sonar.
CO2: Comprehend the Signal processing, filtering and noise impact on sonar systems.
CO3: Classify sonar systems and modern versions.
CO4: Understand underwater sensor networks.

ECPE-421 ARRAY SIGNAL PROCESSING

Pre-requisite: Digital Signal Processing (ECPC 301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course explores techniques for signal detection, enhancement, and characterization using sensor arrays. It covers spatial sampling, beamforming for plane and spherical waves (near-field and far-field), and the application of detection and estimation theory to spatiotemporal filtering.

Course Contents:

UNIT I **10 hrs.**

Introduction: Signal Detection and Enhancement, Signal Characterization, Tracking, Filtering vs Parameter Estimation.

UNIT II **10 hrs.**

Apertures and Arrays: Finite continuous Apertures, Aperture Smoothing Function, Apparent Velocity, Aberrations, Co-Array for Continuous Apertures, Focusing, Spatial Sampling, Periodic Spatial sampling in One Dimension, Sampling of Multidimensional Signals, Arrays of Discrete Sensors, Regular Arrays, Grating Lobes, Irregular Arrays, Correlation sampling and the Co-Array, Sparse Linear Arrays, Random Arrays.

UNIT III **10 hrs.**

Beamforming: Delay-and-Sum Beamforming, Near-Field and Far-Field Sources, Beamforming for Plane Waves, Beamforming for Spherical Waves, Space-Time Filtering, Array Pattern, Plane wave (far-field) array pattern, Point Focusing (near-field) array pattern, wavenumber-Frequency Response, Beampattern and Steered Response, Filter-and-Sum Beamforming, Temporal Filtering, Spatial Filtering, Spatiotemporal Filtering, Frequency-Domain Beamforming, Array Gain, Resolution, Sampling in Time, Discrete-Time Beamforming, Averaging in Time and Space.

UNIT IV **10 hrs.**

Detection Theory: Elementary Hypothesis Testing, Hypothesis Testing in Presence of Unknowns, Detection of Signals in Gaussian Noise, Detection in Presence of Uncertainties, Detection-Based Array Processing Algorithms, Signals with Unknown Parameters.

Estimation Theory: Terminology in Estimation Theory, Parameter Estimation, Signal Parameter Estimation, Linear Signal Waveform Estimation, Spectral Estimation.

Text Book(s) / Reference(s):

[1] Array Signal Processing Concepts and Techniques Don H. Johnson and Dan E. Dudgeon, Prentice Hall Signal Processing Series, Alan V. Oppenheim, Series Editor

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

CO1: Analyze Spatial Sampling: Apply sampling theorems to continuous and discrete sensor configurations to calculate array patterns and eliminate spatial aliasing or grating lobes.
CO2: Design Beamformers: Design and evaluate delay-and-sum, filter-and-sum, and frequency-domain beamformers for both near-field spherical waves and far-field plane waves.
CO3: Implement Spatiotemporal Filters: Characterize multi-dimensional signals in the wavenumber-frequency domain to filter, enhance, and track target signals.
CO4: Apply Statistical Theory: Use hypothesis testing and parameter estimation algorithms to detect signals and determine direction-of-arrival (DOA) in noisy environments.

ECPE-422 OPTICAL SIGNAL PROCESSING

Pre-requisite: Digital Signal Processing (ECPC 301), Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
In this course, students will learn about various types of ultrafast All-Optical Signal Processing Devices, Principles of photonic devices used in optical signal processing, Semiconductor Optical Amplifier Based Ultrafast Signal Processing Devices and Wavelength Conversion Devices.

Course Contents:

UNIT I **10 hrs.**

Introduction: Evolution of Optical Communication Systems and Device Technologies, Increasing Communication Traffic and Power Consumption, Future Networks and Technologies, Ultrafast All-Optical Signal Processing Devices: Challenges, Basics of the Nonlinear Optical Process, Overview of the Devices and Their Concepts.

UNIT II **10 hrs.**

Principal Photonic Devices for Processing: Some Processor Components, Optical Amplifiers, Noise Considerations of EDFAs and Impact on System Performance, Optical Modulators, Lithium Niobate Optical Modulators, Electro-Absorption Modulators, Operational Principles and Transfer Characteristics, Modulation Characteristics and Transfer Function, Chirp in Modulators, Electro-Optic Polymer Modulators, Modulators for Photonic Signal Processing.

UNIT III **10 hrs.**

Semiconductor Optical Amplifier Based Ultrafast Signal Processing Devices: Fundamentals of SOA, SOA as an Ultrafast Nonlinear Medium, Use of Ultrafast Response Component by Filtering, Theoretical Background, Signal Processing Using the Fast Response Component of SOA, Symmetric Mach–Zehnder (SMZ) All-Optical Gate, Fundamentals of the SMZ All-Optical Gate, Technology of Integrating Optical Circuits for an SMZ All-Optical Gate, Optical Demultiplexing, Wavelength Conversion and Signal Regeneration.

UNIT IV **10 hrs.**

Wavelength Conversion Devices: Wavelength Conversion Schemes, Physics of Four-wave Mixing in LDs or SOAs, Wavelength Conversion of Short Pulses Using FWM in Semiconductor Devices, The Future View of Wavelength Conversion Using FWM, Summary and Future Prospects.

Text Book(s) / Reference(s):

[1] Ishikawa, Hiroshi, ed. Ultrafast all-optical signal processing devices. John Wiley & Sons, 2008.
[2] Binh, Le Nguyen. Photonic signal processing Techniques and Applications. Taylor & Francis, a CRC title, 2019.

Course Outcomes:

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

CO1: Understand basics of Non-linear optical processes and types of various types of ultrafast All-Optical Signal Processing Devices

CO2: Comprehend the basic principles of photonic devices used in optical signal processing strategies.

CO3: Understand basics of Semiconductor Optical Amplifier Based Ultrafast Signal Processing Devices

ECPE-423 MIMO SYSTEMS

Pre-requisite: Signals, Systems & Random Variables (ECPC 203), Communication Engineering (ECPC 205), Digital Communication (ECPC 210) and Information Theory and Coding (ECPC 212)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the course:
It is envisaged that the course will provide the fundamentals and basic concepts of SISO, MISO and MIMO wireless channels and their effect on the system performance.

Course Contents:

UNIT I **8 hrs.**

Introduction to multi antenna systems A comparative analysis of single antenna and multi antenna systems. Space time wireless channels systems, Shannon's capacity formula, and Extended Capacity formula for MIMO channels. Capacity of SIMO- MISO channels. Capacity with Rice and Rayleigh channels for multi antenna systems.

