2.5 yrs. M.Tech Programme

In Electronics and communication with specialization
Embedded System and IoT

भारतीय सूचना प्रौद्योगिकी संस्थान राँची

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, RANCHI

(An Institution of National importance under act of Parliament)

(Ranchi - 834010), Jharkhand

I. Format of Course codes

1) Course code AA-XYZZ is explained as

AA - Department

X-Academic year

Y-Theory/Lab; 0 ==Theory and 1== Lab

ZZ-odd/even semester; odd number == odd semester and even number == even semester

2) For project/seminar/comprehensive viva:

AA= PR

X= 1

3) For open electives:

AA= OE

Breakup of the credits semester wise

Credits required for M.Tech Course: 68-78

Semester/ Projects	Credits
I	13-16
II	13-17
III	12-15
IV	14
V	16
Total	68-78

Curriculum for M.Tech in Electronics & Communication Engineering with specialization in Embedded System & IoT.

Semester wise courses

Semester I						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	**EI-5001**	Advanced Digital Design	3	0	0	3
2	**EI-5003**	Advanced Embedded Processors & Microcontroller	3	0	0	3
3	**---**	Elective I	3	1	0	4
4	**EI-5101**	Advanced Digital Design Lab	0	0	3	2
5	**EI-5103**	Embedded Processors & Microcontroller Lab	0	0	3	2
Total			**9**	**1**	**6**	**14**
Semester II						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	**EI-5002**	Embedded OS & Device Drivers	3	0	0	3
2	**EI-5004**	IoT Sensors & Actuators	3	0	0	3
3	**---**	Elective II	3	1	0	4
4	**EI-5102**	Embedded OS & Device Drivers Lab	0	0	3	2
5	**EI-5104**	IoT Sensors & Actuators Lab	0	0	3	2
Total			**9**	**1**	**6**	**14**
Semester III						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	**---**	Elective III	3	1	0	4
2	**---**	Elective IV	3	1	0	4
3	**EI-6001**	Simulation and Modeling	3	0	0	3
4	**EI-6101**	Simulation and Modeling Lab	0	0	3	2
Total			**9**	**2**	**3**	**13**
Semester IV						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	**PR-6102**	Research Project (Stage-I)	0	0	24	12
2	**PR-6104**	Comprehensive Viva	0	0	0	2
Total			**0**	**0**	**24**	**14**
Semester V						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	**PR-7101**	Research Project (Stage-II)	0	0	32	16
Total			**0**	**0**	**32**	**16**

Credit Summary

Semester	**I**	**II**	**III**	**IV**	**V**	**Total**
Credits	**14**	**14**	**13**	**14**	**16**	**71**

Legend:

L - Number of lecture hours per week
T - Number of tutorial hours per week
P - Number of practical hours per week
C - Number of credits for the course

List of Electives (ECE)

Elective I

S. No.	Course code	Course Title
1.	**HI-5001**	Optical Wireless Communication
2.	**HI-5003**	Wireless Sensor Networks
3.	**HI-5005**	Embedded Control Systems
4.	**HI-5007**	Advanced Antenna Design

Elective II

S. No.	Course code	Course Title
1.	**HI-5002**	Real-time operating system (RTOS)
2.	**HI-5004**	MOS Devices
3.	**HI-5006**	Information Theory and Coding
4.	**HI-5008**	Data Analytics for IoT
5.	**HI-5010**	Privacy and Security in IoT

Elective III/IV

S. No.	Course code	Course Title
1.	**HI-6001**	VLSI testing and testability
2.	**HI-6003**	SCADA Systems Applications
3.	**HI-6005**	IoT Architecture & Computing
4.	**HI-6007**	Advanced Optical Communication
5.	**HI-6009**	Material Science for Micro & Nano Electronics
6.	**HI-6011**	Stochastic Processes and Queuing Theory
7.	**HI-6013**	Embedded System Design
8.	**HI-6015**	Cloud Computing
9.	**HI-6017**	Real Time Data Analytics

List of Electives (CSE)

Elective I

S. No.	Course Code	Course Title
1.	**HC-5001**	Advanced Soft Computing
2.	**HC-5003**	Advanced Digital Image Processing
3.	**HC-5005**	Wireless Sensor Networks

Elective II

S. No.	Course Code	Course Title
1.	**HC-5002**	Computer Vision
2.	**HC-5004**	Cloud Computing
3.	**HC-5006**	Ethics of Data Science
4.	**HC-5008**	Real Time Data Analytics

Elective III

S. No.	Course Code	Course Title

1.	**HC-6001**	Data Stream Mining
2.	**HC-6003**	Evolutionary and Randomized Algorithms
3.	**HC-6005**	Data Analytics for IoT

Note:

1. Others elective courses as decided by committee to be taken from NPTEL/MOOCs/SWAYAM/COURSERA or any other online platform. Course codes will be decided later as per the format.
2. Elective courses may be added or removed later on the recommendation of competent authority.

Syllabus M. Tech (Embedded System& IoT)

First Semester

EC-5001	Advanced Digital Design	L-T-P-C:3-0-0-3

Course objective:

- To learn how to design digital systems, from specification and simulation to construction and debugging.
- To learn techniques and tools for programmable logic design
- To understand the limitations and difficulties in modern digital design, including wiring constraints, high-speed, etc.
- To design, construct, test, and debug a moderate-scale digital circuit.

Module I

Combinational Logic Design: Combinational-Circuit Synthesis, Programmed Minimization Methods, Timing Hazards, Circuit Timing, Decoders, Encoders, Three-State Devices, Multiplexers, Exclusive-OR Gates and Parity Circuits, Comparators, Adders, Subtractors, ALUs, Combinational Multipliers

Module II –

Sequential Logic Design: Bistable Elements, Latches and Flip-Flops, Counters, Shift Registers, Clocked Synchronous State, Machine Analysis and Design, Designing State Machines Using State Diagrams, State-Machine Synthesis Using Transition Lists, State-Machine Design Example, Decomposing State Machines, Feedback Sequential Circuits, Feedback Sequential-Circuit Design

Module III

Computer-aided design: Overview of Digital Design with Verilog HDL, Hierarchical Modeling Concepts, Basic Concepts, Modules and Ports, Gate Level Modeling, Dataflow Modeling, Behavioral Modeling, Tasks and Functions, Useful Modeling Techniques, Timing and Delays, User Defined Primitives, Logic Synthesis with Verilog HDL, Testbenches for verification of HDL models, Tools for mapping to PLDs and FPGAs

Module IV - Memory, FPGAs and ASICs: MOSFETs, FPGAs Integrated circuits Circuit boards, High-speed circuits, controlling impedances Read-Only Memory, Read/Write Memory, Static RAM, Dynamic RAM, Complex Programmable Logic Devices, Field-Programmable Gate Arrays, Types of ASICs, ASIC Design flow, Economics of ASICs.

Course Outcome:

Upon Completion of the course, the students will be able to:

- Design digital circuits and subsystems using Verilog HDL.
- Have basic understanding of Memory, CPLDs, FPGAs and ASICs.
- Design dynamic architectures using FPGA's.
- Implement, Design and develop embedded system using EDA tools

Text Book:

1. M.J.S. Smith, "Application Specific Integrated Circuits", 2nd Edition, Pearson, 2016.
2. Peter Ashenden, "Digital Design using VHDL", 3rd Edition Elsevier, 2017.

Reference Book:

1. W.Wolf, "FPGA based system design", 3rd EditionPearson, 2014.
2. Clive Maxfield, "The Design Warriors's Guide to FPGAs", 1st Edition Elsevier, 2014

EC-5101	Advanced Digital Design Lab	L-T-P-C:0-0-3-2

List of Experiments:

1. Tutorials on Software and FPGA Board
2. Design of CMOS Inverter, and basic Digital circuit using Verilog (e.g. Subtractor, Counter and ALU)
3. Implement programme Package sorter, Parking Meter and Traffic Light Controller.
4. Design Snake Game using Verilog Interfacing with PS/2 Keyboard and VGA display
5. Design Stack Calculator Using Block RAMs on FPGAs
6. Design MIPS Processor and Memory BIST
7. Design Bowling Score Keeper to realize State machines, logic design
8. Project

EC-5003	Advanced Embedded Processors and Microcontrollers	L-T-P-C:3-0-0-3

Course objective:

- Understand architecture and advanced features of embedded processors and microcontrollers.
- Understand PIC/ARM processor registers, instruction pipeline, interrupts and architecture.
- Learn about instructions, addressing modes, conditional instructions and programming of advanced embedded processors and microcontrollers.

Module I

Embedded and Microcontroller Concepts: Introduction to embedded processors, Application Areas, Categories of embedded processors, Hardware architecture, Software architecture, Application software, Communication software, Introduction to Harvard & Von Neuman architectures, CISC & RISC Architectures.

Module II

PIC Microcontrollers: Introduction to PIC microcontrollers, architecture and memory organization, registers, I/O ports, interrupts, timer, instruction sets, PIC programming in assembly and C, Sensor interfacing, motor control, SPI bus protocols.

Module III

ARM: ARM design philosophy, data flow model and core architecture, registers, program status register, instruction pipeline, interrupts and vector table, operating modes and ARM processor families.

Instruction Sets: Data processing instructions, addressing modes, branch, load, store instructions, PSR instructions, and conditional instructions.

Module IV

Raspberry Pi: Raspberry Pi board and its processor, Programming the Raspberry Pi using Python, Communication facilities on Raspberry Pi (I2C,SPI, UART), Interfacing of sensors and actuators.

Module V

Intel Galileo or Edison microprocessors for Embedded System and IoT.

Course outcome:

Upon Completion of the course, the students will be able to:

- Understand architecture, instruction set and programming of advanced embedded processors and controllers.
- Work with suitable microprocessor / microcontroller for a specific real world application.

Text Book:

1. Muhammod Ali Mazidi, Rolin D. Mckinlay & Danny Sansey, "PIC Microcontroller and Embeded System SPI, UART using Assembly & C for PICI8," Pearson International Edition, 2008.
2. A. N. Sloss, D. Symes, and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2008
3. S. Monk, "Programming the Raspberry Pi" McGraw-Hill Education, 2013

Reference Book:

1. John .B.Peatman , "Design with PIC Microcontroller", Prentice Hall, 1997.
2. Steave Furber, "ARM system-on-chip architecture", Addison Wesley, 2000.

EC-5103	**Advanced Embedded Processors & Microcontroller LAB**	**L-T-P-C:0-0-3-2**

Experiments related to programming and interfacing of PIC/ARM/Raspberry Pi with LED, LCD, Keyboard, Temperature Sensor, DC Motor Control, Stepper Motors, Set up of file server, Creation of a wireless access point and projects related to Traffic light controller, Digital weather station, and Keyboard control robot.

Second Semester

EC-5002	Embedded OS & Device Drivers	L-T-P-C:3-0-0-3

Course objective:

- To learn embedded system architecture.
- Study in detail process management and memory management.
- To learn Real Time Operating system principles and its components.
- Study in detail Linux kernel and Linux files systems.
- Study in detail device drivers.

Module I

Overview Of Embedded Systems: Embedded System Architecture fundamentals. Hardware and Software abstraction models.

Module II

Operating Systems Overview: Operating Systems fundamentals- Process Creation – Scheduling - Memory Management - Inter Process Synchronization –Inter Process Communication.

Module III

Embedded Operating Systems: Embedded OS overview, Study of Embedded OS principles and requirements. Internal components of Embedded operating systems - Compare and contrast various Embedded OS platforms.

Module IV

Introduction to Device Drivers: Unix/Linux kernel fundamentals-Process Scheduling - Kernel Synchronization, I/O devices - Architecture - Character, Block Device handling, file systems - The Ext2 file System - The Virtual File System and peripheral devices, Linux file system.

Module V

Device Driver Internals: Fundamentals of device drivers-Character and Block Devices - Polling and Interrupts - The Hardware, device enumeration and configuration, Data transfer and management mechanisms.

Course Outcome:

On completion of the course, student will be able to

- Gain adequate understanding of the software architecture of the Embedded OS.
- Develop simple applications for Process Management, Synchronization Techniques, Message Passing, POSIX based application development.
- Describe the Linux Kernel environment; build system, kernel configuration, customization and compilation.

- Set up a Linux environment with basic understanding of kernel programming concepts like Module. Programming and Device Drivers.
- Develop a character driver on x86 PCs and ARM based Linux Environments.
- Understand cross tooling environments and be exposed to development of device drivers for a target hardware platform.

Text/ Reference Book:

1. Charles Crowley," Operating Systems: A Design-Oriented Approach", MGH, 1st Edition, 2001.
2. Christopher Hallinan, "Embedded Linux Primer: A practical Real-World approach", Prentice Hall, 2nd Edition, 2011.
3. Daniel P. Bovet and Marco Cesati, "Understanding the Linux Kernel, O'Reilly, 3rd Edition, 2005.
4. John Madieu, "Linux Device Drivers Development: Develop customized drivers for embedded Linux", Packt Publishing, 1st Edition, 2017.
5. Jonathan Corbet, Alessandro Rubini, Greg Kroah, "Linux Device Drivers", O'Reilly, 3rd Edition, 2005.

EC-5102	Embedded OS & Device Drivers Lab	L-T-P-C:0-0-3-2

List of Experiments:

1. Task management and Software timers.
2. Real-time message queues, semaphores, and mutexs.
3. Process management and Thread management.
4. Scheduling policies and preemptions.
5. Embedded Linux Development environment set-up.
6. Linux Kernel configuration.
7. Building Embedded Linux Device Trees.
8. Linux Kernel Modules and Device model.
9. Sysfs, Char device / drivers.
10. Platform device/driver.

