NOTIFICATION

No. 108 /2025 Date: 19 /07/2025

Subject : Implementation of new syllabus of Semester VII & VIII of the new Under-graduate Course B.E. [(Industrial (IoT)] as per C.B.C.S. Pattern.

It is notified for general information of all concerned that the authorities of the University have accepted to implement the syllabus of the subjects of **Semester VII & VIII** of the new Under-graduate Course **B.E. [(Industrial (IoT)] as per CBCS Pattern** to be implemented from the academic session 2025-2026 & onwards as mentioned below:

Sd/-
(Dr.Avinash Asanare)
Registrar
Sant Gadge Baba Amravati University

syllabus of Semester VII & VIII of B.E. [Industrial (IoT)] CBCS pattern

SEMESTER VII

7IIoT01 PROJECT MANAGEMENT & ENTREPRENEURSHIP

Course Pre-requisite: 1A1 Mathematics-I
4ES06 Environmental Science

Course Objectives:

1. To make students understand the concepts of Project Management for planning and implementation of projects.
2. To make students understand the feasibility analysis in Project Management and network analysis tools for cost and time estimation.
3. To enable students to comprehend the fundamentals of Contract Administration, Costing and Budgeting.
4. To Make students capable to analyze, apply and appreciate contemporary project management tools and methodologies in Indian context.

Course Outcomes:

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

1. Understand basic concept of Project management
2. Explore the knowledge of cost estimation & working capital
3. Prepare Cost Sheets, balance sheets and Cash Flow statements
4. Understand and analyze the Entrepreneurial competencies & traits
5. Discuss the Management skills for Entrepreneurs
6. Elaborate the importance of Social Entrepreneurship

	Subject: Project Management & Entrepreneurship	L
UNIT I	Project management: Definition, Scope & Importance, Role of project manager; Project life-cycle.	7
UNIT II	Project appraisal: Preparation of a real time project feasibility report containing Technical appraisal; Environmental appraisal, Market appraisal and Managerial appraisal.	6
UNIT III	Project Financing: Project cost estimation & working capital requirements, Sources of funds, Capital budgeting, Risk & uncertainty in project evaluation.	6
UNIT IV	Project Report and Finance: Preparation of projected financial statements viz. Projected balance sheet, projected income statement, projected funds & cash flow statements, Preparation of detailed project report, Project finance.	7
UNIT V	Entrepreneurship: Need, Scope, Entrepreneurial competencies & traits, Factors affecting entrepreneurial development, Entrepreneurial motivation (Mc Clellend's Achievement motivation theory), conceptual model of entrepreneurship, Entrepreneur vs. Intrapreneur; Classification of entrepreneurs; Entrepreneurial Development Programmes.	7

UNIT VI	Entrepreneurial Idea and Innovation: Introduction to Innovation, Entrepreneurial Idea Generation and Identifying Business Opportunities, Management skills for Entrepreneurs and managing for Value Creation, Creating and Sustaining Enterprising Model & Organizational Effectiveness.	7
	Total	**40**

Text Books:
1. Innovation and Entrepreneurship by Drucker, P.F.; Harper and Row
2. Business, Entrepreneurship and Management: Rao, V.S.P.; Vikas.

References:
1. Entrepreneurship: Roy Rajeev; OUP.
2. Text Book of Project Management: Gopalkrishnan, P. and Ramamoorthy, V.E.;McMillan
3. Project Management for Engineering, Business and Technology: Nicholas, J.M., and Steyn, PHI

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7IIoT02 INDUSTRIAL SMART SENSORS AND ACTUATORS

Course Pre-requisite: 4IIoT01Transducers and data Acquisition System
5IIoT02 Micro-controllers & Applications

Course Objectives:
1. To acquire fundamental knowledge of Smart Sensors.
2. To study the interfacing of different sensors with microcontroller units (MCUs).
3. To Understand the use of MCUs/DSPs in Increasing Sensor Intelligence.
4. To identify and implement applications of smart sensors in techno-social fields.

Course Outcomes:
After successful completion of the course, students will be able to -
1. Comprehend the knowledge of different types of sensors.
2. Describe the characteristics and operation of thermal sensors.
3. Understand the types of radiation sensors.
4. Understand the smart sensors working and their interface with MCU.
5. Discriminate various control applications for smart sensors.
6. Understand the basic concepts of Actuators and their systems.

	Course: SENSORS AND TRANSDUCERS	L
Unit-1	**Sensors/Transducer :** Principles, Classification, Characterization. Mechanical and Electromechanical Sensors: Introduction, Resistive Potentiometer, Inductive Sensors, Capacitive Sensors- Parallel plate & serrated plate types, Ultrasonic Sensors.	07
Unit-2	**Thermal Sensors**: Introduction, Helium Low Temperature Thermometer, Nuclear Thermometer, Magnetic Thermometer, Junction Semiconductor Types, Magnetic Sensors: Introduction, Sensors and the Principles Behind, Force & displacement Sensors.	07
Unit-3	**Radiation Sensors:** Introduction – Basic Characteristics – Types of Photo sensistors /Photo detectors– X-ray and Nuclear Radiation Sensors – Fiber Optic Sensors.	07
Unit-4	**Smart Sensors:** Introduction, Primary Sensors, Excitation, Amplification, Filters, Converters, , Information Coding/Processing, Data Communication, Standards for Smart Sensor Interface, the Automation.	07
Unit-5	**Applications of Sensors:** Introduction, On-board Automobile Sensors (Automotive Sensors), Home Appliance Sensors, Medical Diagnostic Sensors, Sensors for Manufacturing, Sensors for environmental Monitoring.	07
Unit-6	**Actuators:** Pneumatic and Hydraulic Actuation Systems, Valves, Rotary actuators, Mechanical Actuation Systems Electrical Actuation Systems.	07
	Total	**42**