UNIT – II **12 hrs.**

Introduction to Space time coding Introduction, MIMO System and space time coding: Methodologies and diversity, Overview of diversity techniques of SIMO, MISO and MIMO systems. Space time block codes: Alamouti transmit technique, orthogonal space time block codes. Space time trellis codes: Encoding and decoding, Performance analysis and code design. Spatial multiplexing: V-Blast Algorithm, Space time coding with CSI knowledge, no CSI knowledge and partial CSI knowledge at the transmitter.

UNIT - III **10 hrs.**

Feedback Techniques and Antenna Selection in MIMO Systems Feedback Techniques introduction, Limited feedback MIMO: System Description, channel quantization, quantized signal adaptation, Quantized signal Adaptation algorithms: Beam forming example, precoded orthogonal space time block codes, precoded spatial multiplexing. Antenna Selection: Implementing Antenna Selection: Criteria and Algorithms, Performance with non- idealities. Antenna selection with spatial correlation.

UNIT – IV

10 hrs.

Real Time MIMO Signal Processing and General Issues Implementation Concept, Channel Estimation, Adaptation to time variant channel, Data Reconstruction.

Implementation, Complexity and system integration. Issues: Network planning: Introduction to network planning. Coverage and capacity enhancement methods. Base stations with downlink transmit diversity and beam forming, Deployment, Smart Antenna Planning Example.

Text Books / Reference:

[1] George Tsoulos; MIMO System Technology for wireless communications, Taylor & Francis Group.

[2] Claude Oestges, Bruno Clerckx; MIMO wireless communications: from real world propagation to space time coding design, Elsevier

[3] Volker Kuhn,Wireless Communication over MIMO Channels, John Wiley.

Course Outcomes:

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

CO1: Understand the basics of wireless channels, SIMO, MISO, MIMO systems, and different diversity schemes.

CO2: Apply different diversity techniques to compute system performance.

CO3: Classify and analyse different antenna selection algorithms for MIMO systems.

CO4: Apply network planning to enhance coverage and capacity.

ECPE-424 OPTICAL WIRELESS TECHNIQUES FOR IOT & 5G/6G SYSTEMS

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Optical Wireless Communications (OWC) has become a promising technology for supporting high-data-rate 5G communication and the massive connectivity of IoT. This course broadly covers the four important aspects of OWC systems: (a) the fundamental principles of OWC, (b) devices and systems, (c) modulation techniques and (d) channel models and system performance analysis.

Course Contents:

UNIT I **10 hrs.**

Introduction – Optical Wireless Communication Systems: Existing wireless systems, OWC/Radio Comparison, Potential OWC Application Areas.

Optical Sources: LEDs and Lasers (Internal and External Quantum Efficiency, Power and Luminesce Efficiency and modulation bandwidth).

Detectors: PIN and APD detectors, photo detection techniques, photo detection noise.

UNIT II **10 hrs.**

Indoor Optical Wireless Communication Channel modelling: LOS propagation model, Non-LOS propagation model, Interference from other light sources.

Outdoor Optical Wireless Communication Channel modelling: Atmospheric channel loss, Beam divergence, Pointing loss, Different atmospheric turbulence models.

Underwater Optical Wireless Communication Channel modelling: Absorption, scattering, turbulence, multipath interference, physical obstruction and background noise.

UNIT III **10 hrs.**

Modulation schemes: Digital baseband modulation techniques like PPM, PAM, PIM etc., Multi-Carrier Modulation (OFDM) for OWC, Color shift keying, NOMA etc.

System performance analysis - indoor OWC: Effect of ambient light sources on indoor OWC performance, link performance for multipath propagation

UNIT IV **10 hrs.**

System performance analysis - outdoor OWC: FSO link performance under effect of atmospheric turbulence, atmospheric turbulence induced penalty and mitigation strategies.

Use cases and simulation exercises: Indoor OWC link, O-OFDM and CSK-modulation schemes, Wifi-Lifi coexistence, V2V Communications

Text Book(s) / Reference(s):

[1] Keiser, Gerd. Optical communications essentials. McGraw-Hill Education, 2003.
[2] Ghassemlooy, Zabih, Luis Nero Alves, Stanislav Zvanovec, and Mohammad-Ali Khalighi, eds. Visible light communications: theory and applications. CRC press, 2017.
[3] Ghassemlooy, Zabih, Wasiu Popoola, and Sujan Rajbhandari. Optical wireless communications: system and channel modelling with Matlab. CRC press, 2019.
[4] Majumdar, Arun K., and Jennifer C. Ricklin, eds. Free-space laser communications: principles and advances. Vol. 2. Springer Science & Business Media, 2010.

Course Outcomes:

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

CO1: Identify types of light sources, their structures and optical characteristics

CO2: Understand process of photo-detection, including different type of encountered noise in photo-detection and statistics of optical detection process

CO3: Learn characteristics of channel impulse response for indoor, outdoor and underwater to enable efficient design of OWC systems.

CO4: Select and implement appropriate modulation techniques for indoor/outdoor OWC in terms of power and bandwidth efficiency.

CO5: Learn different OWC use cases in context of 5G/6G and IoT systems including design considerations and performance parameters

ECPE-425 DEEP LEARNING FOR ADVANCED COMMUNICATION SYSTEMS

Pre-requisite: Communication Engineering (ECPC 205), Machine Learning & Data Analytics (CSIC 221)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The purpose of this course is to make students aware of the applications of machine learning and deep learning in various fields of communication systems.

Course Contents:

UNIT I **10 hrs.**

Machine and Reinforcement Learning for Resource Allocation in Cognitive Radio Networks: Use of Q-Learning for Cross-layer Resource Allocation, Deep Q-Learning and Resource Allocation, Cooperative Learning and Resource Allocation, Decentralized Resource Minimization, Resource Minimization Approaches, Optimized Allocation

UNIT II **10 hrs.**

Related Machine Learning Techniques for Autonomous Network Management, Data-Driven Base-Station Sleeping Operations by Deep Reinforcement Learning, Deep Q-Learning Preliminary and its Applications to BS Sleeping Control, Dynamic Frequency Reuse through a Multi-Agent Neural Network Approach

UNIT III **10 hrs.**

Machine Learning–Based Adaptive Modulation and Coding (AMC) Design: Overview of ML-Assisted AMC, k-NN-Assisted AMC, Algorithm for k-NN-Assisted AMC, Performance Analysis of k-NN-Assisted AMC System, RL-Assisted AMC

UNIT IV **10 hrs.**

Machine Learning for Joint Channel Equalization and Signal Detection: Overview of Neural Network-Based Channel Equalization, Multilayer Perceptron-Based Equalizers, Functional Link Artificial Neutral Network-Based Equalizers, Radial Basis Function-Based Equalizers, Deep-Learning-Based Equalizers

Text Book(s) / Reference(s):

