DEPARTMENT OF ELECTRONICS ANDCOMMUNICATION ENGINEERING
NATIONAL INSTITUTE OFTECHNOLOGY KURUKSHETRA

B.Tech. in Industrial Internet of Things (IIoT) ProgrammeScheme

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	pen 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	0	14
PC	00	01	05	05	02	03	02	01	19
PE	-	-	-	-	2	2	2	2	08
OE	-	-	-	-	1	1	1	1	04
NC	1	3	-	2	-	2	-	-	04
Total Credits	20	23	21	23	20	23	23	18	49 171

SEMESTER – I

Course Category	S.No	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T @	P	
IC	1	Communication Skills in English	HSIC 101	2	0	2	**3**
		(OR)					
		Financial Education	HSIC 103	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**
NC	7	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				
	8	Sports	SANC 101	0	0	4	**2***
		Yoga	SANC 102				
		NCC	SANC 103				
	9	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
		Total Credits					**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.

SEMESTER – II

Course Category	S.No	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T @	P	
IC	1	Economics for Engineers (OR) Business Studies	HSIC 102	3	0	0	3
			HSIC 104	3	0	0	
	2	Integral Calculus and Difference Equations	MAIC-102	3	0	0	3
	3	Advanced Engineering Physics	PHIC 105	2	0	2	3
	4	Engineering Graphics (Web Design)^	CSIC 102	1	0	3	2
	5	Programming using Python	CSIC 104	3	0	2	4
NC	6	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				
	7	Sports	SANC 101	0	0	4	2
		Yoga	SANC 102				
		NCC	SANC 103				
	8	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
PC	9	Circuit Theory (Theory & Lab)	IIPC 101	3	0	2	4
		Total Credits					**23**

^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.

SEMESTER – III

Course Category	S.No	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T @	P	
IC	1	Applied Linear Algebra	MAIC 204	3	0	0	3
PC	2	Analog & Digital Electronics	IIPC 201	3	0	0	3
	3	Signals, Systems &Random Variables	IIPC202	3	0	0	3
	4	Automation Fundamentals	IIPC203	3	0	0	3
	5	Introduction to IoT	IIPC204	3	0	0	3
	6	Principles of Communication Engineering	IIPC205	3	0	0	3
	7	Electronics-Lab	IIPC206	0	0	2	1
	8	Signals & Communication Lab using MATLAB	IIPC207	0	0	2	1
	9	IoT Lab	IIPC208	0	0	2	1
NC	10	Sports	SANC 101	0	0	4	2*
		Yoga	SANC 102				
		NCC	SANC 103				
	11	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
		Total Credits					**21**

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

SEMESTER – IV

Course Category	S.No	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T@	P	
IC	1	Machine Learning & Data Analytics (INT)	CSIC 221	3	0	2	4
PC	2	Microprocessors & Computer Architecture	IIPC 209	3	0	0	3
	3	Data Structures and Algorithms	IIPC210	3	0	0	3
	4	Industry 4.0 and IIoT	IIPC211	3	0	0	3
	5	Data Communication & Networking	IIPC212	3	0	0	3
	6	Object Oriented Programming with JAVA (INT)	IIPC213	2	0	2	3
	7	Microprocessors Lab	IIPC214	0	0	2	1
	8	Programming for IoT Devices Lab	IIPC215	0	0	2	1
NC	9	Sports	SANC 101	0	0	4	2
		Yoga	SANC 102				
		NCC	SANC 103				
	10	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
		Total Credits					**23**
Six-week internship during summer vacation Mandatory and it is to be evaluated in the V semester.							

SEMESTER – V

Course Category	S.No	Course Title	Course Code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T@	P	
PC	1	Wireless Sensor Networks	IIPC 301	3	0	0	3
	2	Verilog HDL	IIPC 302	3	0	0	3
PE	3	Program Elective-I	IIPE xxx	3	0	0	3
	4	Program Elective -II	IIPE xxx	3	0	0	3
OE	5	Open Elective-I	xx OE xxx	3	0	0	3
PC-Lab	6	Wireless Sensor Networks Lab	IIPC 303	0	0	2	1
	7	Verilog HDL Lab	IIPC 304	0	0	2	1
	8	Simulation & Modeling Lab	IIPC 305	0	0	2	1
	9	Seminar	IIPC 306	0	0	1	1
	10	# Summer Training	IIPC 307	Six Weeks			1
NC	11	Sports	SANC 101	0	0	4	2*
		Yoga	SANC 102				
		NCC	SANC 103				
	12	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
		Total Credits					**20**

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

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

LIST OF PROGRAM ELECTIVES

Sr.No	Course Code	Course Title
PROGRAM ELECTIVES		
1	IIPE 301	Control System Engineering
2	IIPE 302	Information Theory and Coding
3	IIPE 303	Data Acquisition Systems
4	IIPE 304	Operating Systems
5	IIPE 305	Neuro- Fuzzy Systems
6	IIPE 306	Analog IC Design
7	IIPE 307	Optimization Techniques
8	IIPE 308	System Modeling & Simulation
9	IIPE 309	Smart Materials for IoT Devices
10	IIPE 310	Advanced Microcontroller Architecture

SEMESTER – VI

Course Category	S.No	Course Title	Course code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T@	P	
PC	1	Robotics	IIPC 308	3	0	0	3
	2	Embedded System Fundamentals	IIPC 309	3	0	0	3
	3	Mechatronic Systems & Applications	IIPC 310	3	0	0	3
PE	4	Program Elective-III	IIPE xxx	3	0	0	3
	5	Program Elective -IV	IIPE xxx	3	0	0	3
OE	6	Open Elective-II	xx OE xxx	3	0	0	3
PC-Lab	7	Embedded System Lab	IIPC 311	0	0	2	1
	8	Mechatronics / Industrial Automation Lab	IIPC 312	0	0	2	1
	9	Process Instrumentation Lab	IIPC 313	0	0	2	1
NC	10	Sports	SANC 101	0	0	4	2
		Yoga	SANC 102				
		NCC	SANC 103				
	11	Club	SANC 104	0	0	4	
		NSS	SANC 105				
		Technical Societies	SANC 106				
		Incubation & Start-up	SANC 107				
		Total Credits					23

Six-week internship during summer vacation mandatory and it is to be evaluated in the VII-sem.

LIST OF PROGRAM ELECTIVES

Sr.No	Course Code	Course Title
PROGRAM ELECTIVES		
1	IIPE 311	Digital Signal Processing
2	IIPE 312	Deep Learning
3	IIPE 313	Energy Harvesting
4	IIPE 314	Wireless Communication Technologies for IoT
5	IIPE 315	Digital IC Design
6	IIPE 316	Data Visualization and Presentation
7	IIPE 317	Sensor Data Mining
8	IIPE 318	Introduction to Operational Technologies Networks
9	IIPE 319	ASICs & FPGAs
10	IIPE 320	Block Chain Technologies

SEMESTER – VII

Course Category	S.No	Course Title	Course code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T@	P	
IC	1	Entrepreneurship & Start Ups	MEIC 416	3	0	0	3
PC	2	IoT Security	IIPC 401	3	0	0	3
	3	Cloud, Edge & Fog Computing	IIPC 402	3	0	0	3
PE	4	Program Elective-V	IIPE xxx	3	0	0	3
	5	Program Elective -VI	IIPE xxx	3	0	0	3
OE	6	Open Elective-III	xx OE xxx	3	0	0	3
PC-Lab	7	IoT Security Lab	IIPC 403	0	0	2	1
	8	Project-I	IIPC 404	0	0	6	3
	9	# Summer Training	IIPC 405	Six Weeks			1
		Total Credits					23

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

LIST OF PROGRAM ELECTIVES

Sr.No	Course Code	Course Title
		PROGRAM ELECTIVES
1	IIPE 401	Image Processing
2	IIPE 402	Biomedical Electronics
3	IIPE 403	Optical Communication Networks
4	IIPE 404	RF Microelectronics
5	IIPE 405	Mobile Application Development
6	IIPE 406	Optical Networking &Switching
7	IIPE 407	Cognitive Radio
8	IIPE 408	RADAR & Navigation
9	IIPE 409	Vehicular Ad-hoc Networks
10	IIPE 410	Quantum Communication
11	IIPE 411	Optical Wireless Techniques for IoT & 5G/6G systems
12	IIPE 412	IoT Project Management
13	IIPE 413	SCADA System Applications
14	IIPE 414	Wearable Computing
15	IIPE 415	Parallel Computing
16	IIPE 416	Mobile Computing

SEMESTER – VIII (Project & Course Work)

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

Course Category	S.No	Course Title	Course code	Lecture(L)/ Tutorial(T)/ Practical(P) per week			Credits
				L	T@	P	
PC	1	Selected Topics in Sensors & IoT	IIPC 406	3	0	0	3
PE	2	Program Elective-VII	IIPE xxx	3	0	0	3
	3	Program Elective -VIII	IIPE xxx	3	0	0	3
OE	4	Open Elective-IV	xx OE xxx	3	0	0	3
PC-Lab	5	Project-II	IIPC 407	0	0	12	6
		Total Credits					18

LIST OF PROGRAM ELECTIVES

Sr.No	Course Code	Course Title
PROGRAM ELECTIVES		
1	IIPE 417	Computer Vision
2	IIPE 418	LiDAR & Remote Sensing
3	IIPE 419	MEMS
4	IIPE 420	VLSI Physical Design
5	IIPE 421	DSP Architecture
6	IIPE 422	IoT Enhanced AR&VR
7	IIPE 423	Quantum Computing
8	IIPE 424	6G Networks
9	IIPE 425	Nano Sensors
10	IIPE 426	Bio-Sensors
11	IIPE 427	Image Forensics
12	IIPE 428	Biomedical Signal Processing
13	IIPE 429	E-Commerce and ERP
14	IIPE 430	Soft Computing & Expert Systems
15	IIPE 431	Industrial IoT Markets & Security
16	IIPE 432	Data Base Management Systems

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	IIOC-xxx				3
2	NPTEL Course-2	IIOC-xxx				3
3	NPTEL Course-3	IIOC-xxx				3
4	Internship	IIPC-408				9
Total						18

LIST OF NPTEL COURSES

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

IInd Semester

IIPC 101: CIRCUIT THEORY

Pre-requisite: Engineering Mathematics I (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 circuit excited by DC voltages and current sources.

Course Content:

UNIT - I (12 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 DC and AC 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 AC 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) and Y(s), Nodal and Mesh Analysis in s-Domain, Additional Circuit Analysis Techniques, Poles, Zeros, and Transfer Functions, Convolution Transfer Function.

UNIT - IV (8 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 Circuit Analysis, Tata McGraw Hill, 6th Edition, New Delhi, 2003.

[2] Joseph A. Edminister and Mahmood Nahvi, Electric Circuits, Schaum's Series, Tata McGraw Hill, 4th Edition, New Delhi, 2001.

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

Course Outcomes:

On completion of this course, students should be able to:

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

CO2: Apply circuit theorems and reduce complicated circuits into 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 develop transfer functions.

CO6: Understand Two-Port networks and their parameters.

IIPC 101 LAB: CIRCUIT THEORY LAB

Pre-requisite: Engineering Mathematics I (MAIC 101)

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

Brief Description about the course:

The aim of this course is to make students competent in analyzing electrical circuits and apply Kirchhoff's Voltage and Current Laws to determine voltage, current and power in branches of any circuit excited by DC voltage and current sources.

List of Experiments:

1. DC Measurement: Understand the basics of DC circuits; use a digital multimeter (DMM) to measure DC voltage, current and resistance; understand valid measurement conditions for a DMM.
2. Network Analysis Methods: Analyze a resistive circuit using node or mesh analysis; verify Thevenin's and Norton's theorems; verify the superposition principle.
3. AC Measurement: Understand the basics of AC circuits; use an oscilloscope to display and record a waveform; measure frequency, period, voltage, and DC offset using an oscilloscope.
4. First Order & Second Order Circuits: Study the step response of first and second order circuits; understand the concept of the time constant; understand the difference between overdamped, critically damped and underdamped responses; determine the damped natural frequency experimentally.
5. Sinusoidal Steady State: Understand and calculate the power factor of a passive circuit; verify that resistive components dissipate power while reactive components do not.
6. Transfer Functions: Study the transfer function of a circuit; use the transfer function to find the specified frequency in different cases.
7. Series and Parallel Resonance: Study the behavior of series and parallel LC circuits at resonance; understand resonance frequency, cut-off frequency, bandwidth and quality factor; determine whether the circuit is inductive or capacitive; understand 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.

IIIrd Semester

IIPC 201: ANALOG AND DIGITAL ELECTRONICS

Pre-requisite: Engineering Physics I (PHIC 101), Engineering Physics II (PHIC 105)

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 Analog and Digital Electronics. This course covers a broad spectrum of BJT/FET amplifiers, concept of feedback and oscillators. The course delves into the basics of operational amplifier circuits, A/D and D/A converters, combinational circuits, number systems, Flip-Flops, combinational and sequential logic circuits.

Course Content:

UNIT - I (10 hrs)

PN Junction Diode: Characteristics and analysis, Types of diodes, Rectifiers and Filter Circuit: Half Wave Rectifier, Full Wave Rectifier, Bridge Rectifier and their Analysis, Filters; Series and Shunt Diode Clippers, Clamping Circuit; Basic Regulator Supply using Zener Diode.

Transistor Fundamentals: Construction and Characteristics of BJT, DC operating point and Biasing, Transistor Configuration: CB, CE, CC Configuration; Transistor at Low Frequency, Small Signal Low Frequency Transistor Model (h-parameters), Analysis of Transistor Amplifier (CE) using h-parameters.

UNIT - II (10 hrs)

Amplifiers: MOS amplifiers; Multistage amplifiers, frequency response of amplifiers, Feedback Sinusoidal oscillators.

Introduction to Op-Amp: Ideal Op-Amp, equivalent circuit, transfer characteristics, Op-Amp with negative feedback, inverting and non-inverting amplifiers, frequency response, and slew rate. Applications of Op-Amp: Integrator, Differentiator, summing amplifier. Digital-to-Analog Converters (DAC), Analog-to-Digital Converters (ADC).

UNIT - III (10 hrs)

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

Boolean Algebra and Logic Gates: Boolean laws, De Morgan's theorem, Boolean functions, Karnaugh maps. Basic logic gates, Universal gates and their applications.

UNIT - IV (10 hrs)

Combinational Logic Circuits: Decoders, encoders, multiplexers, de-multiplexers and their applications; three state devices, comparators, programmable logic devices.

Sequential Logic Circuits: Latches and flip-flops, SR, D, J-K, T flip-flops and conversions, shift registers, counters, design and analysis of synchronous and asynchronous sequential circuits.

Text Book(s) / Reference(s):

[1] Sedra & Smith, Microelectronic Circuits, 5th Edition.
[2] Boylestad & Nashelsky, Electronic Devices and Circuit Theory, 9th Edition.

[3] A.P. Malvino, Electronic Principles, Tata McGraw Hill Publications.
[4] William Kleitz, Digital Electronics, Prentice Hall International Inc.
[5] R. T. Howe and C. G. Sodini, Microelectronics: An Integrated Approach, Prentice Hall Inc., 1997.
[6] Jacob Millman and C.C. Halkias, Electronic Devices and Circuits, TMH Publications.
[7] Ben G. Streetman, Solid State Electronic Devices, PHI, 5th Ed., 2001.
[8] Michael Shur, Introduction to Electronic Devices, John Wiley & Sons Inc., 2000.

Course Outcomes:

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

CO1: Develop the ability to analyze and design analog electronic circuits using discrete components.

CO2: Understand the amplifiers, concept of feedback and oscillators.

CO3: Describe the design and analysis of Op-Amp.

CO4: Design the digital circuits using Flip-Flops.

IIPC 202: SIGNALS, SYSTEMS AND RANDOM VARIABLES

Pre-requisite: Engineering Mathematics I (MAIC 101), Engineering Mathematics II (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 Content:

UNIT - I (10 hrs)

LTI Systems: Continuous time and discrete time signals, Even and Odd signals. Classification of signals, Continuous time and Discrete time LTI Systems, convolution Integral and convolution sum, Properties of LTI Systems, causality; stability, time invariance, linearity. 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. Continuous Time Fourier Transform (CTFT), Convergence of FT. 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, moments of random variables. Chebyshev inequality. Distribution functions: uniform, rectangular, Gaussian, Bernoulli, binomial, Poisson, Exponential, Rayleigh, etc. 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, Cyclo-stationary 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:

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 and multiple random variables.
CO5: Understand the concept of random processes and determine covariance and spectral density of stationary random processes.

IIPC 203: AUTOMATION FUNDAMENTALS

Pre-requisite: Engineering Mathematics I & II (MAIC 101-102)

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

Brief Description about the course:

Automation is playing a key role in Industries. Industries rely heavily on automation for economic viability and mass production. It is important for the students to learn the basics of automation, how systems work and the importance of PLC, SCADA and robots in automation. This course will provide an opportunity to learn industrial automation techniques.

Course Content:

UNIT - I (8 hrs)

Introduction to Automation: Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: Modbus & Profibus. Role of computers in measurement and control. Hydraulic and Pneumatic Systems in Automation.

UNIT - II (10 hrs)

Automation Components: Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.

UNIT - III (12 hrs)

Programmable Logic Controllers: Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.

UNIT - IV(10 hrs)

Distributed Control System: Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS, Overview of Industrial automation using robots.

Text Book(s) / Reference(s):

[1] S.K. Singh, Industrial Instrumentation and Control, The McGraw Hill Companies.
[2] C.D. Johnson, Process Control Instrumentation Technology, PHI.
[3] Parr, Industrial Control Handbook, Newnes.
[4] Dunning, Programmable Logic Controller, Delmar.
[5] Mikell Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2019.
[6] Jon Stenerson, Industrial Automation and Process Control, Pearson, 2003.
[7] Frank Lamb, Industrial Automation: Hands On, McGraw-Hill Education, 2013.

Course Outcomes:

CO1: Understanding of automation components and systems application.

CO2: Identify suitable industrial automation hardware for a given application.

CO3: Measure industrial parameters like temperature, pressure, force, displacement, speed, flow, level, humidity and pH.

CO4: Integration of SCADA with PLC Systems.

IIPC 204: INTRODUCTION TO IOT

Pre-requisite: Circuit Theory **(**IIPC 101)

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 and 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 systems.

Course Content:

UNIT - I (10 hrs)

Concept of IoT, Vision, Impact, Challenges in IoT, IoT network architecture, Reference Model, Functional stack, Machine to Machine Communication, Standardization.

UNIT - II (10 hrs)

Smart Things, Sensors, Actuators, Devices for IoT, Interfaces, Data Aggregation, Data analytics for IoT, Big data analytics, IoT security and Privacy.

UNIT - III (10 hrs)

Communication technologies: IEEE 802.15.4, IEEE 802.15.4e, IEEE 802.11ah, NB-IoT, IoT network layer, 6LoWPAN, 6Lo, IoT application layer, Transport methods: CoAP, MQTT, AMQP.

UNIT - IV (10 hrs)

Applications and Case Studies, Implementation of IoT with Raspberry Pi. Case studies: smart homes, smart cities, connected vehicles, Agriculture, Healthcare, environmental monitoring, smart manufacturing.

Text Book(s) / Reference(s):

[1] David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, Pearson India, 2018.

[2] Rajkumar Buyya and Amir V. Dastjerdi, Internet of Things: Principles and Paradigms, Morgan Kaufmann Publisher, 2016.

Course Outcomes:

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

CO1: Understand the fundamentals of IoT and its architectural framework.

CO2: Use sensors and wireless sensor networks for data collection.

CO3: Perform basic data analysis on IoT data.

CO4: Apply IoT technology in real life scenarios.

IIPC 205: PRINCIPLES OF COMMUNICATION ENGINEERING

Pre-requisite: Engineering Mathematics I & II (MAIC 101-102)

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 analog and digital modulation and demodulation schemes and the effect of AWGN noise on these systems.

Course Content:

UNIT - I (10 hrs)

Amplitude Modulation (AM) and Demodulation, Double Sideband Suppressed Carrier (DSB-SC) Modulation and Demodulation, Single Sideband Modulation (SSB), Vestigial Sideband Modulation (VSB), Angle Modulation, Frequency Modulation (FM), Phase Modulation (PM), Modulation Index, Instantaneous Frequency, Carson's Rule for FM Bandwidth, FM Demodulation, Super-heterodyne receivers.