Text Books:

1. Sawney A K and Puneet Sawney, “A Course in mechanical measurements and instrumentation and control”, 12th edition, DhanpatRai and Co, new delhi,2013.
2. D. Patranabis, Principles of Industrial Instrumentation, Tata McGraw Hill Publishing Ltd., New Delhi, 1999.
3. Electronics instrumentation" by H. S. Kalsi [TMH]

Reference Books:

1. DataAcquisitionandControlHandbookbywww.keithley.com
2. David A. Bell, Electronic Instrumentation and Measurements, Third Edition, Oxford Higher Education
3. R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1999.
4. Patranabis-Sensors and Actuators- 2 nd Ed., PHI, 2013.
5. Robert H. Bishop-The Mechatronics Handbook, 2nd Ed., Mechatronic Systems, Sensors and Actuators, fundamentals and modelling
6. D. Patranabis-Sensors and Transducers, PHI Learning Private Limited.
7. W. Bolton-Mechatronics, Pearson Education Limited.

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7IIoT03 PROFESSIONAL ELECTIVE-III (i): VLSI DESIGN

Course Pre-requisite: 3IIoT01 Analog and Digital Electronics

Course Objectives:

1. To study CMOS transistor theory and performance parameters.
2. To design the digital VLSI circuits using computer aided simulation and synthesis tools on programmable chips (FPGA/CPLD) and Verilog HDL.
3. To understand the manufacturing process in VLSI technology and study layout design rules for size & power optimization.

Course Outcomes:

After successfully completing the course, students will be able to -

1. Comprehend the knowledge about the trends in VLSI semiconductor technology and it's impacts on scaling and performance.
2. Understand the different types of analog and digital circuits for VLSI implementation
3. Draw and elaborate CMOS Layouts and Stick diagrams of simple CMOS Circuits.
4. Understand clocking and digital system design in Verilog HDL.
5. Understand Front & Back end design aspects of simple VLSI Digital circuits.
6. Apply the knowledge of model digital circuits with Verilog HDL in order to simulate, synthesize and prototype PLDs.

	Course: VLSI Design	L
Unit-1	**CMOS Circuit Design-I:** Moores Law, MOS structure capacitance, Channel capacitance, Junction capacitance, MOS Transistor Switches, CMOS Logic gates, CMOS Inverter- DC Characteristics, CMOS combinational logic design, Intoroduction to Delays in CMOS, Power consumption / Dissipation Issues.	07
Unit-2	**CMOS Circuit Design-II:** Clocked Latch and Flip-Flop Circuits, CMOS Transmission Gates (Pass Gates), Static Read- Write Memory (SRAM) Circuits, Dynamic Read-Write Memory (DRAM) Circuits	07
Unit-3	**CMOS Technology & Design Rules:** CMOS fabrication processing steps, p-well CMOS Process, n-well CMOS Process, Twin well process, Silicon-on-Insulator Process, CMOS Process enhancements –Interconnect, Circuit Elements, CMOS Lambda-based Design Rules, Stick Diagrams, Physical layout of simple CMOS Logic Gates.	07
Unit-4	**Clocking & Digital System Design using Verilog HDL**: VLSI Design flow, Module, ports, Data types, Compiler, Directives, Operators, Propogation Delay (Inertial & Transport), Clocks Skew, Clock distribution techniques, Clock Jitter. CMOS Clocking Styles, Introduction to basic faults in VLSI: stuck at 0 and stuck at 1 fault.	07
Unit-5	**Digital System Design using Verilog HDL**: Gate-Level Modeling, Data Flow Modelling, Structural Modeling using combinational and sequential circuits examples, behavioural Modeling, Initial & always statements, procedural assignments.	07
Unit-6	**Applications of VLSI in IoT**: Consumer Electronics, automotive industry, healthcare and medical devices, telecommunications, Internet of Things, Computing Systems.	07
	Total	**42**

Text Books:

1. S. M. Kang and Y. Leblebici, "CMOS Digital Integrated Circuits : Analysis and Design", 3rd Edn., MH, 2002.
2. Neil H. Weste, D. Harris, "Principles of CMOS VLSI design A Circuit & System Perspective" 4th Edition, Pearson(Addison-Wesley), 2011.
3. Samir Palnitkar, "Verilog HDL: A guide to Design and Synthesis", 2nd edition, Prentice Hall PTR, 2003.