[1] Fa-Long Luo, "Machine Learning for Future Wireless Communications", John Wiley and Sons, 2020.
[2] Ruisi He, Z Ding, "Applications of Machine Learning in Wireless Communications", IET, 2019 (Volume 81 of Telecommunications Series).
[3] K. K. Singh, A. Singh, K. Cengiz, Dac-Nhuong Le, "Machine Learning and Cognitive Computing for Mobile Communications and Wireless Networks", Wiley 2020.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Design machine learning algorithms for spectrum access and sharing
CO2: Design reinforcement algorithms for resource allocation
CO3: Design deep learning algorithms for optimizing coverage and channel capacity
CO4: Apply machine learning algorithms for optimizing energy efficiency, modulation, coding, channel equalization and signal detection

ECPE-426 SPACE-TIME CODING

Pre-requisite: Communication Engineering (ECPC 205), Information Theory and Coding (ECPC 212)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
Space time coding provides the fundamental principles of space-time coding for wireless communications over multiple-input multiple-output (MIMO) channels. This course introduces the design criteria for space-time codes and contains a detailed treatment of the theory behind space-time block codes and space-time trellis codes. The course also includes practical coding methods for achieving the performance improvements of MIMO communication systems. The students will learn the theory behind space time coding and the design techniques for orthogonal and pseudo orthogonal space time codes, space time trellis codes and differential space time modulation methods with real world examples.

Course Learning Objectives:
To understand the concept of coding for MIMO systems, Design of Orthogonal Space-Time Block Codes and Space-Time Trellis Codes for applications in wireless communication.

Course Content:

UNIT I **10 hrs.**

Orthogonal Space-Time Block Codes: Spatial multiplexing gain and its trade-off with diversity. Transmission model for multiple-input multiple-output channels. Capacity of MIMO channels. Space-time code design criteria: Rank and determinant criteria, Trace criterion, Maximum mutual information criterion. Orthogonal space-time block codes. Alamouti code, Real and complex orthogonal designs.

UNIT II **10 hrs.**

Pseudo-Orthogonal and Quasi-Orthogonal Space-Time Block Codes: Pseudo-orthogonal space-time block codes, Quasi-orthogonal space-time block codes. Pairwise decoding, Rotated QOSTBCs, Optimal rotation and performance of QOSTBCs, Other examples of QOSTBCs, QOSTBCs for other than four transmit antennas.

UNIT III **10 hrs.**

Space-Time Trellis Codes: Introduction to Space-time trellis codes, Improved STTCs, Performance analysis of STTCs, Super-orthogonal space-time trellis codes, CGD

analysis, Encoding and decoding, Performance analysis of super-orthogonal space-time trellis codes Extension to more than two antennas.

UNIT IV **10 hrs.**

Differential Space-Time Modulation and Non-Orthogonal STBCs: Introduction to Differential space-time modulation, Differential encoding and decoding, Extension to more than two antennas. Non-orthogonal space-time block codes, Linear dispersion space-time block codes, Space-time block codes using number theory, Threaded algebraic space-time codes. Implementation of space-time codes in real systems and case studies.

Text Book(s) / Reference(s):

[1] Hamid Jafarkhani, Space-Time Coding: Theory and Practice, Cambridge University Press, 2005.
[2] Erik G. Larsson, Petre Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2008.
[3] M. Jankiraman, Space-Time Codes and MIMO Systems, Artech House, 2004.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: Understand the concept of coding for MIMO systems.
CO2: Analyse the requirement of coding and apply the concept of channel coding for improvement in the performance of the system.
CO3: Understand and design the orthogonal space-time block codes.
CO4: Understand and design the Space-time trellis codes.
CO5: Understand various variants of Space-time codes and apply them.

ECPE-427 OPTICAL NETWORKING AND SWITCHING

Pre-requisite: Fields and Waves (ECPC-204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
To equip students with understanding of Optical Networking and Switching systems. To study the enabling devices used in the networks and the different types of optical networks. Study the algorithms used for routing and access of networks. Management and control issues in optical networks.

Course Content:

UNIT I **10 hrs.**

Telecom network architecture, Advantages of optical network, Optical network evolution, WDM optical networks, Different types of WDM networks, broadcast and select optical WDM network, wavelength routed optical WDM network, Challenges of optical WDM network. Optical network enabling technologies and devices: Optical transmitters, tunable and fixed laser, Optical receivers, tunable and fixed optical filters, optical amplifiers; EDFA, Raman amplifier, SOA, MUX-DEMUX, OADM, OXC, large optical switching fabric architectures, wavelength convertors.

UNIT II **10 hrs.**

Broadcast and Select Networks: single and multi-hop networks, Media-access control protocol, LAMBDANET, STARNET, Rainbow, Shufflenet, De Bruijn Graph, Hypercube. Introduction to access network, Gig Ethernet, Radio over Fiber network, different optical access networks; EPON and WDM EPON; WRPON, Access algorithms, STARGATE.

UNIT III **10 hrs.**

Introduction to metro network, traffic grooming overview, static and dynamic traffic grooming. Traffic grooming in SONET ring and WDM ring, ATM, IP, SONET/SDH layers, RINGOSTAR. Introduction to Wavelength Routing Network, Problem formulation, routing sub-problem: routing algorithms, wavelength assignment subproblem, algorithms, Virtual topology design, ILP formulation.

UNIT IV **10 hrs.**

Optical packet switching, header and packet format, contention resolution in OPS networks, OPS node architecture, optical burst switching, signaling and routing protocols for OBS networks, contention resolution in OPS networks, implementation and application. MEMs based switching, switching with SOAs, lambda switches.

Control and Management functions in optical networks, configuration management, performance management, Fault management

Text Book(s) / Reference(s):

[1] Mukherjee, Biswanath. Optical WDM networks. Springer Science & Business Media, 2006.
[2] Ramaswami, Rajiv, Kumar Sivarajan, and Galen Sasaki. Optical networks: a practical perspective. Morgan Kaufmann, 2009.
[3] Stern, Thomas E., Georgios Ellinas, and Krishna Bala. Multiwavelength optical networks: architectures, design, and control. Cambridge University Press, 2009.
[4] Maier, Martin. Optical switching networks. Cambridge University Press, 2008.
[5] Murthy, C. Siva Ram, and Mohan Gurusamy. WDM optical networks: concepts, design, and algorithms. Prentice Hall, 2002.

Course Outcomes:

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

CO1: Identify different types of networks, the enabling technologies and devices.

CO2: Understand Broadcast and Select network, Single and Multi-hop networks with example of Access networks, PONS etc

CO3: Learn Wavelength Routing network, virtual topology, Metro and Wide area networks.

CO4: Understand Wavelength Routing and Assignment, Traffic Grooming and Protection, Network Control and Management, Optical packet and burst switching, Network Simulation Tools and Design guidelines.

