BVM Engineering College (An Autonomous Institution)
Electronics & Communication Engineering Department
B. Tech. (Electronics & Communication Engineering) Honours Degree*

Sr. No.	Course Code & Course Title	L	T	P	H	C
1	Program Elective I	3	1	0	4	4
2	Program Elective II	3	1	0	4	4
3	Program Elective III	3	1	0	4	4
4	Program Elective IV	3	1	0	4	4
5	**HEC91 : PROJECT**	0	0	8	8	4
	Total	**12**	**4**	**8**	**24**	**20**
	Program Elective - I					
1	**HEC11 : NANO ELECTRONICS**	3	1	0	4	4
2	**HEC12 : ERROR CORRECTING CODES**	3	1	0	4	4
3	**HEC13 : NUMERICAL METHODS**	3	1	0	4	4
4	**HEC14 : ROBOTICS**	3	1	0	4	4
	Program Elective - II					
1	**HEC15 : VLSI DESIGN VERIFICATION AND TEST**	3	1	0	4	4
2	**HEC16 : VLSI PHYSICAL DESIGN**	3	1	0	4	4
3	**HEC17: DIGITAL VLSI TESTING**	3	1	0	4	4
	Program Elective - III					
1	**HEC18 : DESIGN FOR INTERNET OF THINGS**	3	1	0	4	4
2	**HEC19 : INDUSTRIAL INTERNET OF** THINGS	3	1	0	4	4
	Program Elective - IV					
1	**HEC20 : WIRELESS ADHOC AND SENSOR NETWORKS**	3	1	0	4	4
2	**HEC21 : DEEP LEARNING**	3	1	0	4	4
3	**HEC22 : NEURAL NETWORK FOR SIGNAL PROCESSING**	3	1	0	4	4

*A student of B. Tech. Electronics will be eligible to get B. Tech. Degree with Honours, if he/she gets additional Credits as per above structure.

L=Lecture Hrs./wk; T=Tutorial Hrs./wk; P=Practical Hrs./wk; H=Total Contact Hrs./wk; C=Credits of Course

HEC11 : NANO ELECTRONICS
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

The objective of this course is to present the fundamentals in the fields of semiconductor device physics and materials technology to understand Nano electronics. The key aspects of classical CMOS technology will be discussed and the technical problems in scaling MOSFET in the sub100nm regime will be elaborated. In this context, the requirement for non-classical transistors with new device structures and nanomaterials will be elucidated. The obstacles in realizing Germanium and compound semiconductor MOSFET will be explained. Extensive materials characterization techniques will also be discussed, which help in engineering high-performance transistors.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	Overview: Nanodevices, Nanomaterials, Nano characterization. Definition of Technology node, Basic CMOS Process flow. MOS Scaling theory, Issues in scaling MOS transistors: short channel effects, Description of a typical 65 nm CMOS technology. Requirements for Nonclassical MOS transistor.	8
2	MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2 vs High-k gate dielectrics. Integration issues of high-k. Interface states, bulk charge, band offset, stability, reliability - Qbd high field, possible candidates, CV, and IV techniques.	5
3	Metal gate transistor: Motivation, requirements, Integration Issues. Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot.	6
4	SOI - PDSOI and FDSOI. Ultrathin body SOI - double-gate transistors, integration issues. Vertical transistors - FinFET and Surround gate FET. Metal source/drain junctions - Properties of Schottky junctions on Silicon, Germanium, and compound semiconductors -Work function pinning.	8
5	Germanium Nano MOSFETs: strain, quantization, Advantages of Germanium over Silicon, PMOS versus NMOS. Compound semiconductors - material properties, MESFETs Compound semiconductors MOSFETs in the context of channel quantization and strain, Heterostructure MOSFETs exploiting novel materials, strain, quantization.	5
6	Synthesis of Nanomaterials: CVD, Nucleation and Growth, ALD, Epitaxy, MBE. Compound semiconductor hetero-structure growth and characterization: Quantum wells. Thickness measurement techniques: Contact-step height, Optical - reflectance, and ellipsometry. AFM.	8

Unit No	Topics	Teaching Hours
7	Characterization techniques for nanomaterials: FTIR, XRD, AFM, SEM, TEM, EDAX, etc. Applications and interpretation of results. Emerging nanomaterials: Nanotubes, nanorods, and other nanostructures, LB technique, soft lithography, etc. Microwave-assisted synthesis, Self-assembly, etc.	5
	Total	**45**

List of References:

1. Fundamentals of Modern VLSI Devices, Y. Taur and T. Ning, Cambridge University Press.
2. Silicon VLSI Technology, Plummer, Deal, Griffin, Pearson Education India
3. Encyclopedia of Materials Characterization, Edited by: Brundle, C.Richard; Evans, Charles A. Jr.; Wilson, Shaun; Elsevier.