UNIT - II (10 hrs)

Introduction to Sampling, Nyquist Criterion, Signal Reconstruction from Sampled Signal, Pulse Amplitude Modulation, Quantization, Uniform Quantizers: Midrise and Midtread, Quantization noise, Non-Uniform Quantizers, Pulse Code Modulation, DPCM, Delta Modulation, Inter-Symbol Interference.

UNIT - III (10 hrs)

Geometric Representation of Signals, Maximum likelihood detection, Matched filter, Correlation receiver, Coherent Binary Digital Modulation Schemes (Binary PAM, BPSK, QPSK, BFSK), their Spectral Efficiency and Error Performance.

UNIT - IV(10 hrs)

M-ary Digital Modulation Schemes, Noncoherent Modulation and Demodulation, Principle of Spread Spectrum systems, Pseudo-Noise Sequences, Direct Sequence Spread Spectrum and Frequency-Hopped Spread Spectrum systems, CDMA.

Text Book(s) / Reference(s):

[1] Simon Haykin, 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.

Course Outcomes:

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

CO1: Understanding of communication fundamentals.

CO2: Understand different analog modulation and demodulation schemes.

CO3: Understand different digital modulation and demodulation schemes and analyse their performance.

CO4: Understand different spread spectrum systems and their applications.

IIPC 206: ELECTRONICS LAB

Pre-requisite: Engineering Physics I (PHIC 101), Engineering Physics III (PHIC 103), Analog and Digital Electronics (IIPC 201)

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

Brief Description about the course:

This course is designed to apply knowledge of analog electronics and digital electronics to a hands-on laboratory experience. Students design and analyze electronic circuits using p-n junction diode, Zener diode, and make performance measurements on analog circuits. The course also familiarizes students with the working of ICs for logic gates, MUXs, Encoders, Decoders, and Flip-Flops.

List of Experiments:

1. PN Junction diode characteristics: Forward bias and Reverse bias.
2. Zener diode characteristics and voltage regulator.
3. Half wave Rectifier with and without filter and Full wave Rectifier with and without filter.
4. 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.
5. Study and Verify: (a) De Morgan's Theorem for 2 variables. (b) The sum-of-product and product-of-sum expressions using universal gates.
6. Design and implementation of: (a) Full Adder using basic logic gates. (b) Full Subtractor using basic logic gates.
7. Implementation and Verification of Decoder/De-Multiplexer and Encoder using Logic Gates.
8. Realization of the following flip-flops using NAND Gates: (a) Clocked SR Flip-Flop. (b) JK Flip-Flop.
9. Realization of shift registers using IC7474: (a) SISO. (b) SIPO. (c) PISO. (d) PIPO.
10. Design and implementation of MOD-12 up and down counter.

Course Outcomes:

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

CO1: Demonstrate the working and input-output characteristics of p-n junction diode and Zener diode.

CO2: Construct digital circuits to examine Boolean algebra and truth tables of different logic gates.

CO3: Design various combinational and sequential circuits after analyzing their timing properties.

CO4: Understand the use of digital ICs of different logic functions.

IIPC 207: SIGNALS & COMMUNICATION LAB USING MATLAB

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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

Brief Description about the course:

This lab aims to familiarize students with numerical computing using MATLAB. MATLAB allows matrix manipulations, plotting of functions, implementation of algorithms, and creation of user interfaces. The purpose of this course is to familiarize students with the practical implementation of Signals and Communication topics such as analog and digital modulation and demodulation schemes.

List of Experiments:

1. (i) Define and use variables, vectors, matrices, and their functions in MATLAB. (ii) Study various arithmetic operators and mathematical functions in MATLAB.
2. (i) Create and use m-files. (ii) Study various MATLAB commands for creating two- and three-dimensional plots.
3. Write a MATLAB program to plot the following continuous-time and discrete-time signals: Step Function, Impulse Function, Exponential Function, Ramp Function, and Sine Function.
4. (i) Write a MATLAB program to perform amplitude-scaling, time-scaling, and time-shifting on a given signal. (ii) Write a MATLAB program to obtain linear convolution of given sequences.
5. Write a MATLAB program to generate the Fourier series of (i) a square wave and (ii) a triangular wave.
6. Write a MATLAB program to calculate and plot the Fourier transform of: (i) Rectangular pulse. (ii) Triangular pulse. (iii) Gaussian pulse.
7. Write a MATLAB program to find the impulse response and step response of a system from its difference equation.
8. Write a MATLAB program for: (i) Amplitude modulation and demodulation. (ii) Frequency modulation and demodulation.
9. Write a MATLAB program for: (i) DSB-SC modulator and detector. (ii) SSB-SC Modulator and Detector (Phase Shift Method).
10. Write a MATLAB program for the verification of the sampling theorem for: (i) Low pass signals. (ii) Band pass signals.
11. Write a MATLAB program for PAM, PWM, PPM and PCM modulation and demodulation schemes.
12. Write a MATLAB program for PSK, FSK, and ASK modulation and demodulation schemes.

Course Outcomes:

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

CO1: Learn basics of MATLAB programming.

CO2: Write MATLAB programs for analysis of signals and systems.

CO3: Simulate various modulation and demodulation schemes.
CO4: Apply MATLAB-based simulation to verify fundamental signal processing theorems such as the sampling theorem and convolution, and validate their theoretical results experimentally.

IIPC 208: IoT LAB

Pre-requisite: Problems Solving and Programming using C (CSIC 103), Introduction to IoT (IIPC 204)

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

Brief Description about the course:

This lab aims to familiarize students with the Internet of Things through hands-on experiments. The Internet of Things has emerged as a leading technology around the world, and this lab provides practical exposure to IoT hardware, sensor interfacing, and basic connectivity.

List of Experiments:

1. Familiarization with Development board (Arduino/Raspberry Pi etc.) and perform necessary software installation.
2. Interface LED/Buzzer with Development board and write a program to turn ON LED for 1 sec after every 2 seconds.
3. Interface Push button/Digital sensor (IR/LDR) with Development board and write a program to turn ON LED when push button is pressed or at sensor detection.
4. Interface DHT11 sensor with Development board and write a program to print temperature and humidity readings.
5. Interface motor using relay with Development board and write a program to turn ON motor when push button is pressed.
6. Interface OLED with Development board and write a program to print temperature and humidity readings on it.
7. Interface Bluetooth with the Development board and write a program to send sensor data to a smartphone using Bluetooth.
8. Interface Bluetooth with Development board and write a program to turn LED ON/OFF when '1'/'0' is received from a smartphone.
9. Build an Intrusion Detection System with Development board and Ultrasonic Sensor.
10. Modules and Sensors Interfacing (Relay, RGB LED) using Development board.

Course Outcomes:

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

CO1: Understand the concept of Internet of Things.
CO2: Understand the data acquisition from various sensors.
CO3: Implement interfacing of various sensors with Arduino/Raspberry Pi.
CO4: Apply IoT concepts in simple real-life applications.

IVth Semester

IIPC 209: MICROPROCESSORS & COMPUTER ARCHITECTURE

Pre-requisite: Analog and Digital Electronics (IIPC 201)

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

Brief Description about the course:

The course covers a broad spectrum of topics including Microprocessors like the 8085, exploring architecture, pin configurations, addressing modes, and peripheral interfacing devices. The study extends to microcontrollers, focusing on the 8051 architecture, I/O ports, interrupts, and interfacing. The broader context encompasses basic computer architecture, performance measurement, CISC and RISC processors, pipeline concepts, memory technology, cache memory, and virtual memory.

Course Content:

UNIT - I (10 hrs)

Microprocessors: 8085 architecture, operation, pin configuration and functions, bus organization, control signal generation for external operations: fetch, IO/M, read/write, machine cycles and bus timings. Addressing modes, instruction set, overview of peripheral interfacing devices: 8251, 8253, 8255 and 8279.

UNIT - II (10 hrs)

Microcontrollers: 8051 architecture, operation, pin configuration and functions, memory organization, register, I/O ports, addressing modes, instruction sets. Assembly language programming, Interrupts in 8051. Timer/Counter programming, waveform generation. Interfacing with LEDs and seven segment display.

UNIT - III (10 hrs)

Introduction to basic computer architecture. Register transfer and micro-operations, CISC and RISC processors. Hardwired control, Micro programmed control, Pipelining: Basic concepts, instruction pipeline, hazards, techniques for handling hazards. Pipeline optimization techniques.

UNIT - IV (10 hrs)

Input-Output Organization: Peripheral devices, I/O interface, Data transfer schemes, Program control, Interrupt, DMA transfer, I/O processor.

Memory Unit: Memory hierarchy, High-speed memories, Cache memory, Associative memory, Interleave, Virtual memory, Memory management.

Introduction to Parallel Processing: Characteristics of multiprocessors, Interconnection structures, Interprocessor arbitration, Interprocessor communication and synchronization.

Text Book(s) / Reference(s):

[1] Ramesh S. Goankar, 8085 Microprocessors Architecture Application and Programming, Penram International, 5th Edition.

[2] Kenneth J. Ayala, The 8051 Microcontroller, Cengage Learning, 3rd Edition.

[3] R.S. Gaonkar, Microprocessor Architecture, Programming & Applications with the 8085/8080A, Wiley Eastern Ltd.

[4] D.V. Hall, Microprocessors & Interfacing, McGraw Hill.
[5] M. Rafiquzzaman, Microprocessors: Theory & Applications (Intel & Motorola), PHI.
[6] Morris M. Mano, Computer System Architecture, Prentice Hall, 3rd Edition, 1992.
[7] J.P. Hayes, Computer Architecture and Organization, McGraw Hill, 3rd Edition, 1998.
[8] Hennessy, J.L. and Patterson, D.A., Computer Architecture: A Quantitative Approach, Pearson Education Asia, 4th Edition, 2006.
[9] C. Hamacher, Z. Vranesic and S. Zaky, Computer Organization, McGraw-Hill, 5th Ed.

Course Outcomes:

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

CO1: Understand the architecture and memory organization of 8085 and 8051.

CO2: Distinguish various types of Microprocessor and Computer Architecture and impart knowledge about the instruction set.

CO3: Understand the basics of instruction sets and their impact on processor design.

CO4: Demonstrate an understanding of the design of the functional units of a digital computer system.

CO5: Design a pipeline for consistent execution of instructions with minimum hazards.

IIPC 210: DATA STRUCTURES AND ALGORITHMS

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

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

Brief Description about the course:

To introduce first level topics covering basics in Algorithms and Data Structures. To provide examples for various design paradigms. To identify the basic properties of graphs and trees and model simple applications.

Course Content:

UNIT - I (8 hrs)

Mathematical preliminaries, time complexity and space complexity, worst-case and average-case analyses, use of order notations and related results, divide and conquer recurrences, recurrence relations: substitution method, recurrence trees, Master's theorem and its applications. Randomized Algorithms and their Applications.

UNIT - II (12 hrs)

Quick Sort and its analyses, Merge Sort recurrence, Strassen's matrix multiplication, fast multiplication of large integers, binary search trees, priority queues, Heaps and Heap Sort. Data structures for disjoint sets, Path compression, union by rank, Prim's and Kruskal's algorithms, Huffman coding, LZW coding, shortest paths, greedy activity selection, set cover and greedy heuristics. Introduction to advanced data structures like Fenwick trees or segment trees.

UNIT - III (10 hrs)

Dynamic Programming basics, matrix chain multiplication, DP solution for traveling salesman and 0/1 Knapsack problems, least common subsequences, independent sets and backtracking algorithm, Breadth/depth-first algorithms. Introduction to network flow problems beyond shortest paths and spanning trees.

UNIT - IV (10 hrs)

Topological sort, recursive graph algorithms, string matching: KMP algorithm, Rabin-Karp algorithm, number theory algorithms: basics, GCD and extended Euclidean algorithm, primality testing. Introduction to algorithmic game theory or online algorithms.

Text Book(s) / Reference(s):

[1] T. Cormen, C. Leiserson, R. Rivest, and C. Stein, Introduction to Algorithms, Prentice-Hall/India, 3rd Edition, 2009.

Course Outcomes:

CO1: Ability to comprehend the basics in algorithms and data structures.
CO2: Ability to solve problems that involve these concepts and similar problems.
CO3: Ability to provide algorithmic solutions and approaches to new problems.
CO4: Apply graph algorithms, dynamic programming, and string matching techniques to model and solve real-world computational problems efficiently.

IIPC 211: INDUSTRY 4.0 AND IIoT

Pre-requisite: Introduction to IoT (IIPC 204)

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

Brief Description about the course:

The course covers the Industrial IoT (IIoT) Systems, including the Industry 4.0 revolutions, support systems for Industry 4.0, and Smart Factories. It also addresses the exchange of information between communicating device protocols, Next Generation Sensors, and Industrial IoT Applications.

Course Content:

UNIT - I (12 hrs)

Introduction to Industrial IoT (IIoT) Systems: The Various Industrial Revolutions, Role of Internet of Things (IoT) and Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions, Support System for Industry 4.0, Smart Factories.

Implementation Systems for IIoT: Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisition on IoT Platform, Microcontrollers and Embedded PC roles in IIoT, Wireless Sensor nodes with common communication protocols.

UNIT - II (10 hrs)

IIoT Data Monitoring & Control: IoT Gateway, IoT Edge Systems and its Programming, Cloud computing, Real Time Dashboard for Data Monitoring, Data Analytics and Predictive Maintenance with IIoT technology.

UNIT - III (8 hrs)

Cyber Physical Systems: Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Big Data and Advanced Analysis, Digital Twins.

UNIT - IV(10 hrs)

Industrial IoT Applications: Healthcare, Power Plants, Inventory Management and Quality Control, Plant Safety and Security (including AR and VR safety applications), Facility Management.

Case Studies of IIoT Systems: IIoT application development with Embedded PC based development boards, Development of mini-project on new version of Operating systems and Edge development board addressing current societal needs.

Text Book(s) / Reference(s):

[1] Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress.

[2] Christoph Jan Bartodziej, The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistics, Springer.

[3] Rajkamal, Embedded System: Architecture, Programming and Design, TMH.

[4] Ovidiu Vermesan and Peter Friess, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, River Publishers.

Course Outcomes:

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

CO1: Understand the concept of Industry 4.0.

CO2: Be well versed with the design flow of IIoT based systems.

CO3: Understand different communication protocols like GPRS and Wi-Fi for connecting IIoT nodes to a server.

CO4: Develop state-of-the-art IIoT based systems suitable for real life and Industry applications.

IIPC 212: DATA COMMUNICATION & NETWORKING

Pre-requisite: Principles of Communication Engineering (IIPC 205)

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

Brief Description about the course:

The course covers the theoretical aspects of computer networks, including the protocols involved in the exchange of information between communicating devices.

Course Content:

UNIT - I (10 hrs)

Introduction to Data Communication: Goals and Applications of Networks, Wireless Networks, Interfaces, and Services. Reference Models: The OSI reference model and TCP/IP reference model.

Physical Layer: Data and Signals, Digital and Analog transmission, Transmission Media, Wireless transmission, Switching.

UNIT - II (12 hrs)

Data Link Layer: Data link layer design issues, Services provided to Network layers, Framing, Error control, Flow control, Error detection and correction, Elementary data link protocols, Sliding Window protocols, Go-Back-N, Selective Repeat. Example data link protocol: HDLC, PPP.

UNIT - III (10 hrs)

Medium Access Control Sublayer: Channel Allocations, Random Access, ALOHA, Carrier Sense Multiple Access Protocols, Collision free Protocols, Limited contention protocols, Channelization, Wired LANs: Ethernet, Wireless LANs.

Network Layer: Network Layer design issues, Logical Addressing, Address Mapping, Error Reporting and Multicasting, Delivery, Forwarding and Routing.

UNIT - IV (8 hrs)

Transport Layer: Process to Process Delivery: UDP, TCP, and SCTP.

Application Layer: Design issues of the layer, Domain Name Systems, File Transfer, HTTP, web documents, and Virtual Terminals.

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.

[5] S. Keshav, An Engineering Approach to Computer Networking, Addison-Wesley.

[6] Wayne Tomasi, Introduction to Data Communications and Networking, Pearson.

Course Outcomes:

At the end of the 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 protocol stack.

IIPC 213: OBJECT ORIENTED PROGRAMMING WITH JAVA

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

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

To learn object-oriented programming on JAVA frameworks and utilize it in practical applications by demonstrating adeptness of object-oriented programming in developing solutions to problems involving data abstraction, encapsulation, features of exception handling, dynamic binding, polymorphism, and applets.

Course Content:

UNIT - I (10 hrs)

Introduction: Procedure Oriented Programming, Object Oriented Programming. Properties of Object-oriented models. Concepts of Classes and Objects, Nature of an object, Nature of a class, Relationships among objects and classes. Overview of abstraction, Information hiding, Polymorphism, Method Overloading, Inheritance, Method overriding, Dynamic Binding, Message Passing.

UNIT - II (10 hrs)

Fundamentals of Java: Basics of Java: JVM and Bytecode, Data types, variables, expressions, Control Statements, Type conversion and casting. Implementation of OOP using Java: Java Classes and Objects, Constructors, this pointer, Garbage Collection, Method overloading, Nested and Inner class, Inheritance, super pointer, Multilevel class hierarchy, Method overriding, Abstract classes, Interfaces, Packages.

UNIT - III (10 hrs)

Intermediate Java: Exception Handling: Fundamentals, try and catch keywords, Nested try, throw, throws, finally keywords, Java's built-in exceptions and creating custom exceptions.

Multithreaded Programming: Basic concept of threading, Java thread model, the main thread, Creating custom thread, isAlive() and join() methods, Thread priorities.

UNIT - IV (10 hrs)

Advanced Java: Java IO and Applets: Reading and Writing to Console, PrintWriter class, Reading and writing to files, Formatting output, Applet Fundamentals.

Text Book(s) / Reference(s):

[1] Grady Booch et al., Object-Oriented Analysis and Design with Applications.
[2] Blaha and Rumbaugh, Object-Oriented Modeling and Design with UML.
[3] Herbert Schildt, Java: The Complete Reference, 9th Edition.
[4] Joshua Bloch, Effective Java.

Course Outcomes:

CO1: Understand the concepts of object-oriented programming.
CO2: Comprehend the adeptness of OOP in developing solutions demonstrating data abstraction, encapsulation and inheritance.
CO3: Implement patterns involving dynamic binding and utilization of polymorphism.
CO4: Create graphical user interfaces for different applications.

IIPC 213 LAB: OBJECT ORIENTED PROGRAMMING WITH JAVA LAB

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

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

Brief Description about the course:

This lab aims to provide understanding of the basic concepts in object-oriented programming including encapsulation, abstraction, inheritance, and polymorphism. Students design, implement, test, and debug programs to solve real-world problems in Java. The course enhances programming skills through practical assignments and provides requisite knowledge about OOP through Java to develop applications and projects.

List of Experiments:

1. Study of objects and classes in object-oriented programming using Java.
2. Understanding of array of objects in JAVA; create a database of students using class with various attributes.
3. Write a Java program to represent Abstract class with example.
4. Write a Java program to implement Interface using extends keyword.
5. Write a Java program to create a user-defined package.
6. Write a Java program to create inner classes.
7. Study of dynamic memory allocation using operators and pointer to objects.
8. Write a Java program that implements a multi-thread application with three threads.
9. Write a Java program to display File class properties and represent the ArrayList class.
10. Create a graphical user interface (GUI) with necessary features in Java using the AWT package.

Course Outcomes:

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

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

IIPC 214: MICROPROCESSORS LAB

Pre-requisite: Analog and Digital Electronics (IIPC 201)

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

Brief Description about the course:

To study Microprocessor fundamentals and to develop skills for designing flowcharts and writing algorithms. The course enables students to write embedded programs and debug them using 8085 and 8051 trainer kits, and to perform interfacing experiments with various peripherals.

List of Experiments:

Part A: Assembly Language Programming using 8085 Trainer Kit

1. Find the Factorial of a number.
2. Find if a number is prime or a perfect square.
3. Write a program to read a 16-bit integer, store it in a register and display it digit by digit.
4. Write a modular program to perform addition, subtraction, multiplication and division of two 16-bit numbers.
5. Check whether a given string is palindrome or not. Reverse an input string.
6. Find the largest and smallest number in an array of data using the 8085 instruction set.

Part B: Interfacing Experiments using 8085 Trainer Kit

1. Interface 8253 programmable interval timer to 8085.
2. Interface Stepper Motor with 8085.
3. Generate square wave, triangular wave, and sawtooth wave for a given frequency and duty cycle.

Part C: Assembly Language Programming using 8051 Trainer Kit

1. Data transfer/exchange between specified memory locations.
2. Largest/smallest from a series; Sorting (Ascending/Descending).
3. Addition, subtraction, multiplication and division of 8/16 bit data.
4. Sum of a series; Multiplication by shift and add method; Square/cube/square root of 8-bit data.
5. Matrix addition; LCM and HCF of two 8-bit numbers; Code conversion.

