Curriculum for Undergraduate Degree (B.Tech.) in Electronics and Communication (VLSI Design) (w.e.f. AY: 2020-21)

Part III: Detailed Curriculum

Sixth Semester

Course Name:	**Microelectronics Fabrication**		
Course Code:	PC-EC(V)601	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Semiconductor Physics, Chemistry, Materials, MOS
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	Understand basic features of semiconductor process technology
2	Knowledge of different fabrication steps involved in microelectronics fabrication
3	Knowledge of IC fabrication

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Clean Room Technology**: Clean room concept, Clean room classes, surface contamination	2
2	**Wafer Preparation:** Crystal growth: Czochralsky and float zone technique, Electronic grade Si, Wafer cleaning, Wafer identification, wafer characterization	4
3	**Photolithography:** Photoresist and its types, Photoresist spin coating, photolithography process flow, Prebake and postbake, Stripping, Pattern transfer methods	4
4	**Oxidation**: SiO_2 thermal properties, Growth mechanism and kinetic oxidation, oxidation techniques and systems: dry and wet oxidation, oxide induced defects, characterization of oxide films, Use of thermal oxide and CVD oxide, growth and properties of dry and wet oxide, dopant distribution, oxide quality	3
5	**Etching:** Dry and wet etching, Sputter etching, plasma etching, RIE	2

6	**Diffusion:** Fick's equation, atomic diffusion mechanisms: predeposition and drive in, measurement techniques	4
7	**Ion Implantation:** Range theory, Ion implantation process, Equipments, Ion implanter, electronics and nuclear collision, implant damage and annealing Plasma flooding, Ion stopping, shallow junction, high energy implementation.	5
8	**Epitaxy:** Requirements, Epitaxy processes, Physical Vapor Deposition, Chemical Vapor Deposition (CVD), Plasma CVD, Metal Organic CVD, Liquid phase Epitaxy, Molecular Beam Epitaxy	5
9	**Metallization:** Different methods of metallization: evaporation, sputtering, multilevel metallization, electro migration, Uses & desired properties of different metals	3
10	**VLSI process integration:** CMOS fabrication process	2
11	**Packaging, assembly and testing:** Brief introduction on Packaging, assembly, testing	2
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand the necessities of clean room in microelectronics fabrication
2	Describe different common fabrication steps used in microelectronics fabrication and their importance
3	Demonstrate different steps involved in basic CMOS manufacturing procedure starting from bare silicon wafer
4	Understand the importance of IC packaging, assembly and testing

Learning Resources:	
1	Semiconductor Devices Physics and Technology, Author: S.M. Sze; Wiley
2	Fabrication Engineering at the Micro-and Nanoscale, Author: Stephen A. Campbell; Oxford University Press
3	An Introduction to Semiconductor Microtechnology, Author: D.V. Morgan and K. Board; Wiley
4	VLSI Technology, Author: S.M. Sze; MGH
5	Introduction to Microelectronic Fabrication, Author: Richard C. Jaeger; Pearson
6	Silicon VLSI Technology: Fundamentals, Practice, and Modeling, Author; James D. Plummer, M.D. Deal, P.B. Griffin; Pearson
7	Fundamentals of Microfabrication: The Science of Miniaturization, Author: M. J. Madou; CRC Press
8	The Science and Engineering of Microelectronic Fabrication, Author: Stephen A. Campbell; Oxford University Press

Course Name:	**Digital VLSI**		
Course Code:	PC-EC(V)602	**Category**:	Professional Core
Semester:	Sixth	**Credit**:	3
L-T-P:	3-0-0	**Pre-Requisites:**	Digital Electronics
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To provide in-depth understanding of the digital integrated circuit and building blocks
2	To provide a basic idea on digital VLSI circuits