Reference Books:

1. Jan M.Rabaey, A.Chandrakasan, B. Nikolic,"Digital Integrated Circuits:A Design Perspective", 2nd Edn.Pearson.
2. S.K. Ghandhi, "VLSI Fabrication Principles", John Wiley Inc., New York, 1994 (2nd Edition).
3. Plummer, Deal, Griffin, "Silicon VLSI Technology: Fundamentals, Practice & Modeling" PH, 2001.
4. Michael Ciletti, "Advance digital design with the Verilog HDL", Pearson publication.
5. Navabi Z., "Verilog Digital System Design", McGraw-Hill Publishing, New York, 1999. 6. S.M. Sze (Ed), "VLSI Technology", McGraw Hill.
6. Wayne Wolfe, "Modern VLSI Design: IP based Approach", 4th Edition, PHI.

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7IIOT03 Professional Elective- III (ii) 3-D PRINTING AND APPLICATIONS

Course Pre-requisite: 1. B4 Engineering Graphics
2. 6IIoT03 Embedded System & RTOS

Course Objectives:

1. Explain the principles of 3D printing (Additive Manufacturing).
2. Identify suitable materials for 3D printing technologies.
3. Compare and evaluate various 3D printing processes and analyze SLA, SGC, LOM, and FDM technologies.

Course Outcomes:

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

1. Understand the fundamentals, historical development, and advantages of 3D printing in various fields.
2. Describe the 3D printing process chain, including modeling, data handling, building, and post-processing.
3. Explain the working principles, processes, and applications of SLA, highlighting its benefits and limitations.
4. Analyze the process, working principles, and applications of SGC, with its advantages and challenges.
5. Evaluate the LOM process, principles, and applications, emphasizing its strengths and drawbacks.
6. Apply FDM techniques in practical scenarios, understanding its principles, advantages, and real-world uses.

	Subject: 3D PRINTING AND APPLICATIONS	**L**
Unit I	Overview of Manufacturing Processes: Subtractive vs. Additive Manufacturing, History and Evolution of 3D Printing,Fundamentals of Additive Manufacturing, Benefits and Limitations of 3D Printing, Applications in Various Fields: Aerospace, Automotive, Biomedical, Consumer Products.	6
Unit II	Process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of 3D printing process, Applications to various fields.	7
Unit III	Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages.	7
Unit IV	Solid ground curing (SGC): Models and specifications, process, working principle, applications, advantages and disadvantages.	6
Unit V	Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages.	7
Unit VI	Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages.	7
	Total	**40**

Text Books:

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
2. D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001
3. Terry Wohlers, “Wholers Report 2000”, Wohlers Associates, 2000 References.

References:

1. Paul F. Jacobs, “Rapid Prototyping and Manufacturing”, ASME Press, 1996
2. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014

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7IIoT03 Professional Elective - III: (iii) QUANTUM COMPUTING

Course Pre-requisite: 5IIoT04 PE-I (iv) Data Structures
6IIoT02 Cloud Computing

Course Objectives:

1. To learn the background and fundamental concepts of classical computing and quantum computing.
2. To study the details of quantum mechanics and its relation to Computer Science.
3. To understand the basics of quantum information and apply quantum computing techniques.

Course Outcomes:

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

1. Understand the background of classical computing and quantum computing.
2. Comprehend the knowledge of Fundamental Concepts of Quantum Computation with the help of logic gates.
3. Understand Quantum Mechanics and Its Relation to Computer Science
4. Understand the Quantum Computing Models and Hardware.
5. Elaborate the Basics of Quantum Information Theory
6. Implement quantum computing solutions for IoT.

	Subject: QUANTUM COMPUTING	L
Unit I	Basic Concepts of Quantum computing: Complex Numbers - Linear Algebra - Matrices and Operators - Global Perspectives Postulates of Quantum Mechanics – Quantum Bits – Representations of Qubits – Superpositions	7
Unit II	Quantum Gates and Circuits: Universallogicgates-Basicsinglequbitgates-Multiplequbitgates-Circuit development- Quantum error correction	6
Unit III	Quantum Algorithms: Quantum parallelism - Deutsch's algorithm - The Deutsch–Jozsa algorithm - Quantum Fourier transform and its applications - Quantum Search Algorithms: Grover's Algorithm	7
Unit IV	Quantum Information Theory: Data compression - Shannon's noiseless channel coding theorem - Schumacher's quantum noiseless channel coding theorem - Classical information over noisy quantum channels	7
Unit V	Quantum Cryptography: Classical cryptography basic concepts - Private key cryptography - Shor's Factoring Algorithm- Quantum Key Distribution -BB84-Ekart 91	6
Unit VI	Quantum computing applications for Internet of Things: Network optimisation in IoT using QC, faster computation at IoT end points/IoT nodes etc, Securing IoT using QC, basic concepts of quantum computing	7
	TOTAL	**40 hrs**

Text Books:

1. Parag K Lala, Mc Graw Hill Education, "Quantum Computing, A Beginners Introduction", First edition (1 November 2020).
2. Michael A. Nielsen, Issac L. Chuang, "Quantum Computation and Quantum Information", Tenth Edition, Cambridge University Press, 2010.