ECPE-428 WAVELETS

Pre-requisite: Digital Signal Processing (ECPC 301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
The course covers Continuous and Discrete Wavelet Transforms (CWT and DWT), multiresolution analysis, and applications such as noise reduction and image compression.

Course Contents:

UNIT I **10 hrs.**
Fourier Transform: Continuous and discrete Fourier transforms, Fourier series, Properties of Fourier transforms.

UNIT II **10 hrs.**
Time-Frequency Analysis: Short-time Fourier transform (STFT), Spectrogram analysis.

UNIT III **10 hrs.**
Introduction to Wavelets: Motivation for wavelet analysis, Comparison with Fourier analysis, Basic concepts and definitions.

UNIT IV **10 hrs.**
Wavelet Transforms, Families, Properties and Applications: Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Multi-resolution analysis, Haar wavelets, Daubechies wavelets, Symlet wavelets, Biorthogonal wavelets, Orthogonality and biorthogonality, Scaling and translation, Dilations and wavelet functions, Signal denoising, Compression, Image processing, Audio processing.

Text Book(s) / Reference(s):
[1] Image Processing and Analysis: Variational, PDE, Wavelet, and Stochastic Methods by Tony F. Chan and Jianhong (Jackie) Shen (2005).
[2] Digital Signal Processing: Principles, Algorithms, and Applications by John G. Proakis, Dimitris G. Manolakis (relevant for DWT/CWT foundations).

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the fundamental concepts of time-frequency analysis and the limitations of Fourier analysis.
CO2: Comprehend the mathematical foundations of Continuous and Discrete Wavelet Transforms (CWT and DWT).

CO3: Apply multiresolution analysis techniques to signals using specific wavelets like the Haar wavelet.
CO4: Implement wavelet-based solutions for practical engineering problems such as noise reduction and image compression.

ECPE-429 SATELLITE COMMUNICATION

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
To understand the concepts and issues related to earth and space segments of satellite communication, analyse the performance of satellite links, and learn about the future space technologies.

Course Content:

UNIT I **8hrs.**

Overview of Space and Satellite: Some basic definitions, brief history, present status, and future trends of satellite communication. Types of orbits, active and passive satellites, synchronous satellite. Satellite frequency allocations and band spectrum. Technical characteristics of a satellite communication system, advantages of satellite communication.

UNIT II **12 hrs.**

Communication Satellite Link Design: Satellite link attributes, satellite link analysis: path loss, losses in troposphere and atmosphere, modelling rain absorption, ionospheric losses, antenna misalignment loss. Concept of noise temperature, rain fading in terms of noise temperature, noise models, reducing noise effects in a receiving system. Carrier to noise ratio and G/T of a receiving system. Analog link and digital link design.

UNIT III **12 hrs.**

Satellite Access: Types of multiple access, time division multiple access (TDMA), frequency division multiple access (FDMA), code division multiple access (CDMA), space division multiple access (SDMA). Demand assignment multiple access technique.

UNIT IV **8 hrs.**

Satellites Applications: Applications of satellites in different areas: Remote-sensing satellite, Meteorological satellites, Global positioning satellite, scientific research satellites, communication satellites. Currently used satellites in defense services.

Text Book(s) / Reference(s):

[1] Dennis Roddy "Satellite Communications," McGraw-Hill.
[2] Tri T. Ha, "Digital Satellite Communications," Tata McGraw-Hill.
[3] D. C. Agarwal and A. K. Maini, "Satellite Communications," Khanna Publications.
[4] K. N. Raja Rao, "Fundamentals of Satellite Communications," PHI learning.
[5] R. R. Gulati, "Composite Satellite and Cable Television," New Age International

Course Outcomes:

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

CO1: Understand the configuration of the satellite communication system and satellite orbits.

CO2: Analyze the satellite link performance under different conditions.

CO3: Learn about various subsystems of earth stations and satellites.

CO4: Comprehend the techniques for TMMA, FDMA, SDMA and challenges of the space environment.

CO5: Analyze the requirements of satellites for different fields of applications.

ECPE-430 PATTERN RECOGNITION

Pre-requisite: Machine Learning and Data Analytics (CSIC 221)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Learning Objectives:
The student should be able to understand and apply the various concepts of Pattern recognition and machine learning.

Brief Description:
This course provides an introduction to the fundamental principles of automated pattern recognition and data classification. It includes topics like feature extraction, supervised and unsupervised learning, and various decision-making models used to identify structures or regularities in complex datasets.

Course Content:

UNIT I **10 hrs.**

Polynomial Curve Fitting, Probability Theory Model Selection, The Curse of Dimensionality, Decision Theory, Information Theory, Probability Distributions, Binary Variables, Multinomial Variables, The Gaussian Distribution, The Exponential Family, Nonparametric Methods, Linear Models for Regression, Linear Basis Function Models, The Bias-Variance Decomposition, Bayesian Linear Regression, Bayesian Model Comparison, Linear Models for Classification, Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Models, Bayesian Logistic Regression.

UNIT II **10 hrs.**

Network Training, Error Backpropagation, The Hessian Matrix, Regularization in Neural Networks, Mixture Density Networks, Bayesian Neural Networks Dual Representations, Constructing Kernels, Radial Basis Function Networks, Gaussian Processes, Bayesian Networks, Conditional Independence, Markov Random Fields, Inference in Graphical Models.

UNIT III **10 hrs.**

Mixture Models and EM, K-means Clustering, Mixtures of Gaussians, The EM Algorithm in General, Approximate Inference, Sampling Methods, Basic Sampling Algorithms, Markov Chain Monte Carlo, Gibbs Sampling. Principal Component Analysis, Probabilistic PCA, Kernel PCA, Nonlinear Latent Variable Models, Sequential Data, Markov Models, Hidden Markov Models, Linear Dynamical Systems.

UNIT IV **10 hrs.**

Combining Models, Bayesian Model Averaging, Committees, Boosting, Tree-based Models, Conditional Mixture Models. Application of pattern recognition in biometric recognition systems, character/digit recognition etc.

Text Book(s) / Reference(s):

[1] C. M. Bishop, Pattern Recognition and machine learning, springer, 2006.
[2] Duda, Hart and Stork, Pattern Classification, Wiley 2006.
[3] Tom M. Mitchell, Machine Learning, Mc Graw-Hill, 1997.

Course Outcomes:

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

CO1: Develop the understanding about fundamentals of pattern recognition and machine learning.
CO2: Apply supervised and unsupervised learning techniques.
CO3: Understand and apply SVM and graphical models.
CO4: Understand different clustering techniques.

ECPE-431 WIRELESS NETWORK SECURITY

Pre-requisite: Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
The aim of the course is to develop an understanding of security threats in wireless networks. Furthermore, the course aims to help the student to develop knowledge of encryption methods and security protocols that are applied in next generation wireless networks to reduce the probability of a successful attack.