Part D: Interfacing Experiments using 8051 Trainer Kit

1. Time delay generation and relay interface; Display (LED/Seven segments/LCD) and keyboard interface.
2. ADC interface; DAC interface with waveform generation.
3. Stepper motor and DC motor interface; Elevator interfacing.

Part E: Programming/Interfacing Experiments with Arduino/Raspberry Pi

1. Relay control; Distance measurement; Temperature measurement / Digital Thermometer.
2. Txr-Rxr interface; Alphanumeric LCD display interface; Simple project work including multiple interfaces.

Course Outcomes:

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

CO1: Write algorithms and perform programming tasks for a given problem.

CO2: Design and develop modular programming skills.

CO3: Develop a basic understanding of the syntax of the instruction set of 8085/8051.

CO4: Apply knowledge of assembly language to solve various problems.

CO5: Implement various hardware interfaces through assembly language programming.

IIPC 215: PROGRAMMING FOR IoT DEVICES LAB

Pre-requisite: Problems Solving and Programming using C (CSIC 103), Introduction to IoT (IIPC 204)

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

Brief Description about the course:

This lab aims to familiarize students with the programming of IoT devices. Internet of Things has emerged as a leading technology, and advancements in Artificial Intelligence and Machine Learning have made the automation of IoT devices easier. Students gain hands-on experience with cloud platforms, MQTT, and real-world IoT application development.

List of Experiments (Any Ten experiments should be performed):

1. Create a cloud platform account, explore IoT services and register a thing on the platform.
2. Write a program on a Development board (Arduino/Raspberry Pi etc.) to upload temperature and humidity data to the cloud.
3. Write a program on the Development board to retrieve temperature and humidity data from the cloud.
4. Install MySQL database on the Development board and perform basic SQL queries.
5. Write a program on the Development board to publish temperature data to an MQTT broker.
6. Write a program on the Development board to subscribe to an MQTT broker for temperature data and print it.
7. IoT based Web Controlled Home Automation using Development board.
8. Design an IoT based air pollution control system which monitors carbon monoxide, ammonia, etc., and gives an alarm when the pollution level exceeds a pre-defined threshold.
9. Design an IoT-based application for agriculture farming for water supply based on humidity measurement.
10. Write a program to create a TCP server on the Development board and respond with humidity data to a TCP client when requested.
11. Write a program to create a UDP server on the Development board and respond with humidity data to a UDP client when requested.
12. Identify a problem in your local area or college which can be solved by integrating the things you learned and create a prototype to solve it (Mini Project).

Course Outcomes:

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

CO1: Implement interfacing of various sensors with Arduino/Raspberry Pi.
CO2: Demonstrate the ability to transmit data wirelessly between different devices.
CO3: Upload and download sensor data on cloud and server.
CO4: Apply IoT concepts with cloud in real life applications.

Vth Semester

IIPC 301 WIRELESS SENSOR NETWORKS

Pre-requisite: Introduction to IoT (IIPC 204), Data Communication & Networking (IIPC 212)

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 (10hrs)

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:

CO 1: Technical knowledge in building a WSN network.

CO 2: Analysis of various critical parameters in deploying a WSN.

CO 3: Analysis of specific protocols related to medium access control, routing, and time-synchronization problems.

CO 4: Comprehend the study of localization strategies, power management, and security aspects.

IIPC 302 VERILOG HDL

Pre-requisite: Problems Solving and Programming using C (CSIC 103), Analog and Digital Electronics (IIPC 201)

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)

MODELING IN VERILOG HDL: Overview of Behavioral Modeling in Verilog HDL, Data flow and Structural Modeling, and Using Always block and conditional statements in Verilog HDL, Blocking and Non-Blocking Statements, Delay modeling and Timing Control, tasks and Functions, Creating test benches 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:

At the end of the course, the student 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.

IIPE 301 CONTROL SYSTEM ENGINEERING

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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 modeling, 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 (10hrs)

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.

IIPE 302 INFORMATION THEORY AND CODING

Pre-requisite: Principles of Communication Engineering (IIPC 205)

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 signal 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 signal.

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, Shanon's theorem on coding for memoryless noisy channels, Shanon's three fundamental theorems.

Separable binary codes, Shanon-Fano encoding, Noiseless coding, Theorem of decodability, Average length of encoded message, Shanon'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 (8hrs)
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:
At the end of the course, 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.
CO 4: Design the linear block codes and cyclic codes.
CO 5: Understand and apply the convolutions codes state diagrams, code tree and trellis diagrams, decoding algorithms.
CO 6: Understand and evaluate the channel performance using Information theory.

IIPE 303 - Data Acquisition Systems

Pre-requisite: Microprocessors & Computer Architecture (IIPC 209)

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

Course Overview:

This course focuses on the principles, methods, and technologies related to data acquisition (DAQ) systems in the context of Industrial Internet of Things (IIoT). Students will gain an understanding of various sensors, actuators, and communication technologies used to collect and process data from industrial systems. Additionally, students will explore how data acquisition systems play a key role in IIoT architectures for automation, monitoring, and control in industrial environments.

Course Objectives:

By the end of this course, students will be able to:

- Understand the architecture of data acquisition systems in industrial environments.
- Learn the types of sensors, actuators, and transducers used in IIoT applications.
- Explore the importance of processing in data acquisition.
- Design a Data Acquisition system.
- Understand edge computing, data security and emerging trends in Data Acquisition Systems.

Unit 1: Introduction to Data Acquisition Systems (DAQ) (10 hrs)

Overview of Data Acquisition Systems (DAQ): Definition, importance, and components of DAQ systems in IIoT. Role of DAQ in industrial automation and monitoring. Key components: Sensors, actuators, signal conditioning, and data processing.

Industrial Automation and Control Systems: Basics of Industrial Control Systems (ICS). Integration of DAQ systems in industrial automation. Data flow, feedback, and control mechanisms.

Types of Data Acquisition Systems: Analog vs. Digital DAQ systems. Wired and wireless methods of data acquisition.

Unit 2: Data Conversion and Processing (10 hrs)

Analog-to-Digital Conversion (ADC): Basics of ADC: Types, resolution, sampling rate, and accuracy. Techniques for efficient data conversion.

Digital Signal Processing (DSP) in DAQ Systems: Overview of DSP techniques for data analysis. Time-domain and frequency-domain processing. Filtering and noise reduction in IIoT systems.

Data Storage and Management: Real-time data storage techniques. Cloud integration for data storage and management. Data visualization and analytics.

Unit 3: IIoT Data Acquisition System Design (10 hrs)

System Architecture for IIoT Data Acquisition: Components of a DAQ system in IIoT: Sensing, conditioning, processing, communication, and storage. System design considerations for industrial environments.

Data Acquisition in Industrial Automation: Case studies of IIoT applications for industrial automation. Implementing predictive maintenance and monitoring systems using DAQ.
Design and Implementation Project: Hands-on project: Design and implement a basic data acquisition system. Data collection, processing, and communication. Cloud integration for real-time monitoring.

Unit 4: Advanced Topics in IIoT Data Acquisition (10 hrs)
Edge Computing and IIoT: Introduction to edge computing and its role in IIoT data acquisition. Advantages of edge computing over cloud processing. Edge analytics in industrial data processing.
Data Security in IIoT DAQ Systems: Security challenges in IIoT and DAQ systems. Techniques for data encryption, authentication, and access control. Ensuring the integrity and confidentiality of data.
Emerging Trends in IIoT: Integration of AI and machine learning in DAQ systems. Blockchain for secure data acquisition. Future trends and innovations in IIoT data acquisition technologies.

Text Book(s) / Reference(s):
[1] "Industrial Data Communication" by Bogdan M. Wilamowski, J. David Irwin.
[2] "Introduction to Mechatronics and Measurement Systems" by David G. Alciatore, Michael B. Histand.
[3] "Industrial Automation and Control Systems" by Jonathan Love.
[4] "Data Acquisition Systems: From Fundamentals to Applied Design" by Maurizio Di Paolo Emilio.
[5] "The Internet of Things: A Look at Real-World Use Cases and Concerns" by Samuel Greengard.

CO1: Understand the architecture and key components of data acquisition systems and their role in IIoT-based industrial automation and monitoring.
CO2: Apply analog-to-digital conversion techniques and DSP methods for data processing, filtering, and noise reduction in DAQ systems.
CO3: Design and implement a basic IIoT data acquisition system integrating sensing, signal conditioning, processing, communication, and cloud storage.
CO4: Evaluate edge computing strategies and data security mechanisms including encryption, authentication, and access control for industrial DAQ deployments.

IIPE 304 - Operating Systems

Pre-requisite: Problems Solving and Programming using C (CSIC 103), Microprocessors & Computer Architecture (IIPC 209)

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

Course Learning Objectives:

1. To understand the services and design of an operating system.
2. To understand the structure and organization of file system.
3. To understand the process states and various concepts such as scheduling and synchronization related with it.
4. To understand different memory management approaches.
5. Students should be able to use system calls for managing processes, memory and file system.
6. Students should understand the data structures and algorithms for implementation of OS.

Course Content:

Unit-I (10 hrs)

Computer system architecture and organization, Introduction and evolution of OS, Introduction to distributed OS, Real time systems and multimedia systems. OS structures: OS services, system calls and programs, OS design and implementation. Processes: Process concept, scheduling policies, algorithms, multilevel queuing, operations on process, Inter-process communication. Threads: multithreading models and threading issues. CPU scheduling: Criteria and algorithms, multiprocessor and thread scheduling.

Unit-II (10 hrs)

Process synchronization: critical sections, classical two process and n-process solutions, hardware primitives for synchronization, semaphores, monitors, classical problems in synchronization (producer-consumer, readers-writer, dining philosophers, etc.). Deadlocks: modelling, resource allocation, characterization, prevention and avoidance, detection and recovery.

Unit-III (10 hrs)

Memory management: Swapping, contiguous memory allocation, paging, multilevel paging, segmentation, demand paging, page replacement algorithms, allocation of frames, thrashing, working set model. Input/Output: I/O system and services, device controllers and device drivers, disks, scheduling algorithms and management.

Unit-IV (10 hrs)

File system interface: access methods, access control, directory structures, file organization, file sharing and protection. system performance, protection and security, OS design considerations for security, access control lists and OS support, internet and general network security. Operating system as service provider: Access control matrix, access control list, capability matrix, encryption and access permissions in Linux and Windows.

Text Book(s) / Reference(s):

[1] A. Silberschatz, Peter B. Galvin and G. Gagne, "Operating System Concepts," (9th or newer edition), Wiley.
[2] H. Brinch, "Operating System Principles," Prentice Hall of India.
[3] Dhamdhere, "Systems programming & Operating systems," Tata McGraw Hill.
[4] A. N. Habermann, "Introduction to Operating System Design," Galgotia publication, New Delhi.
[5] A.S. Tanenbaum, "Modern Operating Systems," Prentice Hall of India.

Course Outcomes:

At the end of the course student will be able to:

1. Understand functions, structures and history of operating systems.
2. Able to know the design issues associated with operating systems.
3. Master various process management concepts such as scheduling, synchronization, multithreading and deadlocks.
4. Understand the various concepts associated with memory management such as virtual memory, demand paging, page replacements algorithms.
5. Be familiar with various protection and security mechanisms.
6. Be familiar with virtualization and operating system components.

IIPE 305 NEURO-FUZZY SYSTEMS

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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:

At the end of the course student 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.

IIPE 306 ANALOG IC DESIGN

Pre-requisite: Analog and Digital Electronics (IIPC 201)

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 (10hrs)
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:
At the end of the course student 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.

IIPE 307 - Optimization Techniques

Pre-requisite: Engineering Mathematics I (MAIC 101), Engineering Mathematics II (MAIC 102)

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

Course Content:

Unit 1 (10 hrs)

Introduction:

Statement of an optimization problem, Classification of optimization problems, Overview of various optimization Techniques, The simplex optimization technique, Applications of Simplex, Test Functions, Examples.

Unit 2 (10 hrs)

Unconstrained optimization:

Definitions and existence conditions, General properties of minimization algorithms, Line search, The Steepest-Descent Optimization Technique, Newton's method, The Least-path Optimization Technique- Least square Algorithm.

Constrained optimization:

Active Constraints versus Inactive constraints, Transformations, penalty functions Advanced Techniques for Optimization.

Unit 3 (10 hrs)

Genetic algorithm (GA):

Fundamentals of Genetic algorithm, History, Basic concepts, working principle, Applications of GA for standard Bench mark test functions.

Swarm intelligence:

Main inspiration source, early variants of PSO, Basic particle swarm optimization, Initialization techniques, Theoretical investigations and parameter selection, Design of PSO algorithm using computational statistics, Termination conditions. Application of PSO, Standard test function optimization.

Unit 4 (10 hrs)

Differential Evaluation:

Classical differential evaluation- An outline, Mutation, cross over, selection.

Teaching Learning Based Optimization:

Applications of TLBO for standard Bench mark test functions, Case studies.

Learning Resources:

Text Book(s) / Reference(s):

[1] Richard W Daniels, An Introduction to Numerical Methods and Optimization Techniques, Elsevier North Holland Inc.

[2] Milani Mitchel, An introduction to Genetic algorithms, MIT Press, 1998.

[3] AE Eiben and J.E Smith, Introduction to Evolutionary Computing, Springer 2010.

[4] S Rajasekharan, G.A Vijaya Lakshmi Pai, Neural Networks, Fuzzy logic, and Genetic algorithms, Synthesis and Applications, Prentice hall of India, 2007.

[5] Weifan Wang, Xuding Zhu, Ding-Zhu Du, Combinatorial Optimization and Applications: 5th International Conference, Springer Publications, 2011.

Course Outcomes:

At the end of the course student will be able to:

CO1: Formulate mathematical models of real-world problems.

CO2: Understand the major limitations and capabilities of deterministic operations.

CO3: Handle, Solve and analyse problems using linear programming and other mathematical programming algorithms.

CO4: Solve various multivariable optimization problems.

IIPE 308 - SYSTEM MODELING AND SIMULATION

Pre-requisite: Engineering Mathematics (MAIC 101-102), Signals, Systems & Random Variables (IIPC 202)

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

Course Objective:

The aim of this course is to introduce various system modeling and simulation techniques, and highlight their applications in different areas. It includes modeling, design, simulation, planning, verification and validation. After learning the simulation techniques, the students are expected to be able to solve real world problems which cannot be solved strictly by mathematical approaches. This course begins by demonstrating the usefulness of simulation as a tool for problem solving in business, industry, government, and society.

Course Content:

UNIT-I (10 hrs)

Systems, models, simulation, discrete event simulation, steps in a simulation study, review of random variables, stochastic processes, means, variance, correlation, confidence intervals, hypothesis tests.

UNIT-II (10 hrs)

Model validity and credibility, statistical procedures- inspection approach, confidence approach, time series approach, selection of input probability distribution, continuous distribution, discrete distribution, empirical distribution, assessing sample independence, histograms, quantile summaries, estimation of parameters, goodness of fit tests, multivariate distributions.

UNIT-III (10 hrs)

Random numbers generators- linear congruential generators, composites generators, testing random number generators- empirical tests, theoretical tests, generating random variates-inverse transform, convolution, acceptance-rejection, generating- continuous random variates, discrete random variates, random vectors, correlated random variates and stochastic processes.

UNIT-IV (10 hrs)

Simulation of queuing systems- Poisson arrival processes, exponential distribution, service times, normal distribution, queuing disciplines, simulation of single and two server queue application of queuing theory in computer systems, introduction to simulation languages-GPSS, SIMSCRIPT.

Text Book(s) / Reference(s):

[1] Averill M Law, "Simulation Modeling and Analysis" MGH.
[2] Jerry Banks, John S Carson, Barry L Nelson, David M Nicol, "Discrete-event system simulation".

Course Outcome:

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

CO1: Understand different methods for random number generation.

CO2: Have a clear understanding of the need for the development process to initiate the real problem.

CO3: Be able to describe the components of continuous and discrete systems and simulate them.

CO4: Be able to model any system from different fields.

CO5: Be able to implement numerical algorithm to meet simple requirements, expressed in English.

IIPE 309 - Smart Materials for IoT Devices

Pre-requisite: Introduction to IoT (IIPC 204)

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

Course Description:

This course explores the intersection of smart materials and the Internet of Things (IoT). It covers the properties, design, and applications of smart materials that enhance IoT-enabled devices. The course emphasizes material selection for sensors, actuators, and energy-harvesting technologies in smart environments.

Course Outline:

Unit 1 (10 hrs)

Introduction to Smart Materials and IoT:

Definition and Classification of Smart Materials - Stimuli-responsive materials (pH, temperature, light, electric field), Properties: mechanical, electrical, optical, magnetic, Types of Smart Materials (MXenes, graphene, quantum dots, perovskites, shape-memory alloys), Piezoelectric & triboelectric nanomaterials; Basics of IoT - IoT architecture and communication protocols, Role of smart materials in IoT systems.

Unit 2 (10 hrs)

Types of Smart Materials for IoT:

Piezoelectric Materials - Working principles, applications in sensors and actuators; Shape Memory Alloys (SMA) - Fundamentals, thermal/mechanical properties, role in adaptive structures; Electroactive Polymers (EAPs) - Actuation mechanisms, uses in artificial muscles and robotics; Magnetostrictive and Thermoresponsive Materials: Applications in IoT devices; Self-healing Materials - Introduction, mechanisms, and impact on reliability in IoT.

Unit 3 (10 hrs)

Characterization Techniques for Smart Materials:

Structural and Morphological Characterization - X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy; Optical and Spectroscopic Techniques - UV spectroscopy, Raman spectroscopy, Fourier-transform infrared (FTIR) spectroscopy; Electrical and Mechanical Characterization - Electrochemical impedance spectroscopy (EIS), nanoindentation, tensile testing.

Fabrication and Integration of Smart Materials in IoT:

Printing Techniques for Flexible Electronics; Nanomaterials and 3D Printing in IoT Devices; Integration of Smart Materials into IoT Platforms; Challenges in Fabrication and Scalability.

Unit 4 (10 hrs)

Applications of Smart Materials in IoT:

Healthcare: Drug delivery, biosensors; Smart Homes and Cities: Energy-efficient windows, adaptive lighting; Energy Storage - Ion batteries, hydrogen storage, solar cells; Flexible Electronics: Graphene, 2D materials; Sensors - Gas sensors, pressure sensors, humidity sensors, temperature sensors.

Text Book(s) / Reference(s):

[1] Kamal K. Kushwah, Shilpi Jindal, Ajay Kumar Vyas, Prasenjit Chatterjee, Smart Materials and Applications, CRC Press, 2025.
[2] Mohsen Shahinpoor, Fundamentals of Smart Materials, RSC, 2020.
[3] Chaudhery Mustansar Hussain and Paolo Di Sia, Handbook of Smart Materials, Technologies and Devices - Applications of Industry 4.0, Springer Nature, 2022.
[4] Sam Zhang, Lin Li, Ashok Kumar, Materials Characterization Techniques, Taylor & Francis group, 2008.
[5] Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things - Key applications and Protocols, Wiley, 2012.
[6] Dieter Uckelmann, Mark Harrison and Florian Michahelles, Architecting the Internet of Things, Springer, 2011.

Course Outcome:

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

C01: Understand the fundamentals of smart materials and their role in IoT applications.
C02: Analyse various types of smart materials used in IoT devices.
C03: Explore fabrication techniques and integration with IoT systems.
C04: Evaluate real-world applications of smart materials in healthcare, wearables, smart cities, and automation.

IIPE 310 ADVANCED MICROCONTROLLER ARCHITECTURE

Pre-requisite: Microprocessors & Computer Architecture (IIPC 209)

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 microcontrollers 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 levels 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:

At the end of the course, student 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.

IIPC 303 - Wireless Sensor Network Lab

Pre-requisite: Introduction to IoT (IIPC 204), IoT Lab (IIPC 208)

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

Brief Description:

This lab provides hands-on experience with Wireless Sensor Network concepts through simulation and experimentation. Students investigate key WSN performance parameters including communication range, energy consumption, routing, localization, and security, gaining practical insight into the challenges of deploying real-world sensor networks.