Reference Books:

1. Scott Aaronson, "Quantum Computing Since Democritus", Cambridge University Press, 2013.
2. N. David Mermin, "Quantum Computer Science: An Introduction", Cambridge University Press, 2007.
3. Chris Bernhardt, The MIT Press; Reprint edition (8September 2020), "Quantum Computing for Everyone".

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7IIoT03 Professional Elective - III: (iv) FUZZY LOGIC & GENETIC ALGORITHM

Course Pre-requisite: 3IIoT01 Engineering Mathematics-III
6IIoT03 Embedded Systems & RTOS

Course Objectives:

1. To Understand Basic concepts of Fuzzy logic theory.
2. To Understand the Fuzzy logic and Member Functions.
3. To explore Fuzzy Genetic Programming in IoT Systems.

Course Outcomes:

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

1. Understand the basics and architecture of Fuzzy logic systems.
2. Elaborate fuzzy set theory and membership functions.
3. Explore propositional logic and predicate logic in fuzzy system.
4. Elaborate the basics of fuzzy logic system and Membership function.
5. Comprehend the basic knowledge of genetic Algorithm.
6. Apply the knowledge of Fuzzy Genetic Programming to IoT Systems.

	Subject: Fuzzy Logic & Genetic Algorithm	L
Unit I	Introduction: Basic Ideas and Concepts: Introduction, Definition and Terminology, Architecture of Fuzzy Logic systems, Characteristics of Fuzzy Logic Systems.	7
Unit II	Fuzzy Set Theory : Fuzzy vs crisp, Fuzzy sets, Memberships functions, Basic fuzzy set operations, Properties of Fuzzy sets, Fuzzy relations, Fuzzy Cartesian product, operations of Fuzzy relations.	6
Unit III	Fuzzy systems : Laws of Propositional logic, inference in propositional logic, predicate logic, interpretations of predicate, logic formula, inference in predicate logic, fuzzy logic, Fuzzy quantifiers and inference, Fuzzy rule based system.	7
Unit IV	Fuzzy Logic System: Introduction of Fuzzy logic, Membership Functions, Fuzzy logic Operators and Rules, applications with example.	6
Unit V	Introduction to Genetic algorithm: Fundamentals of Genetic Algorithms History, Basic Concepts, Creation of Off-springs, basic concepts of encoding, fitness function, reproduction.	7
Unit VI	Applications of Fuzzy Genetic Programming in IoT Systems: Smart home energy management using fuzzy genetic programming, Fuzzy Genetic Programming for Real-time IoT Data Processing.	7
	TOTAL	**40 hrs**

Text Books:

1. Ulrich Bodenhofer**, "Genetic AlgorithmsTheory and Applications"**LectureNotesThird Edition—Winter 2003/2004"
2. S. Rajesekaran, G. A. Vijayalakshmi Pai: "Neural Network, Fuzzy logic, and Genetic algorithms Synthesis and Applications" PHI.

Reference Books:

1. S.N.Sivanandam & S.N.Deepa,"Principles of Soft Computing", 2nd edition, Wiley India, 2008.
2. David E.Goldberg,"Genetic Algorithms-In Search, optimization and Machine learning", Pearson Education.

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7IIOT04- Professional Elective –IV (i) Advanced RISC Architecture

Course Pre-requisite: 5IIoT02 Microcontrollers & Applications
6IIoT03 Embedded System & RTOS

Course Objectives:

1. Understand the fundamental principles and design philosophies of RISC architecture.
2. Comprehend the concepts of pipelining, superscalar execution, and branch prediction in Microcontroller.
3. Explore fundamental concepts of memory hierarchies and cache in RISC systems.
4. Explore the applications of RISC processors in real-world systems, including IoT, edge computing, and embedded systems.

Course Outcomes:

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

1. Explain the core principles and advantages of RISC architecture.
2. Discuss the performance features such as pipelining and instruction-level parallelism.
3. Elaborate the optimization of memory systems, including caches and virtual memory, for RISC processors.
4. Explain the architecture and advanced features of ARM Microcontroller.
5. Apply the RISC instructions sets for development of coding for embedded and high-performance computing applications.
6. Elaborate modern RISC architectures like ARM, RISC-V, and MIPS in terms of performance, power, and cost.

	Subject: ADVANCED RISC ARCHITECTURE	**L**
Unit I	Introduction to RISC architecture: Definition and overview of RISC, Comparison of RISC and CISC, Characteristics of RISC architecture, Importance of Instruction set design: Simplification and generalization, Early RISC architectures features and evolution, Performance metrics in RISC systems.	7
Unit II	RISC Pipeline Architecture: Fundamentals of pipelining in RISC architectures, Types of hazards: Data, control, and structural, Techniques to resolve pipeline hazards, Superscalar pipelines and dynamic scheduling, Pipeline performance: Metrics and optimization.	7
Unit III	Memory Hierarchy and Management: Registers, cache, main memory, Cache organization and optimization in RISC systems, Virtual memory concepts and address translation, Direct Memory Access (DMA) in RISC systems.	7
Unit IV	Modern RISC Architectures: Introduction to ARM architecture: Features and applications.	6
Unit V	ARM instruction sets and programming model, ARM pipeline architecture and performance optimization.	7
Unit VI	Applications of RISC systems: Real-world applications of RISC processors, RISC in edge computing and IoT applications.	7
	TOTAL	41

Text Books:

1. Patterson, D. A., & Hennessy, J. L. *Computer Organization and Design RISC-V Edition*.
2. Furber, S. *ARM System-on-Chip Architecture*.