Course Contents:

UNIT I **10 hrs.**

Introduction to Wireless Network Security: General Computer Communication Network Architecture, Different Types of Wireless Communication Systems, Network Security and Wireless Security, Basic Network Security Concepts: Security Attacks, Security Services, Security Mechanisms, Cryptographic Systems: symmetric and asymmetric key cryptography, MAC and Hash functions, digital signatures and key management.

UNIT II **8 hrs.**

Security for Wireless Local Area Networks, WLAN Security, Introduction to WLAN, Evolution of WLAN Security, Wired Equivalent Privacy, IEEE 802.1X Authentication Model, IEEE 802.11 security Standards.

UNIT III **12 hrs.**

Security for Next Generation Wireless Networks, IoT security, Attacks on different layers, IoT security issues and challenges, light weight cryptography for resource constrained devices, Security in 5G Wireless Networks, Introduction to 5G Wireless Network Systems, 5G Security Requirements and Major Drives, 5G Wireless Security Architecture, 5G Wireless Security Services, 5G Key Management, Security for New Communication Techniques in 5G, Challenges and Future Directions for 5G Wireless Security

UNIT IV **10 hrs.**

Bluetooth, RFID and Zigbee security, Concept of Physical layer security, Block chains, their application and limitations, cloud security, Case studies

Text Book(s) / Reference(s):

[1] "Wireless Network Security" Osterhage Wolfgang, Taylor & Francis Ltd, 2nd Ed 2018

[2] "Security in Wireless Communication Networks" Qian, Y., Ye, F. and Chen, H.-H. (2022). https://doi.org/10.1002/9781119244400.fmatter, Wiley
[3] B. A. Forouzan, "Cryptography & Network Security", Tata Mc Graw Hill.
[4] W. Stallings, "Cryptography and Network Security", Pearson Education.

Course Outcomes:

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

CO1: Understand the various security issues in wireless networks

CO2: Implement security mechanisms and protocols in wireless communication networks.

CO3: Comprehend and analyze the design principles, mechanisms, and solutions used in wireless network security

CO4: Analyze security challenges in resource constrained devices and future wireless networks

ECPE-432 EMBEDDED SYSTEM SECURITY

Pre-requisite: Embedded System Fundamentals (ECPE 322)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
In this subject, the background, foundation and basic approaches in Embedded Systems security is covered. It also introduces embedded security issues. It includes security major concerns data, design and system protection. The learning of cryptographic concepts in the context of embedded systems and their unique constraints and requirements is done.

Course Content:

UNIT I **10 hrs.**

Introduction to Embedded Systems Security: Security, Identification, Authentication and Authorization, Embedded System Security Requirements and issues, Embedded Security Trends, Security Policies, Security Threats.

UNIT II **10 hrs.**

Systems Software Considerations: The Role of the Operating System, Embedded Software attack and counter-measures, Multiple Independent Levels of Security, Microkemel versus Monolith, Core Embedded Operating System Security Requirements, Access Control and Capabilities, Hypervisors and System Virtualization, I/O Virtualization, Remote Management, Assuring Integrity of the TCB.

UNIT III **8 hrs.**

Secure Embedded Software Development: Introduction to PHASE-Principles, Minimal Implementation, Secure Development Process, Independent Expert Validation, Model-Driven Design.

UNIT IV **12 hrs.**

Embedded Cryptography: The One-Time Pad, Cryptographic Modes, Block Ciphers, Authenticated Encryption, Secret key Cryptography- DES, AES, Public Key Cryptography, Key Agreement, Public Key Authentication, Elliptic Curve Cryptography, Cryptographic Hashes, Message Authentication Codes, Random Number Generation, Key Management for Embedded Systems, Cryptographic Certifications, AES.

Text Book(s) / Reference(s):

[1] Embedded Systems Security: Practical Methods for Safe and Secure Software and Systems Development- David Kleidermacher, Mike Kleidermacher, Publisher Newnes.

[2] Practical Embedded Security: Building Secure Resource Constrained Systems - Timothy Stapko, Publisher Newnes.
[3] Cryptography: Theory and Practice - 3rd Ed. SD Stinson, CRC Press.

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Have a comprehensive overview of Embedded System security.
CO2: Develop an understanding as to why security and its management are important for any modern organization.
CO3: Understand how an Embedded System security management system should be planned, documented, implemented and improved.

ECPE-433 CYBER SECURITY

Pre-requisite: Cryptography (ECPE 327)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
This course is required to create architectural, algorithmic and technological foundations for ensuring cyber security, maintenance of the privacy of individuals, the confidentiality of organizations, and the protection of sensitive information, despite the requirement that information be released publicly or semi-publicly.

Course Contents:

UNIT I **12 hrs.**

Basic Cyber Security Concepts: Introduction to Cyber Security, layers of security, Vulnerability, threat, Harmful acts, Internet Governance – Challenges and Constraints, Computer Criminals, CIA Triad, Assets and Threat, motive of attackers, active attacks, passive attacks, Software attacks, hardware attacks, Spectrum of attacks, Taxonomy of various attacks, IP spoofing, Methods of defense, Security Models, risk management, Cyber Threats-Cyber Warfare, Cyber Crime, Cyber terrorism, Cyber Espionage, etc., Comprehensive Cyber Security Policy, Nodal Authority, International convention on Cyberspace.

UNIT II **10 hrs.**

Cyber Security Vulnerabilities and Cyber Security Safeguards: Cyber Security Vulnerabilities – Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Poor Cyber Security Awareness. Cyber Security Safeguards – Overview, Access control, Audit, Authentication, Biometrics, Cryptography, Deception, Denial of Service Filters, Ethical Hacking, Firewalls, Intrusion Detection Systems, Response, Scanning, Security policy, Threat Management.

UNIT III **9 hrs.**

Cyber Forensics: Introduction to Cyber Forensics, Handling Preliminary Investigations, controlling an Investigation, conducting disk-based analysis, Investigating Information-hiding, Scrutinizing E-mail, Validating E-mail header information, Tracing Internet access, Tracing memory in real-time.

UNIT IV **9 hrs.**

Legal and Ethical Issues: Cybercrime and computer crime, Cyber Warfare, Cyber terrorism, Cyber Espionage, Intellectual property, copyright, patent, trade secret,

Hacking and intrusion, Cyber laws, Roles of International Law, Privacy, identity theft, National Cyber Security Policy.