Course Outcomes (COs):

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

1. Understand basic concepts of designing and scaling methods of nanotechnology.
2. Synthesis & Characterize of Nanomaterials.
3. Tackle the issues realizing Germanium and compound semiconductor MOSFET
4. Identify the concept of the designing and use of non-classical transistors with new device structures and nanomaterials.

HEC12 : ERROR CORRECTING CODES
CREDITS - 4 (LTP : 3,1,0)

Course outline:

Error-correcting codes are in widespread use for data storage as well as most forms of communication where reliability is of importance. Examples range from compact discs to deep-space communication. This course will cover both classical error-correcting codes such as BCH, Reed Solomon and convolutional codes as well as the more modern class of iteratively decodable codes, low-density, parity-check codes in particular.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	Course overview; Basics of binary block codes for the binary symmetric channel; Mathematical preliminaries: groups, subgroups and cosets.	6
2	Linear block codes; Bounds on the size of a block code; Bounded and maximum-likelihood decoding of binary block codes; standard array decoding.	5

Unit No	Topics	Teaching Hours
3	Basics of convolutional codes; the Viterbi decoding algorithm, The generalized distributive law (GDL), The GDL perspective on the Viterbi and BCJR decoding algorithms; Turbo codes in brief.	11
4	LDPC codes, Fields; Polynomials rings; construction of finite fields.	8
5	Deducing the structure of a finite field; Subfields and cyclotomic cosets, The finite field (Fourier) transforms; cyclic codes via finite field transforms.	10
6	BCH and Reed-Solomon codes; decoding of BCH and RS codes.	5
	Total	**45**

List of References :

1. P. V. Kumar, M. Win, H-F. Lu, C. Georghiades, "Error-Control Coding Techniques and Applications", Chapter 17 in Optical Fiber Telecommunications IV-B: Systems and Impairments, Editors: Ivan P. Kaminow and Tingye Li, Elsevier Science Press, 2002.
2. F. J. MacWilliams and N. J. A. Sloane, The Theory of Error-Correcting Codes, North-Holland, 1977.

Course Outcomes (COs):

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

1. Generate the code word and correct the errors of various channel coding technique.
2. Compare different types of channel coding techniques.
3. Analyze different types of channel coding techniques.
4. Apply different types of channel coding techniques to improve the performance of channel.

HEC13 : NUMERICAL METHODS
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

This course contains solutions of systems of linear equations, roots of nonlinear equations, interpolation, numerical differentiation and integration. It plays an important role in solving various engineering sciences problems. Therefore, it has tremendous applications in diverse fields in engineering sciences.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1.	Introduction to significant digits and errors, Solution of system of linear Equations (direct methods, Iterative methods, Ill-conditioned systems)	6
2.	Roots of Nonlinear Equations (Bisection method, Regula-Falsi method, Newton-Raphson method, Fixed point iteration method, convergence criteria)	6

Unit No	Topics	Teaching Hours
3.	Eigenvalues and Eigenvectors, Gershgorin circle theorem , Jacobi method, Power methods, Interpolation (Finite difference operators, difference tables, Newton's Forward/Backward difference)	12
4.	Interpolation (Central difference formula i.e. Bessel and Stirling's interpolation formula, Divided differences, Lagrange interpolation and Newton's divided difference interpolation)	7
5.	Numerical Differentiation (Using Forward/ Backward/central difference formula), Integration (Trapezoidal and Simpson's rules for integration)	9
6.	Solution of first order and second order ordinary differential equations (Euler method, Euler modified method, Runge-Kutta methods, Milne PC method)	5
	Total	**45**

List of References:

1. S. S. Sastry, "Introductory Methods of Numerical Analysis", Prentice Hall of India.
2. S. C. Chapra and R. P. Canale, "Numerical Methods for Engineers", McGraw Hill International Edition.
3. Rajaraman V, "Computer Oriented Numerical Methods", Prentice Hall of India.
4. M. K. Jain, S.R.K. Iyengar and R. K. Jain, "Numerical Methods for Scientific and Engineering Computation", New Age International publishers.