List of Experiments:

1. To study the basic wireless communication range and signal strength of wireless sensor nodes.
2. To measure the energy consumption of different WSN nodes and protocols under various conditions.
3. To evaluate the performance of different routing protocols in WSNs, such as LEACH (Low-Energy Adaptive Clustering Hierarchy) and AODV (Ad hoc On-demand Distance Vector).
4. To analyze data aggregation techniques in a WSN for reducing network traffic and energy consumption.
5. To test localization algorithms for determining the positions of nodes in a WSN.
6. To explore fault tolerance and network recovery mechanisms in WSNs.
7. To measure and optimize Quality of Service (QoS) parameters in a WSN.
8. To evaluate the scalability of WSNs as the number of nodes increases.
9. To investigate security challenges and countermeasures in WSNs.
10. To study how duty cycling (sleep-wake scheduling) can optimize energy consumption in WSNs.
11. To simulate the impact of environmental factors like temperature, humidity, or obstacles on WSN performance.

Course outcomes:

CO1: Analyze communication range and energy consumption characteristics of WSN nodes under varying conditions.

CO2: Evaluate and compare routing protocols such as LEACH and AODV for WSN environments.

CO3: Implement and assess data aggregation and localization techniques in sensor networks.

CO4: Investigate fault tolerance, QoS, and scalability in WSN deployments.

CO5: Examine security challenges and the impact of environmental factors on WSN performance.

IIPC 304 - Verilog HDL Lab

Pre-requisite: Analog and Digital Electronics (IIPC 201), Problems Solving and Programming using C (CSIC 103)

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

Brief Description:

This lab provides hands-on experience with hardware description language programming using VHDL/Verilog. Students design and implement combinational and sequential digital circuits on FPGA kits, progressing from basic logic gates and arithmetic circuits to flip-flops, motor interfacing, and real-time task management using RTOS delay functions.

List of Experiments:

1. Develop a VHDL test bench code for testing and implement addition, subtraction, multiplication and division on FPGA kit.
2. Write a VHDL program for Buzzer Interface.
3. Develop a VHDL test bench code for testing 7 segment LED display.
4. Develop a VHDL test bench code for testing 4-bit binary counters.
5. Develop a VHDL test bench code for testing simple gates.
6. Develop a VHDL test bench code & implement an FPGA kit for Multiplexer and De-Multiplexer.
7. Develop a VHDL test bench & implement an FPGA kit for Encoder and Decoder.
8. Design and implementation of Half Adder and Full Adder.
9. Design and implementation of D flip flop.
10. Write a simple program with two separate LED blinking tasks.
11. To interface a stepper motor and control the speed of rotation by implementing RTOS delay functions.

Course Outcomes:

CO1: Write and simulate VHDL testbench code for basic arithmetic and logic circuits on FPGA. **CO2**: Design and implement combinational circuits including MUX, DEMUX, Encoder, Decoder, and Adders.

CO3: Design and implement sequential circuits including counters and D flip-flops using VHDL.

CO4: Interface peripheral devices such as 7-segment displays, buzzers, LEDs, and stepper motors with FPGA.

CO5: Apply RTOS concepts to manage concurrent hardware tasks on embedded platforms.

IIPC 305 - Simulation and Modeling Lab

Pre-requisite: Problems Solving and Programming using C (CSIC 103-4), Signals, Systems & Random Variables (IIPC 202)

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

Course Objectives:

- To introduce techniques for generating and statistically validating random numbers used in simulation.
- To develop the ability to test whether empirical data conforms to a theoretical probability distribution.
- To apply Monte Carlo simulation for estimating numerical quantities and modeling probabilistic phenomena.
- To build skills in curve fitting, parameter estimation, and model comparison for experimental/observed data.
- To model dynamic real-world systems such as population growth and queueing networks.
- To simulate and analyze communication systems (AM/FM) and evaluate their performance under noise.
- To apply simulation-based decision-making tools (e.g., queueing cost trade-offs) to system design problems.

List of Experiments:

1. Random Number Generation and Testing for Uniformity
    - To generate random numbers using a linear congruential generator (LCG) and test their uniformity using frequency and Kolmogorov–Smirnov (K–S) tests.
2. Goodness of Fit Test
    - To verify whether the given data follows a theoretical distribution using Chi-square and Kolmogorov–Smirnov (K–S) tests.
3. Monte Carlo Simulation Techniques
    - To explore the application of Monte Carlo simulation techniques using different probability distributions for:
        - Estimating the value of π
        - Estimating the area under a curve
        - Simulating Buffon's Needle experiment
4. Curve Fitting and Parameter Estimation
    - To find the best-fitting parameters and evaluate fit quality using curve fitting:
    - Determine the best-fitting parameters of a given dataset.
    - Evaluate the quality of the fi using statistical measures.
    - Compare different model fits and select the most appropriate one.

5. Modeling Population Dynamics
    - To model population dynamics using exponential and logistic growth models.
6. AM & FM Signal Analysis
    - Build and simulate amplitude modulation (AM) and frequency modulation
    - (FM) transmitters and receivers in Simulink.
    - Observe time- and frequency-domain characteristics and verify bandwidth formulas.
    - Quantify effects of modulation index (AM) and frequency deviation (FM) on waveforms and spectra.
    - Implement two demodulation strategies for each scheme and compare performance in noise.
7. **Rejection Sampling Technique**
    - To understand the basic mechanics of rejection sampling and estimate the acceptance rate when the envelope distribution is uniform.
8. **Single-Server Bank Simulation**
    - To simulate a single-server bank (one teller) and measure the average waiting time and server utilization under a given arrival rate and service time distribution.
9. **Single-Server Queue Modeling using Spreadsheet**
    - To study and analyze the performance of a single-server queueing system (M/M/1) using spreadsheet simulation by varying:
        - Arrival rate (λ)
        - Service rate (μ)
        - Number of servers (s)

    and to observe:
        - Variation of number of servers vs. cost
        - Variation of arrival and service rates vs. cost (single server)
        - Variation of arrival and service rates vs. L, L_q, W, and W_q
        - Probability Distribution (PDF) and Cumulative Distribution (CDF) for up to10 customers.

Course Outcomes:

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

CO1 Generate pseudo-random numbers using an LCG and verify whether data follows a theoretical distribution using frequency, K–S, and Chi-square tests.

CO2 Apply Monte Carlo and rejection sampling techniques to estimate π, area under a curve, acceptance rates, and simulate Buffon's Needle experiment.

CO3 Determine best-fit parameters of a dataset, evaluate fit quality using statistical measures, and compare models to select the most appropriate one.

CO4 Model and interpret population dynamics using exponential and logistic growth models.

CO5 Design and simulate AM and FM transmitter–receiver systems in Simulink; analyze time- and frequency-domain behavior, bandwidth, and demodulation performance under noise.

CO6 Simulate and analyze single- and multi-server queueing systems (bank simulation and M/M/1 spreadsheet model) to evaluate waiting time, utilization, cost, and performance measures (L, Lq, W, Wq).

IIPC 306 SEMINAR (SEMESTER V)

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

Brief Description about the course:
The Program Core Seminar is a structured activity in which students explore an emerging or applied topic in the IIoT 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 industrial IoT and related fields.

Course Outcomes:

CO1: Identify and articulate a relevant technical topic in the IIoT 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.

IIPC 307 - SUMMER TRAINING PROGRAM CORE INTERNSHIPS (SEMESTER V)

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. 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.

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

VIth Semester

IIPC 308 Robotics

Pre-requisite: Introduction to IoT (IIPC 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 make students aware of the basic principles and concept of Robotics.

Course Content:

Unit - I (10 hrs)

Introduction to Robotics:

Types and components of a robot, Classification of robots, closed-loop and open-loop control systems; Kinematics systems: Definition of mechanisms and manipulators, Social issues and safety.

Unit – II (10 hrs)

Robot Kinematics and Dynamics:

Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics; Dynamic Modelling: Equations of motion: Euler-Lagrange formulation.

Unit - III (10 hrs)

Sensors and Vision System:

Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc. Introduction to Cameras, Camera calibration, Geometry of Euclidean/Similarity/Affine/Projective transformations, Vision applications in robotics.

Unit – IV (10 hrs)

Robot Control:

Basics of control: Transfer functions, Control laws: P, PD, PID, Non-linear and advanced controls, Robot Actuation Systems: Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

Control Hardware and Interfacing:

Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications.

Text Book(s) / Reference(s):

[1] Saha, S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.

[2] Ghosal, A., "Robotics", Oxford, New Delhi, 2006.

[3] Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", PHI, New Delhi.

[4] Mittal R.K. and Nagrath I.J., "Robotics and Control", Tata McGraw Hill.

[5] Mukherjee S., "Robotics and Automation", Khanna Publishing House, Delhi.

[6] Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 2009.
[7] Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005.
[8] Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003.
[9] Merzouki R., Samantaray A.K., Phathak P.M. and Bouamama B. Ould, "Intelligent Mechatronic System: Modeling, Control and Diagnosis", Springer.

Course Outcomes:

CO1: Gain knowledge of basic mechanical designing, electrical wiring, robotic sensors and actuators, PCB design and communication protocols.
CO2: Gain an understanding of the theoretical background necessary to understand advanced robotic technologies and their specific applications.
CO3: Demonstrate proficiency in design, construction, and operation of robotic systems.
CO4: Develop problem-solving skills by applying principles of robotics engineering to real-world problems.
CO5: Communicate effectively about robotics engineering technologies, their workings and potential applications.

IIPC 309 Embedded Systems Fundamentals

Pre-requisite: Microprocessors & Computer Architecture (IIPC 209)

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:

At the end of this course, 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.

IIPC 310 Mechatronic Systems & Applications

Pre-requisite: Analog and Digital Electronics (IIPC 201), Signals, Systems & Random Variables (IIPC 202)

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

Course Learning Objectives:

- To understand the basic concepts of mechatronics and their applications.
- To understand the functioning of various types of sensors, transducers and their applications.
- To understand the concept of pneumatic, hydraulic and mechanical actuation systems.
- To understand the basics of robotics, robot types, their drive systems and applications.

Course Content:

UNIT-I (10 hrs)

Introduction to Mechatronics and its Systems:

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach. Evolution, Scope, Measurement Systems, Control Systems, open and close loop systems, sequential controllers, microprocessor based controllers, mechatronics approach.

UNIT-II (10 hrs)

Sensors and transducers:

Introduction, performance terminology-Displacement, Position and Proximity, Velocity and motion, force, Fluid Pressure-Temperature Sensors-Light Sensors-Selection of Sensors-Signal Processing. (5 hrs)

Pneumatic, Mechanical and Hydraulic actuation systems:

Actuation systems, Pneumatic and hydraulic systems, Mechanical actuation systems, directional control valves, pressure control valves, cylinders, process control valves, rotary actuators. Design and fabrication of Mechatronics systems. (5 hrs)

UNIT-III (10 hrs)

Programmable Logic Controller:

Introduction, Basic structure, Input/output Processing, Programming, Mnemonics, Timers, Internal relays and counters, Data handling, Analog Input/output, Selection of a PLC. (5 hrs)

Robotics:

Introduction, types of robots, Robotic control, Robot drive systems Robot end effectors, selection parameters of a robot, applications. (5 hrs)

UNIT-IV (10 hrs)

Case study of a mechatronics system:

Introduction of a motion testbed and C++ programming. Programmable motion control and algorithm development. Application 1: Numerical control manufacturing (machining and accumulation). Application 2: Digital fabrication and 3D printing

systems. Application 3: Robotics, scanning and user interaction systems and development project discussion.

Text Book(s) / Reference(s):

[1] Bolton W., "Mechatronics", Longman, Second Edition, 2004.
[2] Histand Michael B. and Alciatore David G., "Introduction to Mechatronics and Measurement Systems", McGraw Hill International Editions, 2003.
[3] Kamm, M.L.J., Mechatronics, Prentice Hall of India, New Delhi (2007).
[4] HMT Ltd., "Mechatronics", Tata McGraw Hill Publishing Co. Ltd., 1998.
[5] Nitaigour Premchand Mahalik, "Mechatronics Principles, Concepts and Applications", Tata McGraw-Hill publishing company Ltd, 2003.
[6] Auslander, D. M. and Kempf, C. J., Mechatronics: Mechanical System Interfacing, Prentice Hall, New Jersey (1996).
[7] Musa Jouaneh, "Fundamentals of Mechatronics", Cengage Learning, 2011.
[8] "Mechatronics: a Foundation Course", Clarence de Silva, CRC Press, 2010.
[9] Rolf Isermann, "Mechatronics Systems Fundamentals", Springer, 2005.
[10] Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Prentice Hall, 2008.

Course Outcomes:

At the end of the course student will be able to:

CO1: Understand the basic concepts of mechatronics and their applications.

CO2: Understand the functioning of various types of sensors, transducers and their applications.

CO3: Understand the concept of pneumatic, hydraulic and mechanical actuation systems.

CO4: Understand the basics of robotics, robot types, their drive systems and applications.

IIPE 311 DIGITAL SIGNAL PROCESSING

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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:

At the end of the course student 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.

IIPE 312 DEEP LEARNING

Pre-requisite: Engineering Mathematics (MAIC 101-2)

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:

At the end of the course student 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.

IIPE-313 ENERGY HARVESTING

Pre-requisite: IIPC 204

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

Course Objectives:

- Understand the various energy sources and energy harvesting based sensor networks
- Learn about the various Piezo electric materials and Non-linear techniques
- Understand the various Power sources for WSN
- Learn about the applications of Energy harvesting systems.

UNIT-I

10Hrs.

ENERGY HARVESTING SYSTEMS Introduction – Energy sources – energy harvesting based sensor networks – photovoltaic cell technologies – generation of electric power in semiconductor PV cells – types.

UNIT-II 10Hrs.

PIEZO-ELECTRIC ENERGY HARVESTING AND ELECTRO MECHANICAL MODELING: Piezoelectric materials – transducers – harvesters – micro generators – strategies for enhancing the performance of energy harvesters. Electromechanical modeling of Lumped parameter model and coupled distributed parameter models and closed-form solutions

UNIT-III 10Hrs

ELECTROMAGNETIC ENERGY HARVESTING AND NON-LINEAR TECHNIQUES :

Basic principles – micro fabricated coils and magnetic materials – scaling – power maximations – micro and macro scale implementations. Non-linear techniques – vibration control & steady state cases

UNIT-IV 05Hrs

ENERGY HARVESTING WIRELESS SENSORS : Power sources for WSN–Power generation– conversion – examples – case studies. Harvesting microelectronic circuits – power conditioning and losses. Energy Harvesting for Smart Cities and Smart Homes

UNIT-V 05Hrs

SELECTED APPLICATIONS OF ENERGY HARVESTING SYSTEMS: Case studies for Implanted medical devices–Bio-MEMS based applications–harvesting for RF sensors and ID tags–powering wireless SHM sensor nodes, usage in FoG computing etc.

TEXTBOOK:

1. Energy Harvesting Systems for IoT Applications: Generation, Storage, and Power Management Hardcover –by Yen Kheng Tan(Author), Mark Wong (Author), first edition 2019.
2. Energy Harvesting: Enabling IoT Transformations: Chapman & Hall/CRC Internet of Things-by Deepti Agarwal, Kimmi Verma, Shabana Urooj, 2024 edition.
3. Energy Harvesting for IoT-enabled Devices: Priyabrata Sinha & Shubham Kumar, Springer (2023).

REFERENCE BOOKS:

1. Danick Briand, EricYeatman, Shad Roundy,"Micro Energy Harvesting" Danick Briand, Eric Yeatman, Shad Roundy JohnWiley & Sons, 21-Apr-2015
2. IoT and Analytics in Renewable Energy Systems, Volume I: Sustainable Smart Grids & Renewable Energy Systems, O. V. Gnana Swathika, K. Karthikeyan, Sanjeevi kumar Padmanaban, 2023.

Course Outcomes:

- The students able to design **IoT**-based systems for real-world problems.
- The Students understands the role of power management in a successful IoT deployment.
- To manage power efficiently for remote devices and long-lived devices.

IIPE 314: Wireless Communication Technologies for IoT

Pre-requisite: Signals, Systems & Random Variables (IIPC 202), Data Communication & Networking (IIPC 212)

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

Brief Description about the course:

The course "Wireless Communication Technologies for IoT" provides an in-depth understanding of the various wireless communication protocols and technologies used in the Internet of Things (IoT) ecosystem. It covers key topics such as: Introduction to IoT (Internet of Things), Wireless Communication Basics, various communication Protocols & Standards, Power and Energy Efficiency, Long Range Wide Area Network, Cellular IoT Networks, IoT Protocol Stack, 6G Technology for IoT, etc. The course is designed for students, engineers, and professionals interested in developing, deploying, and optimizing IoT solutions using modern wireless communication techniques.

Course Content:

Unit - I (10 hrs)

Introduction to IoT (Internet of Things):

Definition, Components, and Applications, IoT Architecture: Sensing, Networking, Data Processing, Actuation, IoT Protocols, CoAP, HTTP.

Wireless Communication Basics:

Types of Wireless Communication: Analog vs. Digital, RF, Optical, etc., Basic Concepts: Frequency, Bandwidth, Modulation, and Demodulation.

Unit – II (10 hrs)

Long-Range Wireless Communication Technologies:

LoRaWAN (Long Range Wide Area Network):

Introduction to LoRa Technology, LoRaWAN Architecture and Protocol, Applications of LoRaWAN in Smart Cities, Agriculture, and Industry.

Cellular IoT Networks:

2G, 3G, 4G, and 5G Networks, LTE and NB-IoT (Narrowband IoT) for IoT Applications, Benefits and Challenges of Cellular Networks for IoT.

Unit - III (10 hrs)

IoT Protocol Stack:

Application Layer Protocols: MQTT, CoAP, Network Layer Protocols: IPv6, 6LoWPAN, RPL, Transport Layer Protocols: UDP, TCP, SCTP, Security Protocols in IoT (TLS, DTLS).

6G Technology and IoT:

Features of 6G: Speed, low latency, high reliability, Network slicing and edge computing in 6G for IoT, Applications of 6G in IoT: autonomous vehicles, smart cities, etc.

Unit – IV (10 hrs)

IoT Network Management:

Network Topologies: Star, Mesh, and Tree Topology, IoT Data Management and Protocol Interoperability, Role of Middleware in IoT Networks.

Visible Light Communication (VLC):

Principles of VLC and its working, Applications of VLC in IoT systems: smart homes, automotive. Privacy and Securities issues in IoT.

Text Book(s) / Reference(s):

[1] Internet of Things: A Hands-On Approach by Arshdeep Bahga and Vijay Madisetti.
[2] Wireless Communications: Principles and Practice by Theodore S. Rappaport.
[3] Wi-Fi 6: The Next Generation of Wireless Networking by S. Keshav.
[4] "Internet of Things: Architectures, Protocols and Standards" by Olivier Hersent, David Boswarthick, and Omar Elloumi.

Course Outcomes:

CO 1: Demonstrate a thorough understanding of the basic concepts and architecture of IoT, including the different layers (sensing, networking, data processing, and actuation).
CO 2: Explain the various wireless communication technologies, their principles, and how they enable communication in IoT systems.
CO 3: Implement and configure IoT devices using Bluetooth and Wi-Fi protocols for communication, understanding their real-world application in various IoT domains.
CO 4: Understand the potential of emerging wireless communication technologies like 5G, VLC (Visible Light Communication), and Terahertz communication for IoT applications.

IIPE 315 Digital IC Design

Pre-requisite: PHIC11 and PHIC13 (Semiconductor Physics), Electronic Devices and Circuits

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

Brief Description of the Course:

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:

Students who successfully complete this course will:

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.

IIPE 316: Data Visualization and Presentation

Pre-requisite: Engineering Mathematics (MAIC 101-102)

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

Brief Description about the course:

The course focuses on fundamental principles, and skills needed to analyze, visualize, and present data effectively using various tools and techniques. The focus will be on real-world applications, especially in the Indian context, covering business, governance, and research applications.

Course Content:

Unit - I (8 hrs)

Foundations of Data Visualization:

Introduction to Data Visualization, Principles of Effective Visual Communication, Data Types & Basic Visualization Techniques: Structured vs. Unstructured Data, Categorical & Numerical Data Representation, Basic Chart Types: Bar, Line, Pie, Histogram, Scatter. Data Ethics and Privacy Considerations.

Unit – II (12 hrs)

Advanced Visualization Techniques:

Multidimensional and Interactive Visualizations: Heatmaps, Bubble Charts, Tree Maps, Geospatial Visualizations (Maps using GIS, Google Maps, Leaflet), Time-Series Analysis (Stock Market, Climate Trends). Visualization Tools & Libraries: Tableau, Power BI, Python: Plotly, Seaborn, R: ggplot2. Introduction to Dashboards, Designing Interactive Dashboards, Data Storytelling for Decision-Making.