References:

1. Hennessy, J. L., & Patterson, D. A. *Computer Architecture: A Quantitative Approach*.
2. Waterman, A., &Asanović, K. *The RISC-V Reader: An Open Architecture Atlas*.
3. Sloss, A. N., Symes, D., & Wright, C. *ARM System Developer's Guide*.

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7IIoT04 Professional Elective - IV: (ii) BIG DATA ANALYTICS

Course Pre-requisite: 3IIoT03 Object oriented Programming
4IIoT03 GNU Linux operating System.
5IIoT03 Python Programming

Course Objectives:
1. To enrich students with the Big Data concept and provide an overview of Apache Hadoop.
2. To explain the concepts and interfacing of HDFS.
3. To explain the concept of Map Reduce Jobs and hands on Hadoop Eco System and provide exposure to Data Analytics with R.

Course Outcome:
After successful completion of the course, students will be able to:
1. Understand the concept of Big Data and its implications in modern business environments.
2. Explain the components of Hadoop its Ecosystem and their functionalities.
3. Demonstrate the ability to access and process data stored on a Distributed File System (HDFS).
4. Understand how to manage and monitor job execution in a Hadoop environment effectively and apply Hadoop Ecosystem tools to develop and implement Big Data solutions.
5. Analyze and Evaluate Big Data recommendations using Infosphere Big Insights.
6. Apply machine learning techniques using R to real-world data analytics solutions.

	Subject: BIG DATA ANALYTICS	**L**
Unit I	**Introduction to Big Data and Hadoop:** Types of Digital Data, Introduction to Big Data, Big Data Analytics, Business Implications of Big Data, History of Hadoop and Apache Hadoop.	7
Unit II	**UNIT II: Hadoop Fundamentals:** Analysing Data with Unix Tools, Analyzing Data with Hadoop, Hadoop Streaming, Hadoop Ecosystem Overview, introduction to IBM Big Data Strategy.	7
Unit III	**Hadoop Distributed File System (HDFS):** The Design of HDFS, HDFS Concepts, Command-Line Interface for HDFS, Hadoop File System Interfaces, Data Flow in HDFS, Data Ingestion with Flume and Sqoop, Hadoop Archives, Hadoop I/O: Compression, Serialization, Avro, and File-Based Data Structures.	7
Unit IV	**Map Reduce Framework:** Anatomy of a Map Reduce Job Run, Handling Failures in Map Reduce, Job Scheduling in Map Reduce, Shuffle and Sort Mechanisms, Task Execution in Map Reduce, Map Reduce Types and Formats, Map Reduce Features.	7
Unit V	**Hadoop Ecosystem Tools:** **Pig-**Introduction to Pig, Execution Modes of Pig, Comparison of Pig with Databases, Grunt Shell, User-Defined Functions (UDFs), Data Processing Operators. **Hive-**Hive Shell and Services, Hive Meta store, Comparison with Traditional Databases, HiveQL, Tables and Querying Data, User-Defined Functions **HBase-**HBase Basics and Concepts, H Base Clients and Examples.	8
Unit VI	**Data Analytics with R and Machine Learning:** Introduction to Machine Learning, Supervised Learning, Unsupervised Learning, Collaborative Filtering, Big Data Analytics with BigR.	6
	Total	42 hrs

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Text Books:
1. Tom White " Hadoop: The Definitive Guide" Third Edit on, O'reily Media, 2012.
2. Seema Acharya, SubhasiniChellappan, "Big Data Analytics" Wiley 2015.

Reference Books:
1. Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007.
2. Jay Liebowitz, "Big Data and Business Analytics" Auerbach Publications, CRC press (2013)

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7IIoT04 Professional Elective - IV: (iii) EDGE COMPUTING

Course Pre-requisite: 5IIoT01 Communication Network
5IIoT03 Python Programming language

Course Objectives:
1. Introduce students to edge computing concepts and technologies and their applications.
2. Conceptualize and model a basic edge-based solutions and IoT service structures.
3. Enrich students with the differences and interoperability between edge computing and other computing technologies.
4. Explore students to IIoT devices, platforms, and networks in context of Artificial Intelligence and block chains.

Course Outcomes:
After completion of the course students will able to:

1. Understand the core principles and architectures of various Computing techniques.
2. Discuss the different network topologies and connectivity models in AI&ML.
3. Comprehend the knowledge of emerging technologies like 5G**,** Mobile Edge Computing**,** Network Slicing**,** and Blockchain on Edge Computing
4. Apply **Edge Computing** concepts to real-world applications, such as Industry 4.0 **and** IoT integration**.**
5. **Understand the challenges of** data confidentiality **and** privacy **in** Edge Computing **along with security practices.**
6. **Explore the role of** Edge Computing **in** Industrial IoT (IIoT).