Course Outcomes (COs):

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

1. Understand various numerical techniques.
2. Apply numerical methods to solve complex engineering problems.
3. Solve an algebraic equation using an appropriate numerical method.

HEC14 : ROBOTICS
CREDITS - 4 (LTP : 3,1,0)

Course outline:

This course is for students to get the basic understanding of robotics. The mechanical, electrical, and computer science aspects of robotics are covered in this course.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defense, rehabilitation, medical etc., Laws of Robotics, Robot mechanisms; Kinematics- coordinate transformations,	6

	DH parameters	
2	Forward kinematics, Inverse Kinematics, Jacobians, Statics, Trajectory Planning	7
3	Actuators (electrical)- DC motors, BLDC servo motors. Sensors , sensor integration	8
4	Control – PWM, joint motion control, feedback control. Computed torque control	8
5	Perception, Localisation and mapping. Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches	8
6	Simultaneous Localization and Mapping, Introduction to Reinforcement Learning	8
	Total	**45**

List of References:

1. Introduction to Robotics. Doctor T. Asokan. Department of Engineering Design. Indian Institute of Technology, Madras
2. Curtis D. Johnson. "Process Control Instrumentation Technology", Prentice Hall, 8/E, 2005
3. Elk, Klaus. *Embedded Software for the IoT*. Walter de Gruyter GmbH & Co KG, 2018.
4. Xiao, Perry. Designing Embedded Systems and the Internet of Things (IoT) with the ARM Mbed. United Kingdom, Wiley, 2018.
5. Embedded Systems - SoC, IoT, AI and Real-Time Systems | 4th Edition. N.p., McGraw-Hill Education, 2020.

Course Outcomes (COs):

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

1. Understand application of Robotics
2. Study and understand basics of mechanism and kinematics
3. Study and use sensors and actuators in Robotics
4. Understand and apply software algorithms and techniques for localization, planning and mapping.

HEC15 : VLSI DESIGN VERIFICATION AND TEST
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

Digital VLSI Design flow comprises three basic phases: Design, Verification and Test. The course would cover theoretical, implementation and CAD tools pertaining to these three phases. Although there can be individual full courses for each of these phases, the present course aims at covering the important problems/algorithms/tools so that students get a comprehensive idea of the whole digital VLSI design flow. **VLSI Design:** High level Synthesis, Verilog RTL Design, Combinational and Sequential Synthesis Logic Synthesis (for large circuits). **Verification Techniques:** Introduction to Hardware Verification and methodologies, Binary Decision Diagrams(BDDs) and algorithms over BDDs, Combinational equivalence checking, Temporal Logics, Modeling sequential systems and model checking, Symbolic model checking. **VLSI Testing:** Introduction, Fault models, Fault Simulation, Test generation for combinational circuits, Test generation algorithms for sequential circuits and Built in Self-test.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1.	Introduction and Overview of VLSI Design ,Scheduling in High-Level Synthesis	8
2.	Resource Sharing and Binding in HLS ,Logic Synthesis and Physical Design	8
3.	Introduction to Verification Techniques,Syntax and semantics of CTL (Computation Tree logic), Equivalences between CTL formulas and Introduction to Model Checking	8
4.	CTL Model checking Algorithms and Introduction to Binary Decision Diagrams,Binary Decision Diagram and Symbolic model checking	6
5.	Introduction to Digital Testing ,Fault Simulation and Testability Measures	7
6.	Combinational Circuit Test Pattern Generation,Sequential Circuit Testing and Scan Chains and Built In Self-Test (BIST)	8
	Total	**45**

List of References:

1. Verification of Digital and Hybrid Systems, *M. Kemal Inan, Robert P. Kurshan* · 2012
2. Testing of Digital Systems, *N. K. Jha, S. Gupta* · 2003
3. VLSI Test Principles and Architectures: Design for Testability, Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen · 2006