Unit – III (12 hrs)

Data-Driven Presentations & Reports:

Designing Effective Presentations, Tools for data Presentation: PowerPoint, Google Slides, Canva. Embedding Live Charts and Dashboards. Visual analytics, Dashboard development, Exploratory visualization.

Unit – IV (8 hrs)

Real-World Applications:

Case Studies from India (e.g., UPI transactions, COVID-19 data visualization, election results analysis) and Project.

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:

CO 1: Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains.

CO 2: Incorporate transfer of knowledge in machine learning algorithms.

CO 3: Implement deep learning algorithms and solve real-world problems.

CO 4: Implementation of Deep Learning techniques using Python.

IIPE 317: Sensor Data Mining

Pre-requisite: Wireless Sensor Networks (IIPC 301)

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

Brief Description about the course:
Sensor data mining is an interdisciplinary field focused on extracting meaningful patterns, and insights from data generated by sensors embedded in environments or systems. It combines principles from data mining, machine learning, signal processing, and IoT to analyse high-dimensional, noisy, and real-time sensor data. Sensor data mining enables automated decision-making in real-world systems, turning raw sensor streams into actionable insights. It bridges gaps between physical sensing and data-driven intelligence, driving innovations in sustainability, healthcare, and industry 4.0.

Course Content:

Unit - I (8 hrs)
Introduction to Sensor Data Mining: Characteristics of sensor data: streaming, noisy, high-dimensional, temporal-spatial correlation; Model-based sensor data acquisition; Model-based sensor data cleaning; Model-based query processing; Topologies of wireless sensor networks (WSNs); data acquisition and aggregation.

Unit – II (12 hrs)
Event processing in sensor streams; feature engineering for sensor data; spatial and temporal feature extraction; dimensionality reduction and filtering on time-series sensor streams, tracking correlations and hidden variables (SPIRIT), forecasting and missing values, pattern discovery across time; Classification; Clustering; Anomaly detection; Sensor stream mining issues; stream mining algorithms.

Unit – III (12 hrs)
Real-Time Data Analytics in Sensor Networks: Data collection and preprocessing; real-time vs batch processing; Distributed Data Mining in Sensor Networks: clustering in WSN, classification in WSN, outlier detection in WSN; Social sensing; privacy issues in social sensing; trajectory mining for social sensing; Social sensing applications.

Unit – IV (8 hrs)
Sensing for Mobile Objects: Data management for mobile objects, probabilistic models for tracking, mining mobility data; Case studies: RFID and GPS data mining, Industrial IoT: predictive maintenance and fault detection.

Text Book(s) / Reference(s):

[1] Charu C. Aggarwal, Tarek Abdelzaher, "Managing and Mining Sensor Data" Springer, 2013.
[2] Jaiwei Han et al., "Data Mining: Concepts and Techniques", 3rd/4th edition, Elsevier.
[3] Charu C. Aggrawal, "Sensor Streams: Models and Algorithms".

Course Outcomes:

CO 1: Preprocess and analyze heterogeneous sensor data.

CO 2: Design and implement data mining pipelines for real-time and batch sensor data.

CO 3: Address challenges like noise, scalability, and data dimensionality.

CO 4: Understanding core data mining concepts including classification, clustering, missing values, correlation, etc.

CO 5: Mine spatial-temporal patterns from sensor data.

IIPE 318 Introduction to Operational Technologies Networks

Pre-requisite: Data Communication & Networking (IIPC 212)

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

Brief Description about the course:

This course provides an introduction to Operational Technology (OT) networks, which are used to monitor and control industrial processes, critical infrastructure, and manufacturing systems. It covers fundamental concepts of OT networks, differences between IT and OT networks, common industrial communication protocols, cybersecurity concerns, and best practices for OT security. By the end of this course, learners will have a strong foundational understanding of OT network architectures, protocols, and security measures.

Course Content:

Unit - I (10 hrs)

Fundamentals of Operational Technology Networks:

Introduction to OT Networks: Definition and Importance, Differences Between IT and OT Networks, Overview of Industrial Control Systems (ICS), Components of OT Networks: PLCs, SCADA, DCS, RTUs, Real-world Applications of OT Networks in Various Industries, Challenges in Implementing and Managing OT Networks.

Unit - II (10 hrs)

Industrial Communication Protocols:

Introduction to Industrial Protocols and Standards, Understanding Modbus Protocol (Function Codes, Communication Mechanism), DNP3 (Distributed Network Protocol) Basics, OPC-UA and Its Role in OT Networks, PROFINET and EtherNet/IP Protocols, Real-World Case Studies of Industrial Protocols in Action.

Unit – III (10 hrs)

OT Network Architectures and Security:

Overview of OT Network Architecture (ISA-95 Model), Network Segmentation and Air-Gapped Systems, Common Vulnerabilities in OT Networks, Introduction to OT Cybersecurity (NIST & IEC 62443 Standards), Secure Remote Access in OT Environments, Risk Assessment and Incident Response in OT Networks.

Unit – IV (10 hrs)

Case Studies and Best Practices:

Case Study: Cyberattacks on OT Networks (Stuxnet, Triton, BlackEnergy), Best Practices for OT Network Design and Implementation, Compliance and Regulatory Requirements (NERC CIP, ISO 27001), Future Trends in OT Security and Emerging Technologies, Hands-on Exercises: Analyzing Network Traffic in OT Environments.

Text Book(s) / Reference(s):

[1] Knapp, E. D., & Langill, J. T. (2014). Industrial Network Security: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems (2nd ed.). Syngress. ISBN-13: 978-0124201149.

[2] Macaulay, T., & Singer, B. L. (2012). Cybersecurity for Industrial Control Systems: SCADA, DCS, PLC, HMI, and SIS (1st ed.). Auerbach Publications. ISBN-13: 978-1439801963.
[3] Knapp, E. D., & Samani, R. (2013). Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure (1st ed.). Syngress. ISBN-13: 978-1597499989.
[4] Bhattacharjee, S. (2018). Practical Industrial Internet of Things Security (1st ed.). Packt Publishing. ISBN-13: 978-1788625821.
[5] Lee, R. (2015). SCADA and Me: A Beginner's Guide to Supervisory Control and Data Acquisition (1st ed.). CreateSpace Independent Publishing Platform. ISBN-13: 978-1500734756.
[6] Mackay, S., Wright, E., Reynders, D., & Park, J. (2004). Practical Industrial Data Networks: Design, Installation and Troubleshooting. Newnes. ISBN-13: 978-0750663955.
[7] Boyer, S. A. (2010). SCADA: Supervisory Control and Data Acquisition (4th ed.). ISA. ISBN-13: 978-1936007097.

Course Outcomes:

At the end of the course student will be able to...

CO 1: Understand the basic concepts and architecture of Operational Technology (OT) networks.

CO 2: Differentiate between IT and OT networks and their unique requirements.

CO 3: Identify and explain key OT communication protocols such as Modbus, DNP3, and OPC-UA.

CO 4: Understand industrial control system (ICS) components and how they interact within OT networks.

CO 5: Recognize key cybersecurity challenges and best practices for securing OT networks.

IIPE 319 ASICs & FPGAs

Pre-requisite: Microprocessors & Computer Architecture (IIPC 209)

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 (10hrs)

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 (10hrs)

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 (10hrs)

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 (10hrs)

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, Edr, 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 Pubin, 1992.
[7] J. Old Field, R. Dorf, Field Programmable Gate Arrays, John Wiley & Sons, New York, 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:

At the end of the course, student 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.

IIPE 320 BLOCK CHAIN TECHNOLOGIES

Pre-requisite: Problems Solving and Programming using C (CSIC 103), Data Communication & Networking (IIPC 212)

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

Brief Description about the course:

Blockchain is an emerging technology platform for developing decentralized applications and data storage, over and beyond its role as the technology underlying the cryptocurrencies. The basic tenet of this platform is that it allows one to create a distributed and replicated ledger of events, transactions, and data generated through various IT processes with strong cryptographic guarantees of tamper resistance, immutability, and verifiability. Public blockchain platforms allow us to guarantee these properties with overwhelming probabilities even when untrusted users are participants of distributed applications with ability to transact on the platform. Even though, blockchain technology has become popularly known because of its use in the implementation of Cryptocurrencies such as BitCoin, Ethereum, etc., the technology itself holds much more promise in various areas such as time stamping, logging of critical events in a system, recording of transactions, trustworthy e-governance etc. Many researchers are working on many such use cases such as decentralized public key infrastructure, self-sovereign identity management, registry maintenance, health record management, decentralized authentication, decentralized DNS, etc. Also, corporations such as IBM and Microsoft are developing their own applications in diverse fields such as the Internet of Things (IoT), etc., even enabling blockchain platforms on the cloud.

Course Content:

UNIT-1 (8 hrs)

INTRODUCTION:

Introduction: Need for Distributed Record Keeping Modelling faults and adversaries Byzantine Generals problem Consensus algorithms and their scalability problems. Why Nakamoto Came up with Blockchain based cryptocurrency? Technologies Borrowed in Blockchain - hash pointers, consensus, byzantine fault-tolerant distributed computing, digital cash.

UNIT-2 (10 hrs)

BASIC DISTRIBUTED COMPUTING AND CRYPTO PRIMITIVES:

Basic Distributed Computing: Atomic Broadcast, Consensus, Byzantine Models of fault tolerance.

Basic Crypto Primitives: Hash functions, Puzzle friendly Hash, Collision resistant hash, digital signatures, public key crypto, verifiable random functions, Zero-knowledge systems.

UNIT-3 (12 hrs)

BLOCKCHAIN 1.0; BLOCKCHAIN 2.0 and BLOCKCHAIN 3.0:

Blockchain 1.0: Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their use.

Blockchain 2.0: Ethereum and Smart Contracts, The Turing Completeness of Smart Contract Languages and verification challenges, Using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum Smart Contracts.
Blockchain 3.0: Hyperledger fabric, the plug and play platform and mechanisms in permissioned blockchain.

UNIT-4 (12 hrs)

PRIVACY, SECURITY ISSUES IN BLOCKCHAIN:

Privacy, Security issues in Blockchain: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains - such as Sybil attacks, selfish mining, 51% attacks - advent of algorand, and Sharding based consensus algorithms to prevent these.

Text Book(s) / Reference(s):

[1] Draft version of S. Shukla, M. Dhawan, S. Sharma, S. Venkatesan, 'Blockchain Technology: Cryptocurrency and Applications', Oxford University Press, 2019.
[2] Josh Thompson, 'Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming', Create Space Independent Publishing Platform, 2017.
[3] Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Imran Bashir, Packt Publishing, 2020, ISBN: 9781839213199.
[4] Chakraborty, R., Ghosh, A., Balas, V.E., & A Elngar, A. (Eds.). (2022). Blockchain: Principles and Applications in IoT (1st ed.). Chapman and Hall/CRC.

Course Outcomes:

At the end of the course, the students will be able to:
CO1: Illustrate and understand basic Cryptographic primitives used in Blockchain.
CO2: Explain the concepts basic Distributed System - distributed consensus and atomic broadcast, Byzantine fault-tolerant consensus methods.
CO3: Analyze basic Blockchain (Blockchain 1.0) - concepts germane to Bitcoin and contemporary proof-of-work based consensus mechanisms.
CO4: Explain the concepts of Blockchain 2.0 - Blockchains with smart contracts and Turing complete blockchain scripting.
CO5: Apply the theory of Blockchain 3.0 - Plug-and-play mechanisms for consensus and smart contract evaluation engines.
CO6: Apply the knowledge of Beyond Cryptocurrency - applications of blockchain in cyber security, integrity of information, E-Governance and other contract enforcement mechanisms.

IIPC 311 EMBEDDED SYSTEM LAB

Pre-requisite: Problems Solving and Programming using C (CSIC 103), Microprocessors & Computer Architecture (IIPC 209)

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

Brief Description:
This lab provides hands-on experience with embedded system programming across multiple microcontroller platforms including 8051, ARM (LPC 2148), PIC (16F877), and AVR (ATmega16). Students write and debug C and assembly programs, interface I/O devices such as LEDs, LCD displays, keypads, and motors, and gain practical exposure to industry-standard development tools like the KEIL IDE.

List of Experiments:
ARM: LPC 2148 ARM 7 Processor

1. ARM programming in C language using KEIL IDE.
2. Implement the lighting and winking of LEDs on the ARM I/O port via programming.
3. Change ARM state mode using MRS/MSR instructions and specify a start address of the text segment using the command line.
4. Read analog voltage and display its digital equivalent on LCD using ARM.

PIC: PIC 16F877

5. Reading matrix keypad using PIC 16F877.

AVR: ATmega16

6. Stepper Motor Control using ATmega16 Microcontroller.
7. 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 subsystems of functional requirements in optimal hardware and software components.

IIPC 312 Mechatronics / Industrial Automation Lab

Pre-requisite: Analog and Digital Electronics (IIPC 201)

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

Brief Description about the course:

This lab focuses on hands-on learning, enabling students to design, test, and analyze mechatronic systems used in robotics, automation, control systems, and IoT applications. The Course includes the explanation of the principles and practices governing many kinds of devices and sensors used to control pressure, temperature, flow, color sorting, proximity level, etc. The course also describes the proper use of the TIA Portal and PLC system.

List of Experiments:

1. Understanding the fundamentals of sensors, actuators, and controllers.
2. To understand the basics of the PLC system (S7-1200).
3. To study and understand functionalities in TIA Portal.
5. To study and analyze various sorting functionalities.
6. To understand and study proximity sensor and its types.
7. To study LVDT sensors.
8. To study color sensors.
9. To study a pneumatic sensor to measure its various pressure values.
10. To design various logic gates using ladder logic.

Course Outcomes:

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

CO1: Illustrate and understand basic PLC systems.
CO2: To understand the basics of TIA Portal.
CO3: To understand the basics of the PLC system (S7-1200).
CO4: Analyze and implement various sensors.

IIPC 313 Process Instrumentation Lab

Pre-requisite: Wireless Sensor Networks (IIPC 301)

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

Brief Description about the course:

This laboratory course provides comprehensive hands-on experience in Programmable Logic Controller (PLC) based industrial automation and process control. Students begin with the fundamentals of PLC architecture and progress through increasingly complex control applications using industry-standard platforms including CODESYS, Siemens SIMATIC Manager (S7-400), and Open PLC Runtime on Arduino. The course covers essential PLC programming constructs such as timers, counters, and ladder logic, and applies them to real-world scenarios including traffic light control, pump systems, heating loops, and conveyor automation. Students further explore industrial sensor integration — encompassing ultrasonic flow, electromagnetic flow (Magmeter), and ultrasonic level sensors — to design complete measurement, monitoring, alarm, and batch control systems within simulated PLC environments. The course bridges theoretical control concepts with practical industrial automation skills relevant to modern manufacturing and process industries.

Course Objectives

- To introduce students to PLC fundamentals, architecture, and operation, and to develop basic PLC programs using CODESYS and Siemens SIMATIC Manager platforms.
- To train students in the use of PLC timer and counter instructions to implement time-based and event-driven industrial control applications.
- To enable students to design and simulate closed-loop process control systems such as pump control and heating loop control using PLC software.
- To expose students to alternative PLC platforms by implementing control logic on an Arduino-based Open PLC Runtime environment.
- To develop the ability to design and simulate industrial flow measurement and monitoring systems using ultrasonic and electromagnetic flow sensors within a PLC environment.
- To equip students with skills to implement complete level sensing, process monitoring, alarm management, and batch control automation systems using PLC software.

List of Experiments:

1. Introduction to PLC systems.
    - Understand PLC fundamentals and architecture
    - Explain PLC operation and applications
    - Use CODESYS to develop basic PLC programs - Create, simulate, and test

2. To understand the basics of Siemens SIMATIC Manager software and the S7- 400 PLC hardware, and to develop a simple PLC program to turn an LED ON and OFF.
3. To implement industrial control applications using Timers (TP, TON) and Counters (CTU, CTD) in CODESYS PLC environment.
   - Pulse Timer (TP) – Buzzer for fixed duration
   - Traffic Light Controller – Timed Sequential Operation
   - Staircase Lighting Control – Light ON for fixed duration
   - Digital Counter (CTU / CTD) – Object Counting on Conveyor
4. To design and simulate a Pump Control System using CODESYS PLC software, where the pumpoperation is controlled by Start/Stop push buttons and water level sensors (Low-Level Sensor andHigh-Level Sensor).
5. To design and simulate a Heating Loop Control System using CODESYS PLC software, where a heaterelement maintains a desired (set-point) temperature inside a process chamber or tank. The heater isswitched ON/OFF or modulated based on continuous feedback from a temperature sensor.
6. To implement a fully functional Traffic Light Control System on an Arduino Uno microcontroller boardprogrammed as a Programmable Logic Controller (PLC) using the OpenPLC Runtime.
7. To design and simulate a complete Ultrasonic Flow Sensor measurement and monitoring systementirely within the CODESYS PLC software environment.
8. To design and simulate a complete Electromagnetic Flow Sensor (Magmeter) measurement, monitoringand batch control system entirely within the CODESYS PLC software environment.
9. To design and simulate a complete Ultrasonic Level Sensor measurement, monitoring, alarm, andprocess automation system entirely within the CODESYS PLC software environment.

Course Outcomes:

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

CO1 Explain PLC fundamentals, architecture, and operation; develop, simulate, and test basic PLC programs using CODESYS and Siemens SIMATIC Manager (S7-400) to perform simple control tasks such as LED ON/OFF operation.

CO2 Implement industrial control applications using PLC timer instructions (TP, TON) and counter instructions (CTU, CTD) in CODESYS to realize systems such as timed buzzers, traffic light controllers, staircase lighting, and conveyor object counters.

CO3 Design and simulate closed-loop process control systems — including a pump control system with start/stop push buttons and water level sensors, and a heating loop control system with temperature sensor feedback — using CODESYS PLC software.

CO4 Implement a functional PLC-based control system on an Arduino Uno microcontroller using Open PLC Runtime, demonstrating the application of embedded PLC concepts for real-world control tasks such as traffic light sequencing.

CO5 Design and simulate complete flow measurement and monitoring systems using Ultrasonic Flow Sensors and Electromagnetic Flow Sensors (Magmeters), including batch control logic, entirely within the CODESYS PLC software environment.
CO6 Design and simulate a complete Ultrasonic Level Sensor-based system within CODESYS incorporating measurement, real-time monitoring, alarm management, and process automation functions for industrial-level control applications.

VIIth SEMESTER

IIPC 401 IoT Security

Pre-requisite: Data Communication & Networking (IIPC 212)

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

Brief Description about the course

This course explores the fundamental security challenges and threats within the IoT ecosystem, focusing on vulnerabilities and privacy issues. Students learn to design secure systems using cryptography, lightweight encryption, and intrusion detection tailored for constrained environments.

Course Contents:

Unit I: FUNDAMENTALS OF IoT ECOSYSTEM (10 hrs)

IoT security issues, Security challenges, threats, and privacy issues specific to IoT environments. Security vulnerabilities, security attacks, Security mechanisms and services in IoT, design of secure IoT system, Basics of cryptography, Resource-efficient encryption methods designed for constrained environments.

Unit II: (10 hrs)

Key management and exchange protocols (Diffie-Hellman, Elliptic Curve Cryptography). Authentication mechanisms, lightweight cryptographic algorithm for IoT, Real time security attacks in IoT environment, Intrusion detection system design for IoT.

Unit III: (10 hrs)

IoT security protocols, Physical and MAC layer security of standards- IEEE 802.15.4, 802.11ah, and LoRaWAN, **Network and Transport Layer Protocols:** Security aspects of IPv6 over Low-Power Wireless Personal Area Networks (6LoWPAN), TCP, and UDP **Application Layer Protocols:** Security mechanisms in application protocols such as MQTT (Message Queuing Telemetry Transport), CoAP (Constrained Application Protocol), HTTP/HTTPS, and AMQP.

Unit IV: (10 hrs)

Implementation and deployment of IoT security techniques: Case studies in smart homes, smart cities, industrial IoT (Industry 4.0), and automotive applications.

Text Book(s) / Reference(s):

[1] David Etter, “IoT Security: Practical Guidebook," Create Space, 1st Edition, 2016.
[2] Drew Van Duren, Brian Russell, “Practical Internet of Things Security”, Packt, 1st Edition, 2016.
[3] Sean Smith, “The Internet of Risky Things”, O’Reilly Media, 1st Edition, 2017.
[4] Brian Russell, Drew Van Duren, “Practical Internet of Things Security: Design a security framework for an Internet connected ecosystem”, 2nd Edition, 2018.