Text Book(s) / Reference(s):

[1] B. Raghunathan, The Complete Book of Data Anonymization: From Planning to Implementation, Auerbach Pub, 2013.
[2] L. Sweeney, Computational Disclosure Control: A Primer on Data Privacy Protection, MIT Computer Science, 2002.
[3] B. B. Gupta, D. P. Agrawal, Haoxiang Wang, Computer and Cyber Security: Principles, Algorithm, Applications, and Perspectives, CRC Press, ISBN 9780815371335, 2018.
[4] Raef Meeuwisse, Cyber Security for Beginners, Cyber Simplicity Ltd., 2017.
[5] William Stallings, "Cryptography and Network Security: Principles and Practice.", PrenticeHall.
[6] William R. Cheswick and Steven M. Bellovin, "Firewalls and Internet Security: Repelling the Wily Hacker", Addison-Wesley.
[7] Charles P. Pfleeger, "Security in Computing", Pearson Education.
[8] Edward Amoroso, "Fundamentals of Computer Security Technology", Prentice-Hall.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: To understand cyber security concepts.
CO2: Analyse Cyber Security Vulnerabilities and Cyber Security Safeguards
CO3: Study of Cyber Forensics
CO4: Study of Legal and Ethical Issues of cyber security

ECPE-434 SATELLITE IMAGE PROCESSING

Pre-requisite: Digital Signal Processing (ECPC 301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
This course introduces the basics of remote sensing and the digital fundamentals of satellite imagery. Students learn about image preprocessing (radiometric and geometric corrections), spatial domain enhancement techniques, and advanced topics like hyperspectral image processing and SAR (Synthetic Aperture Radar) data fusion.

Course Content:

UNIT I **10 hrs.**

Introduction to Remote Sensing: Basics of remote sensing, Types of satellite sensors, Applications of satellite imagery.

Digital Image Fundamentals: Image representation and characteristics, Image acquisition and resolution, Color models in satellite imagery.

UNIT II **10 hrs.**

Image Preprocessing: Radiometric and geometric corrections, Atmospheric correction, Noise reduction techniques.

Image Enhancement: Histogram equalization, Contrast stretching, Spatial domain enhancement techniques.

UNIT III **10 hrs.**

Image Classification: Supervised and unsupervised classification, Image segmentation, Feature extraction for classification.

UNIT IV **10 hrs.**

Geospatial Analysis: Geographic Information Systems (GIS), Integration of satellite imagery with GIS, Spatial analysis techniques.

Change Detection: Techniques for detecting changes over time, Applications of change detection in satellite imagery, Accuracy assessment in change detection.

Advanced Topics in Satellite Image Processing: Hyperspectral image processing, SAR (Synthetic Aperture Radar) image processing, Fusion of different sensor data.

Text Book(s) / Reference(s):

[1] Image Analysis, Classification and Change Detection in Remote Sensing: With Algorithms for ENVI/IDL and Python by Morton J. Canty (2018).

[2] Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods (2018) (Standard text for fundamental image processing concepts).

Course Outcomes:

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

CO1: Understand the basics of remote sensing, including satellite sensors and their diverse applications.

CO2: Perform image preprocessing, including radiometric, geometric, and atmospheric corrections to improve data quality.

CO3: Apply various image enhancement and classification techniques (supervised and unsupervised) for feature extraction.

CO4: Integrate satellite imagery with Geographic Information Systems (GIS) for spatial analysis and change detection.

ECPE-435 QUANTUM COMPUTING

Pre-requisite: Applied Linear Algebra (MAIC 204)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
This course provides a review of quantum mechanics and its motivation for computation, including multi-qubit states and the Bloch sphere representation. It explores quantum protocols like teleportation, universal gates, and specialized algorithms such as Deutsch-Josza and Shor's prime factoring.

Course Contents:

UNIT I **10 hrs.**

Review of Quantum Mechanics and Motivation for Quantum Computation, Qubit: The qubit state – matrix and Bloch sphere representation – computational basis – unitary evolution, multi-qubit states – No cloning theorem – Superdense coding – Pure states to Bell states – Bell inequalities.

UNIT II **10 hrs.**

Protocols with multi-qubits: Swapping – Teleportation – gates: CNOT – Toffoli gate – NAND – FANOUT – Walsh Hadamard, Measurement: Projective operators – General, Projective and POVM measure, Ensemble: Density operators – pure and mixed ensemble – time evolution.

UNIT III **10 hrs.**

Composite systems: Partial trace – Reduced density operator – Schmidt decomposition – Purification – bipartite entanglement. Classical computing using qubits – Quantum parallelism – Deutsch's algorithm – Deutsch Josza algorithm, Quantum circuits: Basic gates – ABC decomposition – Gray codes – Universal gates, discrete logarithm, Role of prime factoring in classical cryptography, search algorithms.

UNIT IV **10 hrs.**

Quantum error correcting codes, Physical realization of qubits

Text Book(s) / Reference(s):

[1] Quantum Computation and Quantum Information, M.A. Nielsen and I.L. Chuang, Cambridge University Press.
[2] Quantum Information and Computation, CIT Lecture Notes by J. Preskill
[3] Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand quantum computing
CO2: Analyse the qubits
CO3: Evaluate the performance of quantum computing systems
CO4: Application of quantum error codes

ECPE-436 6G NETWORKS

Pre-requisite: Microwave Theory and Devices (ECPC 310), Communication Engineering (ECPC 205)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Course Description:
This course covers the principles and applications of 6G networks. Topics include the requirements and challenges for 6G networks, key technologies such as terahertz communication, AI-based networking, and new network architectures, and their applications in various domains.

Course Contents:

UNIT I **10 hrs.**

Introduction to 6G Networks, Historical background and motivation for 6G networks, Overview of 6G network requirements and challenges, Terahertz Communication for 6G Networks, Principles of terahertz communication, Design of terahertz communication systems

UNIT II **10 hrs.**

Artificial Intelligence-based Networking for 6G Networks, Principles of AI-based networking, Design of AI-based networking systems, New Network Architectures for 6G Networks, Principles of new network architectures (e.g., cell-free networks, network slicing), Design of new network architectures for 6G networks

UNIT III **10 hrs.**

Applications of 6G Networks in Different Domains, Applications of 6G networks in healthcare, transportation, and smart cities, Case studies of 6G networks in different domains, Advanced Topics in 6G Networks, Intelligent edge computing for 6G networks, Quantum communication for 6G networks, Distributed ledger technology for 6G networks

UNIT IV **10 hrs.**

Performance Analysis of 6G Networks, Metrics and performance evaluation of 6G networks, Interference analysis and mitigation techniques for 6G networks, Future Directions in 6G Networks, Emerging trends in 6G networks research, Potential impact of 6G networks on society and the economy

Text Book(s) / Reference(s):

[1] "6G Technology: Performance, Applications, and Challenges" by Mohammad Patwary, Mohammad Alamgir Hossain, and Atiqur Rahman

[2] "6G Wireless Communications: Vision and Potential Techniques" by Muhammad Zeeshan Shakir, Bilal Muhammad, and Halim Yanikomeroglu
[3] "6G Mobile Networks: Vision, Requirements and Challenges" edited by Sudhir Dixit, Ramjee Prasad, and Johan Torsner

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the 6G networks
CO2: Understand the artificial Intelligence-based Networking for 6G Networks.
CO3: Understand the applications of 6G Networks in Different Domains
CO4: Find the future Directions in 6G Networks.