Course Outcomes (COs):

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

1. Synthesize digital circuit using Verilog HDL.
2. Implement efficient techniques at circuit level for improving power and speed of combinational and sequential circuits.
3. Tackle the issues related with IC testing at earlier design stages to notably reduce the testing costs.
4. Identify the design for testability methods for digital circuits and Recognize the BIST
5. techniques for improving testability

HEC16 : VLSI PHYSICAL DESIGN
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

The course will introduce the participants to the basic design flow in VLSI physical design automation, the basic data structures and algorithms used for implementing the same. The course will also provide examples and assignments to help the participants to understand the concepts involved, and appreciate the main challenges therein.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1.	Introduction to physical design automation,Partitioning, Floor planning and Placement	8
2.	Grid Routing and Global Routing ,Detailed Routing and Clock Design	8
3.	Clock Routing and Power/Ground , Static Timing Analysis and Timing Closure	8
4.	Physical Synthesis and Performance Driven Design Flow, Interconnect Modeling and Layout Compaction	7
5.	Introduction to Testing, Fault Modeling and Simulation ,Test Pattern Generation, DFT and BIST	6
6.	Low Power Design Techniques-I ,Low Power Design Techniques-II	8
	Total	**45**

List of References:

1. VLSI Physical Design: From Graph Partitioning to Timing Closure Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu 2011, Springer
2. Handbook of Algorithms for Physical Design Automation, Charles J. Alpert, Dinesh P. Mehta, Sachin S. Sapatnekar · 2008
3. VLSI Physical Design Automation: Theory and Practice, Sadiq M. Sait, Habib Youssef-2000

Course Outcomes (COs):

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

1. Analyze physical design problems and apply appropriate algorithms for partitioning, floor planning, placement and routing.
2. Understand the concept of Clock Routing, Static Timing Analysis and Timing Closure.
3. Identify the design for testability & BIST methods and understand the concept of Low Power design techniques.

HEC17: DIGITAL VLSI TESTING
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

Testing is an integral part of the VLSI design cycle. With the advancement in IC technology, designs are becoming more and more complex, making their testing challenging. Testing occupies 60-80% time of the design process. A well-structured method for testing needs to be followed to ensure high yield and proper detection of faulty chips after manufacturing. Design for testability (DFT) is a matured domain now, and thus needs to be followed by all the VLSI designers. In this context, the course attempts to expose the students and practitioners to the most recent, yet fundamental, VLSI test principles and DFT architectures in an effort to help them design better quality products that can be reliably manufactured in large quantities.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1.	Introduction: Importance, Challenges, Levels of abstraction, Fault Models, Advanced issues ,Design for Testability: Introduction, Testability Analysis, DFT Basics, Scan cell design, Scan Architecture	8
2.	Design for Testability: Scan design rules, Scan design flow Fault Simulation: Introduction, Simulation models,Fault Simulation: Logic simulation, Fault simulation	8
3.	Test Generation: Introduction, Exhaustive testing, Boolean difference, Basic ATPG algorithms,Test Generation: ATPG for non-stuck-at faults, Other issues in test generation Built-In-Self-Test: Introduction, BIST design rules	8
4.	Built-In-Self-Test: Test pattern generation, Output response analysis, Logic BIST architectures,Test Compression: Introduction, Stimulus compression	7
5.	Test Compression: Stimulus compression, Response compression, Memory Testing: Introduction, RAM fault models, RAM test generation	6
6.	Memory Testing: Memory BIST Power and Thermal Aware Test: Importance, Power models, Low power ATPG ,Power and Thermal Aware Test: Low power BIST, Thermal aware techniques	8
	Total	**45**

List of References:

1. VLSI Test Principles and Architectures: Design for Testability, Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen · 2006
2. Digital Systems Testing and Testable Design, Miron Abramovici, Melvin A. Breuer, Arthur D. Friedman · 1994
3. Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, M. Bushnell, Vishwani Agrawal · 2006

Course Outcomes (COs):

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

1. Apply the idea in digital VLSI testing which can help to implement a good yield in IC design.
2. Tackle the issues related with IC testing at earlier design stages to notably reduce the testing costs.
3. Identify the design for testability methods for digital circuits and Recognize the BIST techniques for improving testability