Course Outcomes (COs):

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

CO1: Understand the fundamental security issues, vulnerabilities, and privacy challenges specific to the IoT ecosystem.
CO2: Apply resource-efficient cryptographic algorithms and key exchange protocols like Diffie-Hellman and ECC for constrained environments.
CO3: Design intrusion detection systems and analyze security aspects of physical, network, and application layer protocols (6LoWPAN, MQTT, CoAP).
CO4: Evaluate and deploy security techniques through case studies in smart homes, industrial IoT, and automotive applications.

IIPC 402: CLOUD, EDGE AND FOG COMPUTING

Pre-requisite: Data Communication &Networking (IIPC 212)

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

Brief Description about the course

This course provides a comprehensive overview of the computing paradigm shift from centralized cloud to decentralized edge and fog computing. It covers the architectural principles, service models and deployment strategies of cloud Computing, followed by an in-depth study of fog and edge computing architectures designed to handle latency-sensitive applications. The course also addresses resource allocation, security challenges and the integration of these technologies with IoT and 5G networks.

Course Contents:

Unit I (10 hrs)

Overview of Computing Paradigms (Grid, Cluster, Utility), Evolution of Cloud Computing, NIST Model, Cloud Service Models (IaaS, PaaS, SaaS), Cloud Deployment Models (Public, Private, Hybrid, Community). Virtualization: Introduction, Types of Virtualizations (Server, Storage, Network), Hypervisors (Type 1 and Type 2), Virtual Machine Migration, Introduction to Containerization (Docker, Kubernetes) and Microservices.

Unit II (10 hrs)

Cloud Data Center Design, Service Level Agreements (SLA), Resource Scheduling and Management, Load Balancing techniques. Cloud Security: Shared Responsibility Model, Data Security and Privacy, Identity and Access Management (IAM). Introduction to Big Data Analytics in Cloud (MapReduce, Hadoop). Serverless Computing and FaaS (Function as a Service).

Unit III (10 hrs)

Limitations of Cloud for Latency-sensitive applications, Definition and Characteristics of Fog Computing, Fog Architecture (OpenFog Reference Architecture), Fog vs. Cloud, Fog Nodes and Hierarchy. Connectivity and Protocols for Fog (MQTT, CoAP, AMQP). Computation Offloading fundamentals. Fog Data Management.

Unit IV (10 hrs)

Introduction to Edge Computing, Multi-access Edge Computing (MEC) in 5G Networks, Mobile Cloud Computing (MCC) vs. MEC. Deep Learning at the Edge (Edge AI). Security and Privacy in Edge/Fog. Use Cases: Smart Cities, Connected Vehicles (V2X), Industrial IoT (IIoT), and Augmented Reality. Orchestration of Cloud-Fog-Edge continuum.

Text Book(s) / Reference(s):

[1] Rajkumar Buyya, Christian Vecchiola and S. Thamarai Selvi, Mastering Cloud Computing, McGraw Hill, 2013.

[2] Rajkumar Buyya and Satish Narayana Srirama, Fog and Edge Computing: Principles and Paradigms, Wiley, 2019.

[3] Kai Hwang, Geoffrey C. Fox, and Jack J. Dongarra, Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Morgan Kaufmann.

Course Outcomes (COs):

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

CO1: Understand the core architecture, service models, and virtualization techniques of Cloud Computing.

CO2: Analyze resource management strategies and security implications in distributed cloud environments.

CO3: Evaluate the need for Fog computing and explain its architecture and protocols in the context of IoT.

CO4: Design and analyze Edge and MEC based solutions for latency-critical and bandwidth-intensive applications.

IIPE 401 IMAGE PROCESSING

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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:(6 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. 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 (COs):

At the end of the course student 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.

IIPE 402 BIOMEDICAL ELECTRONICS

Pre-requisite: Analog and Digital Electronics (IIPC 201)

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: Physiological Systems and Signals (10 hrs)

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: Physiological Transducers (10 hrs)

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: Recording Systems (10 hrs)

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: Diagnostic and Therapeutic Equipment (10 hrs)

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, Maxwell Macmillan International Publishing Company.

[2] Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment and Technology, 4th Edition, Prentice-Hall, 2001.

[3] John G Webster, Medical Instrumentation Applications and Design, John Wiley and Sons, 3rd Edition, 2011.
[4] R S Khandpur, Handbook of Biomedical Instrumentation, McGraw Hill, 3rd Edition, 2014.
[5] L A Geddes, L E Baker, Principles of Applied Medical Instrumentation, Wiley India, 3rd Edition, 2008.

Course Outcomes (COs):

At the end of the course the student 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 design diagnostic devices and evaluate quality of diagnostic devices.

IIPE403 OPTICAL COMMUNICATION NETWORKS

Pre-requisite: Principles of Communication Engineering (IIPC 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 algorithm such as SONET/SDH and optical CDMA. Further students will explore trends of optical fiber measurement systems.

Course Contents:

Unit I: Introduction to Optical Fibers(10 hrs)

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: Fiber Optical Sources and Coupling(10 hrs)

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, Lencing schemes, Fiber-to-Fiber joints, Fiber splicing, Signal to Noise ratio, Detector response time.

Unit III: Fiber-Optic Receiver and Measurements(10 hrs)

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: Optical Networks and System Transmission(10 hrs)

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 (COs):

At the end of the course student 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.

IIPE 404 RF MICROELECTRONICS

Pre-requisite: Analog and Digital Electronics (IIPC 201), Principles of Communication Engineering (IIPC 205)

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

Brief Description of the Course:

This course imparts knowledge on high-frequency integrated circuit design, specifically focusing on RF filters, amplifiers, and oscillators. Students learn to manage noise in RF circuits and design phase-locked loops (PLL) for wireless communication systems.

Course Contents:

Unit I: Active RF Components and RF Filter Design (8 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: High-Frequency Amplifier Design (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: Noise in RF Circuits (8 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.

Unit IV: Phase-Locked Loops and RF Oscillators (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] R. E. Best, Phase-Locked Loops: Design, Simulation and Applications, Fifth Edition, MH.

Course Outcomes (COs):

At the end of the course student 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.

IIPE 405 Mobile Application Development

Pre-requisite: Object Oriented Programming with JAVA (INT) (IIPC 213)

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

Brief Description:

Focused on the Android ecosystem, this course teaches the mobile development lifecycle, UI design, and data storage using SQLite. It specifically highlights integrating mobile apps with IIoT services and real-time cloud data platforms like Firebase.

Course Contents:

Unit I: Introduction to Mobile Application Development (10 hrs)

Evolution of mobile computing, Mobile platforms overview: Android, iOS, Cross-platform frameworks, Mobile OS architecture and components, Mobile application types: Native, Hybrid, Web apps, Mobile application development life cycle, Overview of Android ecosystem.

Unit II: Android User Interface Design (10 hrs)

Android application structure, Activity and Activity lifecycle, Layouts: Linear and Relative Layout, Basic UI components: TextView, EditText, Button, ImageView, Event handling using buttons, Intents (explicit and implicit).

Unit III: Data Storage and Connectivity (10 hrs)

Data storage methods: Shared Preferences, SQLite (basic CRUD operations), Introduction to Internet permissions, Basic networking concepts, Introduction to REST APIs, Fetching and displaying data from API (JSON basics).

Unit IV: Mobile Apps for IIoT (10 hrs)

Introduction to IoT and IIoT, Role of mobile apps in IIoT, Mobile app communication with IoT devices, Introduction to MQTT protocol, Cloud platforms overview (Firebase basics), Real-time data display on mobile app. Mobile application security threats, Secure data storage and encryption, Authentication and authorization, App testing: Unit testing and UI testing, Debugging and performance optimization, App packaging and signing, Google Play Store publishing process, Case studies: IIoT mobile applications.

Text Book(s) / Reference(s):

[1] Internet of Things: A Hands-on Approach by Arshdeep Bahga and Vijay Madisetti.
[2] Android Programming: The Big Nerd Ranch Guide by Bill Phillips, Chris Stewart, Kristin Marsicano.

Course Outcomes (COs):

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

CO1: Understand the mobile application development life cycle and the architecture of the Android ecosystem.

CO2: Design and develop Android applications with advanced UI components and efficient event handling.

CO3: Implement data storage solutions using SQLite and integrate mobile apps with cloud platforms like Firebase.
CO4: Develop industry-ready applications that integrate with IIoT services and real-time data messaging.

IIPE 406 OPTICAL NETWORKING AND SWITCHING

Pre-requisite: Principles of Communication Engineering (IIPC 205), Data Communication and Networking (IIPC 212)

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 Contents:

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, implementation and application. MEMs based switching, switching with SOAs, lamda 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, 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 (COs):

Upon successful completion of the 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.

IIPE 407 COGNITIVE RADIO

Pre-requisite: Principles of Communication Engineering (IIPC 205)

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

Course 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 (COs):

Upon successful completion of the 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.

IIPE 408 RADAR & Navigation

Pre-requisite: Signals, Systems & Random Variables (IIPC 202), Introduction to IoT (IIPC 205)

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

Brief Description:

The curriculum covers RADAR operating principles, signal processing for target detection, and various navigation systems including GPS and INS. It also investigates the integration of radar sensors with IIoT environments for autonomous and industrial applications.

Course Contents:

Unit I: Fundamentals of RADAR Systems (10 hrs)

Basic RADAR principle and block diagram, RADAR equation and power calculations, radar cross section, RADAR frequencies and spectrum allocation, Types of RADAR: Pulse RADAR, Continuous Wave (CW) RADAR, FMCW RADAR. Applications of RADAR.

Unit II: RADAR Signal Processing, Performance and Antennas (10 hrs)

RADAR range equation and maximum detection range, Minimum detectable signal, Range resolution and accuracy, Doppler shift & effect and velocity measurement, RADAR antennas: Parabolic reflector antennas, Phased array antennas, Beamwidth, gain, and sidelobes, Clutter, noise model and signal to noise ratio, Pulse compression techniques, Moving Target Indication (MTI).

Unit III: Navigation Systems (10 hrs)

Fundamentals of navigation, Coordinate systems and reference frames, Radio navigation systems, Hyperbolic navigation systems, Satellite Navigation systems, Inertial Navigation System (INS): Gyroscopes, Accelerometers. Global Navigation Satellite Systems (GNSS/GPS). Marine, air, and land navigation systems.

Unit IV: RADAR & Navigation in IIoT Applications (10 hrs)

RADAR sensors in IIoT environments, Automotive RADAR for ADAS, Defense and surveillance, Industrial RADAR for: Level measurement, Collision avoidance, Object tracking. Integration of RADAR with: IoT gateways, Edge computing, Cloud analytics. Cybersecurity challenges in RADAR & navigation systems.

Text Book(s) / Reference(s):

[1] Merrill I. Skolnik, Introduction to Radar Systems, McGraw-Hill, 2002.
[2] Peebles, Radar Principles, Wiley, NY, 1993.
[3] Bassem R. Mahafza, Radar Systems Analysis and Design Using MATLAB, Chapman & Hall, 2000.
[4] E. Kaplan & C. Hegarty, Understanding GPS/GNSS, Artech House, 2006.
[5] Byron Edde, Radar: Principles, Technology, Applications, Pearson Education, 2004.
[6] Myron Kayton, Walter R. Fried, Avionics Navigation Systems, 2nd Edition, John Wiley & Sons, 1997.

Course Outcomes (COs):

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

CO1: Explain basic RADAR principles, equations, types, and applications.

CO2: Analyze RADAR performance, antennas, and signal processing techniques.

CO3: Understand the navigation systems including radio, satellite, and inertial navigation.

CO4: Apply RADAR and navigation concepts in IIoT and industrial applications.

IIPE 409 Vehicular Ad-hoc Networks

Pre-requisite: Data Communication and Networking (IIPC 212), Principles of Communication Engineering (IIPC 205)

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

Brief Description about the course

In this course, students will learn the fundamentals of Vehicular Ad-hoc Networks (VANETs), including their architecture and communication models. They will study vehicular communication standards, routing, and data dissemination techniques. Students will also understand security and privacy challenges in vehicular environments. The course explores applications of VANETs in Industrial Internet of Things and smart transportation systems.

Course Contents:

Unit I: Fundamentals of Vehicular Ad-hoc Networks (10 hrs)

Introduction to Intelligent Transportation Systems (ITS), Motivation for vehicular communication, Evolution of vehicular networks, Overview of Mobile Ad-hoc Networks (MANETs), Comparison of MANETs, VANETs, and IoT networks, Characteristics of VANETs: High mobility, Rapidly changing topology, Variable network density, Predictable mobility patterns. Challenges in VANETs: Scalability, Network fragmentation, Latency constraints, Reliability and real-time requirements. VANET application domains: Road safety and accident prevention, Traffic monitoring and congestion control, Infotainment and comfort services, Emergency and disaster management.

Unit II: VANET Architecture, Communication Models and Standards (10 hrs)

VANET system architecture, Key components: On-Board Unit (OBU), Road-Side Unit (RSU), Trusted Authority (TA). Network architectural models: Pure ad-hoc architecture, Infrastructure-based architecture, Hybrid architecture. Communication models: V2V, V2I, V2X. Mobility modeling in VANETs; Dedicated Short Range Communication (DSRC); IEEE 802.11p physical and MAC layer overview; WAVE architecture and IEEE 1609.x protocol stack; Cellular-V2X (C-V2X) communication; Role of LTE and 5G in vehicular networking.

Unit III: Routing and Data Dissemination in VANETs (10 hrs)

Issues and challenges in VANET routing, Classification of routing protocols: Topology-based routing (proactive and reactive), Position-based (geographic) routing, Cluster-based routing. Greedy forwarding and location-based routing principles, Broadcast and geocast routing protocols, Beaconing mechanisms, Event-driven message dissemination, Store-carry-and-forward paradigm, Delay Tolerant Networks (DTN) in VANETs. Performance evaluation metrics: End-to-end delay, Packet delivery ratio, Throughput, Routing overhead.

Unit IV: Security, Privacy and Industrial IoT Applications (10 hrs)
Security requirements in VANETs: Authentication, Integrity, Confidentiality, Availability, Non-repudiation. Security threats and attacks: Sybil attack, Denial of Service (DoS), Message spoofing and replay attacks, False data injection. Public Key Infrastructure (PKI) for VANETs, Authentication and key management techniques, Trust and reputation management systems, Privacy preservation mechanisms, Secure routing and secure data dissemination, Integration of VANETs with Industrial IoT. VANET role in: Smart transportation systems, Smart logistics and fleet management, Autonomous and connected vehicles.

Text Book(s) / Reference(s):
[1] Vehicular Applications and Inter-Networking Technologies, Hannes Hartenstein & Kenneth P. Laberteaux, Wiley.
[2] Vehicular Networking, Christoph Sommer & Falko Dressler, Cambridge University Press.
[3] Routing in Vehicular Ad Hoc Networks, Fan Li & Yu Wang, Springer.
[4] Ad Hoc Wireless Networks: Architectures and Protocols, C. Siva Ram Murthy & B. S. Manoj.

Course Outcomes (COs):
At the end of the course student will be able to:
CO1: Explain the concepts, characteristics, and applications of VANETs.
CO2: Describe VANET architectures, communication models, and standards.
CO3: Analyze routing, broadcasting, and data dissemination techniques.
CO4: Apply security mechanisms and VANET concepts to IIoT applications.

IIPE 410 QUANTUM COMMUNICATION

Pre-requisite: Principles of Communication Engineering (IIPC 205)

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

Course 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 (COs):

The students will demonstrate the ability to:

CO1: Understand quantum communication.
CO2: Analyse quantum cryptography.
CO3: Evaluate the performance of quantum communication.
CO4: Apply quantum teleportation.

IIPE 411 OPTICAL WIRELESS TECHNIQUES FOR IOT & 5G/6G SYSTEMS

Pre-requisite: Principles of Communication Engineering (IIPC 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: Introduction – Optical Wireless Communication Systems(10 hrs)

Existing wireless systems, OWC/Radio Comparison, Potential OWC Application Areas. Optical Sources: LEDs and Lasers (Internal and External Quantum Efficiency, Power and Luminescence Efficiency and modulation bandwidth). Detectors: PIN and APD detectors, photo detection techniques, photo detection noise.

Unit II: Channel Modelling(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: Modulation Schemes and System Performance (Indoor)(10 hrs)

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: System Performance (Outdoor) and Use Cases(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 et al. 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. Springer, 2010.

Course Outcomes (COs):

At the end of the course student 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 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 technique 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.

IIPE 412 IoT Project Management

Pre-requisite: Introduction to IoT (IIPC 204)

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

Course Description:

This course teaches the management of IoT initiatives, addressing unique challenges like real-time data needs and device heterogeneity. Students learn to apply agile methods, risk mitigation, and security-by-design across the project lifecycle.

Course Contents:

Unit I: Introduction to IoT and Project Management Fundamentals (10 hrs)

This unit introduces Internet of Things basics: definitions, characteristics, architecture (physical and logical), levels, and enablers like sensors, actuators, protocols, and cloud/edge computing. It highlights differences between traditional IT projects and IoT projects due to heterogeneity, real-time needs, privacy, and scale. Project management fundamentals include life cycle phases (initiation to closure) and relevant PMBOK areas. It covers stakeholders, business case, feasibility studies, and examples from smart cities, agriculture, healthcare, and industrial IoT.

Unit II: IoT Project Planning and Requirements Management (10 hrs)

This unit focuses on IoT requirements engineering: capturing functional and non-functional needs, user stories, use cases, and sensor-actuator mapping. Scope management includes defining boundaries and creating WBS for hardware, firmware, middleware, and cloud tasks. Time management covers Gantt charts, CPM, and PERT for IoT timelines. Resource management addresses hardware procurement, team roles (embedded, cloud, data), and agile vs waterfall suitability. Cost estimation includes budgeting for devices, cloud, testing, deployment, and maintenance.

Unit III: Risk, Quality, and Agile Management in IoT Projects (10 hrs)

This unit covers IoT risk management: identifying threats like security flaws, interoperability issues, network failures, and mitigation via redundancy, encryption, and OTA updates. Quality management includes testing levels (unit to field), reliability metrics, and standards compliance. Agile practices for IoT feature Scrum, Kanban, sprints, MVP development, and DevOps with CI/CD pipelines. It also addresses configuration management, version control for firmware/hardware, change handling, and vendor coordination for IoT components.

Unit IV: IoT Project Execution, Monitoring, Deployment, and Closure (10 hrs)

This unit discusses execution coordination, communication plans, and tools for distributed IoT teams. Monitoring uses KPIs (uptime, latency, security), dashboards, and earned value management. Deployment covers edge vs cloud models, pilot testing, scaling, and rollback plans. It emphasizes security-by-design, regulatory compliance (e.g., GDPR), and ethical aspects. Closure includes handover, documentation, lessons learned, and long-term maintenance planning, with case studies of successful and failed real-world IoT projects.

Text Book(s) / Reference(s):

[1] Internet of Things: A Hands-on Approach by Arshdeep Bahga and Vijay Madisetti.
[2] A Guide to the Project Management Body of Knowledge (PMBOK Guide) – 7th Edition by PMI.
[3] Project Management in Cloud and IoT Applications by Pramod Chandra P. Bhatt.
[4] Building the Internet of Things by Maciej Kranz.
[5] Internet of Things: Principles and Paradigms by Rajkumar Buyya and Amir Vahid Dastjerdi.

Course Outcomes (COs):

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

CO1: Master the concepts of project initiation, planning, and execution specifically tailored for IoT environments.

CO2: Apply risk management, quality assurance, and security-by-design principles to complex IoT projects.

CO3: Utilize Agile methodologies, such as Scrum and Kanban, to manage the rapid prototyping and deployment of IoT solutions.

CO4: Effectively manage project costs, resources, and stakeholders while addressing the technical constraints of device heterogeneity.

IIPE 413 SCADA System Applications

Pre-requisite: Automation Fundamentals (IIPC 203)

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

Brief Description:

Focusing on industrial automation, this course covers the architecture of SCADA systems and industrial communication protocols. Students learn to configure SCADA for real-world monitoring and control of industrial processes.

Course Contents:

Unit I: Introduction to SCADA Systems (10 hrs)

Evolution of Industrial Automation and Control Systems, Definition, Need, and Scope of SCADA, SCADA vs DCS vs PLC-based Control Systems. Basic SCADA Architecture: Field Devices (Sensors, Actuators), Remote Terminal Units (RTUs), Programmable Logic Controllers (PLCs), Human Machine Interface (HMI). Data Acquisition and Supervisory Control Concepts, Overview of Industrial Applications of SCADA.