EC-5004	IoT Sensors & Actuators	L-T-P-C:3-0-0-3

Course Objective: Internet of Things (IoT) is presently a hot technology worldwide. Government, academia, and industry are involved in different aspects of research, implementation, and business with IoT. IoT cuts across different application domain verticals ranging from civilian to defence sectors. These domains include agriculture, space, healthcare, manufacturing, construction, water, and mining, which are presently transitioning their legacy infrastructure to support IoT. Today it is possible to envision pervasive connectivity, storage, and computation, which, in turn, gives rise to building different IoT solutions. IoT-based applications such as innovative shopping system, infrastructure management in both urban and rural areas, remote health monitoring and emergency notification systems, and transportation systems, are gradually relying on IoT based systems. Therefore, it is very important to learn the fundamentals of this emerging technology.

Module I

Introduction to IoT, Sensing, Actuation, Basics of Networking, Basics of Networking, Communication Protocols

Module II

The Architecture of IoT : RFID Story, Opportunities for IoT, Some interesting IoT projects\ Architecture of IoT. The Web of Things: Linked data- value is greatest when linked, Enterprise data – shared v. public v. private, Importance of security, privacy and authenticity Standards, Web of Things layer – driver for IOT systems

Lessons from the Internet: Is the Internet the right technology to hook together a network of things? The key lessons that our experience with the Internet teaches us about a future of things. A focus on network management, security, mobility and longevity. The desirable features of a distributed architecture for a system of things.

Module III

Network Connectivity for IoT: A simplified IoT network architecture, Room/body-are networks: Bluetooth Low Energy, Extending communication range, Data Processing and Storage: Managing high rate sensor data, Processing data streams, Data consistency in an intermittently connected or disconnected environment, Identifying outliers and anomalies. Localization: Localization algorithms, Indoor localization, Localization for mobile systems, Applications.

Module IV

Security in IoT: Why is security for IoT so hard?, Threat models, Defensive strategies and examples
HCI in an IoT World: Theory and applications of spoken dialogue for human-computer interaction, Combining speech with other modalities for natural interaction, Considerations for multilingual interactions, Paralinguistic information from speech for enhanced HCI, Future challenges for ubiquitous speech interfaces. **Robotics and Autonomous Vehicles:** Potential benefits of self-driving vehicles and service robots, Sensing and data processing, Simultaneous mapping and localization, Levels of autonomy, Future research challenge

Module V

Application: Beyond IoT - Ubiquitous Sensing and Human Experience: Emerging Descriptive data standards for IoT and sensors, Immersive visualization of diverse sensor data using game engines (part of IoT's 'control panel'), Wearable sensing for IoT (future user interfaces for IoT - new ways to control and interact with your environment), Sensors and paradigms for seamless Interaction with the Built Environment (lighting, heating, etc.), Smart Tools for IoT, Smart, sensate materials
Wireless Technologies for Indoor Localization, Smart Homes, and Smart Health:Smart health, Home automation, Location tracking.
Smart Cities: The city as a cyber physical system, Principles of cybernetics: sensing and actuating, Collection of information: opportunistic sensing (a), Collection of information: crowd sensing (b), Collection of information: ad hoc sensing (c), Response of the system: analytics and optimization, Response of the system: distributed action, people as intelligent actuators, Price of anarchy, Hacking the city: the risk for cyber attacks in centralized and distributed systems, Smart city equals Smart Citizens

Course outcome: This course will provide students with a strong background in IOT enabling them to contribute to research and development for the emerging high speed and wireless information infrastructure.

Text Book:

1. Samuel Greengard "The Internet of Things" MIT Press Essential Knowledge Series, 2015, ASIN: B00VB719VS
2. Peter Waher "Learning Internet of Things", Packt Publishing, 2015, ISBN: 1783553537

EC-5104	IoT Sensors & Actuators LAB	L-T-P-C:0-0-3-2

IoT Sensor & Actuators lab experiment:

1. Study and Install Python in Eclipse and WAP for data types in python.
2. Write a Program for arithmetic operation in Python.
3. Write a Program for looping statement in Python.
4. Study and Install IDE of Arduino and different types of Arduino.
5. Write program using Arduino IDE for Blink LED.
6. Write Program for RGB LED using Arduino.
7. Study the Temperature sensor and Write Program foe monitor temperature using Arduino.
8. Study and Implement RFID, NFC using Arduino.
9. Study and implement MQTT protocol using Arduino.
10. Study and Configure Raspberry Pi.
11. WAP for LED blink using Raspberry Pi.
12. Study and Implement Zigbee Protocol using Arduino / Raspberry Pi.

Third Semester

	Simulation and Modeling	L-T-P-C: 3-1-0-4
Course Objective:	Students will learn different types of simulation techniques.	

Unit-I

Introduction to simulation: Advantages & Dis-advantages of simulation – Areas of applications, Systems and Systems Environment, Concept of a system, Discrete & Continuous system – Models, types of models, Steps in a simulation study – Examples, Discrete – Event System simulation.

Unit-II

Overview of Statistical Models and Queuing Systems, Programming languages for Simulation: Continuous and Discrete Simulation Languages – GPSS, SIMAN, SIMSCRIPT, MATLAB and SIMULINK.

Unit-III

Random Numbers: Generation, Properties of Random Numbers, Generation of Pseudo Random Numbers, Tests for Random Numbers. Random Variate: Generation, Inverse Transformation Technique, Uniform Distribution, Exponential Distribution, Weibul's Distribution, Triangular Distribution, Empirical Continuous Distribution, Discrete Distributions, Direct Transformation for the Normal Distribution, Convolution Method of Erlang Distribution, Acceptance Rejection Techniques: Poisson Distribution, Gamma Distribution.

Unit-IV

Input Data Analysis: Data Collection: Identify the Distribution, Parameter and Estimation.

Goodness of fit tests: Chi-Square Test – KS Test; Multivariate and time series input models, Verification and Validations of Simulation Models, Model Building, Verification and Validation: Verification of Simulation Models, Calibration and Validation of Models, face validity, Validation of Model Assumptions. Validation Input/output Transformations, Input/output Validation using Historical Input Data, Input/output Validation Sing Turning Test.

Unit-V

Output Data Analysis, Stochastic, Nature of output data, Types of Simulation with respect to output Analysis, Measures of Performance and their Estimation, output Analysis for Terminating Simulations, Output Analysis for steady – State Simulations. Comparison and Evaluation of Alternative System Designs: Comparison of several system Designs, statistical Models for Estimating the Effect of Design Alternatives

Course outcome:	Students can solve various complicated engineering problems.
Text Books:	1. Jabey Banks, John S. Cansen and Barry L. Nelson, Discrete – Event System Simulation, Prentice Hall of India, 2001. 2. Nursing Deo, System Simulation with Digital computer, Prentice Hall of India, 1979.
Reference Book:	1. Anerill M. Law and W. David Kelton, Simulation Modelling and Analysis, McGraw Hill. 2001.

	Simulation and Modeling Lab	L-T-P-C: 0-0-3-2

List Of Experiments:

1. Computer Generation of Random Numbers.
2. Chi-square goodness-of-fit test.
3. One-sample Kolmogorov-Smirnov test.
4. Test for Standard Normal Distribution.
5. Testing Random Number Generators.
6. Monte-Carlo Simulation.
7. Simulation of Single Server Queuing System.
8. Simulation of Two-Server Queuing System.
9. Simulate and control a conveyor belt system.
10. Two-sample Kolmogorov-Smirnov test.

M. Tech (Embedded System& IoT) Electives Syllabus

Electives I/II

EC-5005	Optical Wireless Communication	L-T-P-C: 3-1-0-4

Course objective:

- To present the basic principles that underline the analysis and design of optical wireless communication system.
- To understand the transmitter and receiver design considerations for optical wireless communication.

Course content:

Unit 1: Introduction to optical wireless communication (OWC), optical wireless channels: atmospheric channel, underwater optical channel, atmospheric losses, weather condition influence, atmospheric turbulence effects i.e. scintillation, beam spreading, etc. optical wireless communication application areas, OWC challenges.

Unit 2: Optical wireless transmitter design, transmitter design considerations, optical source characteristics, optical wireless receiver design, receiver design considerations, photo detection in reverse biased diodes. choosing the photodetector, receiver noise consideration

Unit 3: Channel modeling: linear time invariant model, channel transfer function, models of turbulence induced fading such as log-normal turbulence model, exponential, K distribution, gamma distribution, indoor and outdoor optical wireless communication channel, LOS propagation model, Non-LOS propagation model, spherical model.

Unit 4: Modulation techniques: analog intensity modulation, digital baseband modulation techniques: baseband modulations, on–off keying, error performance on Gaussian channels, power efficiency, BW efficiency, bit versus symbol error rates, different modulation schemes such as M-ary PSK, M-ary QAM, M-PPM, DPPM, subcarrier modulation, optical polarization shift keying: binary PolSK, bit error rate analysis.

Unit 5: Detection techniques: direct detection optical receivers, PIN/APD, coherent techniques i.e. homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, spatial diversity receivers, effect of turbulence and weather conditions i.e. drizzle, haze fog on error performance and channel capacity, MIMO optical wireless channel.

Course outcome: At the end of this course, student will be able to:

- Learn the principles of optical wireless communication (OWC) and the light transmission through the air, it must contend with a complex and not always predictable channel - the atmosphere.
- Understand about the modulation and demodulation techniques used in OWC systems.
- Design transmitter and receiver for OWC link and analyze the link feasibility in terms of error performance and channel capacity.

Text Book:

1. Z.Ghassemlooy, W.Popoola, S.Rajbhandari, Optical Wireless Communications, CRC Press, 2013.
2. Gerd Keiser, Optical Fiber Communication, 4th Edition, Tata McGraw-Hill Ltd., 2008
3. L.C.Andrews, R.L.Phillips, Laser Beam Propagation through Random Media, SPIE Press,USA, 2005.

Reference Book:

1. Matthew N. O. Sadiku, Optical and Wireless Communications", CRC Press.
2. Steve Hranilovic,Wireless Optical Communication Systems" Springer.

EC-5007	Advanced Digital Image Processing	L-T-P-C: 3-1-0-4

Course objective:

- To develop a theoretical foundation of image processing techniques.
- To understand techniques and algorithms to segment / classify/ represent the image.
- To provide analytic skills to process the images with applications.

Course Content:

Unit-I

Digital Image Fundamentals: Elements of Visual Perception; Image Sensing and Acquisition; Image Sampling and Quantization; Basic Relationships between Pixels; Monochromatic Vision Models; Colour Vision Models; Colour Fundamentals; Colour Models; Conversion of Colour Models; Colour Transformations.

Unit-II

Enhancement and Restoration : Introduction; Point Processing - Image Negatives, Log transformations, Power Law Transformations, Piecewise-Linear Transformation Functions; Arithmetic/Logic Operations - Image Subtraction, Image Averaging; Histogram Processing - Histogram Equalization, Histogram Matching; Spatial filtering - Smoothing, Sharpening; Smoothing Frequency Domain Filters - Ideal Low Pass, Butterworth Low Pass, Gaussian Low Pass; Sharpening Frequency Domain Filters – Ideal High Pass, Butterworth High Pass, Gaussian High Pass; Model of Image Degradation/Restoration Process; Noise Models; Inverse Filtering; Geometric Transformations.

Unit-III

Image Analysis and Representation: Introduction; Image Segmentation - Point, Line, Edge, Boundary Detection; Colour Image Segmentation; Thresholding - Basic Global Thresholding, Multiple Thresholding, Variable Thresholding; Region Based Segmentation; Representation: Chain codes, Signatures, Boundary segments, Skeletons, Description: Boundary Descriptors, Regional Descriptors.

Unit-IV

Morphological Processing and Compression: Morphological Image Processing - Logic Operations involving Binary Images; Dilation and Erosion; Opening and Closing; Hit or Miss Transform, Basic Morphological Algorithms - Boundary Extraction, Region Filling, Thickening, Thinning; Image Compression - Compression Model, Huffman Coding, Arithmetic Coding.

Unit-V

Classification and Applications: Object Recognition and Classification, Statistical classification, Structural /Syntactic Classification, 3D Image Processing, 3D Visualization: Surface rendering, Volume rendering; Applications: Motion Analysis, Image Fusion, Image Classification.

Course Outcome:

On completion of the course, student will be able to

- Understand the fundamentals of Digital Image Processing.
- Know the Image Enhancement in the Spatial & Frequency Domain and model the noises and restoration.
- Analyze various and segmentation and representation techniques.
- Analyze various morphological algorithms and compression techniques.
- Understand the various classification techniques.

- Apply classification algorithms for various applications.

Text/ Reference Book:

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson, 3rd Edition, 2018.
2. Anil K. Jain, "Fundamentals of Digital Image Processing", PHI Learning Private Limited, New Delhi, 2002.
3. John C. Russ, "The Image Processing Handbook", CRC Press, Taylor & Francis Group, 6th Edition, 2011.
4. Geoff Dougherty, "Digital Image Processing for Medical Applications", Cambridge University Press, 2009.
5. William K. Pratt, "Digital Image Processing", John Wiley & Sons, 4th Edition, 2007.

EC-5009	Embedded Control Systems	L-T-P-C: 3-1-0-4

Course objective:

- Understand the basics of control systems.
- Understand control theory as used in embedded systems.

Course Content:

Unit-I

Control System Basics: Z-transforms, performance requirements, block diagrams, analysis and design, sampling theory, difference equations.

Unit-II

Control System Implementation: Discretization method, fixed point mathematics, nonlinear controller elements, gain scheduling, controller implementation & testing in embedded systems. Case study of robotic control system.

Unit-III

Input Devices: Keyboard basics, keyboard scanning algorithm, character LCD modules, LCD module display configuration, time-of-day clock, timer manager, interrupts, interrupt service routines, interrupt-driven pulse width modulation.

Triangle waves analog vs. digital values , auto port detect, capturing analog information in the timer interrupt service routine, multiple channel analog to digital data acquisition.

Unit-IV

H Bridge, relay drives, DC/ Stepper Motor control, optical devices.

Unit-V

Sensors: Linear and angular displacement sensors: resistance sensor, induction displacement sensor, digital optical displacement sensor, pneumatic sensors.

Speed and flow rate sensors: electromagnetic sensors, fluid flow sensor, thermal flow sensor.