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Introduction to VLSI Design Flow	2
2	MOS Design: Pseudo NMOS Logic – Inverter, Inverter threshold voltage, Output high voltage, Output Low voltage, Gain at gate threshold voltage, Transient response, Rise time, Fall time, Pseudo NMOS logic gates, Transistor equivalency, CMOS Inverter logic.	8
3	Combinational MOS Logic Circuits: MOS logic circuits with NMOS loads, Primitive CMOS logic gates – NOR & NAND gate, Complex Logic circuits design – Realizing Boolean expressions using NMOS gates and CMOS gates , AOI and OIA gates, CMOS full adder, CMOS transmission gates, Designing with Transmission gates.	10
4	Sequential MOS Logic Circuits: Behavior of bistable elements, SR Latch, Clocked latch and flip flop circuits, CMOS D latch, and edge triggered flip-flop.	8
5	Dynamic Logic Circuits: Basic principle, Voltage Bootstrapping, Synchronous dynamic pass transistor circuits, Dynamic CMOS transmission gate logic, High performance Dynamic CMOS circuits.	6
6	Semiconductor Memories: Types, RAM array organization, DRAM – Types, Operation, Leakage currents in DRAM cell and refresh operation, SRAM operation Leakage currents in SRAM cells, Flash Memory- NOR flash and NAND flash.	4
Total		**38**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand the MOS and CMOS Invertor Circuits
2	Analyze digital circuits using CMOS Logic gates
3	Design of combinational and sequential logic circuits using CMOS
4	Apply the MOS logic circuits for Dynamic Logic Circuits and Semiconductor Memories

Learning Resources:	
Books	
1	Ken Martin, "Digital Integrated Circuit Design", Oxford University Press, 2011.
2	Sung-Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", TMH, 3rd Edition, 2011.
3	Ming-BO Lin, "Introduction to VLSI Systems: A Logic, Circuit and System Perspective", CRC Press, 2011
4	Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, "Digital Integrated Circuits – A Design Perspective", 2nd Edition, PHI.

Course Name:	**Computer Network**		
Course Code:	PE- EC(V)601A	**Category**:	Professional Elective
Semester:	Sixth	**Credit**:	3
L-T-P:	3-0-0	**Pre-Requisites:**	Digital and Analog Communication
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To have a basic idea of communication network and layered protocol architecture.
2	To understand different flow control and error control mechanisms and to analyze the performance of different multiple access protocols.
3	To understand internet addressing, routing techniques, process to process delivery, congestion control and their associated protocols.
4	To understand different application layer protocols and modern communication technologies.
5	To have the basic idea of cryptography and network security.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Overview of Data Communication and Networking:** Introduction; Data communications: components, data representation (ASCII, ISO etc.), direction of data flow (simplex, half duplex, full duplex); network criteria, physical structure (type of connection, topology), categories of network (LAN, MAN, WAN); Internet: brief history, Protocols and standards; Reference models: OSI reference model, TCP/IP reference model, their comparative study.	4
	Physical Level: Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus; Telephone Network.	2
2	**Data link Layer:** Types of errors, framing (character and bit stuffing), error detection & correction methods; Flow control; Protocols: Stop & wait ARQ, Go-Back-N ARQ, Selective repeat ARQ, HDLC.	4
	Medium Access sub layer: Point-to-Point Protocol, LCP, NCP, Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA Traditional Ethernet, fast Ethernet (in brief).	6
3	**Network layer:** Internetworking & devices: Repeaters, Hubs, Bridges, Switches, Router, Gateway; Addressing: IP addressing, subnetting; Routing: techniques, static vs. dynamic routing, Unicast Routing Protocols: RIP, OSPF, BGP; Other Protocols: ARP, IP, ICMP, IPV6.	6
	Transport layer: Process to Process delivery; UDP; TCP; Congestion Control: Open Loop, Closed Loop choke packets; Quality of service: techniques to improve QoS: Leaky bucket algorithm, Token bucket algorithm.	6
4	**Application Layer:** Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW; Security: Cryptography (Public, Private Key based), Digital Signature, Firewalls.	4
	Modern topics: ISDN services & ATM, DSL technology, Cable Modem: Architecture & Operation in brief, Wireless LAN: IEEE 802.11, Introduction to blue-tooth.	4
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand basic idea of communication network and layered protocol architecture.
2	Understand different flow control and error control mechanisms and analyze the performance of different multiple access protocols.
3	Understand internet addressing, routing techniques, process to process delivery, congestion control and design a subnet as per the requirement.
4	Apply different application layer protocols and modern communication technologies.
5	Understand the basic idea of cryptography and network security.