Unit II: SCADA Hardware and Communication Protocols (10 hrs)

SCADA Hardware Components: RTU Architecture and Functions, PLC Integration in SCADA, Intelligent Electronic Devices (IEDs). Data Transmission Media: Wired (RS-232/485, Ethernet, Fiber Optics), Wireless (Radio, GSM/GPRS, Wi-Fi, LPWAN). Industrial Communication Protocols, Network Topologies for SCADA, Time Synchronization and Data Integrity.

Unit III: SCADA Software, HMI Design and Industrial Applications (10 hrs)

SCADA Software Architecture, SCADA Configuration Concepts, Tag Management and Database Connectivity, HMI Design Principles, Data Logging and Historical Data Analysis, SCADA System Deployment, Case Studies.

Unit IV: Advanced SCADA Concepts, Cybersecurity and IIoT Integration (10 hrs)

SCADA System Reliability and Redundancy, Performance and Scalability Issues, SCADA Cybersecurity, Standards and Guidelines (IEC 62443, NIST overview), Integration of SCADA with: IIoT platforms, Cloud computing, Data analytics. Emerging Trends.

Text Book(s) / Reference(s):

[1] Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition, 4th Edition, ISA, USA.

[2] David Bailey and Edwin Wright, Practical SCADA for Industry, Newnes (Elsevier).

[3] Gordon Clarke and Deon Reynders, Practical Modern SCADA Protocols: DNP3, 60870.5 and IEC 61850, Newnes (Elsevier).

[4] Gary Dunning, SCADA Systems and Control, Industrial Press Inc.

Course Outcomes (COs):

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

CO1: Explain the architecture, components, and operating principles of SCADA systems used in industrial automation and process control.

CO2: Analyze SCADA hardware and industrial communication protocols to support reliable data acquisition, monitoring, and control of field devices.
CO3: Design and configure basic SCADA applications, including HMI screens, alarms, data logging, and reporting, for representative industrial processes.
CO4: Evaluate advanced SCADA systems with respect to performance, cybersecurity challenges, and integration with IIoT and Industry 4.0 technologies.

IIPE 414: Wearable Computing

Pre-requisite: Microprocessors & Computer Architecture (IIPC 209)

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

Brief Description:

This course integrates Internet of Things technologies with immersive platforms to create intelligent digital experiences. It covers wearable sensors, haptic devices, and their integration into real-time digital environments like healthcare and smart cities.

Course Contents:

Unit I: Introduction to Wearable Technologies (8 hrs)

Fundamentals of Wearable Technologies, History of wearable Technologies, User Experience Design for Internet of Things, Social Aspects of Wearability, Internet of Things – Applications, Wearable Chemical and Biochemical Sensors, Technology of Connected Devices – Device Types, Sensors, Actuators.

Unit II: Wearable Computing Applications (8 hrs)

Medical Applications of Wearable Technologies, Wearable Technologies – Energy Expenditure and Energy Harvesting, Technology of Connected Devices – Energy Considerations, Flexible Electronics and Textiles for Wearable Technologies.

Unit III: Wearable Computing Architecture (8 hrs)

Wearable Algorithms, Web of Things – Architecture Standardization, Data Mining for Body Sensor Network, Internet of Things – Embedded Device UX Design.

Unit IV: Communication Technologies and Wearable Computing Case Studies (8 hrs)

Physical Activity Modeling and Behavior Change, Internet of Things – Interface and Interaction Design, Human Body Communication for a Data Rate Sensor Network, Internet of Things – Networking, Wireless Body Area Networks, Wearable Computing as a form of urban design,

Wearable Sensors for Monitoring of Physical and Physiological Changes and for Early Detection of Diseases, Wearable and Non-Invasive Assistive Technologies.

Text Book(s) / Reference(s):

[1] Practical Electronics for Inventors, Third Edition, by Paul Scherz and Simon Monk, 2016.

[2] Fundamentals of Wearable Computers and Augmented Reality, Second Edition by Woodrow Barfield, 2015.

[3] Making Sense of Sensors: End-to-End Algorithms and Infrastructure Design By Omesh Tickoo, Ravi Iyer, 2016.

[4] Programming Interactivity, Second Edition By Joshua Noble, 2012.

Course Outcomes (COs):

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

CO1: Understand advanced and emerging technologies.

CO2: Extend the knowledge achieved and apply it to solve real world problems.

CO3: Understanding of different methodologies for research on wearable technology.
CO4: Ability to analyse ethical issues related to the Wearable devices.
CO5: Contribute innovative thinking and innovation processes.
CO6: Ability to integrate several domains through wearable technology.

IIPE 415 Parallel Computing

Pre-requisite: Microprocessors & Computer Architecture (IIPC 209)

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

Brief Description:

Students learn to develop scalable programs using hardware models like SIMD/MIMD and programming standards like OpenMP, MPI, and CUDA. The course focuses on optimizing data-intensive tasks by managing hierarchical memory and thread scheduling.

Course Contents:

Unit I (8 hrs)

Introduction to Parallelism: Motivation, scope, and the shift from sequential to parallel execution. Parallel Hardware: The Von Neumann model and its modifications; Flynn's Taxonomy (SISD, SIMD, MISD, MIMD); Cache coherence and the Memory Wall. Interconnection Networks: Static and dynamic networks (Bus, Crossbar, Mesh, Hypercube), routing mechanisms, and communication costs. Analytical Modeling: Sources of overhead (Synchronization, Communication, Idleness). Performance Metrics: Speedup, Efficiency, and Cost. Laws of Scalability: Amdahl's Law for strong scaling and Gustafson's Law for weak scaling.

Unit II (10 hrs)

Principles of Algorithm Design: Decomposition techniques (Recursive, Data, Task, and Hybrid); Mapping techniques for load balancing; Reducing interaction overheads. Shared Memory Systems: UMA vs. NUMA. Programming with Pthreads & OpenMP: Thread creation, join, and synchronization using Mutexes and Condition Variables. OpenMP: Compiler directives, loop-level parallelism, data scoping (Private vs. Shared), and synchronization (Critical, Atomic, Barriers). Common Pitfalls: Race conditions, deadlocks, and false sharing.

Unit III (10 hrs)

The Message Passing Model: Principles of distributed memory; the SPMD paradigm. MPI Basics: Environment setup, communicator, and process ranks. Point-to-Point Communication: Blocking vs. Non-blocking communication; handling deadlocks. Collective Communication: MPI_Bcast, MPI_Scatter, MPI_Gather, MPI_Allgather, MPI_Reduce, MPI_Allreduce, and Prefix Sum. Derived Data Types: Creating custom MPI types for complex data structures.

Unit IV:(12 hrs.)

Heterogeneous Computing: The Host (CPU) + Device (GPU) execution model. CUDA Programming Model: Kernels, Thread, and compilation workflow. Memory Hierarchy in GPUs: Global memory, Constant memory, and the importance of Shared Memory for thread coordination. Performance Optimization: Memory Coalescing, Warp Divergence, Parallel Patterns: Implementing high-performance Convolution, Stencil operations, and Histogram generation on GPUs.

Text Book(s) / Reference(s):

[1] P. S. Pacheco, An Introduction to Parallel Programming, 2nd ed. Morgan Kaufmann, 2021.
[2] A. Grama, A. Gupta, G. Karypis, and V. Kumar, Introduction to Parallel Computing, 2nd ed. Pearson Education, 2003.
[3] D. B. Kirk and W. W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach, 4th ed. Morgan Kaufmann, 2022.

Course Outcomes (COs):

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

CO1: Identify various parallel architectural paradigms and quantify the performance of parallel programs using speedup, efficiency, and scalability metrics.

CO2: Implement efficient shared-memory programs using OpenMP and Pthreads, ensuring correct synchronization and optimal thread management on multi-core processors.

CO3: Design and debug scalable message-passing applications using MPI for execution on distributed-memory clusters.

CO4: Develop massively parallel applications using CUDA, applying memory coalescing and shared memory techniques to optimize throughput on NVIDIA GPU architectures.

IIPE 416: Mobile Computing

Pre-requisite: Principles of Communication Engineering (IIPC 205), Data Communication & Networking (IIPC 212)

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

Brief Description about the course:

This course introduces the fundamentals of mobile computing and mobile communication systems, covering mobile technologies, cellular architectures, network protocols, and mobile applications. It focuses on mobility management, ad hoc and vehicular networks, transport and application layer protocols, mobile platforms, and mobile commerce, with emphasis on security and emerging trends in mobile communication.

Course Contents:

Unit I: Fundamentals of Mobile Computing (10 hrs)

Mobile Computing: Concepts and Applications — Evolution of Mobile Communication (1G–5G overview) — Cellular Principles — Multiple Access Techniques (FDMA, TDMA, CDMA, OFDMA) — Multiplexing — Spread Spectrum — MAC Protocols.

Unit II: Cellular and Mobile Communication Systems (10 hrs)

Cellular System Architecture — GSM (Architecture & Services - Overview) — GPRS and UMTS (Architecture & Features) — LTE/5G Introduction — Mobility Management — Handover Techniques — Frequency Allocation — Routing — Security in Cellular Networks.

Unit III: Mobile Network Layer and Ad Hoc Networks (10 hrs)

Mobile IP — DHCP — Mobile Ad Hoc Networks (MANETs) — Routing Protocols: Proactive (DSDV), Reactive (DSR, AODV), Hybrid (ZRP) — Multicast Routing (ODMRP - overview) — Vehicular Ad Hoc Networks (VANETs) — MANET vs VANET — Security Issues.

Unit IV: Mobile Transport, Application Layer, Platforms and Applications (10 hrs)

Mobile TCP — Wireless Application Protocol (WAP): Architecture — WDP, WTLS, WTP, WSP — Wireless Application Environment (WAE) — WML. Mobile Device Operating Systems — Design Constraints and Requirements — Modern Mobile OS (Android, iOS - overview) — SDKs — Introduction to Mobile Application Development — Mobile Commerce: Architecture, Applications, Advantages & Limitations — Mobile Payment Systems — Security and Privacy Issues.

Text Book(s) / Reference(s):

[1] Fundamentals of Mobile Computing – Prasant Kumar Pattnaik & Rajib Mall, 2nd Edition, PHI Learning.
[2] Mobile Communications, 2/e, Jochen Schiller, Pearson Education.
[3] Mobile Computing, Raj Kamal, 3rd Edition, Oxford University Press.
[4] Uwe Hansmann et al., Principles of Mobile Computing, Springer, 2003.
[5] Gibson, J.D. ed., 2017. Mobile communications handbook. CRC press.

Course Outcomes (COs):

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

CO1: Understand fundamentals of mobile computing and modern mobile communication technologies.

CO2: Explain cellular system architectures, mobility management, and security mechanisms.

CO3: Analyze mobile network layer protocols and routing in MANETs and VANETs.

CO4: Describe transport and application layer protocols for mobile environments.

CO5: Identify mobile platforms, application development frameworks, and mobile commerce systems with security considerations.

IIPC 403: IoT Security LAB

Prerequisites: Problem Solving and Programming using C (CSIC 103), Introduction to IoT (IIPC 204)

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

Brief Description:

This lab aims to familiarize the students with numerical computing in various fields. The Internet of Things has emerged as a leading technology around the world. Also, the advancements in artificial intelligence and machine learning have made the automation of IoT devices easy. An IoT security lab serves to research, train, and test endpoints, networks, and protocols against real-world threats. Its primary goal is to evaluate, harden, and secure smart ecosystems across industrial, commercial, and consumer environments.

List of Experiments (Any ten experiments should be performed):

1. Implement a basic block cipher algorithm to understand how encryption secures data in IoT devices.
2. Implement the Diffie-Hellman key exchange algorithm for a given problem.
3. Implement the elliptic curve cryptography key exchange algorithm for a given problem.
4. Demonstrate intrusion detection system (IDS) using any tool, e.g., Snort or any other software.
5. Create a simple blockchain to understand its structure and relevance in IoT security.
6. Set up an IoT device (like a Raspberry Pi) and identify potential security vulnerabilities.
7. Integrate various sensors and actuators into an IoT system, understanding their role in cyber-physical systems and exploring common security challenges.
8. Conduct experiments to read RFID tags, and discuss security implications.
9. Use cryptographic libraries to create digital signatures using elliptic curves.
10. Implement Merkle trees and experiment with elliptic curve digital signatures to secure communication on basic IoT hardware like Arduino.
11. Simulate the working of Proof of Work and Proof of Stake algorithms in the context of cryptocurrencies and IoT.
12. Set up different IoT networking protocols and analyze their security features.
13. Create a simple smart contract using Ethereum to understand its application and the challenges in verification.
14. Identify a problem in your local area or college that can be solved by integrating the things you learned and create a prototype to solve it (mini project).

Course Outcomes (COs):

At the end of the course the student will be able to:

CO1: Implement a basic block cipher algorithm to understand how encryption secures data in IoT devices.

CO2: Replicating real-world smart networks to identify, analyze, and mitigate hardware and firmware vulnerabilities.
CO3: Implementing defense mechanisms like firewalls, secure boot processes, and zero-trust architectures for connected devices.
CO4: Safeguarding information generated by IoT devices by enforcing strong encryption, data integrity, and privacy-by-design.

IIPC 404 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 IIoT 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 IIoT 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.

IIPC 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 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.

VIIIth SEMESTER

IIPC 406 Selected Topics in Sensors & IOT

Pre-requisite: Introduction to IoT (IIPC 204)

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

Brief Description:

Students are exposed to emerging fields like Nanosensors, BioMEMS, and advanced IoT reference architectures. The course reviews wireless technologies (Zigbee, BLE) and IP-based protocols such as 6LowPAN and MQTT.

Course Contents:

Unit I: (10 hrs)

IoT Reference Architecture: Getting Familiar with IoT Architecture, Reference Model of IoT, Various architectural views of IoT such as Functional, Information, Operational and Deployment. Constraints affecting design in IoT world – Introduction, Technical design Constraints. An emerging industrial structure for IoT.

Unit II: (10 hrs)

Sensors Networks: Definition, Types of Sensors, Types of Actuators, Examples and Working, IoT Development Boards: Arduino IDE and Board Types, Raspberry Pi Development Kit, RFID Principles and components, Wireless Sensor Networks: History and Context, the node, Connecting nodes, Networking Nodes, WSN and IoT.

Unit III: (10 hrs)

Wireless Technologies for IoT: Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination. WPAN Technologies for IoT: IEEE 802.15.4, Zigbee, HART, NFC, Z-Wave, BLE, Bacnet Modbus. IP Based Protocols for IoT: IPv6, 6LowPAN, RPL, REST, AMQP, CoAP, MQTT. Edge connectivity and protocols.

Unit IV: (10 hrs)

The topic clouds for the course include some contemporary topics in sensors and IoT (but not restricted to) like Nanosensors, MEMS/NEMS sensors, biosensors modeling and design, and industrial IoT. The topics may be further updated according to the instructor.

Text Book(s) / Reference(s):

[1] Hakima Chaouchi, The Internet of Things Connecting Objects to the Web, Wiley Publications.

[2] Olivier Hersent, David Boswarthick, and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley Publications.

[3] Vijay Madisetti, Arshdeep Bahga, Internet of Things (A Hands-on Approach), 1st Edition, VPT, 2014.

[4] J. Biron, J. Follett, Foundational Elements of an IoT Solution, O'Reilly Media, 2016.

Course Outcomes (COs):

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

CO1: Identify and analyze advanced IoT reference architectures and industrial standards.

CO2: Gain hands-on understanding of specialized sensor networks and development kits like Raspberry Pi and Arduino.

CO3: Compare and contrast wireless technologies and IP-based communication protocols like Zigbee, BLE, and 6LowPAN.

CO4: Explore emerging trends in the field, including Nanosensors, BioMEMS, and the Internet of Everything.

IIPE 417 Computer Vision

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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

Brief Description:

This course introduces the concepts of geometric and photometric image formation, feature detection, and 3D structure from motion. It covers practical computer vision tasks such as pose estimation, triangulation, and global optimization.

Course Contents:

Unit I: Introduction (10 hrs)

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: Feature Detection and Matching (10 hrs)

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: Dense Motion Estimation (10 hrs)

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: Stereo Correspondence and 3D Reconstruction (10 hrs)

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, Light fields and Lumigraphs, Recognition: Object detection, Face recognition, Instance recognition, Category recognition, Context and scene understanding.

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, 2012.

Course Outcomes (COs):

At the end of the course student will be able to:

CO1: Understand the mathematical principles of geometric and photometric image formation and camera calibration.

CO2: Implement techniques for feature detection, descriptor matching, and 2D-to-3D image transformations.

CO3: Apply algorithms for structure from motion, triangulation, and 3D reconstruction from multiple views.

CO4: Evaluate and utilize global optimization methods like bundle adjustment for complex visual computing tasks.

IIPE 418 LiDAR and Remote Sensing

Pre-requisite: Principles of Communication Engineering (IIPC 205)

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

Brief Description about the course:

LiDAR and Remote Sensing introduces the principles, technologies, and applications of Light Detection and Ranging (LiDAR) systems for remote sensing. Students explore LiDAR design, platforms (terrestrial, airborne, spaceborne), georeferencing, error correction, data processing, and classification.

Course Contents:

Unit I: LiDAR System Design (10 hrs)

Introduction to laser and LiDAR, Definitions of LiDAR, History of LiDAR and development, Types of LiDAR, LiDAR types based on eye safety, LiDAR technology and components, Examples of LiDAR components, Types of LiDAR sensors, Discussion on LiDAR sensor characteristics, Working principle of LiDAR, LiDAR waveform and generation, Photon counting.

Unit II: LiDAR Remote Sensing Platform (10 hrs)

Introduction to the LiDAR remote sensing platform – Historical development of LiDAR remote sensing platforms, airborne platforms, Laser scanning, Fixed-wing platforms, Rotary Wing platforms – Terrestrial, airborne, and spaceborne types – Spaceborne platforms – Orbits – Bathymetric mapping, Types of scanning mechanism, Ground measuring pattern.

Unit III: Georeferencing and LiDAR Errors (10 hrs)

Direct Georeferencing technology – Methodology adopted for Georeferencing, Boresight calibration – Project coverage verification – Review LiDAR data against field control – LiDAR data errors and rectifications, processes calibration of LiDAR data – artifacts and anomalies – LiDAR data errors – LiDAR error budget.

Unit IV: LiDAR Data Processing and Classification (10 hrs)

Introduction to LiDAR data formats, Examples of data format, Types of data format – Terrestrial, Types of data format – Airborne, Storing LiDAR data, LiDAR data preprocessing – LiDAR filtering, Layer Extraction – Automated filtering – Manual editing and product generation – Surface editing, LiDAR data products, Definitions, LiDAR data classification and accuracy assessment.

Text Book(s) / Reference(s):

[1] Floyd M. Henderson, Principles & Applications of Imaging Radar, John Wiley & Sons, New York, 1998.

[2] Cheng Wang, Xuebo Yang, Xiaohuan Xi, Sheng Nie, Pinliang Dong, Introduction to LiDAR Remote Sensing, CRC press, 2024.

[3] Raymond M. Measures, Laser Remote Sensing: Fundamentals and Applications, John Wiley & Sons, New York, 1984.

[4] Cracknell, Arthur .P, Hayes, Ladson, Introduction to Remote Sensing (2 ed.), London: Taylor and Francis, 2007.

Course Outcomes (COs):

At the end of the course student will be able to:

CO1: Explain LiDAR system components, types, working principles, and waveform generation, including photon counting techniques.

CO2: Analyze LiDAR remote sensing platforms, scanning mechanisms, and ground measurement patterns across airborne, terrestrial, and spaceborne systems.

CO3: Apply georeferencing methods, boresight calibration, and error rectification processes to ensure LiDAR data accuracy and verify project coverage.

CO4: Process, classify, and assess LiDAR data using standard formats, filtering algorithms, and editing tools to produce geospatial products with quantified accuracy.

IIPE 419 MEMS

Pre-requisite: Analog & Digital Electronics (IIPC 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 Contents:

Unit I: Introduction to MEMS and Micro fabrication (10 hrs.)

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: MEMS Devices (10 hrs.)

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: Mechanics of MEMS Materials (10 hrs)

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

Unit IV: Applications (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, 2015.
[4] S. D. Senturia, Microsystem Design, Springer, 2000.
[5] M. J. Madou, Fundamental of Microfabrication, Second Edition CRC Press, 2002.

Course Outcomes (COs):

At the end of this course, 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: Consider recent advancements in the field of MEMS and devices.

IIPE 420 VLSI Physical Design

Pre-requisite: Analog & Digital Electronics (IIPC 201)

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

Brief Description:

This course focuses on the physical implementation of integrated circuits. It covers various stages of the VLSI design flow, including partitioning, floorplanning, placement, routing, and timing analysis.