Force sensors: piezoelectric sensors, strain gauge sensor, magnetic flux sensor, inductive pressure sensor, capacitive pressure sensor. Temperature sensors: electrical, thermal expansion, optical.

Course outcome:

Upon Completion of the course, the students will be able to:

- Understand application of control systems in embedded systems.
- Learn I/O devices used in control systems.

Text Book:

1. Jim Ledin, "Embedded control systems in C/C++", CMP Books, 2004.
2. TimWiscott, "Applied control for embedded systems", Elsevier Publications, 2006.

Reference Book:

1. Jean J. Labrosse, "Embedded Systems Building Blocks: Complete and Ready-To-Use Modules in C", The publisher, Paul Temme, 2011.
2. Ball S.R., "Embedded microprocessor Systems - Real World Design", Prentice Hall, 2002.
3. Lewin A.R.W. Edwards, "Open source robotics and process control cookbook", Elsevier Publications, 2005. 6.Ben-Zion Sandler, "Robotics", Elsevier Publications, 1999.

EC-5011	VLSI Testing & Testability	L-T-P-C:3-1-0-4

Course objective:

- To provide an in-depth understanding of the testing and verification of faults affecting VLSI circuits
- To provide a basic idea on fault tolerance after testing.

Course content:

Unit-I

Physical Faults and their modeling; Stuck at Faults, Bridging Faults; Fault collapsing; Fault Simulation: Deductive, Parallel, and Concurrent Fault Simulation.

Unit-II

ATPG for Combinational Circuits: D-Algorithm, Boolean Differences, PODEM Random, Deterministic and Weighted Random Test Pattern Generation; Aliasing and its effect on Fault Coverage.

Unit-III

PLA Testing, Cross Point Fault Model and Test Generation.

Unit-IV

Memory Testing- Permanent, Intermittent and Pattern Sensitive Faults, Marching Tests; Delay Faults.

ATPG for Sequential Circuits: Time Frame Expansion; Controllability and Observability Scan Design, BILBO, Boundary Scan for Board Level Testing; BIST and Totally self-checking circuits.

Unit-V

System Level Diagnosis & repair- Introduction; Concept of Redundancy, Spatial Redundancy, Time Redundancy, Error Correction Codes. Reconfiguration Techniques; Yield Modeling, Reliability and effective area utilization.

Course outcome: After completion of the course students will be able to uunderstand testing and verification related concepts in VLSI circuits.

Text/ Reference Book:

1. Abramovici, M., Breuer, M. A. and Friedman, A. D. Digital systems testing and testable design. IEEE press (Indian edition available through Jayco Publishing house), 2001.
2. Bushnell and Agarwal, V. D. VLSI Testing. Kluwer.
3. Agarwal, V. D. and Seth, S. C. Test generation for VLSI chips. IEEE computer society press.
4. Hurst, S. L. VLSI testing: Digital and mixed analog/digital techniques. INSPEC/IEE, 1999

EC-5013	Advanced Antenna Design	L-T-P-C: 3-1-0-4

Course objective:

- To study issues related to the design and analysis of antenna for various applications.
- To learn the features of real wireless communication.
- To study the various types of antenna.

Unit I

Antenna Fundamentals: Introduction, Types of Antennas, Radiation Pattern and mechanism, Antenna Parameters, Antenna Losses, Duality Theorem, Reciprocity Theorem.

Unit II

Elementary Antennas: Linear Wire Antennas, Monopole, Infinitesimal Dipole, Small Dipole, Finite Length Dipole, Half Wavelength Dipole, Loop Antenna, Small Circular Loop.

Unit III

Aperture and Broadband Antennas: Huygens' Principle, Radiation from Rectangular and Circular Apertures, Babinet's Principle, E-Plane and H-Place Sectorial Horn, Pyramidal Horn, Conical Horn, Broadband Antennas.

Unit IV

Microstrip Antennas: Basic Characteristics of Microstrip Antennas, Antenna Miniaturization, Feeding Methods, Introduction to Patch and its types, Methods of Analysis, Design of Rectangular and Circular Patch Antennas. Quality Factor, Bandwidth, Efficiency.

Unit V

Reflector and Smart Antennas: Plane, Corner, Parabolic and Spherical Reflector, Introduction to Smart Antennas, Switched Beam Systems, Adaptive Array Systems, Spatial Division Multiple Access, MANETs.

Course Outcome:

Upon Completion of the course, the students will be able to:

- Gain Knowledge about Antenna System.
- Attain knowledge about real time wireless communication.

TEXT BOOK(S):

[1] Balanis C.A., "Antenna Theory and Design", 3rd Edition, John Wiley & Sons., 2005, ISBN: 978-81-265-2422-8.

[2] Elliot R.S., "Antenna Theory and Design", Revised Edition, Wiley-IEEE Press, 2003.

REFERENCE BOOK(S):

[1] Stutzman W.L., and Thiele G.A., "Antenna Theory and Design", 2nd Edition., John Wiley & Sons., 1998.

CS-5005	IoT Architecture & Computing	L-T-P-C:3-1-0-4

Course objective:

- To learn how to design and implement IoT applications that manage big data, streaming data, and/or distributed data
- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

Module I

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

Module II

IoT Protocols: IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN, Zigbee protocol, Network Layer: IP versions, Constrained Nodes and Constrained Networks, Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, Application Transport Methods: Supervisory Control and Data Acquisition, Application Layer Protocols: CoAP and MQTT

Module III

Design and Development: Design Methodology, Embedded computing logic, Microcontroller, System on Chips, IoT system building blocks, Arduino–Board details, IDE programming, Raspberry Pi and Interfaces

Module IV

Data Analytics and Supporting Services: Structured Vs Unstructured Data and Data in Motion Vs Data in Rest, Role of Machine Learning-No SQL Databases, Hadoop Ecosystem, Apache Kafka, Apache Spark, Edge Streaming Analytics and Network Analytics, Xively Cloud for IoT, Python Web Application Framework, Django, AWS for IoT, System Management with NETCONF-YANG, Kibana, Fault-tolerant data processing on devices

Module V

Case Studies/Industrial Applications: Cisco IoT system, IBM Watson IoT platform, Manufacturing, Converged Plantwide Ethernet Model (CPwE), Power Utility Industry, GridBlocks Reference Model, Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

Course outcome: At the end of the course, student will able to

- Describe the term IoT in different contexts.
- Analyze various protocols for IoT.
- Design a PoC of an IoT system using Rasperry Pi/Arduino
- Apply data analytics and use cloud offerings related to IoT.
- Analyze applications of IoT in real time scenario

Text Book:

4. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, IoT Fundamentals:Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
5. Arshdeep Bahga, Vijay Madisetti, Internet of Things – A hands-on approach, Universities Press, 2015

Reference Book:

1. Olivier Hersent, David Boswarthick, Omar Elloumi , The Internet of Things – Key applications and Protocols, Wiley, 2012
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand, DavidBoyle, From Machine-to-Machine to the Internet of Things –Introduction to a New Age of Intelligence, Elsevier, 2014.
3. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), Architecting the Internet of Things, Springer, 2011.
4. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

CS-5019	Stochastic Processes and Queuing Theory	L-T-P-C: 3-1-0-4

Unit-I

Poisson Processes : Introduction to stochastic processes, Poisson process: Definition, Properties of Poisson processes, Generalization of Poisson processes

Unit-II

Renewal Theory and Regenerative Processes: Renewal Process: Introduction, Limit Theorems, Blackwell's Theorem, Renewal Equation, Renewal theorems, Regenerative Processes

Unit-III

Discrete Time Markov Chains: Markov Chains: Definitions, Class Properties of Transience and Recurrence, Limiting distributions of Markov chains, Tests for transience, null recurrence and positive recurrence, Reversible Markov Chains, Rate of convergence to the stationary distribution

Unit-IV

Continuous-Time Markov Chains: Introduction, Markov property, Minimal construction, Chapman Kolmogorov equations, Irreducibility and Recurrence, Time Reversibility, Birth-Death process, Reversibility of Birth-Death process

Unit-V

Martingales: Introduction, Sampling Theorem, Martingale inequalities, McDiarmid's Inequality: Applications, Martingale Convergence Theorem, Applications to Markov chain,

Random Walks Definitions, Ladder Heights, Maxima, GI/GI/1 Queue, Ladder Epochs

Unit-VI

Queuing Theory: GI/GI/1 Queue, Palm Theory, PASTA, Rate conservation laws, PASTA, Product-form Networks, M/M/1 queue, Tandem Queues, Open Jackson, Closed queueing networks, Product-Form Networks: Quasireversible networks, Quasireversible Queues, Networks of Quasireversible Queues.

Text Book

[1] Stochastic Processes, Sheldon M. Ross, 2nd edition, 1996.
[2] Introduction to Stochastic Processes, Erhan Cinlar, 2013.

[3] Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues, Pierre Bremaud, 1999.

Reference Books

[1] S. Assmussen,"Applied Probability and Queues", 2nd ed., Springer, 2003.
[2] B. Hajek,"Random Processes for Engineers", Cambridge Univesity press, 2015.
[3] S. Karlin and H.M. Taylor,"A First Course in Stochastic Processes", 2nd ed., 1975. [4] S.M. Ross, "Stochastic Processes",2nd ed., Wiley, 1996.
[5] J. Walrand,"An introduction to Queueing Netwoorks", Prentice Hall, 1988.

CS-5021	Information and Coding Theory	L-T-P-C:3-0-0-3

Unit-I

Introduction: Introduction to information theory & error control coding, Information measure, Entropy, Differential Entropy, Conditional Entropy, Relative Entropy, Information rate, Mutual Information, Channel Capacity.

Unit-II

Source Coding: Shannon's Source Coding Theorem, Prefix Coding, Huffman Coding, Shannon-Fano Coding, Arithmetic Coding, Lempel-Ziv Algorithm, Rate Distortion Theory.

Unit-III

Channel Capacity & Coding: Channel Coding Theorem, Markov Sources, Discrete Channel with discrete Noise, BSC, BEC, Capacity of a Gaussian Channel, channel capacity for MIMO system, Bandwidth-S/N Trade-off.

Unit-IV

Block Codes: Galios Fields, Hamming Weight and Hamming Distance, Linear Block Codes, Encoding and decoding of Linear Block-codes, Parity Check Matrix, and Bounds for block codes, Hamming Codes, Syndrome Decoding.

Unit-V

Cyclic Codes: Introduction to cyclic code, Method for generating Cyclic Codes, Matrix description of Cyclic codes, Cyclic Redundancy Check (CRC) codes, Circuit implementation of cyclic codes, Burst error correction, BCH codes.

Unit-VI

Convolutional Codes: Introduction to Convolutional Codes, Polynomial description of Convolutional Codes, Generating function, Matrix description of Convolutional Codes, Viterbi Decoding of Convolutional code, Introduction to Turbo Code.

Unit-VII

Coding for Secure Communications: Introduction to Cryptography, Overview of Encryption Techniques, Secret-Key Cryptography, Data Encryption, Standard (DES), Public-Key Cryptography, RSA algorithm, Digital signature, One- way Hashing.

Text Books:

1. "Information Theory, Coding & Cryptography", by Ranjan Bose, TMH, Second Edition.
2. "Communication Systems", by S. Haykin, 4th Edition, Wiley-Publication.

Reference Books:

1. "Elements of Information Theory" by Thomas M. Cover, J. A. Thomas, Wiley-Inter science Publication.
2. "Error Correction Coding Mathematical Methods and Algorithms" by Todd K. Moon, Wiley India Edition.
3. "Cryptography and Network Security", Fourth Edition, by William stallings.

CS-5023	Data Analytics for IOT	L-T-P-C:3-1-0-4

Course objective: To provide the basics of organization of big data, architectural issues of big data tools.

Course Content:

Unit-I

Fundamentals of Big-data analytics, Overview & analytics life cycle, Need, Structured and multi-structured data analysis, Big- data analytics major components, Analytical models and approaches, Big data challenges.

Unit-II

Designing and building big data applications, Big data architecture, Distributed Computing platforms and Data Storage, Security and Data Privacy, Application Areas, Application Tools and Platforms.

Unit-III

Clustered Hadoop environment, HDFS and data managements using HDFS, Analytics Using Map Reduce and programming, Map Reduce design patterns.

Unit-IV

Introduction to Modern databases-No SQL, New SQL, No SQLVs RDBMS databases Tradeoffs, Working with MongoDb, Data warehouse system for Hadoop

Unit-V

Introduction to Pig and HIVE- Programming Pig: Engine for executing data flows in parallel on Hadoop, Programming with Hive.

Course Outcome:

- Students will attain in-depth knowledge and understanding of the big data technologies.

- Students will become familiar with various search methods and visualization techniques for big data analytics.

Text/ Reference Book:

1. Dean Wampler, Jason Rutherglen, Edward Capriolo,"Programming Hive" O'Reilly Media, 1st Edition, 2012.
2. Sawant, Nitin, Shah, Himanshu, "Big Data Application Architecture Q & A: A Problem-Solution Approach", Apress, 1st Edition, 2013.

Reference Books

1. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann, 1st Edition, 2013.
2. Jonathan R. Owens, Jon Lentz, Brian Femiano, "Hadoop Real, World Solutions Cookbook", Packt, 2nd Edition, 2016.

CS-5025	Privacy and Security in IoT	L-T-P-C: 3-1-0-4

Course objective: To learn the security principles and methodologies for Internet of Things.

Course Content:

Unit-I

Introduction: Securing the Internet of Things: Security Requirements in IoT Architecture - Security in Enabling Technologies - Security Concerns in IoT Applications. Security Architecture in the Internet of Things - Security Requirements in IoT - Insufficient Authentication/Authorization – Insecure Access Control - Threats to Access Control, Privacy, and Availability - Attacks Specific to IoT. Vulnerabilities – Secrecy and Secret-Key Capacity - Authentication/Authorization for Smart Devices - Transport Encryption – Attack & Fault trees.