	Subject: EDGE COMPUTING	**L**
Unit I	**Fundamentals of Edge Computing** Distributed systems and edge computing core concepts, Edge computing architectures, IoT devices and edge computing in IoT gateways, Edge computing interfaces, Edge computing vs cloud computing vs fog computing,	8
Unit II	**Edge Computing Networks** Network topologies and connectivity, Edge servers and other devices, Sealing, Tiered network architecture, Data transmissions in edge networks, Edge networks vs cloud networks vs fog networks.	7
Unit III	**Network advancements and Edge Computing** 5G technologies, Mobile edge computing, Network slicing, Software-defined clouds. **Block chain and Edge Computing:** Introduction to block chain, Types of block chain, Block chain architecture.	7
Unit I	**Edge Computing Case studies** Edge computing in Industry 4.0, IoT service architectures and devices, Edge computing integrated with block chain: concepts and applications, Intelligent IoT applications**.**	7
Unit V	**Infrastructure and Application Security** Threat modelling and common security issues, Physical and device-level security, Logical security, Application security, Scaling edge computing security with block chain technologies.	7
Unit VI	**Industrial IoT (IIoT)** Basics of Industrial Edge computing, IIoT and digital transformation across Industry 4.0 sectors, IIoT devices, platforms, and networks, Smart machines, Smart Factory architectures and protocols.	6
	TOTAL	**42 hrs**

Text Books:
1. Edge Computing: A Primer **by** Sudeep Tanwar, Rajkumar Buyya, and others
2. Edge Computing: A New Paradigm for the Internet of Things **by** Flavio Bonomi, Rodolfo Milito, Jiang Zhu, and Sateesh Addepalli

References:
1. Industrial Internet of Things (IIoT): Cybermanufacturing Systems **by** Sabina Jeschke, Christian Brecher, Houbing Song, and Dinesh C. Verma
2. Blockchain for Fog and Edge Computing **by** Mehmet S. C. (Editor)
3. Cloud and Fog Computing: Theory and Practices **by** J. P. (Jay) Singh and G. M. (Girish) Nair.

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7IIOT04 Professional Elective – IV: (iv) VIRTUAL REALITY

Course Pre-requisite: 1B4 Engineering Graphics
3IIoT03 Object Oriented Programming
5IIoT03 Python Programming

Course Objectives:
1. To understand the fundamental concepts, components, and technologies of Virtual Reality (VR) systems.
2. To explore the functionality of input and output devices in creating immersive experiences.
3. To study virtual modeling techniques, including geometric, kinematic, physical and behavior modeling.
4. To study the importance of human factors and safety issues applications in Virtual Reality systems.

Course Outcome:

After successfully completing the course, students will be able to:

1. Understand the basic concepts of Virtual Reality.
2. Elaborate the input devices like trackers, navigation systems, and gesture interfaces in VR.
3. Understand the output devices like displays and sound for immersive experiences.
4. Develop virtual models using geometric, kinematic, physical, and behavior modeling.
5. Understand human factors, safety, and health considerations in VR.
6. Apply VR concepts to real-world applications and analyze trends like AR/VR integration and AI.

	Subject: Virtual Reality	L
Unit I	**Introduction to Virtual Reality:** Definition and Overview of Virtual Reality, The Three I's of Virtual Reality: Immersion, Interaction, and Imagination, Commercial VR Technology, The Five Classic Components of a VR System.	6
Unit II	**Input Devices:** Trackers: Three-Dimensional Position Trackers, Navigation Interfaces Manipulation Interfaces, Gesture Interfaces in VR.	6
Unit III	**Output Devices:** **Graphics Displays:** Graphics Displays Overview, The Human Visual System, Personal Graphics Displays, Large-Volume Displays **Sound Displays:** The Human Auditory System, The Convolvotron, Speaker Based Three-Dimensional Sound.	7
Unit IV	**Modeling:** Geometric Modeling, Kinematics Modeling, Physical Modeling, Behavior Modeling, Model Management.	6
Unit V	**Human Factors in Virtual Reality:** Methodology and Terminology in Human Factors, User Performance Studies in VR, VR Health and Safety Issues	6
Unit VI	**Applications of Virtual Reality:** Entertainment and Gaming, Education and Training Simulations, Medicine and Healthcare, Engineering and Design,Military and Aerospace Applications.	7
	Total	**38 hrs**

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Text Books:

1. Gregory C. Burdea& Philippe Coiffet, -Virtual Reality Technology, Second Edition, John Wiley & Sons, Inc.,
2. Andrew Davison, - Killer Game Programming in Java—, Oreilly-SPD, 2005.

Reference Books:

1. Understanding Virtual Reality, interface, Application and Design, William R.Sherman, Alan Craig, Elsevier(Morgan Kaufmann).
2. Bill Fleming, -3D Modeling and surfacing -, Elsevier(Morgan Kauffman).

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SEMESTER VII

8IIoT01 Industry 4.0 and IoT Applications

Course Pre-requisite: 5IIoT05 OE-I(iii) Industry 4.0

Course Objectives:

1. To understand the business perspective and hardware used in Industry 4.0.
2. To study the need of machine learning and various IoT Layers.
3. To study the Hands-on on cloud computing technologies.
4. To Understand the implementation of IoT for smart manufacturing for the need of Industry 4.0.