ECPE-437 CLOUD COMPUTING

Pre-requisite: Computer Networks (ECPC 308)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description of the Course:
This subject provides end-to-end coverage of cloud computing topics, focusing on both technical underpinnings and business considerations. It covers the evolution of computing paradigms (grid, cluster, utility), data center architecture, and challenges like resource management, security, and Quality of Service (QoS).

Course Content:

UNIT I **10 hrs.**

Introduction and Evolution of Computing Paradigms: Overview of Existing Hosting Platforms, Cluster Computing, Grid Computing, Utility Computing, Autonomic Computing, mesh, Introduction to Cloud Computing, Cloud Computing history and evolution, practical applications of cloud computing for various industries, economics and benefits of cloud computing.

Cloud Issues and Challenges: Cloud computing issues and challenges like Security, Elasticity, Resource management and scheduling, QoS (Quality of Service) and Resource Allocation, Cost Management, Big Data.

UNIT II **10 hrs**

Data Center: Classic Data Center, Virtualized Data Center (Compute, Storage, Networking and Application), Business Continuity in VDC.

Cloud Computing Architecture: Cloud Architecture model, Types of Clouds: Public Private & Hybrid Clouds, Cloud based services: Iaas, PaaS and SaaS. Core IoT Functional Stack, Fog, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors, Actuators, Smart Objects and Connecting Smart Objects.

UNIT III **10 hrs.**

Classification of Cloud Implementations: Amazon Web Services, The Elastic Compute Cloud (EC2), The Simple Storage Service (S3), The Simple Queuing Services (SQS), Google AppEngine - PaaS, Windows Azure, Aneka, A Comparison of Cloud Computing Platforms.

Virtualization: Virtualization, Advantages and disadvantages of Virtualization, Types of Virtualization: Resource Virtualization i.e. Server, Storage and Network virtualization, Migration of processes, VMware vCloud – IaaS.

UNIT IV **10 hrs.**

Cloud based Data Storage: Introduction to Map Reduce for Simplified data processing on Large clusters, Design of data applications based on Map Reduce in Apache Hadoop, Task Partitioning, Data partitioning, Data Synchronization, Distributed File system, Data Replication, Shared access to weakly consistent to data stores.

Introduction to Python Runtime Environment: The Datastore, Development Workflow.

Applications & Case Study: Real world design constraints, Applications, Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities, participatory sensing. Data Analytics for IoT. Software & Management Tools for IoT Cloud Storage Models & Communication APIs. Cloud for IoT: Amazon Web Services for IoT.

Text Book(s) / Reference(s):

[1] Cloud Computing: A practical Approach Anthony Velte, Toby Velte and Robert Elsenpeter by Tata McGrawHill

[2] Cloud Computing Principles and Paradigms, Rajkumar Buyya, James Broberg and Goscinski by John Wiley and Sons

[3] Raj Kumar Buyya, James Broberg, Andrezei M. Goscinski, Cloud Computing: Principles and Paradigms, 2011

[4] Michael Miller, Cloud Computing, 2008

[5] Judith Hurwitz, Robin Bloor, Marcia Kaufmann, Fern Halper, Cloud computing for Dummies, 2009

[6] Granjal, J., Monteiro, E., & Silva, J. S. (2015). Security for the internet of things: a survey of existing protocols and open research issues. IEEE Communications Surveys & Tutorials, 17(3), 1294-1312.

Course Outcomes:

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

CO1: Analyze the evolution of computing paradigms and identify the economic benefits and practical applications of cloud computing.

CO2: Understand and address technical challenges in cloud environments, including resource management, security, and Quality of Service (QoS).

CO3: Evaluate and compare different cloud architectures (Public, Private, Hybrid) and service models (IaaS, PaaS, SaaS).

CO4: Implement and manage virtualization technologies and data storage solutions like MapReduce and Hadoop for simplified large-scale data processing.

ECPE-438 SOFT COMPUTING & EXPERT SYSTEMS

Pre-requisite Machine Learning and Data Analytics (CSIC 221)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course covers fundamental concepts used in Soft computing, including the concepts of Fuzzy logic (FL), Artificial Neural Networks (ANNs), and optimization techniques using Genetic Algorithm (GA). Applications of Soft Computing techniques to solve a number of real-life problems are also covered.

Course Contents:

UNIT I **10 hrs.**

Fundamentals: Concept of computing systems, "Soft" computing versus "Hard" computing, Neurons and neural networks, Artificial neural networks: single-layer perceptron, multilayer perceptron, Back propagation, modifications to back-propagation, Radial basis function networks, Recurrent neural networks, Training of neural network, Applications of neural networks.

UNIT II **10 hrs.**

Fuzzy Logic: Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Fuzzy relations, rules, propositions, implications and inferences, Defuzzification techniques, Fuzzy logic controller design, Adaptive Neuro-Fuzzy systems, training methods, Some applications of Fuzzy logic.

UNIT III **10 hrs.**

Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques, Basic GA framework and different GA architectures, GA operators: Encoding, Crossover, Selection, Mutation, etc., Solving single-objective optimization problems using GAs.

UNIT IV **8 hrs.**

Combined techniques – Genetic Algorithms–Fuzzy Logic, Genetic Algorithms–Neural Networks, Neural Networks–Fuzzy Logic, Application of ANN and Fuzzy systems to non-stationary time series prediction, pattern recognition, control & communication engineering, and system identification.

Text Book(s) / Reference(s):

[1] S. Haykin, Neural Networks - A Comprehensive Foundation, Pearson Education, India

[2] Jang, Sun and Mizutani, Neuro-Fuzzy and Soft-Computing – A computational approach to learning and machine intelligence, Prentice Hall of India.
[3] S. Kumar, Neural Networks: A Classroom approach, Tata McGraw Hill.

Course Outcomes:

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

CO1: Able to carry out research and development of the neural network and fuzzy logic.

CO2: Understanding of soft computing techniques and their application in diverse fields.

CO3: In-depth analysis on technology variations in soft computing depending on the application and involvement of neural learning, classification

CO4: Application of neural network and fuzzy logic for different applications like time series prediction, control, etc.

ECPE-439 COMPUTER VISION

Pre-requisite: Digital Signal Processing (ECPC 301)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description:
The student should be able to understand and apply the various concepts of Computer Vision.