Unit-II

Cryptographic fundamentals for IoT: Cryptographic primitives and its role in IoT – Encryption and Decryption – Hashes – Digital Signatures – Random number generation – Cipher suites – key management fundamentals – cryptographic controls built into IoT messaging and communication protocols – IoT Node Authentication.

Unit-III

Identity & access management solutions for IoT: Identity lifecycle – authentication credentials – IoT IAM infrastructure – Authorization with Publish / Subscribe schemes – access control

Unit-IV

Privacy preservation and trust models for IoT: Concerns in data dissemination – Lightweight and robust schemes for Privacy protection – Trust and Trust models for IoT – self-organizing Things - Preventing unauthorized access.

Unit-V

Cloud security for IoT: Cloud services and IoT – offerings related to IoT from cloud service providers – Cloud IoT security controls – An enterprise IoT cloud security architecture – New directions in cloud enabled IoT computing

Course Outcome:

On completion of the course, student will be able to

- understand the Security requirements in IoT.
- understand the cryptographic fundamentals for IoT.
- understand the authentication credentials and access control.
- understand the various types Trust models and Cloud Security.

Text/ Reference Book:

1. Russell, Brian, and Drew Van Duren. Practical Internet of Things Security: Design a security framework for an Internet connected ecosystem. Packt Publishing Ltd, 2018.
2. Li, Shancang, and Li Da Xu. Securing the internet of things. Syngress, 2017.
3. Hu, Fei. Security and privacy in Internet of things (IoTs): Models, Algorithms, and Implementations. CRC Press, 2016.

Electives III/IV

EC-5006	Wireless Sensors Networks	L-T-P-C:3-0-0-3

Course objective:

- To understand the fundamental concept of wireless sensor network protocol.
- To deliberate importance of wireless communication protocols. To explain challenges in routing protocol and overview of different layer protocols.
- To aware with current applications of wireless sensor network in difference field.

Module I

Introduction: Basic concept of Wireless Sensor Networks – History, Motivation, DesignObjectives, Characteristics, Challenges, Applications, Technological Background – Transmission Fundamental, Actuator, MEMS Technology, Wireless Sensor: Topology, Sensor Network Architecturesand Protocol Stack, Network Standards.

Module II

Medium Access Control: Fundamentals of MAC protocols, Objectives of MAC design, Energy efficiency in MAC design, MAC protocols for wireless sensor networks – Contention based protocols, Contention free protocols, Hybrid protocols. WSN protocols: synchronized, duty cycled.

Module III

Network and Transport Layer: Overview, Fundamentals and Challenges of Routing protocol, Issues with the adoption of ad hoc Location-aided protocols, Layered and In-network processing-basedprotocols, Data centric and multipath Protocols. Traditional transport protocols, Traditional Transport protocols for sensor networks: Principles, Performance Metrices, Congestion Control, Reliability, Loss Recovery, Design Guidelines,Case study- Implementation and analysis of Routing protocol or transport layer protocol in Tiny OS.

Module IV

Network Security and Attack Defense: Fundamentals of network security-challenges and attacks - Protocols and mechanisms for security. Confidentiality, Integrity, Authenticity, Nonrepudiation, Freshness, Availability, Intrusion Detection, Key Management Case study- Handling attacks in Tiny OS.

Module V

Applications Of WSN: WSN Applications - Home Control - Building Automation - Industrial Automation - Medical Applications - Reconfigurable Sensor Networks - Highway Monitoring - Military Applications - Civil and Environmental Engineering Applications - Wildfire Instrumentation - Habitat Monitoring - Nanoscopic Sensor Applications – Case Study: IEEE 802.15.4 LR-WPANs Standard - Target detection and tracking - Contour/edge detection - Field sampling.

Course outcome:

After completion of course students can be able to:

- To understand technological background of sensor networks.
- To design and apply various existing routing protocols of sensor networks.

Text Book:

1. Jun Zheng, Abbas, "Wireless sensor networks A networking perspective", WILEY, 2009.
2. Kazem Sohraby, Daniel Minoli, &TaiebZnati, "Wireless Sensor Networks-Technology,Protocols, And Applications", John Wiley, 2007.

Reference Book:

1. Thomas Haensel Mann, "Wireless Sensor Networks: Design Principles for ScatteredSystems", Oldenbourg Verlag, 2011.
2. E. H. Callaway, E. H. Callaway, "Wireless Sensor Networks Architecture and Protocols", CRC Press, 2009.

3. F. Zhao and L. Guibas, "Wireless Sensor Network: Information Processing Approach", Elsevier, 2009.
4. A. Hac, "Wireless Sensor Network Designs", John Wiley & Sons, 2009.

EC-5008	SCADA Systems Applications	L-T-P-C: 3-1-0-4

Course objective:

- To prepare students to understand concepts of supervisory control and data acquisition (SCADA) system.
- To acquire the concept of SCADA architecture and to have knowledge on the various SCADA system components.
- To acquire the concept of design and implementation of a SCADA System.

Course content:

Unit-I

Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, SCADA applications in Industries

Unit-II

SCADA System Components: Schemes- Remote Terminal Unit (RTU),Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

Unit-III

SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850

Unit-IV

SCADA Communication:various industrial communication technologies -wired and wireless methods and fiber optics. open standard communication protocols

Unit-V

SCADA Applications: Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation, Simulation Exercises

Course outcome:

After studying this course, the students will be able to

- Describe the basic tasks of supervisory control and data acquisition(SCADA) Systems as well as their typical applications
- Understand about SCADA architecture, various advantages and disadvantages of each system
- Learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server
- Learn about SCADA communication, various industrial communication technologies, open standard communication protocols
- Learn and understand about SCADA applications in transmission and distribution sector, industries etc.
- Gain knowledge and understanding for the design and implementation of a SCADA system.

Text Book:

1. Stuart A. Boyer,"SCADA-Supervisory Control and Data Acquisition", 4th edition,International Society of Automation, USA,2016

Reference Book:

1. Gordon Clarke, Deon Reynders, "Practical Modern SCADA Protocols: DNP3, 60870.5 andRelated Systems", Newnes Publications, Oxford, UK.
2. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books.
3. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes.
4. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electricPower", PennWell.

EC-5010	Real-time operating system	L-T-P-C: 3-1-0-4

Course objective: The syllabus deals with the adequate understanding of Real time operating system. Student will be able to understand and design real time operating systems which are backbone of embedded industry.

Module I

Introduction to Real time systems:-Need for RTOS, Structure of RTOS, Classification of Real time system, Difference between GPOS and RTOS:- Real Time, Issues in real time operating system. Performance measures for real time system:- Properties, traditional performance measures, cost functions, hard deadlines, and Estimating program run times. Introduction to LINUX/ UNIX OS.

Module II

Performance metrics and scheduling Algorithms: - Performance Metrics of RTOS, Task Specifications, Task state. Real Time Scheduling algorithms:- Cyclic executive, Rate monotonic, IRIS and Least laxity scheduling, Schedulability Analysis.

Module III

Features of Real Time Operating System:- Messages, queues, mailboxes, pipes, timer function events, memory management. Interrupt basic system design using an RT (OS design principles, interrupt routines, task structures and priority.) Current research in RTOS.

Module IV

Real Time Databases:-Real time v/s general purpose databases, main memory databases, transaction priorities, transaction aborts. Concurrency control issues:- pessimistic concurrency control and optimistic concurrency control, Disk scheduling algorithms.

Module V

Fault Tolerance Techniques:-Causes of failure, Fault types, Fault detection, Fault and error containment. Redundancy:- hardware redundancy, software redundancy, Time redundancy, information redundancy.
Data diversity, Integrated failure handling.

Course outcome:

- Student will be able to solve scheduling problems and can apply them in real time applications in industry.
- Student can also design a RTOS and will be able to interpret the feasibility of a task set to accomplish or not.

Text Book:

1. David E. Simon, "An Embedded Software Primer", Pearson Education Asia Publication, ISBN: 9780201615692
2. C.M. Krishna and Kang G. Shin," Real Time Systems", TMH Publication, ISBN : 9780070701151

Reference Book:

1. Raj kamal ," Embedded system: Architecture Programming and Design", TMH Publication, ISBN : 9780070667648
2. Mazidi," PIC Microcontroller and Embedded Systems" , Pearson, ISBN:9788131716755

EC-5012	Advanced Optical Communication	L-T-P-C:3-1-0-4

Course objective:

- To provide in-depth knowledge of modern optical communication systems
- To understand the characteristics and limitations of system components
- To analyze the performance of optical fiber systems and networks

- Explore the principles of wireless optical communication

Unit-I

Optical communication system evolution, Generic optical system, Optical fibers, Wave propagation in optical fiber, Fiber nonlinearities, Polarization, Interference, Fiber fabrication, Attenuation in fibers, Absorption and scattering losses, Bending losses, Dispersion

Unit-II

Basic concepts of optical sources, semiconductor lasers, distributed feedback lasers, Frequency chirping, LED, Source to fiber power launching, Lensing schemes, Fiber to fiber joints, Fiber splicing, Fiber connectors, Optical modulators

Unit-III

Optical detectors, Principles of photo detector, PIN and avalanche photo diode, Phototransistor, Responsivity, Bandwidth, Noise, Optical amplifiers and filters

Unit-IV

Optical transceivers, Direct detection and coherent receivers, Noise in detection process, WDM, Modulation techniques, homodyne and heterodyne keying formats, System design, BER in synchronous and asynchronous receivers, Power budgeting, Rise time budgeting, OTDR principles, Attenuation and dispersion limits

Unit-V

Basic networks, sonnet/ SDH, Wavelength routed networks, Nonlinear effects on network performance, Ultra high capacity networks, Optical wireless communication, Applications and design challenges, Introduction to Massive MIMO

Course outcome:

- Identify and characterize different components of an optical fiber communication link.
- Compute optical fiber link design parameters
- Design considerations and assess the performance of optical devices and systems

Text Book:

1. G. Keiser, Optical Fiber Communications, McGraw-Hill, 2008.
2. J. M. Senior, Optical Fiber Communications. Principle and Practice, Prentice Hall.
3. G. P. Agrawal, Fiber-Optic Communication Systems, 3rd Edition, John Wiley & Sons, Inc., 2002.

Reference Book:

1. R. Papannareddy, “Lightwave Communication Systems: A Practical Perspective”, Penram International.
2. B. Razavi, “Design of Integrated Circuits for Optical Communications”, McGraw-Hill.

A. Yariv, "Optical Electronics in Modern Communications", Oxford University Press.
4. B. Razavi, "Design of Integrated Circuits for Optical Communications", McGraw-Hill.
5. Joseph C. Palais , Fiber Optic Communications, 4th Edition, Prentice Hall.

EC-5014	Material Science For Micro & Nano Electronics	L-T-P-C:3-1-0-4

Course objective:

- Understand concepts of semiconductor device physics for electrical and electronics applications.
- Understand fabrication and characterization techniques for semiconductor devices.
- Understand the characteristics of different semiconductor devices.

Unit-I

Introduction of Materials: Particles and Waves, Wave Particle Duality, Wave Mechanics, The Schrodinger Wave Equations, Atoms and atomic orbitals, Matter and Energy, structure property relationship, Phase transitions, Crystalline materials, amorphous materials, Liquid Crystals, polymers, organic materials, bio-materials, ceramics, glasses, superconductivity, thin films, metals, semiconductors, alloys.

Unit-II

Electronic Materials: Properties of metals and insulators, band theory of solids, band gaps in metals, semiconductors and insulators, thermal excitation, photo-excitation, the Maxwell Boltzmann distribution, intrinsic and extrinsic semiconductors, doped materials, compound semiconductors.

Unit-III

Growth and characterization of Micro and Nanoelectronic materials: Bulk crystal and hetero-structure growth, nano-lithography, etching and other means of fabrication of nanostructures and nano-devices, Techniques for characterization of nanostructures, spontaneous formation and ordering of nanostructures, clusters and nano-crystals, Methods of nanotube growth, chemical and biological methods of growing nano-structures, fabrication of nano-electromechanical systems, Characterization of Nano-electronic materials: Photo-luminance, X-Ray diffraction, TEM, DLTS, AFM, SEM.

Unit-IV

Micro & Nano-electronics Materials and Devices: Bulk Materials, 2D, 1D Materials, Nanomaterials, Graphene, carbon nanotubes, nanowires Shrink down approaches, CMOS scaling, nanoscale MOSFETs, FINFETs, Vertical MOSFETs, Resonant tunnel diodes, Field effect transistors, single electron transfer devices, potential effect transistors, light emitting diodes and lasers, nano electro mechanical system devices.

Course outcome:

Upon Completion of the course, the students will be able to:

- implement concepts of semiconductor device physics for electrical and electronics applications.
- Analyze the characteristics of different semiconductor devices.
- Utilize the basic governing equations to analyze semiconductor devices.

Text Book:

1. D. K. Schroder, "Semiconductor Materials and Device Characterization", Wiley Interscience
2. Poole, Owens, "Introduction to Nanotechnology", Wiley
3. Drexler, "Nanosystems", Wiley
4. RanierWaser, "Nanoelectronics and Information Technology" Wiley-VCH
5. Mitin, Kochelap, Stroscio, "Introduction to Nanoelectronics", Cambridge University Press.
6. L. H. V. Vlack, "Elements of Material Science & Engineering", PHI
7. M Shur, "Physics of Semiconductor devices" , PHI
8. William, Smith, "Fundamentals of Materials Science and Engineering", McGraw Hill, 1998.

EC-5016	MOS Devices	L-T-P-C:3-1-0-4

Course objective: The course will provide detail understanding of Metal-Oxide-Semiconductor (MOS) Capacitor and allied field effect devices, required for designing VLSI&ULSI CMOS circuits.