Course Outcomes:

After successfully completing the course, students will be able to:

1. Elaborate the concept of Industry 4.0 for Smart Manufacturing and its scope.
2. Explain Design thinking principles and its usage for problem solution.
3. Comprehend the knowledge of various tools and technologies of cloud computing.
4. Understand the concepts of Augmented Reality and virtual Reality.
5. Understand the concept of design thinking and problem solving processes.
6. Discuss the Industry process in IoT and security concepts in Industry 4.0.

	Subject: Industry 4.0	L
Unit I	**Introduction to 4.0 Industry:** Introduction to Sensing & Actuation, Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected business perspective.	7
Unit II	**Industry 4.0:** Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Life cycle Management, Big Data and Advanced Analysis.	7
Unit III	**Cloud Computing Technologies:** Introduction to Cloud Technologies, Study of top cloud services providers platforms and their real life use cases exploration.	7
Unit IV	**Augmented Reality and Virtual Reality:** Introduction to AR and VR, applications of AR and VR in Industry.	6

Unit V	**Design Thinking as a Problem-Solving Process:** Principles of Design Thinking and process for design thinking problem solution .	6
Unit VI	**Basics of Industrial Internet of Things(IIOT):** Introduction to Industrial Internet system, Industrial process, Key enablers of IIOT, basics of Cyber Security in Industry 4.0	7
	Total	**40 hrs**

Text Books:
1. The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistics By Christoph Jan Bartodziej.
2. Industry 4.0: Entrepreneurship and Structural Change in the New Digital Landscape, By Springer.

Reference Books:
1. Virtual and Rapid Manufacturing: Advanced Research in Virtual and Rapid Prototyping, By Bartolo, P J, Taylor and Francis.
2. Rapid Manufacturing: An Industrial Revolution for a Digital Age By Hopkinson, N, Haque, R., and Dickens, P., Wiley.

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8IIOT02– WIRELESS SENSOR NETWORKS

Course Requisite: 4IIoT04 Wireless Communication

Course Objectives:
1. To Explore the basic concepts, challenges and architecture of Wireless Sensor Network (WSN).
2. To comprehend the knowledge of advance technology in Wireless Sensor Network.
3. To understand use of routing, MAC Protocols and study protocols at various layers.
4. To learn the process of Data storage, traffic and data management techniques in WSN's.

Course Outcomes:
After successful completion of the course, students will be able to -
1. Discuss the basic concepts and Architecture of Wireless Sensor Networks.
2. Explain Mobile Ad-hoc Networks and design principles of WSN Technology.
3. Elaborate different communication standards and transmission Technologies in WSN's.
4. Explore the Knowledge of various protocols in wireless Sensor Networks.
5. Elaborate the techniques used for data storage and management.
6. Elaborate the concepts and design principles for WSN's and internet communication.

	Subject: Wireless Sensor Networks	L
Unit-1	**Overview and Basics of WSN:** Introduction to Wireless Sensor Networks, WSN Architecture, Design Issues and challenges, Characteristics of WSN, Types of wireless sensor networks, Advantages, Applications of WSNs	06
Unit-2	**WSN Technology:** Mobile Ad-hoc Networks and Wireless Sensor Networks, Architectures of Sensor Network & node, Wireless Sensor Technology, Structure of WSN (topology only), Design principles for WSNs	07
Unit-3	**Wireless Transmission Technology:** Radio Technology, Deployment and Configuration: Localization and positioning, Coverage and connectivity, Single-hop and multi-hop localization, sensor management; Topology control, clustering protocols, transport protocols, security information assurance protocols.	07
Unit-4	**WSN Routing protocols:** Basics of WSN Routing and its challenges, design issues and routing strategies in WSN, Energy-efficient routing, Unicast, Broadcast and multicast geographic routing; MAC Protocols: Classification, Issues in designing MAC protocol for WSNs.	07
Unit-5	**Data Storage and management:** Data centric and content based routing, storage and retrieval in network, compression technologies for WSN, Applications: Detecting unauthorized activity using a sensor network, WSN for Habitat Monitoring.	07
Unit-6	**WSN Traffic Management:** Design Principles for WSNs, Gateway Concepts and need for gateway, WSN to Internet Communication, and Internet to WSN Communication, Hardware components & design constraints.	06
	Total	**40**

Text Books:
1. Kazem Sohrby, Daniel Minoli, 'Wireless Sensor Networks: Technology, Protocols and Applications', Wiley-Inter Science
2. Waltenegus Dargie, Christian Poellabauer, 'Fundamentals of Wireless Sensor Networks Theory and Practice', John Wiley & Sons Publications, 2011

Reference Books:
1. SabrieSoloman, 'Sensors Handbook', McGraw Hill Publication, 2009
2. Feng Zhao, Leonidas Guibas, 'Wireless Sensor Networks', Elsevier Publications, 2004
3. Philip Levis, David Gay, 'TinyOS Programming', Cambridge University Press, 2009.