Learning Resources:	
1	B. A. Forouzan - "Data Communications and Networking (4th Ed.)" - TMH
2	A. S. Tanenbaum - "Computer Networks (4th Ed.)" - Pearson Education/PHI
3	W. Stallings - "Data and Computer Communications (5th Ed.)" - PHI/ Pearson Education
4	Zheng & Akhtar, Network for Computer Scientists & Engineers, OUP
5	Black, Data & Computer Communication, PHI
6	Kurose and Rose - " Computer Networking -A top down approach featuring the internet" - Pearson Education
7	Leon, Garica, Widjaja - "Communication Networks" - TMH

Course Name:	**Instrumentation and Measurement**		
Course Code:	PE- EC(V)601B	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Electrical & Electronics [ES-EE 101], Analog Electronic Circuits[PC-EC302]
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To impart basic concept of instrument characteristics.
2	To impart knowledge about different required Measuring Instruments.
3	To understand the operational technique of different Signal Analyzers.
4	To understand the basic principle of operation of various Oscilloscopes.
5	To develop an insight into the construction and working of different Transducers.
6.	To understand and analyze the concept of Bridges and DAS.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Block Schematics of Measuring Systems: Performance characteristics, Static characteristics, Accuracy, Precision, Resolution, Types of Errors, Dynamic Characteristics, Repeatability, Reproducibility, Fidelity, Lag, Standards.	4
2	Measuring Instruments: DC Voltmeters, DC Current Meters, AC Voltmeters and Current Meters, Ohmmeters, Multimeters, Meter Protection, Extension of Range, True RMS Responding Voltmeters, Specifications of Instruments.	6
3	Signal Analyzers: Wave Analyzers, Harmonic Distortion, Spectrum Analyzers, Signal Generators, Frequency Synthesizer.	6
4	Oscilloscopes: CRT, Block Schematic of CRO, Time Base Circuits, Lissajous Figures, CRO Probes,Delay lines, Applications: Measurement of Time, Period and Frequency. Special Purpose Oscilloscopes: Dual Trace, Dual Beam CROs, Digital Storage CROs.	6
5	Transducers: Classification, Strain Gauges, Force and Displacement Transducers, Resistance Thermometers, LVDT, Thermocouples, Piezoelectric Transducers.	6
6	Bridges: Wheat Stone Bridge, Kelvin Bridge, and Maxwell Bridge.	4
7	Display Device: Classification of Display device, LED Display, LCD Display, Segmental Display, Dot Matrix Display.	4
8	Data Acquisition System: Single channel DAS, Multi-channel Das, Data logging, IEEE-488.	4
Total		**40**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the basic concept of instrument characteristics.
2	Execute the process of different required Measuring Instruments.
3	Understand the operational technique of different Signal Analyzers.
4	Understand the insight of the construction and working of different Transducers
5	Understand and analyze the concept of Bridges and DAS.

Learning Resources:	
1	Electronic Instrumentation: H.S.Kalsi, TMH, 2nd Edition 2004.
2	Modern Electronic Instrumentation and Measurement Techniques: A.D. Helbincs, W.D.

	Cooper: PHI, 5th Edition, 2003
3	Electronic Measurements and Instrumentations by K. Lal Kishore, Pearson Education, 2010.
4	Electronic Instrumentation and Measurements, David A. Bell, Oxford Uiv. Press, 1997.
5	Electronic Measurements and Instrumentation: B. M. Oliver, J. M. Cage TMH Reprint.
6	A Course in Electronics and Electrical Measurements and Instrumentation: S K Kataria and Sons,2013.

Course Name:	**Sensors and Transducers**		
Course Code:	PE-EC(V)602A	**Category**:	Professional Elective
Semester:	Sixth	**Credit**:	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Knowledge of Instrumentation Measurement
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	Understand Characteristics and choice of Sensors
2	Understand basic principles and applications of resistive and reactive transducers
3	Analyze the self generating sensors i.e thermocouple, piezoelectric sensors
4	Understand basic principles of thickness, level and vacuum measurement
5	Analyze the signal conditioning circuits of resistive and reactive transducers
6	Understand basics of Instrument buses for VLSI testing