HEC18 : DESIGN FOR INTERNET OF THINGS
CREDITS - 4 (LTP : 3,1,0)

Course outline:

Design of smart objects that provide collaboration and ubiquitous services will be explored in this course. Design for longevity/energy efficiency will be highlighted. Step by step system design will be introduced. At the end of the course, the student is expected to make the right choice of hardware, software and protocols for the proposed application.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	Introduction to IoT – Definition, Applications, Challenges – Unique ID, Power, Security, Location, Addressing the Power challenge – RFID, Energy harvesting, Battery based systems, Power management systems	10
2	System design for low power – LDO, DC-DC converters, low power software. Sensors and actuators – Temperature sensor, Air quality, Solenoid valves	11
3	Power management algorithms	6
4	IoT protocols – MQTT, COAP, and Websockets with associated applications	6
5	Low power wireless technologies – BLE, IEEE 802.15.4e, Wi-Fi	6
6	Low Power Wire area technologies – NBIoT, CAT – LTE-M1, , LORA	6
	Total	**45**

List of References:

1. Introduction to Industry 4.0 and Industrial Internet of Things. Prof. Sudip Misra, Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur
2. Raj Kamal. Internet of Things. McGraw-Hill Education, 2017
3. Elk, Klaus. *Embedded Software for the IoT*. Walter de Gruyter GmbH & Co KG, 2018.
4. Xiao, Perry. Designing Embedded Systems and the Internet of Things (IoT) with the ARM Mbed. United Kingdom, Wiley, 2018.
5. Embedded Systems - SoC, IoT, AI and Real-Time Systems | 4th Edition. N.p., McGraw-Hill Education, 2020.
6. Schwartz, Marco. Internet of Things with ESP8266. United Kingdom, Packt Publishing, 2016.
7. Schwartz, Marco. ESP8266 Internet of Things Cookbook. United Kingdom, Packt Publishing, 2017..
8. Miller, Michael. The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World. N.p., Pearson Education, 2015.

Course Outcomes (COs):

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

1. Recollect basics about IOT systems
2. Understand and apply power management in IOT Systems
3. Design IOT systems with power conservation techniques
4. Study and understand IOT protocols and wireless technologies

HEC19 : INDUSTRIAL INTERNET OF THINGS
CREDITS - 4 (LTP : 3,1,0)

Course outline:

Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the different drivers necessary for the transformation. Industrial Internet of Things (IIoT) is an application of IoT in industries to modify the various existing industrial systems. IIoT links the automation system with enterprise, planning and product lifecycle.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	Introduction: Sensing & actuation, Communication-Part I, Part II, Networking-Part I, Part II. Industry 4.0: Globalization, The Fourth Revolution, LEAN Production Systems	6
2	Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management,Cybersecurity in Industry 4.0, Basics of Industrial IoT: Industrial Processes-Part I, Part II, Industrial Sensing & Actuation	7
3	IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models-Part I, Part II, IIoT Reference Architecture-Part I, Part II. Industrial IoT- Layers: IIoT Sensing-Part I, Part II, IIoT Processing-Part I, Part II, IioT Communication-Part I.	8
4	Industrial IoT- Layers: IIoT Communication, IIoT Networking-Part I, Part II, Part III. Industrial IoT: Big Data Analytics and Software Defined Networks: IIoT Analytics - Introduction, Machine Learning and Data Science Part I, Part Il	8
5	Industrial IoT: Big Data Analytics and Software Defined Networks: SDN in IIoT-Part I, Part II, Data Center Networks, Industrial IoT. Industrial IoT: Security and Fog Computing - Fog Computing in IIoT, Security in IIoT-Part I,	8

Unit No	Topics	Teaching Hours
6	Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management. Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case study	8
	Total	**45**

List of References:

1. Introduction to Industry 4.0 and Industrial Internet of Things. Prof. Sudip Misra, Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur
2. Raj Kamal. Internet of Things. McGraw-Hill Education, 2017
3. Elk, Klaus. *Embedded Software for the IoT*. Walter de Gruyter GmbH & Co KG, 2018.
4. Xiao, Perry. Designing Embedded Systems and the Internet of Things (IoT) with the ARM Mbed. United Kingdom, Wiley, 2018.
5. Embedded Systems - SoC, IoT, AI and Real-Time Systems | 4th Edition. N.p., McGraw-Hill Education, 2020.
6. Schwartz, Marco. Internet of Things with ESP8266. United Kingdom, Packt Publishing, 2016.
7. Schwartz, Marco. ESP8266 Internet of Things Cookbook. United Kingdom, Packt Publishing, 2017..
8. Miller, Michael. The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World. N.p., Pearson Education, 2015.