Unit-I

MOS Capacitor: Energy band diagram of Metal-Oxide-Semiconductor contacts, Mode of Operations: Accumulation, Depletion, Mid gap, and Inversion, 1D Electrostatics of MOS, Depletion Approximation, Accurate Solution of Poisson's Equation, CV characteristics of MOS, LFCV and HFCV, Non-idealities in MOS, oxide fixed charges, interfacial charges, Mid gap gate Electrode, Poly-Silicon contact, Electrostatics of non-uniform substrate doping, ultrathin gate-oxide and inversion layer quantization, quantum capacitance, MOS parameter extraction

Unit-II

Physics of MOSFET: Drift-Diffusion Approach for IV, Gradual Channel Approximation, Sub-threshold current and slope, Body effect, Pao & Sah Model, Detail 2D effects in MOSFET, High field and doping dependent mobility models, High field effects and MOSFET reliability issues (SILC, TDDB, & NBTI), Leakage mechanisms in thin gate oxide, High-K-Metal Gate MOSFET devices and technology issues, Intrinsic MOSFET capacitances and resistances, Meyer model.

Unit-III

SOI MOSFET: FDSOI and PDSOI, 1D Electrostatics of FDSOI MOS, VT definitions, Back gate coupling and body effect parameter, IV characteristics of FDSOI-FET, FDSOI-sub-threshold slope, Floating body effect, single transistor latch, ZRAM device, Bulk and SOI FET: discussions referring to the ITRS.

Unit-IV

Nanoscale Transistors: Diffusive, Quasi Ballistic & Ballistic Transports, Ballistic planer and nanowire-FET modeling: semi-classical and quantum treatments

Unit-V

Advanced MOSFETs: Strain Engineered Channel materials, Mobility in strained materials, Electrostatics of double gate, and Fin-FET devices

Text/ Reference Book:

1. S.M. Sze & Kwok K. Ng, Physics of Semiconductor Devices, Wiley, 2007

2. Yuan Taur & Tak H. Ning, Fundamentals of Modern VLSI Devices, Cambridge, 1998.
3. Mark Lundstrom& Jing Guo, Nanoscale Transistors: Device Physics, Modeling & Simulation, Springer, 2005.
4. Yannis Tsividis, Operation and Modeling of the MOS Transistor, Oxford University Press, 2nd edition.
5. J.P. Colinge, Silicon-on-Insulator Technology: Materials to VLSI, Springer, 1997.
6. Research papers in specific area.

EC-5018	Embedded System Design	L-T-P-C: 3-1-0-4

Course objective:

- To acquire the knowledge of embedded systems and application of knowledge to understand design paradigms, architectures, possibilities, and challenges, both with respect to software and hardware.
- To prepare students to perform the testing, verification, and validation in order to engineer reliable and safe embedded system designs.

Course content:

Unit-I

Introduction: Concept of embedded system design: design challenge, processor technology, IC technology, design technology, trade-offs.

Unit-II

Processor and Memory: Introduction to processors, basic architecture, operation, super-scalar and VLSIIW architecture, Application Specific Instruction Set Processors (ASIPS), microcontrollers, digital signal processors, selecting a microprocessor, introduction to memory, memory writes ability, storage performance, tradeoffs, common memory types, memory hierarchy and cache.

Unit-III

Microcontroller: Architecture and programming in assembly and C, interfacing analog and digital blocks: Analog-to-Digital Converters (ADCs), Digital to-Analog Converters (DACs),communication basics and basic protocol concepts, microprocessor interfacing: I/O addressing, port and bus based I/O, memory mapped I/O, standard I/O interrupts, direct memory access, advanced communication principles parallel-serial-wireless, serial protocols I2C, parallel protocols PCI bus, wireless protocol IrDA, blue tooth.

Unit-IV

Peripheral Devices: Buffers and latches, crystal, reset circuit, chip select logic circuit, timers, counters, Universal Asynchronous Receiver Transmitter (UART), pulse width modulators, LCD controllers, keypad controllers, design tradeoffs due to thermal considerations and effects of EMI/ES etc.

Unit-V

Embedded Software Development: Real time operating systems, Kernel architecture: hardware, task/process control subsystem, device drivers, file subsystem, system calls, embedded operating systems, task scheduling in embedded systems: task scheduler, first in first out, shortest job first, round robin, priority based scheduling, context switch: task synchronization: mutex, semaphore, timers, types of embedded operating systems, programming languages: assembly languages, high level language.

Unit-VI

Embedded System Development: Embedded system development process, determine the requirements, design the system architecture, choose the operating system, choose the processor, choose the development platform, choose the programming language, coding issues, code optimization, efficient input/output, testing and debugging.

Course outcome:

After studying this course, the students will be

- able to acquire knowledge and understand fundamental embedded systems design paradigms, architectures, possibilities, and challenges, both with respect to software and hardware.
- able to analyze a system both as whole and in the included parts, to understand how these parts interact in the functionality and properties of the system
- able to practically apply gained theoretical knowledge in order to design, analyze and implement embedded systems, e.g. integrating embedded subsystems and applications in building a fully functional autonomous robot.
- able to apply formal method, testing, verification, validation and simulation techniques and tools in order to engineer reliable and safe embedded systems.
- able to demonstrate a deeper understanding of the electronics and physical principles used for embedded systems.

Text Book:

1. Jack Ganssle, "The Art of Designing Embedded Systems", Newnes, 1999.
2. R. Kamal, “Embedded Systems: Architecture, Programming and Design” MGH, 2008.
3. Shibu, “Introduction to Embedded Systems”, McGraw Hill, 2017.

Reference Book:

1. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.
2. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Cengage, 2000.
3. Bahadure, “Microcontrollers and Embedded System Design” Wiley, 2019.
4. Mazidi, “PIC Microcontroller and Embedded Systems” Pearson, 2008.

CS-5008	Cloud Computing	L-T-P-C:3-0-0-3

- To enable students to deliver an application built in the cloud with the concept of application-based building blocks for processing of data.
- To acquire the concept of cloud computing and to have knowledge on the various issues in cloud computing.
- To appreciate the emergence of cloud as the next generation computing paradigm.

Module I

Introduction: Introduction to Cloud Architecture and Computing Concepts, Why Clouds, What is a Cloud, Introduction to Clouds: History, What's New in Today's Clouds, New Aspects of Clouds, Economics of Clouds, cloud distributed system, MapReduce: Paradigm, Scheduling, Fault-Tolerance.

Module II

Multicast Problem and P2P Systems: Introduction to Multicast Problem, Gossip Protocol – analysis – implementation, Failure Detectors, Gossip-Style Membership, Dissemination and suspicion, Grid Applications, Grid Infrastructure, P2P Systems Introduction, Napster, Gnutella, FastTrack and BitTorrent, Chord, Pastry, Kelips.

Module III

Design of key-value/NoSQL storage/database systems: Introduction to Key-Value/NOSQL, Cassandra, Cap Theorem, Consistency Spectrum, HBase, Cristian's Algorithm, Network Time Protocol (NTP), Lamport Timestamps, Vector Clocks

Module IV

Machine Coordination in a Distribution system: The Election Problem, Ring Leader Election, Election in Chubby and ZooKeeper, Bully Algorithm, Distributed Mutual Exclusion, Ricart-Agrawala's Algorithm, Maekawa's Algorithm.

Module V

Transactions and Replication Controlling Cloud Systems: Remote Procedure Calls (RPCs), Transactions, Serial Equivalence, Pessimistic Concurrency, Optimistic Concurrency Control, Replication, Two-Phase Commit.

Module VI

Emerging Paradigms and Classical Systems: Stream Processing in Storm, Distributed Graph Processing, Structure of Networks, Single-processor Scheduling, Hadoop Scheduling, Dominant-Resource Fair Scheduling, File System Abstraction, Network File System (NFS) and Andrew File System (AFS), Distributed Shared Memory.

Course outcome:

After studying this course, the students will be able to

- Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
- Understand core techniques, algorithms, and design philosophies – all centered around distributed systems.

- Analyze and implement concepts include: clouds, MapReduce, key-value/NoSQL stores, classical distributed algorithms, widely-used distributed algorithms and scalability.
- Learn the key and enabling technologies that help in the development of cloud.
- Develop the ability to understand and use the architecture of compute and storage cloud, service and delivery models.
- Evaluate and choose the appropriate technologies, algorithms and approaches for implementation and use of cloud.

Text Book:

1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, "Distributed and cloud computing from Parallel Processing to the Internet of Things", Morgan Kaufmann, Elsevier, 2012.
2. Rittinghouse, John W., and James F. Ransome, "Cloud Computing: Implementation, Management and Security", CRC Press, 2017.

Reference Book:

1. Rajkumar Buyya, Christian Vecchiola, S. ThamaraiSelvi, "Mastering Cloud Computing", Tata Mcgraw Hill, 2013.
2. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing – A Practical Approach, Tata Mcgraw Hill, 2009.
3. Barrie Sosinsky, "Cloud Computing Bible" John Wiley & Sons, 2010.
4. Tim Mather, Subra Kumaraswamy, and Shahed Latif, "Cloud Security and Privacy An Enterprise Perspective on Risks and Compliance", O'Reilly, 2009.

CS-5016	Real Time Data Analysis	L-T-P-C: 3-1-0-4

Course objective:

- To study issues related to the design and analysis of systems with real-time constraints.
- To learn the features of Real time OS.
- To study the various Uniprocessor and Multiprocessor scheduling mechanisms.
- To learn about various real time communication protocols.
- To study the difference between traditional and real time databases.
-

Unit-I

Introduction to real time computing: Concepts; Example of real-time applications – Structure of a real time system – Characterization of real time systems and tasks - Hard and Soft timing constraints - Design Challenges - Performance metrics - Prediction of Execution Time : Source code analysis, Micro-architecture level analysis, Cache and pipeline issues- Programming Languages for Real-Time Systems

Unit-II

Real time OS: Threads and Tasks – Structure of Microkernel – Time services – Scheduling Mechanisms Communication and Synchronization – Event Notification and Software interrupt Task assignment and Scheduling

Unit-III

Task allocation algorithms: Single-processor and Multiprocessor task scheduling - Clock-driven and priority-based scheduling algorithms Fault tolerant scheduling

Unit-IV

Real Time Communication: Network topologies and architecture issues – protocols –contention based, token based, polled bus, deadline based protocol, Fault tolerant

routing. RTP and RTCP.

Unit-V

Real time Databases

Transaction priorities – Concurrency control issues – Diskscheduling algorithms – Two phase approach to improve predictability

Course Outcome:

Upon Completion of the course, the students will be able to:

- Gain Knowledge about Schedulability analysis.
- Learn about the Real-time programming environments.
- Attain knowledge about real time communication and databases.
- Develop real time systems.

Text Book:

[1]C.M. Krishna, Kang G. Shin – " Real Time Systems", International Edition,

McGrawHill Companies, Inc., New York, 1997.

[2]Jane W.S. Liu, "Real-Time Systems", Pearson Education India, 2000

Reference Book:

[1]Philip A. Laplante and Seppo J. Ovaska, "Real-Time Systems Design and Analysis:Tools for the Practitioner'' IV Edition IEEE Press, Wiley, 2013.

[2]Sanjoy Baruah, Marko Bertogna, Giorgio Buttazzo, "Multiprocessor Schedulingfor Real-Time Systems ", Springer International Publishing, 2015.

List of Electives (CSE)

CS-5005	IoT Architecture & Computing	L-T-P-C:3-1-0-4

Course objective:

- To learn how to design and implement IoT applications that manage big data, streaming data, and/or distributed data

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

Unit I

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

Unit II

IoT Protocols: IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN, Zigbee protocol, Network Layer: IP versions, Constrained Nodes and Constrained Networks, Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, Application Transport Methods: Supervisory Control and Data Acquisition, Application Layer Protocols: CoAP and MQTT

Unit III

Design and Development: Design Methodology, Embedded computing logic, Microcontroller, System on Chips, IoT system building blocks, Arduino–Board details, IDE programming, Raspberry Pi and Interfaces

Unit IV

Data Analytics and Supporting Services: Structured Vs Unstructured Data and Data in Motion Vs Data in Rest, Role of Machine Learning-No SQL Databases, Hadoop Ecosystem, Apache Kafka, Apache Spark, Edge Streaming Analytics and Network Analytics, Xively Cloud for IoT, Python Web Application Framework, Django, AWS for IoT, System Management with NETCONF-YANG, Kibana, Fault-tolerant data processing on devices

Unit V

Case Studies/Industrial Applications: Cisco IoT system, IBM Watson IoT platform, Manufacturing, Converged Plantwide Ethernet Model (CPwE), Power Utility Industry, GridBlocks Reference Model, Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

Course outcome: At the end of the course, student will able to

- Describe the term IoT in different contexts.
- Analyze various protocols for IoT.
- Design a PoC of an IoT system using Rasperry Pi/Arduino
- Apply data analytics and use cloud offerings related to IoT.
- Analyze applications of IoT in real time scenario

Text Book:

6. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, IoT Fundamentals:Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
7. Arshdeep Bahga, Vijay Madisetti, Internet of Things – A hands-on approach, Universities Press, 2015

Reference Book:

5. Olivier Hersent, David Boswarthick, Omar Elloumi , The Internet of Things – Key applications and Protocols, Wiley, 2012
6. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand, DavidBoyle, From Machine-to-Machine to the Internet of Things –Introduction to a New Age of Intelligence, Elsevier, 2014.
7. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), Architecting the Internet of Things, Springer, 2011.
8. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

CS-5007	Advanced Data Structures and algorithms	L-T-P-C:3-1-0-4

Course objective:

- The course is intended to provide the foundations of the practical implementation and usage of Algorithms and Data Structures. One objective is to ensure that the student evolves into a competent programmer capable of designing and analyzing implementations of algorithms and data structures for different kinds of problems. The second objective is to expose the student to the algorithm analysis techniques, to the theory of reductions, and to the classification of problems into complexity classes like NP

Course content:

Unit 1 Advanced Data Structures

Importance and need of good data structures and algorithms, Heaps, AVL Trees (Search, Insertion, and ,Deletion), Red-Black Trees (Search, Insertion, and Deletion), Splay Trees (Search, Insertion and Deletion), B trees, B+ Trees (Search, Insertion and Deletion), Fibonacci heaps, Data Structures for Disjoint Sets, Augmented Data Structures, Self-Adjusting Data Structures, Temporal data structures, Succinct data structures, Dictionaries and cuckoo hashing.