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to Sensor Based Measurement Systems-General concept and Terminology, Transducer, Sensor and Actuator, Sensor classification, Static and dynamic characteristics of measurement system. Primary Sensing Elements: Transducers- Characteristics and choice of transducer- Input characteristics, loading effect, Transfer characteristics, errors, output characteristics. Factors influencing the choice of transducer.	4
2	Resistive Sensors: Strain Gauge- Basic Theory, Types of strain gauge, semiconductor strain gauge and it's advantages, Gauge factor, Gauge sensitivity, Temperature compensation and cancellation techniques, Applications. Resistance Temperature Detectors(RTD)- Basic theory, linear approximation, quadratic approximation. Thermistor- Basic theory, construction, Resistance Temperature characteristics,	7

	voltage current characteristics, Applications. IC Temperature Detectors: LM 335, LM 34, AD 592	
3	Capacitive Sensors: Basic Theory, sensing through change of physical parameters, change of dielectric constant, Frequency response, disadvantages.	4
4	Self Generating Sensors: Thermocouple- Basic Theory, construction, measurement of output, Errors occurring in measurement, Advantages and Disadvantages. Piezoelectric Sensors- Basic Theory, Modes of operation, properties, equivalent circuit, impulse response, applications.	5
5	Thickness Measurement- Electronic Gauges, Inductive gauges (Eddy current sensing) , Hall effect gauges. Level Measurement through electrical properties. Vacuum Measurement- Basic concept of Direct Reading Gauges. Indirect Gauges. Viscosity method , Pirani Gauge and Thermistor. Basic concept of Fibre optic sensor.	8
6	Signal Conditioning Circuits: Signal conditioning for Resistive Sensors- Voltage divider, Wheatstone bridge, linearization, calibration and balance of resistive sensor bridges, compensation techniques, Differential and Instrumentation amplifier. Signal conditioning for reactive sensors- Ac Bridge ,sensitivity, linearization, Amplifier and power supply decoupling, Signal conditioning for self Generating Sensors- Chopper and Low-Drift Amplifiers, Trans impedance Amplifiers, Noise in Amplifiers.	6
7	Introduction to Instrument Buses and VLSI Testing: IEEE 488 bus- Major specifications, GPIB operation, Signals and lines, Polling, Physical and Electrical characteristics. RS232 interface, VXI bus – specifications, VLSI testing and automatic test equipment.	2
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand Characteristics and choice of transducer
2	Understand basic principles and applications of resistive and reactive transducers.
3	Analyze the self generating sensors i.e thermocouple, piezoelectric sensors
4	Understand basic principles of thickness, level and vacuum measurement
5	Analyze the signal conditioning circuits of resistive and reactive transducers
6	Understand basics of Instrument buses for VLSI testing

Learning Resources:	
1	Electrical and Electronics Measurement and Instrumentation by A.K. Sawhney, Dhanpat Rai and Sons.
2	Sensors and Signal Conditioning by John G. Webster, John Wiley and Sons, INC.
3	Measurement, Instumentation and Sensor Handbook , 2nd edition, by John G. Webster and Halit Eren. CRC Press.

Course Name:	**MEMS**		
Course Code:	PE-EC(V)602B	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic knowledge of Physics and Mechanics (BS-PH101, ES-EE101)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the operation of major classes of MEMS devices/systems
2	To give the fundamentals of standard micro fabrication techniques and processes
3	To understand the unique demands, environments and applications of MEMS devices

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction and Historical Background	2
2	Scaling Effects. Micro/Nano Sensors, Actuators and Systems overview, Applications of Micro and Nano electromechanical systems	4
3	Mechanics of solids in MEMS/NEMS: Stresses, Strain, Hookes's law, Poisson effect, Linear Thermal Expansion, Bending, Energy methods, Beams, Cantilevers, Plates, Diaphragms – Typical applications	5
4	Materials for MEMS and NEMS: Silicon, silicon compounds, polymers, metals. Case studies: Capacitive Pressure sensors, Piezoelectric energy harvester, Accelerometers etc	5
5	Basic MEMS fabrication modules: Micromachining: Surface Micromachining, sacrificial layer processes, Stiction; Bulk Micromachining, Isotropic Etching and Anisotropic Etching, LIGA process	8

6	Micro system Packaging: general considerations in packaging design – Levels of Micro system packaging	4
7	Bonding techniques for MEMS : Surface bonding , Anodic bonding , wire bonding , Sealing –Assembly of micro systems	4
8	Overview of MEMS areas : RF MEMS, Bio-MEMS, MOEMS, NEMS	4
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Appreciate the underlying working principles of different MEMS and NEMS devices.
2	Understand the typical materials used for fabrication of micro systems
3	Understand the principles of standard MEMS fabrication techniques
4	Describe the challenges in MEMS packaging and assembly