Course Outcomes (COs):

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

1. Study Industry 4.0 systems and platforms
2. Study and Understand security in Industry 4.0 systems and its architecture
3. Understand & Analyze requirement and significance of processing and communication in Industry 4.0 applications
4. Integrate machine learning, analytics and computing techniques in industry 4.0 systems
5. Applications of Industry 4.0

HEC20 : WIRELESS ADHOC AND SENSOR NETWORKS
CREDITS - 4 (LTP : 3,1,0)

Course Objective:

To design the wireless sensor network and its applications using MAC, routing and transport protocol with network management and different operating systems.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1.	MANET (Introduction, Self-organizing behaviour, Co-operation)	6
2.	MANET (MAC, Routing)	5
3.	MANET (Multicast routing, Mobility model, Transport layer), Opportunistic Mobile Networks)	7
4.	Opportunistic Mobile Networks, UAV networks, Wireless Sensor Networks (Introduction)	7
5.	WSN (Coverage, Topology management), Mobile Sensor Networks, WSN (MAC, Congestion control, Routing)	11
6.	WSN (Routing), Underwater WSN, Security, Structure of sensor nodes	9
	Total	**45**

List of References:

1. K. Sohraby, D. Minoli, T. Znati, "Wireless Sensor Networks – Technology, Protocols and Applications",Wiley Publications, 2nd Edition, 2007.
2. H. Karl, A. Willig, "Protocols and Architectures for Wireless Sensor Networks", Wiley Publication, 2nd Edition, 2005.
3. E. H. Collaway, "WirelessSensor Networks – Architectures and Protocols", CRC press, 2nd Edition, 2004.

Course Outcomes (COs):

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

1. Understand the concept of wireless sensor network and its architecture.
2. Illustrate the architectures, functions and performance of wireless sensor networks and its applications.
3. Explain the various wireless sensors and transmission technology.
4. Analyze the specific requirements for applications in wireless sensor networks regarding energy supply, memory, and processing and transmission capacity.
5. Design the WSN based on various protocols like MAC, routing, and transport layer.
6. Understand the concept of network management and operating systems for WSN

HEC21 : DEEP LEARNING
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

Deep Learning has received a lot of attention over the past few years and has been employed successfully by companies like Google, Microsoft, IBM, Facebook, Twitter etc. to solve a wide range of problems in Computer Vision and Natural Language Processing. In this course we will learn about the building blocks used in these Deep Learning based solutions. Specifically, we will learn about feedforward neural networks, convolutional neural networks, recurrent neural networks and attention mechanisms. We will also look at various optimization algorithms such as Gradient Descent, Nesterov Accelerated Gradient Descent, Adam, AdaGrad and RMSProp which are used for training such deep neural networks. At the end of this course students would have knowledge of deep architectures used for solving various Vision and NLP tasks

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent	7
2	Feed Forward Neural Networks, Back propagation, Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD	7
3	Principal Component Analysis and its interpretations, Singular Value Decomposition, Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto-encoders	8
4	Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Greedy Layer wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization	8
5	Learning Vectorial Representations Of Words, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet	7
6	Recurrent Neural Networks, Back propagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs, Encoder Decoder Models, Attention Mechanism, Attention over images.	8
	Total	**45**

List of References:

1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
3. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
4. Golub, G.,H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
5. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004

Course Outcomes (COs):

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

1. Understand the basic concepts in Neural Networks and applications.
2. Discuss feed forward networks and their training issues.
3. Distinguish different types of ANN architectures.
4. Understand the deep learning concepts using Back Propagation Network.
5. Discuss Convolutional Neural Network models to various real world applications.