Unit 2 Algorithms Complexity and Analysis

Probabilistic Analysis with example, Amortized Analysis with example, Competitive Analysis with example, Internal and External Sorting algorithms like external merge sort, distribution sorts.

Unit 3 Graphs & Algorithms

Representation, Type of Graphs, Paths and Circuits: Euler Graphs, Hamiltonian Paths & Circuits; Cut-sets, Connectivity and Separability, Planar Graphs, Isomorphism, Graph Coloring, Covering and Partitioning, Topological sort, Max flow: FordFulkerson algorithm, max flow – min cut, Dynamic Graphs, Few Algorithms for Dynamic Graphs, Union-Find Algorithms.

Unit 4 Algorithms Terminology

String Matching Algorithms: Suffix arrays, Suffix trees, tries, Rabin-Karp, Knuth-Morris-Pratt, Boyer Moore algorithm.

Approximation Algorithms: Need of approximation algorithms: Introduction to P, NP, NP-Hard and NP-Complete; Deterministic, non-Deterministic Polynomial time algorithms; Knapsack, TSP, Set Cover, Open Problems.

Randomized Algorithms: Introduction, Type of Randomized Algorithms, Quick Sort, Min- Cut, 2-SAT; Game Theoretic Techniques, Random Walks.

Online Algorithms: Introduction, Online Paging Problem, Adversary Models, k-server Problem.

Genetic Algorithm: Introduction to GA, implementation in Python, problem solving using GA such as subset problem, TSP, Knapsack.

Unit 5 Advance Data Structure in Python

List, Tuple, Dictionary, Set, Stack.

Laboratory work: Implementation of various advanced data structures and algorithms for the problems like MAZE etc. Implementation of various advanced data structures with Graphs and GUI based results to explore the use of formal verification algorithms and verification tools.

Course outcome:

- Design and analyze programming problem statements.
- choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a specific problem.
- understand the necessary mathematical abstraction to solve problems.
- come up with analysis of efficiency and proofs of correctness
- comprehend and select algorithm design approaches in a problem specific manner**.**

Text Book:

1. Cormen, Leiserson, Rivest, & Stein, Introduction to Algorithms, The MIT Press (2009), 3rd Edition.
2. Goldberg, Genetic Algorithms, Pearson Education India (1 December 2008), 1st Edition.
3. Sedgewick & Wayne, Algorithms, Addison-Wesley Professional (March 19, 2011), 4th Edition.

Reference Book:

1. Sahni, Data Structures, Algorithms and Applications in C++, Universities Press (2005), 2nd Edition.

CS-5009	**Software and System Engineering**	**L-T-P-C:3-1-0-4**

Course objective:

- To discuss various System design methodologies, the impact of cohesion and coupling measures on the goodness of the software design.
- To discuss various System Testing methodologies
- To discuss the importance of practicing different coding standards, guidelines along with reliability metrics and management techniques & standards.

Course content:

UNIT 1

Introduction

Importance of System Engineering Paradigms for Software Systems; Life Cycle Models- Project scheduling and tracking, System Configuration Management.

UNIT 2

Requirement Analysis – Functional Modelling of Software Systems

Requirements Analysis and Specifications, Analysis Modeling, Design Concepts and Principles, Function-oriented design, Architectural design, User Interface Design, Component Level Design. UML Modelling

UNIT 3

Quality Assurance of Software Systems

Testing Techniques for Software Systems: Black box and White box Testing, Regression testing, Reliability Modelling of Software Systems, Quality Assurance and Maintenance

UNIT 4

Measurement of Software Systems

Metrics for Measurement of Software Systems, Direct Measurement, Indirect Measurement: Product Metrics: Product metrics Process Metrics, Project Metrics

UNIT 5

Software Configuration Management

Change Requirements, Version control, Change management, scheduling, estimating, etc. Manual and Automatic Test Data Generation for Software Systems/Embedded Systems.

Course outcome:	After reading this subject, students will be able to: • Choose a proper life cycle model for different real life industrial applications, design software using function-oriented approach (DFDs) and object-oriented approach (UML diagrams). • Understand the concepts of computer aided software engineering (CASE) and use different CASE tools in the development, maintenance and reuse of software systems. • Know the emerging concepts like SOA etc., their functioning and their applications in real life problems.
Text Book:	1. R. S. Pressman, Software Engineering A Practitioner's Approach, McGraw Hill Publications , 2006 2. R. Mall, Fundamentals of Software Engineering, Prentice Hall of India , 2014
Reference Book:	1. I. Sommerville, Software Engineering, Pearson Education, Asia , 2006 2. P. Jalote, An Integrated Approach to Software Engineering, Narosa , 2006

CS-5011	**Ethics and Data Science**	**L-T-P-C: 3-1-0-4**

Unit-I

Overview of ethical issues in data-driven organizations: Overview of data science as an ethical practice, Introduction to the unique ethical challenges of 'big data', Ethical Theory - Philosophical frameworks for assessing fairness, Early theories of fairness, Moving towards contemporary theories of fairness.

Unit-II

Research ethics for data science: Ethical side effects of the publish or perish system: p-hacking and small sample size, The misapplication of informed consent in dataveillance practices. Techniques of data ethics:

Getting from data to individuals: Internet traces and Geofingerprints. All data are human data: On the discriminatory trouble with training data.

Unit-III

Discrimination and algorithms: The ethics of price discrimination, Criminal justice by algorithm. The philosophical challenge of thinking in categories-How humans explain their social worlds through perceptions and statistics, Social processes and the impact of categorical life. Data ethics for researchers-Health Research, Educational Research.

Unit-IV

The ethics of data scraping and storage, Mosaic data, found data, and designed data.

Unit-V

Privacy and Surveillance, Special topics in surveillance: Adtech, Special topics in surveillance: Employment, Differential privacy.

Text Book

[1] Ethics and Data Science, by DJ Patil, Hilary Mason, and Mike Loukides, 25 July 2018.

CS-5013	WEB SERVICES AND E-COMMERCE	L-T-P-C: 3-1-0-4

Unit-I

Introduction to XHTML and Javascript, XML Elements and Attributes, XML Document Structure and Syntax, XML Namespaces, XML Data Validation, XML 1.1 new features, XML Namespaces, XML parsers for data validation, Document Type Definitions, W3C XML Schemas.

Unit-II

Parsing XML with Document Object Model (DOM), Parsing XML and with Simple API for XML(SAX), XSLT concepts and transformations, Storing and Binding data in HTML, Navigation from record to record, Extracting data from DSO, Binding XML data into HTML tables, Reading XML and Extracting data from it, Creating a DOM Document Object, Getting a Document's Document Element, Searching for XML Elements by name, Extracting Data from XML attributes, Xquery and its usage.

Unit-III

Design of Information system, Architecture of an Information system, Understanding Middleware, RPC and related Middleware, TP Monitors, object Brokers, Message Oriented Middleware, Web Service concept, SOAP, WSDL, UDDI, Creating and Deploying, Accessing and Building .NET Web Services, Authentication and Security for Web Services; Major components of e-Commerce, e-Commerce framework, Media Convergence.

Unit-IV

Anatomy of e-Commerce application, Types of e-Commerce: Inter-organizational, Intra-organizational, C2B, Communication Security goals; E commerce privacy policy, Network security policy, Firewall security policy, Requirements of transaction security, E commerce encryption, Digital Money Security Payment Transaction, Electronic Security basics, Limitation of e-Commerce, Security measures.

Text Book

[1] Web Services Security and E-business, by Radhamani, G., Rao, G. S.V. Radha Krishna, Idea Group Inc (IGI), 31-Oct-2006.

CS-5015	Pattern Recognition	L-T-P-C: 3-1-0-4

Unit-I

Basics of Probability, Random Processes and Linear Algebra (recap): Probability: independence of events, conditional and joint probability, Bayes theorem Random Processes: Stationary and non-stationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra.

Unit-II

Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors, singular values, singular vectors. Bayes Decision Theory : Minimum-error-rate classification. Classifiers, Discriminant functions, Decision surfaces. Normal density and discriminant functions. Discrete features.

Unit-III

Parameter Estimation Methods : Maximum-Likelihood estimation :Gaussian case. Maximum a Posteriori estimation. Bayesian estimation: Gaussian case. Unsupervised learning and clustering - Criterion functions for clustering. Algorithms for clustering: K-Means, Hierarchical and other methods. Cluster validation. Gaussian mixture models, Expectation-Maximization method for parameter estimation. Maximum entropy estimation. Sequential Pattern Recognition. Hidden Markov Models (HMMs). Discrete HMMs. Continuous HMMs. Nonparametric techniques for density estimation. Parzen-window method. K-Nearest Neighbour method.

Unit-IV

Dimensionality reduction: Principal component analysis - it relationship to eigen analysis. Fisher discriminant analysis - Generalised eigen analysis. Eigen vectors/Singular vectors as dictionaries. Factor Analysis, Total variability space - a dictionary learning methods. Non negative matrix factorisation - a dictionary learning method.

Linear discriminant functions : Gradient descent procedures, Perceptron, Support vector machines - a brief introduction.

Unit-V

Artificial neural networks: Multilayer perceptron - feedforwark neural network. A brief introduction to deep neural networks, convolutional neural networks, recurrent neural networks.

Non-metric methods for pattern classification : Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART).

Text Book

[1] R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001

[2] S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009

[3] C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006

CS-5017	Evolutionary and Randomized Algorithms	L-T-P-C:3-1-0-4

Course objective:

- The objective of this course is to familiarize students with some contemporary research in the emerging areas of algorithm design and analysis such as techniques to solve optimization problems and use of randomness to help in computing.
- The main focus will be on the details of the techniques such as ACO, PSO and artificial neural System and related learning algorithms

Course content:

Unit-I: Reducibility between problems and NP-completeness:

Computational Models; Problems, computability, Algorithms, Resources, and Complexity; Turing machines (time and space bounds, non-determinism); Complexity classes (hierarchy theorem, P, NP, Co-NP, NP-hard); Reduction and completeness; Polynomial Hierarchy; Logarithmic space; Polynomial space; Exponential time and space; Discussion of different NP-complete problems like satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, TSP, knapsack, set cover, bin packing, etc.

Unit II: Evolutionary Computation:

Introduction to Models and Concept of Computational Intelligence, Social Behavior as Optimization: Discrete and Continuous Optimization Problems, Classification of Optimization Algorithms, Evolutionary Computation Theory and Paradigm, Genetic Algorithm, Genetic Representations, Initial Population, Fitness Function, Selection and Reproduction, Genetic Operators (Selection, Crossover, Mutation), Artificial Immune Systems, Other Algorithms Harmony Search, Honey-Bee Optimization, Memetic Algorithms, Co-evolution, MultiObjective Optimization, Artificial Life, Constraint Handling

Unit-III: Neural Networks:

Neuron Models, Neuron Architecture, Mathematical Model of Neural Networks, , Artificial Neural Network Learning Methods and Learning Strategies, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Activation Functions, Pattern Classification and Linear Separability, Single and Multilayer Perceptron Network, Self-Organizing Map (Kohonen network), Hopfield Network, Back Propagation Network, Radial Basis function Network

Unit-IV: Swarm Intelligence

Swarm and Collective intelligence, Swarm Intelligence Techniques: Particle Swarm Optimization, Ant Colony Optimization, Artificial Bees and Firefly Algorithm etc., Hybridization and Comparisons of Swarm Techniques, Artificial evolution of Competing Systems, Artificial Evolution of cooperation and competition, Application of Swarm Techniques in Different Domains and Real World Problems.

Unit-V: Randomized Algorithms:

Probabilistic Recurrence, Basic Power and Efficiency of Randomization and Approximation, Classification of randomized algorithms: Las Vegas and Monte Carlo, Minimum cut algorithm, Bin-Balls Problem, Birthday-Paradox, Coupon-Collector, Stable Marriage Problem, Game Theory, Random variables and Basic inequalities (Markov, Chebyshev), Chernoff Bounds, Martingale Bound, Max-cut, Random Graphs, Markov chains and random walks, Random graph models for real-world networks, social networks, etc. Algorithms for 2-SAT and 3-SAT.

Course outcome:

After completing this course, students will

Have working knowledge of Evolutionary Theory and Algorithms and be able to explain how biological systems exploit natural processes.

Understand the impact of using randomization for designing algorithms that are simpler and often more efficient than the deterministic counterparts

Text Book:

1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press.
2. Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms, Second Edition, MIT Press/McGraw-Hill, 2001.
3. A.E. Elben and J. E. Smith, “Introduction to Evolutionary Computing”, Springer, 2010.
4. Eberhart, E. and Y. Shi., “Computational Intelligence: Concepts and Implementations”, Morgan Kauffmann, San Diego, 2007
5. Kenneth DeJong, Evolutionary Computation A Unified Approach, 2006.
6. Gusz Eiben and Jim Smith, Introduction to Evolutionary Computing, 2007.

Reference Book:

1. M. Kearns and U. Vazirani, An Introduction to Computational Learning Theory. MIT Press.
2. N. Alon and J. H. Spencer, The Probabilistic Method, John Wiley.
3. Christos H. Papadimitriou, Computational Complexity, Addison-Wesley Longman.
4. John E. Hopcroft and Jeffrey D. Ullman, Introduction to Automata, Languages and Computation, Addison-Wesley, 1979.
5. Bonabeau, E., Dorigo, M. and Theraulaz, G., Swarm Intelligence: From Natural to Artifical Systems, Oxford University Press, 1999
6. Dario Floreano, Claudio Mattiussi, “Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies”, MIT Press, 2008.
7. Engelbrecht, A.P. Computational Intelligence: An Introduction, Second Edition, John Wiley and Sons, 2007.
8. Kennedy, J. and Eberhart, R.C., Swarm Intelligence, Morgan Kaufmann Publishers, 2001
9. Parsopoulos, K.E., Vrahatis, M.N., Particle Swarm Optimization and Intelligence: Advances and Applications, Information Science Reference, IGI Global, 2010
10. D. E. Goldberg, “Genetic algorithms in search, optimization, and machine learning”, AddisonWesley, 1989
11. R. C. Ebelhart et al., “Swarm Intelligence”, Morgan Kaufmann, 2001.
12. M. Dorigo and T. Stutzle, “Ant Colony Optimization”, A Bradford Book, 2004.