Learning Resources:	
1	G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan K. N. Bhat, V. K. Aatre, Micro and Smart Systems, Wiley India, 2012.
2	S. E.Lyshevski, Nano-and Micro-Electromechanical systems: Fundamentals of Nano- and Micro engineering (Vol 8), CRC Press
3	S.D. Senturia, Microsystem Design, Kluwer, Academic Publishers, 2001.
4	M. Madou, Fundamentals of Microfabrication, CRC Press, 1997.
5	Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture
6	Chang C Y and Sze S. M., VLSI Technology, McGraw-Hill, New York, 2000
7	Julian W Gardner, Micro sensors: Principles and Applications, John Wiley & Sons, 1994

Course Name:	**Artificial Intelligence**		
Course Code:	OE-CS601B	**Category:**	Open Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Data Structure & Algorithm, Mathematics
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the basic concepts of AI and its use as optimization technique
2	To understand different search strategies and Resolution in AI.
3	To understand classification and clustering methodology
4.	To understand Deep Learning Paradigms

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Introduction to AI, Machine Learning, AI VS Machine learning Vs. Deep Learning	2
2	Problems, Problem Space & search: Defining the problem as state space search, production system, problem characteristics, Issues in the design of search programs.	3
3	Search techniques :- Solving problems by searching: problem solving agents, searching for solutions; uniform search strategies: breadth first search, depth first search, depth limited search, bidirectional search, comparing uniform search strategies. Heuristic search strategies:- Greedy best-first search, A* search, memory bounded heuristic search: local search algorithms & optimization problems: Hill climbing search, simulated annealing search, local beam search,	8
4	Genetic algorithms; constraint satisfaction problems, local search for constraint satisfaction problems.	2
5.	Adversarial search Games, optimal decisions & strategies in games, the Mini-max search procedure, alpha-beta pruning, additional refinements, Iterative deepening.	3
6.	Concept of Probabilistic Reasoning, Dempster Shafer theory, concept of False Positive and False Negative, Bayes Theorem	3
7.	Representing simple fact in logic, representing instant & ISA relationship, computable functions & predicates, resolution, natural deduction.	4
8.	Introduction to Machine Learning , Difference between Supervised and unsupervised learning, Linear regression and Logistic regression , Multivariate Logistic Regression	4
9.	Forecasting Techniques using Time Series, Unsupervised Learning – Clustering, Advanced Topics like SVM. And Case Study.	4
10.	Deep Learning - Neural Network Basics, Shallow Neural Network and Deep Neural Network with Case Study.	3
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand the concept of AI, Genetic Algorithm and Search Techniques
2	Understand and Implement supervised and Unsupervised Techniques
3	Understand the concept of Deep Learning
4.	Apply different Techniques by understanding the pattern of problems.

Learning Resources:	
1	Artificial Intelligence- Stuart Russel & Norvig Pearson (India) Pvt. Ltd.
2	Artificial Intelligence with Python – Prateek Joshi PACKT Publishing
3	Deep Learning – Ian GoodFellow , MIT Press
4	Genetic Algorithms- Goldberg, Pearson
5	Machine Learning – Tom Mitchell , TMH

Course Name:	**Machine Learning**		
Course Code:	OE-IT601A	**Category:**	Open Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Data Structure & Algorithm, Mathematics
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To learn the concepts of data and patterns
2	To design and analyze various machine learning algorithms.
3	Explore supervised and unsupervised machine learning
4.	Explore Deep Learning Techniques and various feature extraction.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Supervised Learning: - Distance based methods, Nearest Neighbor. Learning Techniques with Decision Tree and Naïve Bayes Classifier.	6
2	Supervised Learning (Regression/Classification):- Linear Regression, Logistic Regression, Linear Models optimization SVM, Dealing with Non Linearity and Kernel Methods. Multi class classification, Ranking	8
3	Introduction to Unsupervised Learning:- K-Means Clustering, Kernel K-Means, Dimensionality Reduction with PCA and Kernel PCA. Preliminary idea of Factorization and generative models (Mixture model and Latent factor model).	8
4	Evaluating Machine Learning Algorithms model selection, Introduction to statistical learning theory and Ensemble Methods (Bagging, Boosting and Random Forests).	6
5.	Model Estimation, Modeling Time Series Data, Deep Learning and Feature Extraction Techniques. Shallow Neural Network and Deep Neural Network.	7
6.	Case Study: - Selection from a Technique and Implementing with a chosen model.	1
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain different supervised Learning Techniques
2	Identify the difference between Linear and Non Linear Models
3	Understand different unsupervised learning techniques.
4.	Understand the concept of model estimation and deep learning techniques