HEC22 : NEURAL NETWORK FOR SIGNAL PROCESSING
CREDITS - 4 (LTP : 3,1,0)

Course Outline:

Signal Processing encapsulates daily lives without any of us even knowing. Computers, radios, videos, mobile phones are all enabled by signal processing. Signal Processing is a branch of electronics and communication engineering that models and analyzes data representations of physical events. It is at the core of the digital world. Speech and audio, autonomous driving, image processing, wearable technology, and communication systems all work appreciations to signal processing. So this course is an introductory graduate-level course in neural networks for signal processing is much simpler to get used to because the underlying mathematics is fairly straightforward regardless of what network architecture we use. The course starts with a motivation of how the human brain is inspirational to building artificial neural networks. The neural networks are viewed as directed graphs with various network topologies towards learning tasks driven by various optimization techniques.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	1	0	4	60	40	20	30	150

Course Contents:

Unit No	Topics	Teaching Hours
1	Introduction, Human brain, models of a neuron, Neural communication, Neural networks as directed graphs, network architectures (feed-forward, feedback, etc.), knowledge representation, Learning processes, Learning tasks, Perceptron, Perceptron convergence theorem, relationship between perceptron and Bayes classifiers, Batch perceptron algorithm.	8
2	Modeling through regression, Linear, and logistic regression for multiple classes, Multilayer perceptron, Batch and online learning, derivation of the back-propagation algorithm, XOR problem, Role of Hessian in online learning, annealing, and optimal control of learning rate.	8
3	Approximations of functions, Cross-validation, Network pruning, and complexity regularization, convolution networks, non-linear filtering, Cover's theorem and Pattern separability, The interpolation problem, RBF networks, Hybrid learning procedure for RBF networks, Kernel regression, and relationship to RBFs.	8
4	Support vector machines, Optimal hyperplane for linear separability, Optimal hyperplane for nonseparable patterns, SVM as a kernel machine, Design of SVMs, XOR problem revisited, robustness considerations for regression, SVMs contd. The optimal solution of the linear regression problem, Representer theorem, and related discussions. Introduction to regularization theory.	8
5	Hadamard's condition for well-posedness, Tikhonov regularization, Regularization networks, generalized RBF networks, Estimation of the regularization parameter, etc., L1 regularization basics, algorithms, and extensions	7
6	Principal component Analysis: Hebbian-based PCA, Kernel-based PCA, Kernel Hebbian algorithm, Deep multi-layer perceptrons, Deep autoencoders, and stacked denoising auto-encoders.	6
	Total	**45**

List of References:

1. Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press
2. Tom Mitchell, “Machine Learning”, McGraw Hill
3. Nils J Nilsson , “Introduction to Machine Learning”, Stanford University
4. C. Bishop, “Pattern Recognition and Machine Learning”, Springer
5. Smola and Vishwanathan, “Introduction to Machine Learning “, Cambridge University Press
6. Stuart Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson Education

Course Outcomes (COs):

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

1. Understand the fundamental theory and concepts of neural networks, neuro-modeling, several neural network paradigms.
2. Discuss various signal processing tools like autocorrelation, convolution, fourier and wavelet transforms, adaptive filtering via Least Mean Squares (LMS) or Recursive Least Squares (RLS), linear estimators, compressed sensing and gradient descent using neural networks.
3. Apply various neural network models to the field of signal processing like image processing, pattern recognition, speech signal processing and video signal processing etc.

HEC91 : PROJECT
CREDITS - 4 (LTP : 0,0,4)

Course Outline:

The primary objective of this course is to design and develop a state of the art project in the trending areas of the Electronics and communication focusing on VLSI, IoT, Embedded System design, Antenna design, Machine learning, Artificial intelligence, Networking etc.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
0	0	8	4	00	00	120	180	300

Course Outcomes (COs):

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

1. Apply the knowledge of electronics and communication engineering to the solution of electronics and communication engineering problems/project.
2. Review the research literature of selected project, and analyze complex engineering problems reaching substantiated conclusions.
3. Use research-based knowledge and research methods, including design of experiments, analysis and interpretation of data to design electronics and communication project.
4. Apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to design electronics circuits using relevant software and hardware for embedded, IOT, signal processing and communication based application.
5. Understand the impact of the electronics communication engineering solutions to societal and environmental contexts, ethical principles and norms of the engineering practice.