Simon O. Haykin, “Neural Networks and Learning Machines”, Third Edition, Prentice Hall, 2008

CS-5019	Stochastic Processes and Queuing Theory	L-T-P-C: 3-1-0-4

Unit-I

Poisson Processes : Introduction to stochastic processes, Poisson process: Definition, Properties of Poisson processes, Generalization of Poisson processes

Unit-II

Renewal Theory and Regenerative Processes: Renewal Process: Introduction, Limit Theorems, Blackwell's Theorem, Renewal Equation, Renewal theorems, Regenerative Processes

Unit-III

Discrete Time Markov Chains: Markov Chains: Definitions, Class Properties of Transience and Recurrence, Limiting distributions of Markov chains, Tests for transience, null recurrence and positive recurrence, Reversible Markov Chains, Rate of convergence to the stationary distribution

Unit-IV

Continuous-Time Markov Chains: Introduction, Markov property, Minimal construction, Chapman Kolmogorov equations, Irreducibility and Recurrence, Time Reversibility, Birth-Death process, Reversibility of Birth-Death process

Unit-V

Martingales: Introduction, Sampling Theorem, Martingale inequalities, McDiarmid's Inequality: Applications, Martingale Convergence Theorem, Applications to Markov chain,

Random Walks Definitions, Ladder Heights, Maxima, GI/GI/1 Queue, Ladder Epochs

Unit-VI

Queuing Theory: GI/GI/1 Queue, Palm Theory, PASTA, Rate conservation laws, PASTA, Product-form Networks, M/M/1 queue, Tandem Queues, Open Jackson, Closed queueing networks, Product-Form Networks: Quasireversible networks, Quasireversible Queues, Networks of Quasireversible Queues.

Text Book

[1] Stochastic Processes, Sheldon M. Ross, 2nd edition, 1996.

[2] Introduction to Stochastic Processes, Erhan Cinlar, 2013.

[3] Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues, Pierre Bremaud, 1999.

Reference Books

[1] S. Assmussen,"Applied Probability and Queues", 2nd ed., Springer, 2003.

[2] B. Hajek,"Random Processes for Engineers", Cambridge Univesity press, 2015.

[3] S. Karlin and H.M. Taylor,"A First Course in Stochastic Processes", 2nd ed., 1975. [4] S.M. Ross, "Stochastic Processes",2nd ed., Wiley, 1996.

[5] J. Walrand,"An introduction to Queueing Netwoorks", Prentice Hall, 1988.

EC-3006	Information and Coding Theory	L-T-P-C:3-0-0-3

Unit-I

Introduction: Introduction to information theory & error control coding, Information measure, Entropy, Differential Entropy, Conditional Entropy, Relative Entropy, Information rate, Mutual Information, Channel Capacity.

Unit-II

Source Coding: Shannon's Source Coding Theorem, Prefix Coding, Huffman Coding, Shannon-Fano Coding, Arithmetic Coding, Lempel-Ziv Algorithm, Rate Distortion Theory.

Unit-III

Channel Capacity & Coding: Channel Coding Theorem, Markov Sources, Discrete Channel with discrete Noise, BSC, BEC, Capacity of a Gaussian Channel, channel capacity for MIMO system, Bandwidth-S/N Trade-off.

Unit-IV

Block Codes: Galios Fields, Hamming Weight and Hamming Distance, Linear Block Codes, Encoding and decoding of Linear Block-codes, Parity Check Matrix, and Bounds for block codes, Hamming Codes, Syndrome Decoding.

Unit-V

Cyclic Codes: Introduction to cyclic code, Method for generating Cyclic Codes, Matrix description of Cyclic codes, Cyclic Redundancy Check (CRC) codes, Circuit implementation of cyclic codes, Burst error correction, BCH codes.

Unit-VI

Convolutional Codes: Introduction to Convolutional Codes, Polynomial description of Convolutional Codes, Generating function, Matrix description of Convolutional Codes, Viterbi Decoding of Convolutional code, Introduction to Turbo Code.

Unit-VII

Coding for Secure Communications: Introduction to Cryptography, Overview of Encryption Techniques, Secret-Key Cryptography, Data Encryption, Standard (DES), Public-Key Cryptography, RSA algorithm, Digital signature, One- way Hashing.

Text Books:

1. "Information Theory, Coding & Cryptography", by Ranjan Bose, TMH, Second Edition.
2. "Communication Systems", by S. Haykin, 4th Edition, Wiley-Publication.

Reference Books:

1. "Elements of Information Theory" by Thomas M. Cover, J. A. Thomas, Wiley-Inter science Publication.
2. "Error Correction Coding Mathematical Methods and Algorithms" by Todd K. Moon, Wiley India Edition.
3. "Cryptography and Network Security", Fourth Edition, by William stallings.

CS-5023	Data Analytics for IOT	L-T-P-C:3-1-0-4

Course objective: To provide the basics of organization of big data, architectural issues of big data tools.

Course Content:

Unit-I

Fundamentals of Big-data analytics, Overview & analytics life cycle, Need, Structured and multi-structured data analysis, Big- data analytics major components, Analytical models and approaches, Big data challenges.

Unit-II

Designing and building big data applications, Big data architecture, Distributed Computing platforms and Data Storage, Security and Data Privacy, Application Areas, Application Tools and Platforms.

Unit-III

Clustered Hadoop environment, HDFS and data managements using HDFS, Analytics Using Map Reduce and programming, Map Reduce design patterns.

Unit-IV

Introduction to Modern databases-No SQL, New SQL, No SQLVs RDBMS databases Tradeoffs, Working with MongoDb, Data warehouse system for Hadoop

Unit-V

Introduction to Pig and HIVE- Programming Pig: Engine for executing data flows in parallel on Hadoop, Programming with Hive.

Course Outcome:

- Students will attain in-depth knowledge and understanding of the big data technologies.
- Students will become familiar with various search methods and visualization techniques for big data analytics.

Text/ Reference Book:

3. Dean Wampler, Jason Rutherglen, Edward Capriolo,"Programming Hive" O'Reilly Media, 1st Edition, 2012.
4. Sawant, Nitin, Shah, Himanshu, "Big Data Application Architecture Q & A: A Problem-Solution Approach", Apress, 1st Edition, 2013.

Reference Books

3. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann, 1st Edition, 2013.
4. Jonathan R. Owens, Jon Lentz, Brian Femiano, "Hadoop Real, World Solutions Cookbook", Packt, 2nd Edition, 2016.

CS-5025	Privacy and Security in IoT	L-T-P-C: 3-1-0-4

Course objective: To learn the security principles and methodologies for Internet of Things.

Course Content:

Unit-I

Introduction: Securing the Internet of Things: Security Requirements in IoT Architecture - Security in Enabling Technologies - Security Concerns in IoT Applications. Security Architecture in the Internet of Things - Security Requirements in IoT - Insufficient Authentication/Authorization – Insecure Access Control - Threats to Access Control, Privacy, and Availability - Attacks Specific to IoT. Vulnerabilities – Secrecy and Secret-Key Capacity - Authentication/Authorization for Smart Devices - Transport Encryption – Attack & Fault trees.

Unit-II

Cryptographic fundamentals for IoT: Cryptographic primitives and its role in IoT – Encryption and Decryption – Hashes – Digital Signatures – Random number generation – Cipher suites – key management fundamentals – cryptographic controls built into IoT messaging and communication protocols – IoT Node Authentication.

Unit-III

Identity & access management solutions for IoT: Identity lifecycle – authentication credentials – IoT IAM infrastructure – Authorization with Publish / Subscribe schemes – access control

Unit-IV

Privacy preservation and trust models for IoT: Concerns in data dissemination – Lightweight and robust schemes for Privacy protection – Trust and Trust models for IoT – self-organizing Things - Preventing unauthorized access.

Unit-V

Cloud security for IoT: Cloud services and IoT – offerings related to IoT from cloud service providers – Cloud IoT security controls – An enterprise IoT cloud security architecture – New directions in cloud enabled IoT computing

Course Outcome:

On completion of the course, student will be able to

- understand the Security requirements in IoT.
- understand the cryptographic fundamentals for IoT.
- understand the authentication credentials and access control.
- understand the various types Trust models and Cloud Security.

Text/ Reference Book:

4. Russell, Brian, and Drew Van Duren. Practical Internet of Things Security: Design a security framework for an Internet connected ecosystem. Packt Publishing Ltd, 2018.
5. Li, Shancang, and Li Da Xu. Securing the internet of things. Syngress, 2017.
6. Hu, Fei. Security and privacy in Internet of things (IoTs): Models, Algorithms, and Implementations. CRC Press, 2016.

CS-5006	**Big Data Analytics**	**L-T-P-C:3-1-0-4**
Course objective:	• To gain an understanding of Relational Database Management Systems • To gain an understand and use Structured Query Language • To gain an understanding of Data Analytics and Visualization • To gain an understanding of how managers use analytics to formulate and solve business problems and to support managerial decision making.	
Course content: **Course content:**		

Unit 1
Overview of Big Data, Stages of analytical evolution, State of the Practice in Analytics, The Data Scientist, Big Data Analytics in Industry Verticals, Data Analytics Lifecycle

Unit 2
Operationalizing Basic Data Analytic Methods Using R, Advanced Analytics Analytics for Unstructured Data Map Reduce and Hadoop, The Hadoop Ecosystem

Unit 3
In database Analytics, Data Visualization Techniques, Stream Computing Challenges, Systems architecture

Unit 4
Main memory data management techniques, energy efficient data processing, Benchmarking, Security and Privacy, Failover and reliability.

Unit 5

Machine Learning Algorithms Application in Data Analysis

Course outcome:	Upon successful completion of this course students should be able to: • These conclusions are made possible by using the various analytic tools currently available, i.e. MS Power • Business Intelligence(BI), Hadoop, Tableau, Excel, SAS, etc.

Text Book:

1. Business Intelligence Guidebook - From Data Integration to Analytics, First Edition, Rick Sherman
2. Morgan Kaufmann; 1 edition (November 21, 2014), 550 pages
   ISBN-10: 012411461X | ISBN-13: 978-0124114616 |

CS-5008	Cloud Computing	L-T-P-C:3-1-0-4

- To enable students to deliver an application built in the cloud with the concept of application-based building blocks for processing of data.
- To acquire the concept of cloud computing and to have knowledge on the various issues in cloud computing.
- To appreciate the emergence of cloud as the next generation computing paradigm.

Module I

Introduction: Introduction to Cloud Architecture and Computing Concepts, Why Clouds, What is a Cloud, Introduction to Clouds: History, What's New in Today's Clouds, New Aspects of Clouds, Economics of Clouds, cloud distributed system, MapReduce: Paradigm, Scheduling, Fault-Tolerance.

Module II

Multicast Problem and P2P Systems: Introduction to Multicast Problem, Gossip Protocol – analysis – implementation, Failure Detectors, Gossip-Style Membership, Dissemination and suspicion, Grid Applications, Grid Infrastructure, P2P Systems Introduction, Napster, Gnutella, FastTrack and BitTorrent, Chord, Pastry, Kelips.

Module III

Design of key-value/NoSQL storage/database systems: Introduction to Key-Value/NOSQL, Cassandra, Cap Theorem, Consistency Spectrum, HBase, Cristian's Algorithm, Network Time Protocol (NTP), Lamport Timestamps, Vector Clocks

Module IV

Machine Coordination in a Distribution system: The Election Problem, Ring Leader Election, Election in Chubby and ZooKeeper, Bully Algorithm, Distributed Mutual Exclusion, Ricart-Agrawala's Algorithm, Maekawa's Algorithm.

Module V

Transactions and Replication Controlling Cloud Systems: Remote Procedure Calls (RPCs), Transactions, Serial Equivalence, Pessimistic Concurrency, Optimistic Concurrency Control, Replication, Two-Phase Commit.

Module VI

Emerging Paradigms and Classical Systems: Stream Processing in Storm, Distributed Graph Processing, Structure of Networks, Single-processor Scheduling, Hadoop Scheduling, Dominant-Resource Fair Scheduling, File System Abstraction, Network File System (NFS) and Andrew File System (AFS), Distributed Shared Memory.

Course outcome:

After studying this course, the students will be able to

- Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
- Understand core techniques, algorithms, and design philosophies – all centered around distributed systems.
- Analyze and implement concepts include: clouds, MapReduce, key-value/NoSQL stores, classical distributed algorithms, widely-used distributed algorithms and scalability.
- Learn the key and enabling technologies that help in the development of cloud.
- Develop the ability to understand and use the architecture of compute and storage cloud, service and delivery models.
- Evaluate and choose the appropriate technologies, algorithms and approaches for implementation and use of cloud.

Text Book:

3. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, "Distributed and cloud computing from Parallel Processing to the Internet of Things", Morgan Kaufmann, Elsevier, 2012.
4. Rittinghouse, John W., and James F. Ransome, "Cloud Computing: Implementation, Management and Security", CRC Press, 2017.

Reference Book:

5. Rajkumar Buyya, Christian Vecchiola, S. ThamaraiSelvi, "Mastering Cloud Computing", Tata Mcgraw Hill, 2013.
6. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing – A Practical Approach, Tata Mcgraw Hill, 2009.
7. Barrie Sosinsky, "Cloud Computing Bible" John Wiley & Sons, 2010.
8. Tim Mather, Subra Kumaraswamy, and Shahed Latif, "Cloud Security and Privacy An Enterprise Perspective on Risks and Compliance", O'Reilly, 2009.

CS-5010	Software Defects and Quality Prediction Techniques	L-T-P-C:3-1-0-4

Course objective:

- To discuss various Ways of Measuring Software.
- To discuss On Different type of Software Metrics
- To discuss on various software defect prediction models.
- To discuss on Software Quality Prediction Models.