Learning Resources:	
1	Machine Learning, Tom Mitchell, McGraw Hill, 1997.
2	Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007
3	Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
4	Hastie, Tibshirani, Friedman The Elements of Statistical Learning Springer 2007
5.	Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido Released October 2016 Publisher(s): O'Reilly Media, Inc. ISBN: 9781449369415

Course Name:	**Digital VLSI Lab**		
Course Code:	PC-EC(V)692	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Digital Electronics
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To learn Hardware Descriptive Language(Verilog/VHDL)
2	To learn the fundamental principles of VLSI circuit design in digital domain
3	To familiarize implementation of logical modules on FPGAs

Course Contents:

Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1.	Introduction to HDL.	2
2.	Design of a Sub tractor and its implementation using FPGA.	2
3.	Design of priority Encoder and its implementation using FPGA.	2
4.	Design of a 4 bit parallel adder and its implementation using FPGA	2
5.	Design of up-down counter using HDL its implementation using FPGA	2
6.	Design and simulation of XOR and MUX using TG.	2
7.	Design and simulation of Decoder using TG.	4
8.	Design of a SR Flip-Flop using SPICE	2
9.	Design of a JK Flip-Flop using SPICE	2
10.	Innovative Experiment	4
Total		**24**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understanding the hardware design language (HDL).
2	Design of the Combinational circuit using hardware description language or tools and validate its functionality
3	Design of the Sequential circuit using hardware description language or tools and validate its functionality
4.	Design and implement on a FPGA board..

Learning Resources:	
1	Laboratory and FPGA Manual
2	[Peter_J._Ashenden]_Digital_Design_(VHDL)
3	FPGA prototyping by Verilog Xilinx SpartanTM-3V ersion Pong P. Chu Cleveland State University
4	A VHDL Primer Jayaram Bhasker, Prentice Hall Englewood Cliffs, New Jersey

Course Name:	**Computer Network Lab**		
Course Code:	PE- EC(V)691A	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Basic programming concept in C under Linux environment
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To design the structure of a LAN and select the components required to install it.
2	To configure NIC for multiple operating systems.
3	To write programs in C for inter process communication using Pipe in Linux environment.
4	To write network programs in C using Socket in Linux environment.

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	Familiarization of different Networking devices, such as hub, switch etc. and writing a report on structures and layouts of a LAN.	2
2	Preparation of Straight-Trough and Cross-Over cable and testing the performance of them.	2
3	Configuration of IP address on Windows and Linux platforms.	2
4	Write a program for ECHO Server using TCP that will receive a string from a client and will send it back to the client. The client will display the receive text.	2
5	Write a program for ECHO Server using UDP that will receive a string from a client and will send it back to the client. The client will display the receive text.	2
6	Write a program for Day-Time Server using TCP.	2
7	Write a program for Day-Time Server using UDP.	2
8	Write a Concurrent ECHO Server program using TCP.	2

9	Write a program to implement flow control mechanism.	2
10	Write a program to implement error detection mechanism using Cyclic Redundancy Check (CRC).	2
11	Write a program to implement error control mechanism.	2
12	Write a program to implement multicast/broadcast sockets.	2
Total		**24**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Design the structure of a LAN and the components required to install it.
2	Configure NIC for multiple operating systems.
3	Write programs in C for inter process communication using Pipe in Linux environment.
4	Write network programs in C using Socket in Linux environment.