Course Contents:

Unit I: Introduction and Partitioning (10 hrs)

Introduction to VLSI physical design and its role in the overall ASIC design flow, including physical versus logical design and key design constraints such as area, power, and performance. Modeling of VLSI circuits using graphs and hypergraphs, formulation of cost functions, and basic optimization concepts. Study of partitioning techniques for large-scale designs, including Kernighan–Lin and Fiduccia–Mattheyses algorithms, and an overview of multilevel partitioning methods.

Unit II: Floorplanning and Placement (10 hrs)

Concepts and objectives of floorplanning and placement in VLSI physical design. Slicing and non-slicing floorplans, floorplan representations, shape functions, and cost evaluation metrics. Introduction to placement techniques including analytical placement and min-cut based placement, with emphasis on wirelength minimization, congestion control, and placement legalization.

Unit III: Routing and Clock Design (10 hrs)

Routing fundamentals including routing problem formulation, routing layers, and design rules. Concepts of global routing, congestion estimation, and detailed routing, along with classical routing algorithms such as maze routing and Lee's algorithm. Introduction to clock distribution challenges, clock skew and jitter, and basic principles of clock tree synthesis.

Unit IV: Timing Closure and Physical Verification (10 hrs)

Timing analysis concepts including timing graphs, setup and hold constraints, and slack computation, STA. Timing-driven optimization techniques for placement and routing. Discussion of signal integrity issues such as crosstalk, power planning, and IR drop. Design closure techniques including engineering change orders, followed by physical verification methods such as design rule checking, layout versus schematic verification, and antenna effects.

Text Book(s) / Reference(s):

[1] Kahng, A. B., Lienig, J., Markov, I. L., Hu, J., VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer, 2011.

[2] Sherwani, N. A., Algorithms for VLSI Physical Design Automation, 3rd Edition, Springer, 1999.

[3] Sait, S. M., Youssef, H., VLSI Physical Design Automation, McGraw-Hill, 1995.

Course Outcomes (COs):
Upon successful completion of the course, students will be able to:
CO1: Explain the complete VLSI physical design flow.
CO2: Apply partitioning, floorplanning, placement, and routing concepts.
CO3: Analyze timing and clock distribution issues in VLSI designs.
CO4: Understand design closure and physical verification techniques.

IIPE 421 DSP ARCHITECTURE

Pre-requisite: Signals, Systems & Random Variables (IIPC 202)

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

Brief Description:

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: Architectures for Programmable Digital Signal-Processing Devices (8 hrs)

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: Programmable Digital Signal Processors (12 hrs.)

Introduction, Commercial Digital Signal-processing Devices, Data Addressing Modes of TMS320C54XX, Memory Space of TMS320C54xx Processors, Program Control, Detail Study of TMS320C54X & 54xx Instructions and Programming, On-Chip Peripherals, Interrupts of TMS320C54XX Processors, Pipeline Operation of TMS320C54xx Processor.

Unit III: Implementation of Basic DSP Algorithms (12 hrs.)

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 TMS320C54xx.

Unit IV: Interfacing Memory and Parallel I/O Peripherals (8 hrs)

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 Edition, 2010.
[4] Peter Pirsch, Architectures for Digital Signal Processing, John Wiley, 2008.

Course Outcomes (COs):

At the end of this course, students would 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.

IIPE422: IoT Enhanced AR & VR

Pre-requisite: Introduction to IoT (IIPC 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 make students aware of the IoT-Enabled Augmented and Virtual Reality Systems, which is an interdisciplinary subject that integrates Internet of Things technologies with immersive AR and VR platforms to create intelligent, interactive and real-time digital experiences for smart and futuristic applications.

Course Contents:

Unit I: Fundamentals of IoT, AR and VR (10 hrs)

Introduction to Internet of Things, IoT architecture including sensing, network, data and application layers, sensors and actuators, edge devices, basics of augmented reality, basics of virtual reality, AR versus VR versus mixed reality, human–computer interaction in immersive systems.

Unit II: IoT Communication and Immersive System Integration (10 hrs)

IoT communication protocols such as MQTT, CoAP, HTTP and WebSockets, wireless technologies including Wi-Fi, Bluetooth, ZigBee, LoRa and 5G, cloud, fog and edge computing, data acquisition, storage and real-time streaming, integration of IoT data into AR and VR environments.

Unit III: AR & VR Platforms, Devices and Development (10 hrs)

AR devices including mobile AR and smart glasses, VR devices such as head-mounted displays, controllers and haptic devices, wearable and embedded IoT sensors, AR and VR development platforms like Unity and Unreal Engine, AR SDKs including ARCore, ARKit and Vuforia, visualization of sensor data in immersive environments.

Unit IV: Applications, Intelligence and Security (10 hrs.)

IoT-enabled AR and VR in healthcare, manufacturing, education and smart cities, space and astronaut training applications, artificial intelligence and machine learning in immersive IoT systems, real-time analytics and digital twins, cybersecurity and privacy in IoT-AR-VR systems, performance issues such as latency, bandwidth and synchronization, future trends including Metaverse, XR and intelligent environments.

Text Book(s) / Reference(s):

[1] Rajkumar Buyya — Internet of Things: Principles and Paradigms.
[2] Alan B. Craig — Understanding Augmented Reality: Concepts and Applications.
[3] Tony Parisi — Learning Virtual Reality.
[4] Jonathan Linowes — Augmented Reality for Developers.

Course Outcomes (COs):

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

CO1: Understand the fundamental concepts of Internet of Things, Augmented Reality, Virtual Reality and immersive system architectures.

CO2: Explain IoT communication technologies, data acquisition methods and their integration with AR and VR platforms for real-time applications.

CO3: Develop and implement basic AR and VR applications using IoT devices, sensors and immersive development tools.

CO4: Analyze the use of IoT-enabled AR and VR systems in domains such as healthcare, manufacturing, education and space applications.

IIPE 423 QUANTUM COMPUTING

Pre-requisite: MAIC 204 (Applied Linear Algebra), IIPC 201 (Analog & Digital Electronics)

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

Brief Description of the Course:
This course introduces the fundamental concepts of quantum computation, including qubits, unitary evolution, and multi-qubit states. Students explore quantum algorithms like Deutsch-Josza and Grover's search, as well as physical realizations of qubits.

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 (COs):
Upon successful completion of the course, the students will be able to:
CO1: Understand quantum computing.
CO2: Analyze the qubits.
CO3: Evaluate the performance of quantum computing systems.
CO4: Apply quantum error codes.

IIPE424 6G NETWORKS

Pre-requisite: Principles of Communication Engineering (IIPC 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 (COs):

At the end of the 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.

IIPE 425 Nano Sensors

Pre-requisite: Advanced Engineering Physics (PHIC 105)

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

Brief Description:

This course on Nano Sensors is designed for undergraduate students. Students will be introduced to basic understanding and principle of sensors and sensor interface. The course will also include classification of sensors and their characteristics like sensitivity, transfer function, selectivity, calibration, etc. Various material properties and materials required for nano sensor applications will be discussed. Finally, the application of nano sensors for environment monitoring, healthcare, electronics and food safety will be covered.

Course Contents:

Unit I:(12 hrs.)

Introduction, fundamental principle of nano sensing and classification of sensors. Basic transduction system in sensors. Sensor characteristics – Transfer functions, Resolution, Selectivity & sensitivity, Calibration, Noise: electronics, environmental and internal.

Unit II (10 hrs)

Physical effects involved in signal transduction – Capacitance, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall effect, Thermoelectric effect. Sensor Interface – Interface circuit.

Unit III (8 hrs)

Materials for nanosensors – nanotubes, nanowires, nanoparticles, metal oxides, quantum dots, layered nanomaterials. Properties of materials for nanosensors. MEMS and Microfluidics.

Unit IV (10 hrs)

Optical sensor. Chemical and Gas sensor. Wearable sensors. Temperature sensor. Mechanical sensor. Application of nanosensors for environmental monitoring, healthcare, food safety.

Text Book(s) / Reference(s):

[1] J. Vetelino and A. Reghu, Introduction to Sensors, 1st Ed., CRC Press, 2011.
[2] Jacob Fraden, Handbook of Modern Sensors, 4th Ed., Springer, 2010.
[3] E. G. Bakhoum, Micro- and Nano-Scale Sensors and Transducers, 1st Ed., Taylor & Francis, 2019.
[4] Vinod Kumar Khanna, Nanosensors: Physical, Chemical, and Biological, 2nd Ed., CRC, 2021.
[5] R. P. Areny, John G. Webster, Sensors and signal conditioning, 2nd Ed., John Wiley & Sons, 2001.

Course Outcomes (COs):

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

CO1: Understand the fundamental principles of nano sensing technology.

CO2: Develop an understanding of various physical effects involved in signal transduction of a sensor.

CO3: Comprehend the properties of nanomaterials for nano sensors and differentiate between nano and bulk materials.

CO4: Acquire knowledge about various nano sensors viz. gas sensor, temperature sensor, wearable sensors, optical sensors.

CO5: Apply knowledge for designing functional nano sensors for various applications like environment monitoring, wearable electronics, healthcare, etc.

IIPE 426 BIO SENSORS

Pre-requisite: Advanced Physics (PHIC 105)

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

Brief Description:
This subject is covered as a specialized topic within the Sensor and IIoT curriculum, focusing on the modeling and design of biosensors. It examines the application of micron-scale machines (MEMS) in medical diagnostic devices, such as DNA chips and micro-arrays.

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, Enzyme and Microbial Biosensors Techniques and Protocols, Humana Press, 1998.
[2] J.Cooper, T.Cass, Biosensors, Oxford University Press, second edition, 2004.
[3] Chen Jianrong, Miao Yuqing et al., Nanotechnology and biosensors, Biotechnology Advances, Volume 22, Issue 7, 2004.

Course Outcomes (COs):
At the end of the course student 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.

IIPE 427 IMAGE FORENSICS

Pre-requisite: Digital Signal Processing (IIPE 311)

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:(12 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 by Lars Daniel, 2017.
[3] Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods, 2018.
[4] Digital Watermarking and Steganography by Ingemar J. Cox, Matthew L. Miller, and Jeffrey A. Bloom, 2007.

[5] Digital Image Forensics: There is More to a Picture than Meets the Eye, Springer, 2012.

Course Outcomes (COs):

Upon completion of this course, 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.

IIPE 428 BIOMEDICAL SIGNAL PROCESSING

Pre-requisite: Digital Signal Processing (IIPE 311)

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: Signal Processing (10 hrs)

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: Introduction to Biomedical Signals (10 hrs)

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: Biomedical Signal Processing (10 hrs)

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: Biomedical Signal Processing Methods and Applications (10 hrs)

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, 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, First Edition, 2002.

[4] John G Proakis, Dimitris and G. Manolakis, Digital Signal Processing Principles algorithms, applications, PHI Third Edition, 2006.

Course Outcomes (COs):

At the end of the course the student 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.

IIPE 429: E-Commerce and ERP

Pre-requisite:–

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

Brief Description about the course:

This course introduces students to the fundamental concepts of electronic commerce and enterprise resource planning (ERP) systems with emphasis on their role in modern industrial enterprises. It provides an understanding of digital business models, electronic payment systems, and secure e-commerce infrastructure. The course also covers ERP architecture, functional modules, and implementation methodologies. Further, it highlights integration of ERP with cloud computing, Industrial Internet of Things (IIoT), and Industry 4.0 for smart manufacturing environments.

Course Contents:

Unit I: Fundamentals of E-Commerce (10 hrs)

Introduction to E-Commerce and Digital Business, Traditional Commerce vs E-Commerce, E-Commerce Framework and Architecture, Types of E-Commerce: B2B, B2C, C2C, C2B, G2B, Digital Markets and Digital Goods, Business Models: E-tailer, Marketplace, Portal, Subscription, On-demand, E-Commerce Applications in Manufacturing and Industrial Sector.

Unit II: E-Commerce Infrastructure, Payments and Security (10 hrs)

Web Technologies for E-Commerce, E-Commerce Hardware and Software Infrastructure, Electronic Payment Systems, Credit/Debit Cards, Net Banking, UPI and Mobile Payments, Digital Wallets, Payment Gateways, Security Issues in E-Commerce, Encryption, Digital Signatures, SSL, Authentication, Cyber Laws and IT Act – Overview.

Unit III: ERP Concepts and Enterprise Integration (10 hrs)

Enterprise Resource Planning: Concepts and Evolution, Benefits and Challenges of ERP, ERP Architecture and Components, Business Process Reengineering (BPR), ERP Implementation Life Cycle, Open Source vs Proprietary ERP, Role of ERP in Manufacturing Enterprises.

Unit IV: ERP Modules and IIoT Integration (10 hrs)

ERP Functional Modules: Finance and Accounting (FI), Human Resource Management (HRM), Production Planning (PP), Sales and Distribution (SD); Cloud-based ERP Systems, ERP and Industrial Internet of Things, Case Studies: SAP S/4HANA, Oracle ERP Cloud, Microsoft Dynamics.

ext Book(s) / Reference(s):

[1] Kenneth C. Laudon and Carol G. Traver, E-Commerce: Business, Technology, Society, Pearson.

[2] Alexis Leon, ERP Demystified, Tata McGraw-Hill.

[3] Joseph P. Brady, Ellen F. Monk, Bret Wagner, Concepts in Enterprise Resource Planning, Cengage Learning.

[4] Rainer & Prince, Introduction to E-Commerce, Wiley.

Course Outcomes (COs):

After completion of this course, students will be able to:

CO1: Explain E-Commerce concepts, models, and infrastructure.

CO2: Describe electronic payment systems and security mechanisms.

CO3: Understand ERP architecture and implementation methodology.

CO4: Analyze major ERP functional modules.

CO5: Explain integration of ERP with IIoT, cloud, and smart manufacturing.

IIPE 430 SOFT COMPUTING & EXPERT SYSTEMS

Pre-requisite: Machine Learning and Data Analytics (CSIC 221), Data Structures and Algorithms (IIPC 210)

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: Fundamentals (10 hrs)

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: Fuzzy Logic (10 hrs)

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: Genetic Algorithms (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: Combined Techniques (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 (COs):

Upon successful completion of the 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.

IIPE 431 Industrial IoT Markets & Security

Pre-requisite: Introduction to IoT (IIPC 204), IoT Security (IIPC 401)

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

Brief Description:

This course examines the industrial structure for IoT, focusing on reference architectures and technical design constraints. It addresses critical security requirements like authentication and integrity, alongside the emerging roles of IIoT in smart logistics and autonomous systems.

Course Contents:

Unit I: Industry 4.0 and Markets (10 hrs)

Essentials of Industrial IoT concepts and their transformative role in industrial processes, Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories, Application in healthcare and power plants. Consumer behavior models applicable to IoT markets.

Unit II: Data Acquisition, Model & Architecture (10 hrs)

Various types of sensors and the criteria for selecting the right sensor for specific applications, Reinforcing fundamental sensor concepts and addressing key principles critical for sensor integration. IIoT – Introduction, IIoT Business Models Part I & Part II, IIoT Reference Architecture Part I & Part II.

Unit III: Networking and Protocols (10 hrs)

Explores industrial networks, wireless communications (GPRS, WiFi). Wireless Technologies for IoT: Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination. WPAN Technologies for IoT: IEEE 802.15.4, Zigbee, HART, NFC, Z-Wave, BLE, Bacnet Modbus. IP Based Protocols for IoT: IPv6, 6LowPAN, RPL, REST, AMQP, CoAP, MQTT. Edge connectivity and protocols.

Unit IV: IoT Connectivity Protocols and Security (10 hrs)

The diverse landscape of IIoT connectivity, examining wireless long-range protocols. IIoT security concerns, including device security, access management, and data protection in industrial applications. On-off time measurement, showcasing the application of IIoT in monitoring and optimizing industrial processes. Quantum Computing role in network security and challenges.

Text Book(s) / Reference(s):

[1] Industrial Internet of Things (IIoT) by Shreyanka Jha et al.
[2] Practical Industrial Cybersecurity: ICS, Industry 4.0, and IIoT (2nd Ed.) by Charles J. Brooks, Philip A. Craig Jr.
[3] Industrial Network Security (3rd Ed.) by Eric D. Knapp.
[4] Cybersecurity of Industrial Internet of Things (IIoT) by Nicola Palmarini et al.

Course Outcomes (COs):

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

CO1: Analyze the industrial market structure, value chains, and emerging business models driven by IIoT.

CO2: Evaluate technical design constraints and reference architectures (IIRA) for industrial-grade deployments.

CO3: Implement robust security protocols for authentication, integrity, and privacy in industrial networks.

CO4: Understand the practical applications and impact of IIoT on smart logistics, autonomous systems, and Industry 4.0.

IIPE432 Database Management Systems

Pre-requisite: Data Communication & Networking (IIPC 212)

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

Brief Description:

This course provides a foundation in relational database theory, covering normalization, ER modeling, and SQL query writing. It also introduces transaction processing, concurrency control, and practical skills using MySQL.

Course Learning Objectives:

1. To understand data models and database systems. 2. To understand relational database theory. 3. To learn database design and its normalization. 4. To understand concepts of transaction, its processing, and management. 5. To learn concurrency control techniques. 6. To develop practical skills in using MySQL DBMS.

Course Contents:

Unit I: Introduction (10 hrs)

Data, Database, Database management system, Historical background from file systems to Database Systems, Data Models, Relational Data Model, ER model, Schemas and Instances, Database users, DBMS architecture.

Unit II: Relational Model and Query Language (10 hrs)

Theory of Relational Database, Key Integrity constraint, Relational Algebra, Relational Calculus: Domain Relational Calculus, Tuple Relational Calculus, SQL, queries writing in SQL.

Unit III: Database Design (10 hrs)

Normalization, Database Anomalies, Functional Dependencies, Candidate and Super Key, Non-loss Decomposition, Dependency Preservation, First, Second, Third Normal Form, BCNF, etc.

Unit IV: Transaction Processing and Concurrency Control (10 hrs)

Transaction concept, a simple transaction model, states, ACID Properties, implementation of ACID properties, Serializability. Concurrency Control: Need for Concurrency, Lock-based protocols, Deadlock, Starvation, deadlock handling, time-stamp based protocols, validation-based protocols.

Text Book(s) / Reference(s):

[1] A Silberschatz, H.F. Korth & S. Sudarshan: Data Base System Concepts, McGraw Hill, 4th, 5th or 6th edition.

[2] Elmasri & Navathe: Fundamentals of Database Systems, 5th, 6th, or 7th edition, Pearson.

Course Outcomes (COs):

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

CO1: Gain knowledge of fundamentals of DBMS, database design and normal forms.

CO2: Design and Implement a small database for applications using MySQL DBMS.

CO3: Apply the concepts of normalization to database design.
CO4: Master the basics of SQL for retrieval and management of data.
CO5: Be acquainted with the basics of transaction processing and concurrency control.

IIPC 407 Project-II

L	T	P	Credits	Total contact hours
0	0	12	6	-

Brief Description:
Project-II is a full-semester supervised major project undertaken in the eighth semester, building upon the work initiated in Project-I. Students extend their prototype into a complete, tested, and documented IIoT system, culminating in a final thesis submission and viva voce examination.

Course Outcomes:
CO1: Define a well-scoped IIoT 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 IIoT system or application.
CO4: Evaluate system performance against defined objectives through testing and analysis.
CO5: Produce a well-structured thesis and deliver a professional oral presentation.

IIPC 408 Internship

L	T	P	Credits	Total contact hours
-	-	-	9	-

Brief Description:
The full-semester internship provides students with sustained professional experience in an industry, research organisation, or start-up relevant to IIoT and related fields. Students work on a defined technical assignment under the joint supervision of a faculty mentor and an industry guide, translating academic knowledge into professional engineering practice.

Assessment Details:
Each student is assigned a faculty supervisor responsible for monitoring progress throughout the semester. Assessment is based on a Reflective Diary maintained during the internship, an Interim Progress Report, a Final Report with Learning Outcomes, and a Final Presentation and Viva conducted by the faculty supervisor. The industry guide provides an independent performance assessment on the designated form.

Course Outcomes:
CO1: Acquire hands-on knowledge of professional engineering practices in the area of the internship.
CO2: Apply technical skills to carry out design, development, or analysis tasks in a real-world setting.
CO3: Demonstrate effective teamwork, initiative, and adaptability in a professional environment.
CO4: Communicate technical work through written reports and oral presentations to a professional standard.
CO5: Reflect on professional responsibilities, ethical practice, and personal dev