Course content:

Unit 1: Fundamentals of Measurements and Experimentation

Software Measurements, Software Metrics, Representational Theory of Measurements, Goal Based Framework for Software Measurements, Software Metrics and Data Collection, Analyzing Software-Measurements Data.

Unit 2: Software Defect Prediction

Software Testing, Software Defects, Bugs and Failures, Defect Prediction Based on Bugs, Defect Prediction Based on Metrics and other parameters.

Unit 3: Time Series Analysis of Software Defects

Basics of Time Series Analysis, Stationary and Non-Stationary Models of Time Series, Linear and Non-Linear Time Series Models for Software Defect Prediction, Advantages of Time Series Analysis over Other Prediction Models.

Unit 4: Software Reliability Prediction

Software Reliability, Software Reliability Prediction Models, Software Reliability Prediction Based on Fault Data.

Unit 5: Research Project on Software Quality Prediction

Software Maintainability Prediction, Software Testability Prediction, Prediction of Non-Functional Requirements of Software, Quality Assurance and CMMI Models.

Course outcome:

After reading this subject, students will be able to:

- Will be helpful in Quantifying Software Quality and Better analysis of Software Internal Parameters.
- Early Prediction of Software Reliability, Maintainability and Testability will be helpful in developing Better Quality Software.

Text Book:

1. R. S. Pressman, Software Engineering: A Practitioner's Approach, McGraw Hill Publications , 2006

2. R. Mall, Fundamentals of Software Engineering, PHI Learning , 2014

Reference Book:	1. I. Sommerville, Software Engineering, Pearson Education , 2006 2.A. Behferooz and F. J. Hudson, Software Engineering Fundamentals, Oxford University Press , 2000

CS-5012	**Simulation and Modeling**	**L-T-P-C: 3-1-0-4**

Unit-I

Introduction to simulation: Advantages & Dis-advantages of simulation – Areas of applications, Systems and Systems Environment, Concept of a system, Discrete & Continuous system – Models, types of models, Steps in a simulation study – Examples, Discrete – Event System simulation.

Unit-II

Overview of Statistical Models and Queuing Systems, Programming languages for Simulation: Continuous and Discrete Simulation Languages – GPSS, SIMAN, SIMSCRIPT, MATLAB and SIMULINK.

Unit-III

Random Numbers: Generation, Properties of Random Numbers, Generation of Pseudo Random Numbers, Tests for Random Numbers.

Random Variate: Generation, Inverse Transformation Technique, Uniform Distribution, Exponential Distribution, Weibul's Distribution, Triangular Distribution, Empirical Continuous Distribution, Discrete Distributions, Direct Transformation for the Normal Distribution, Convolution Method of Erlang Distribution, Acceptance Rejection Techniques: Poisson Distribution, Gamma Distribution.

Unit-IV

Input Data Analysis: Data Collection: Identify the Distribution, Parameter and Estimation.

Goodness of fit tests: Chi-Square Test – KS Test; Multivariate and time series input models, Verification and Validations of Simulation Models, Model Building, Verification and Validation: Verification of Simulation Models, Calibration and Validation of Models, face validity, Validation of Model Assumptions. Validation Input/output Transformations, Input/output Validation using Historical Input Data, Input/output Validation Sing Turning Test.

Unit-V

Output Data Analysis, Stochastic, Nature of output data, Types of Simulation with respect to output Analysis, Measures of Performance and their Estimation, output Analysis for Terminating Simulations, Output Analysis for steady – State Simulations.

Comparison and Evaluation of Alternative System Designs: Comparison of several system Designs, Statistical Models for Estimating the Effect of Design Alternatives

Text Book:

1. Jabey Banks, John S. Cansen and Barry L. Nelson, Discrete – Event System Simulation, Prentice Hall of India, 2001.

2. Nursing Deo, System Simulation with Digital computer, Prentice Hall of India, 1979.

3. Anerill M. Law and W. David Kelton, Simulation Modelling and Analysis, McGraw Hill. 2001.

4. Agam kumar tyagi, MATLAB and Simulink for Engineers, Oxford Publishers, 2011

CS-5016	**Advanced Database Management Systems**	**L-T-P-C:3-1-0-4**
Course objective:	• To evaluate emerging architectures for database management systems. • To develop an understanding of the manner in which relational systems are implemented and the implications of the techniques of implementation for database performance.	

	• To assess the impact of emerging database standards on the facilities which future database management systems will provide.

Course content:

Unit 1 Theoretical concepts, Relational model conformity and Integrity, Advanced SQL programming

Unit 2 Query optimization, Concurrency control and Transaction management, Database performance tuning, Distributed relational systems and Data Replication

Unit 3 Object oriented, deductive, spatial, temporal and constraint database management systems, New database applications and architectures: e.g. Data Warehousing; Multimedia; Mobility; NoSQL, Native XML databases (NXD), Document orientated databases

Unit 4 SQL standards development, Standards for interoperability and integration e.g. Web Services

Unit 5 Database security - Data Encryption, redaction and masking techniques. Authentication and authorization. Database auditing

Course outcome:	After reading this subject, students will be able to: • Critically assess new developments in database technology • Interpret and explain the impact of emerging database standards • Evaluate the contribution of database theory to practical implementations of database management systems.

Text Book:

1. Date C. J., An Introduction to Database Systems, AddisonWesley Longman (8th Ed), 2003
2. Silberschatz A., Korth H., and Sudarshan S., Database System Concepts, McGraw-Hill (6th Ed), 2010

Reference Book:

3. Melton, J., & Simon A., SQL 1999, Understanding Relational Language Components, Morgan-Kaufmann, 2003.
4. Peter Adams : SQL: The Ultimate Guide from Beginner to Expert - Learn and Master SQL in No Time, Addison Wesley, 2016

CS-5014	Real Time Data Analysis	L-T-P-C: 3-1-0-4

Course objective:

- To study issues related to the design and analysis of systems with real-time constraints.
- To learn the features of Real time OS.
- To study the various Uniprocessor and Multiprocessor scheduling mechanisms.
- To learn about various real time communication protocols.
- To study the difference between traditional and real time databases.
-

Unit-I

Introduction to real time computing: Concepts; Example of real-time applications – Structure of a real time system – Characterization of real time systems and tasks - Hard and Soft timing constraints - Design Challenges - Performance metrics - Prediction of Execution Time : Source code analysis, Micro-architecture level analysis, Cache and pipeline issues- Programming Languages for Real-Time Systems

Unit-II

Real time OS: Threads and Tasks – Structure of Microkernel – Time services – Scheduling Mechanisms Communication and Synchronization – Event Notification and Software interrupt Task assignment and Scheduling

Unit-III

Task allocation algorithms: Single-processor and Multiprocessor task scheduling - Clock-driven and priority-based scheduling algorithms Fault tolerant scheduling

Unit-IV

Real Time Communication: Network topologies and architecture issues – protocols –contention based, token based, polled bus, deadline based protocol, Fault tolerant routing. RTP and RTCP.

Unit-V

Real time Databases

Transaction priorities – Concurrency control issues – Diskscheduling algorithms – Two phase approach to improve predictability

Course Outcome:

Upon Completion of the course, the students will be able to:

- Gain Knowledge about Schedulability analysis.
- Learn about the Real-time programming environments.
- Attain knowledge about real time communication and databases.
- Develop real time systems.

Text Book:

[1]C.M. Krishna, Kang G. Shin – " Real Time Systems", International Edition, McGrawHill Companies, Inc., New York, 1997.
[2]Jane W.S. Liu, "Real-Time Systems", Pearson Education India, 2000

Reference Book:

[1]Philip A. Laplante and Seppo J. Ovaska, "Real-Time Systems Design and Analysis:Tools for the Practitioner'' IV Edition IEEE Press, Wiley, 2013.
[2]Sanjoy Baruah, Marko Bertogna, Giorgio Buttazzo, "Multiprocessor Schedulingfor Real-Time Systems ", Springer International Publishing, 2015.

CS-5022	Deep and Reinforcement Learning Techniques	L-T-P-C:3-1-0-4

- To understand the fundamental principles and techniques in deep and reinforcement learning.
- Helps to understand different algorithms in deep and reinforcement learning.
- Helps to understand few applications of deep and reinforcement learning.
- To analyze few active research topics in deep and reinforcement learning areas.

Unit 1

Introduction

Introduction- Historical Trends in Deep Learning, Machine Learning Basics, History of Reinforcement Learning – Examples - Elements of Reinforcement Learning - Limitations and Scope.

Unit 2

Deep Networks

Deep Feedforward Networks-Example-Gradient-Based Learning-Hidden Units-Architecture Design- Back-Propagation and Other Differentiation Algorithms, Regularization for Deep Learning, Optimization for Training Deep Models - Challenges - Basic Algorithms - Parameter Initialization - Algorithms with Adaptive Learning Rates - Approximate Second-Order MethodsOptimization Strategies and Meta-Algorithms

Unit 3
Convolution Networks
Convolutional Networks -Operation - Motivation - Pooling - Variants of the Basic Convolution Function - Efficient Convolution Algorithms -Random or Unsupervised Features, Sequence Modeling: Recurrent and Recursive Nets - Unfolding Computational Graphs - Recurrent Neural Networks - Bidirectional RNNs - Encoder-Decoder Sequence-to-Sequence Architectures -Deep Recurrent Networks -Recursive Neural Networks, Applications.

Unit 4
Tabular Solution Methods
Multi-armed Bandits-Dynamic Programming - Monte Carlo Methods -Temporal-Difference Learning -n-step Bootstrapping

Unit 5
Approximate Solution Methods

On-policy Prediction with Approximation -On-policy Control with Approximation –Off policy Methods with Approximation -Policy Gradient Methods

Course outcome:

- Ability to explain and describe the basics of deep learning and reinforcement techniques
- Ability to investigate different regularization and optimization techniques for training deep neural networks.
- Ability to implement convolution and recurrent neural networks
- Ability to implement and compare various iteration, Monte Carlo temporal-difference reinforcement learning algorithms
- Ability to construct and apply on-policy and off-policy reinforcement learning algorithms with function approximation

Text Book:

1. Ian Goodfellow, YoshuaBengio, and Aaron Courville, "Deep Learning" MIT Press, 2016.
2. Richard S. Sutton and Andrew G. Barto,"Reinforcement Learning: An Introduction" second edition, MIT Press.

Reference Book:

1. CosmaRohillaShalizi, Advanced Data Analysis from an Elementary Point of View, 2015.
2. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013.

CS-5024	Advanced Soft Computing	L-T-P-C:3-1-0-4

- The course help in understanding the concepts in Soft Computing techniques VIZ Fuzzy systems, Genetic algorithms, Simulated annealing, Ant Colony Optimization and Artificial Neural Networks, to apply these tools in solving problems, to analyze the strengths and weakness of these methods and to choose appropriate Soft Computing technique(s) for a given problem.

Unit 1
FUZZY SET THEORY
Introduction to Soft Computing. Fuzzy sets and relations- operations – composition. Membership functions – features –

Fuzzification - membership value assignments. Defuzzification – Lambda cuts (sets and relations) – Defuzzification to scalars.

Fuzzy Logic – approximate reasoning – different forms of implication. Natural language and Linguistic hedges. Fuzzy Rule-based

systems – graphical techniques for inference. Extension principle and Fuzzy arithmetic.

Case Studies (minimum two) – application of Fuzzy Logic.

Unit 2
OPTIMIZATION
Genetic algorithm – Biological background – Search space – Basic terminologies in GA – a simple GA – General GA – Operators in GA (Encoding, Selection, Crossover – mutation) – stopping conditions – Constraints – Problem solving - The schema theorem –advantages – applications.

Case study - Application of GA. Simulated Annealing: Annealing Schedule, Parameter Selection, Applications.

Case study - Application of SA. Ant Colony Optimization: Ant Foraging Behavior, artificial ants and minimum cost paths, ACO Metaheuristic, ACO algorithm for

TSP problem, Theoretical considerations, convergence proof, ACO and Model based search. ACO optimization for subset problem

Unit 3
NEURAL NETWORKS -I
Supervised Learning Neural Networks – Perceptrons - Adaline – BackpropagationMutilayerPerceptrons – Radial Basis Function Networks – Unsupervised Learning Neural Networks – Competitive Learning Networks – Kohonen Self-Organizing Networks.

Case study – Application of ANN.

Unit 4
NEURAL NETWORKS -II
Adaptive Resonance Theory – Introduction – ART 1 – ART2 – Applications. Basic concepts in Associative memory – BAM.

Extreme Learning Machines - introduction – theory – applications- case study.

Hybrid soft computing systems – ANFIS – concepts and architecture - case study.

Unit 5

DEEP NETWORKS

Introduction to Deep learning – Deep neural networks – concepts. Recurrent neural network - concepts – applications.

Convolutional neural network – concepts – case study based on image classification.

Course outcome:

- Explain concepts in Fuzzy sets, Fuzzy Logic, Genetic Algorithm, Simulated Annealing and Ant Colony Optimization.

- Illustrate how Fuzzy Logic, Simulated annealing, Genetic Algorithm and Ant Colony optimization are used to solve problems.
- Explain concepts in Artificial Neural Networks (MLP, RBFN, KSOM, ART, BAM, ELM, Deep NN, CNN, RNN).
- Illustrate the use of ANN in solving problems.
- Select appropriate Soft Computing technique to solve a problem.
- Solve Engineering problems using Soft Computing techniques.

Text Book:

1. Sivanandam&Deepa, "Principles of Soft Computing", 2nd Edition, Wiley India, 2011
2. T. J. Ross, "Fuzzy Logic with Engineering Applications", 3rd Edition, Wilev, 2014
3. Dorigo Marco, Stützle Thomas, "ANT COLONY OPTIMIZATION", PHI, 2005

Reference Book:

1. Rajasekaran and G A V Pai, " Neural Networks, Fuzzy Logic and Genetic Algorithm", 1st Edn, PHI, 2011

2. D. E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", 1st Edn, Pearson, 2016