Learning Resources:	
1	Comer - "Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.)" - Pearson Education/PHI
2	Stevens, "TCP/IP Illustrated, Volume 1", (2nd Edition), Addision Wesley
3	Lab Manual

Course Name:	**Instrumentation and Measurement Lab**		
Course Code:	PE-EC(V)691B	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Basic Electrical & Electronics [ES-EE 101], Analog Electronic Circuits[PC-EC302]
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To impart the concept of instrument characteristics.
2	To impart the knowledge about error.
3	To understand the operation of different required measuring instrument.
4	To understand the basic principle of operation of LVDT.
5	To develop an insight into the construction and working of VCO or PLL.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Study of Static Characteristics of a Measuring Instrument	6
2	Study of Dynamic Characteristics of a Measuring Instrument	2
3	Statistical analysis of errors in measurement .	2
4	Calibration of Load cell and measurement of unknown load	2
5	Acquaintance with basic structure of DMM and measurement of different electrical parameters	4
6	Wave analysis using Q meter.	2
7	Study the operation of LVDT.	2
8	Study of CRO and detection of usual faults	4
Total		**24**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the instrument characteristics.
2	Understand the clear knowledge about error.
3	Execute the operation of different required measuring instrument.
4	Understand the basic principle of operation of LVDT.
5	Understand the insight of construction and working of VCO or PLL.

Learning Resources:	
1	Electronic instrumentation: H.S.Kalsi, TMH, 2nd Edition 2004.
2	Modern Electronic Instrumentation and Measurement Techniques: A.D. Helbincs, W.D. Cooper: PHI, 5th Edition, 2003
3	Electronic Measurements and Instrumentations by K. Lal Kishore, Pearson Education, 2010.
4	Electronic Instrumentation and Measurements, David A. Bell, Oxford Uiv. Press, 1997.
5	Electronic Measurements and Instrumentation: B. M. Oliver, J. M. Cage TMH Reprint.
6	A Course in Electronics and Electrical Measurements and Instrumentation: S K Kataria and Sons,2013.

Course Name:	**Artificial Intelligence Lab**		
Course Code:	OE-CS691B	**Category:**	Open Elective
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Data Structure & Algorithm, Mathematics
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To implement different gaming design Techniques using AI
2	To implement different Searching Strategies
3	To implement different classification and clustering Technique
4.	To implement neural network models and understand deep learning methodologies.

Course Contents:

Module No.	**Description of Topic**	**Contact Hrs.**
1	Implementation of some problems related with Production System, BFS, DFS with Python/R	2
2	Implementation of Heuristic Search Strategies using Python/R (Any 2 search strategies)	4
3	Games Designing with AI Techniques using Python/R (Using MINIMAX)	2
4	Implementation of Bayesian technique with Python /R	2
5.	Logic Programming using PROLOG/LISP and difference in Python/R implementation	4
6.	Implementation of Linear Regression , logistic regression, multivariate logistic regression	4
7.	LSTM algorithm-Time Series Analysis	2
8.	Clustering Techniques Implementation – Different Techniques, SVM implementation	4
9.	Simple neural network implementation, Deep Learning techniques – Shallow and Deep Neural network Concept of Keras , Tensor Flow	4
Total		**28**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Implement different searching and gaming strategies using AI.
2	Implement different classification and clustering algorithm
3	Understand and implement decision tree
4.	Should be able to implement Deep Learning Techniques.

Learning Resources:	
1	Artificial Intelligence with Python – Prateek Joshi PACKT Publishing
2	Hands-On Machine Learning with Scikit-Learn and TensorFlow- Aureillen Garon O Reilley
3	Hands-On Deep Learning Algorithms with Python-Sudharsan Ravichandiran Packt Publishing
4	Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido Released October 2016 Publisher(s): O'Reilly Media, Inc. ISBN: 9781449369415
5.	Practical Machine Learning Released January 2016 Publisher(s): Packt Publishing ISBN: 9781784399689 – Sunita Gollapudi

Course Name:	**Machine Learning Lab**		
Course Code:	OE-IT691A	**Category:**	Open Elective
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Data Structure & Algorithm, Mathematics
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To learn the concepts of data and patterns
2	To design and implement various machine learning algorithms.
3	Implement supervised and unsupervised machine learning
4.	Implement Deep Learning Techniques and various feature extraction with case study.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Implementation of Linear Regression , logistic regression, multivariate logistic regression	4
2	Decision Tree and Ensemble Techniques, Bagging, Boosting	4
3	LSTM algorithm-Time Series Analysis	4
4	Clustering Techniques Implementation – Different Techniques, SVM implementation	6
5.	Simple neural network implementation, Deep Learning techniques – Shallow and Deep Neural network Concept of Keras , Tensor Flow	6
6.	Factorization and Generative Model implementation	2
Total		**26**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Implement different classification and clustering algorithm
2	Understand and implement decision tree
3	Implement Deep Learning Techniques.
4.	Implement different classification and clustering algorithm