Course Content:

UNIT I **10 hrs.**

Introduction: What is computer vision? A brief history, Image formation Geometric primitives and transformations, Photometric image formation, The digital camera, Point operators, Linear filtering, More neighborhood operators, Fourier transforms, Pyramids and wavelets, Geometric transformations, Global optimization.

UNIT II **10 hrs.**

Feature Detection and Matching: Points and patches, Edges, Lines, Segmentation: Active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts and energy-based methods, Feature-based-alignment: 2D and 3D feature-based alignment, Pose estimation, Geometric intrinsic calibration, Structure from motion: Triangulation, Two-frame structure from motion, Factorization, Bundle adjustment, Constrained structure and motion.

UNIT III **10 hrs.**

Dense Motion Estimation: Translational alignment, Parametric motion, Spline-based motion, Optical flow, Layered motion, Image stitching; Motion models, Global alignment, Compositing, Computational photography: Photometric calibration, High dynamic range imaging, Super-resolution and blur removal, Image matting and compositing, Texture analysis and synthesis.

UNIT IV **10 hrs.**

Stereo Correspondence: Epipolar geometry, Sparse correspondence, Dense correspondence, Local methods, Global optimization, Multi-view stereo, 3D-reconstruction: Shape from X, Active range finding, Surface representations, Point-based representations, Volumetric representations, Model-based reconstruction, Recovering texture maps and albedos, Image-based rendering: View interpolation, Layered depth images, Light fields and Lumigraphs, Environment mattes, Video-based rendering, Recognition: Object detection, Face recognition, Instance recognition, Category recognition, Context and scene understanding, Recognition databases and test sets.

Text Book(s) / Reference(s):

[1] Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited, 2011.
[2] Simon J. D. Prince, Computer Vision: Models, learning and Interface, Cambridge University Press, NY, USA, 2012.

Course Outcomes:

Upon successful completion of this course, the students will be able to:
CO1: Develop the understanding about fundamentals of computer vision.
CO2: Find features of the given image.
CO3: Apply matching techniques.
CO4: Understand different motion techniques.
CO5: Apply super-resolution on images.
CO6: Construct 3D images from various image segments.

ECOE-403 INTERNET OF THINGS

Pre-requisite: Computer Networks (ECPC 308)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
This course will be focused on introducing students to new trends, applications, system architecture and challenges involved in developing/deploying internet of things systems using real industrial use cases. A number of systems are getting connected to the internet, where the sensor data is analyzed to monitor and control the systems. Correctly analyzing data coming from multiple sensors, choosing the right hardware given the power and performance tradeoff, hardware heterogeneity and security are some of the challenges involved in developing IoT applications. The course will cover the real-world use cases of IoT applications and hands-on projects related to those based on the concepts learned in the class.

Course Contents:

UNIT I **8 hrs.**
Overview of IoT systems: New trends, applications and challenges. IoT system architecture: Edge devices, sensors, actuators, gateway, data storage and historical analysis in the cloud.

UNIT II **12 hrs.**
Sensor networks: Wireless sensor networks (WSN), localization, node mobility, energy efficiency in WSN. Communication: MQTT, wifi, Bluetooth, RFID, LoRa, communication security.

UNIT III **8 hrs.**
IoT system optimization: Low power devices, energy harvesting, performance trade-off, choosing the right hardware.

UNIT IV **12 hrs.**
Smart and connected devices: Raspberry-pi, Google home mini, Alexa, Echo show Case studies: Smart cities, transportation, manufacturing, automobile.

Text Book(s) / Reference(s):
[1] Peter Waher "Learning Internet of Things"
[2] S. Misra, C. Roy, and A. Mukherjee, 2020 "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press.
[3] Simone Cirani, Gianluigi Ferrari, Marco Picone, and Luca Veltri, "Internet of Things: Architectures, Protocols and Standards" WILEY.

[4] Andrew Minteer, "Analytics for the Internet of Things (IoT): Intelligent analytics for your intelligent devices".

Course Outcomes:
Upon successful completion of this course, the students will be able to:
CO1: Understand the IoT system and its applications.
CO2: Understand IoT systems and sensor networks.
CO3: Apply the IoT system and optimization
CO4: Apply the IoT knowledge in smart cities, transportation and manufacturing.

ECOE-404 COMPUTER NETWORKS AND INFORMATION SECURITY

Pre-requisite: Computer Networks (ECPC 308)

L	T	P	Credits	Total contact hours
3	0	0	3	40

Brief Description about the course:
The objective of this course is to provide an understanding of theoretical aspects of computer networks and network security, including the protocols involved in the secure exchange of information between communicating devices.

Course Content:

UNIT I **10 hrs.**

Introduction: Overview and motivation: Telephone Network and the Internet Network, Circuit Switching vs. Packet Switching, Architecture-OSI, TCP/IP models, Physical and Data link layer protocols: Encoding, Framing, Error detection, HDLC, PPP, sliding window protocols.

UNIT II **10 hrs.**

Network Layer protocols: Internet addressing, IP, ARP, ICMP, CIDR, Routing algorithms. Transport Layer protocols: UDP, TCP, flow control, congestion control. Application Layer protocols: DNS, Web, HTTP, email, authentication, encryption.

UNIT III **10 hrs.**

Introduction to Network Security, Need for Network Security, Network Security Fundamentals, Security Concepts and Terminology, TCP/IP and OSI Network Security, Access Control Issues (Packet Filters, Firewalls)

UNIT IV **10 hrs.**

Communication Security (OSI Layer Security Protocols), Security Tools, Cryptography, System Security - Intruders and Viruses, E-mail and Web Security.

Text Book(s) / Reference(s):

[1] Michael Goodrich, Roberto Tamassia, Introduction to Computer Security: Pearson publications, 2nd edition, 2021, ISBN-13: 978-0133575477.
[2] L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach, 6th edition, Elsevier publications, 2021, Paperback ISBN: 9780128182000.
[3] A. S.Tanenbaum and D.J. Wetherall, Computer Networks, Pearson publications, 5th Edition, 2013, ISBN-13: 978-8131770221.
[4] W. Stallings, "Cryptography and Network Security", Pearson Education.
[5] J. F. Kurose and K. W. Ross, Computer Networking: A Top-Down Approach, 7th Edition, Pearson publications, 2017, ISBN-13: 9780134296159.

[6] Kun Peng, Anonymous Communication Networks: Protecting Privacy on the Web, Auerbach publications, 2019, ISBN: 9780367378738.

Course Outcomes:

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

CO1: Understand the architecture and protocols of computer networks.

CO2: Understand the various layers of OSI/TCP IP model.

CO3: Comprehend the necessity of network security along with the basic concept of Network security.

CO4: Investigate various network vulnerabilities like virus, worm, malware, rootkit and devise strategies to mitigate them.