Learning Resources:	
1	Practical Machine Learning Released January 2016 Publisher(s): Packt Publishing ISBN: 9781784399689 – Sunita Gollapudi
2	Hands-On Machine Learning with Scikit-Learn and TensorFlow- Aureillen Garon O Reilley
3	Hands-On Deep Learning Algorithms with Python-Sudharsan Ravichandiran Packt Publishing
4..	Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido Released October 2016 Publisher(s): O'Reilly Media, Inc. ISBN: 9781449369415

Course Name:	**Mini Project**		
Course Code:	PW-EC(V)681	**Category:**	Sessional
Semester:	Sixth	**Credit:**	1.5
L-T-P:	0-0-3	**Pre-Requisites:**	Analog Electronics, Digital Electronics, Microprocessor & Microcontrollers
Full Marks:	100		
Examination Scheme:	Semester Examination: 40	Continuous Assessment: 55	Attendance: 05

Course Objectives:	
1	To impart the essential knowledge of electronic circuit design.
2	To enhance hands on experience and to encourage innovativeness.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
	Guidelines: 1. The mini-project is a team activity having 3-4 students in a team. This is electronic product design work with a focus on electronic circuit design. 2. The mini project may be a complete hardware or a combination of hardware and software. 3. Mini Project should cater to a small system required in laboratory or real life. 4. It should encompass components, devices, analog or digital ICs, micro controller with which functional familiarity is introduced. 5. After interactions with mentor and based on comprehensive literature survey/need analysis; the student shall identify the title and define the aim and objectives of mini-project. The project should provide enough room for the student to learn and innovate. If same job is assigned to more than one group, it must be with different parameter values. 6. Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within two weeks from the starting of the semester. 7. The student is expected to follow the timeline as given for design, development and testing of the proposed work. 8. Layout should be made using CAD based simulation software, if required. Due considerations should be given for power requirement of the system, mechanical aspects for enclosure and control panel design.	

	9. The student must always make a comparative study between the theoretical and measured performance parameters and analyze their causes. 10. Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester. 11. Few sessions should be considered for discussion on standard practices used for electronic circuits/product design, converting the circuit design into a complete electronic product, PCB design using suitable simulation software, estimation of power budget analysis of the product, front panel design and mechanical aspects of the product, and guidelines for documentation /report writing. **Grading System:** 1. The total score of 100 will be in three parts, a) Continuous evaluation: 55 b) Semester end viva: 40 c) Attendance: 05 2. The teacher will evaluate the performance of each student on the basis of initiative, innovativeness, speed, ability to follow timeline and insight for continuous evaluation. 3. At the end of the semester, the student will be interviewed by a panel of examiners to assess his/her expertise in various facets of the work.	
Total		**40**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify a problem statement, analyze it after literature survey or from given conditions.
2	Design the prototype in order to solve the conceived problem.
3	Implement and test the prototype in order to solve the conceived problem.

Learning Resources:	
1	The Art of Electronics, Paul Horowitz and Winfield Hill, 2nd edition, Cambridge University Press
2	Electronics for You, EFY Group

Course Name:	**Aptitude Skill Development-II**		
Course Code:	MC671	**Category:**	Mandatory Course
Semester:	Second	**Credit:**	0
L-T-P:	2-0-0	**Pre-Requisites:**	Quantitative Ability, Logical and Verbal Reasoning
Full Marks:	100		
Examination Scheme:	Semester Examination: NA	Continuous Assessment: 100	Attendance: NA

Course Objectives:	
1	To be prepared in the area of Quantitative Ability as well as Logical and Verbal Reasoning for Campus Placements and different Competitive Exams

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Solve company oriented campus placements aptitude papers covering Quantitative Ability, Logical Reasoning and Verbal Ability.	20
2	Mock test	10
Total		30

Course Outcomes:	
After completion of the course, students will be able to:	
1	Prepared for Campus Placements and different Competitive Exams

Learning Resources:	
1	ArunSharma,"Quantitative abilities", McGraw-Hill
2	R.S.Agrawal, "Quantitative Aptitude for Competitive Examinations", S. Chand
3	R.S.Agarwal,"A Modern Approach to Verbal & Non-Verbal Reasoning ",S.Chand