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8IIoT03 ECONOMICS FOR ENGINEERS

Course Pre-requisite: 1A1 Engineering Mathematics-I
4IIoT05 Social Science

Course Objectives:
1. To provide knowledge of basic economic concepts and understand firm objectives in engineering economics.
2. To impart knowledge of demand determinants and cost concepts in engineering economics.
3. To explain and sensitize students to accounting concepts, Indian economy, globalization, privatization and role of banking and economic policies.

Course Outcomes:
After successfully completing the course, students will be able to:
1. Understand basic functions of Economics for engineers.
2. Comprehend the knowledge of various firms and their need in economics.
3. Elaborate the demand theory and its characteristics.
4. Understand different cost concepts used in economics.
5. Explore the concept of accounting for systems.
6. Explore Indian Economy and Globalization.

	Subject: ECONOMICS FOR ENGINEERS	**L**
Unit I	**Introduction to Engineering Economics:** Definition and Functions of Economics, Scope of Engineering Economics, The Basic Economic Problem, Relationship Between Science, Engineering, Technology, and Economics	7
Unit II	**Firms and Their Objectives:** Theories of Maximization: Profit Maximization, Growth Maximization, Sales Revenue Maximization, Utility Maximization, Wealth Maximization	7
Unit III	**Theory of Demand:** Demand Schedule, Nature and Characteristics of Demand, Law of Demand and Its Limitations **Elasticities of Demand:** Price Elasticity, Income Elasticity, Cross Elasticity **Demand Forecasting**: Definition, Factors Determining Demand Forecasting, Methods of Demand Forecasting	7
Unit IV	**Cost Concepts** Types of Costs: Fixed Cost, Variable Cost, Average Cost Marginal Cost, Real Cost, Opportunity Cost, Accounting and Economic Cost , Cost-Volume Profit Analysis, Break-Even Analysis.	7
UNIT V	**Accounting Concepts** Overview of Accounting Concepts, Double Entry System, Journal, Ledger, and Trial Balance, Final Accounts Bookkeeping System **Depreciation**: Definition and Functions, Methods of Depreciation: Straight Line, Declining Balance, Sum of Years Digits Method	7
Unit VI	**Indian Economy and Globalization** Nature and Characteristics of the Indian Economy Banking: Meaning and Functions of Commercial Banks, Functions of RBI, Globalization and Privatization: Meaning, Merits, and Demerits. **Elementary Concepts**: WTO, GATT, TRIPS, Monetary Policy and Fiscal Policy.	7
	Total	**42**

Text Books:
1. Riggs, Bedworth and Randhwa, Engineering Economics, McGrawhill Education India.
2. S.C.Sharma and T.R.Banga, Industrial Organisation and Engineering Economics, Khanna Publishers.
3. S.K.Misra and V.K.Puri, Economic Environment of Business, Himalaya Publishing House,2003.

References:
1. Singh A and Sadh A.N., Industrial Economics , Himalaya Publishing House , Bombay.
2. H.L.Ahuja, Managerial Economics,S.Chand Publishing ,2007 Ediction 3. Datt&Sundharam, Indian Economy , S.Chand Publishing, 2014 Edition.

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8IIOT04 - Professional Elective –V (i) CRYPTOGRAPHY AND NETWORK SECURITY

Course Pre-requisite: 1B1- Engineering Mathematics-II
5IIoT01- Communication Network

Course Objectives:
1. Make students aware of the principles of security, threats and attack mechanisms in network security.
2. Enrich students with network security protocols to ensure secure communication while upholding ethical and legal standards in cyber security.
3. Enable students to implement cryptographic techniques including DES,AES,RSA and DIFFIE-Hellman.

Course Outcomes:
Upon successful completion of this course, students will be able to:
1. Understand the principles of security and cryptographic techniques to identify various types of attacks.
2. Elaborate the symmetric key ciphers algorithms for secure communication.
3. Discuss public key cryptosystems and different types of asymmetric algorithms.
4. Explain the various types of cryptographic data integrity algorithms.
5. Elaborate the network security applications to ensure data protection.
6. Understand intrusions and intrusion detection to promote ethical practices in information security.

	Subject: Cryptography and Network Security	**L**
UNIT I	Introduction - Need for Security, Security Approaches, Principles of Security, Security services, Types of security Attacks, a model for network security cryptography concepts and techniques: introduction, plain text and cipher text.	7
UNIT II	Symmetric key Ciphers: Block Cipher principles, DES, AES, Blowfish, IDEA, Block cipher operation, Stream ciphers.	6
UNIT III	Asymmetric key Ciphers: Principles of public key cryptosystems, RSA algorithm, Diffie-Hellman Key Exchange, Knapsack Algorithm.	6
UNIT IV	Cryptographic Hash Functions: Message Authentication, Secure Hash Algorithm (SHA-512), Message authentication codes: Authentication requirements, HMAC, CMAC, Digital signatures.	6
UNIT V	**Transport-level Security:** Web security considerations, Secure Socket Layer and Transport Layer Security, HTTPS, Secure Shell (SSH).	6
UNIT VI	**E-Mail Security:** Pretty Good Privacy, S/MIME IP Security: IP Security overview, IP Security architecture, Authentication Header, Internet Key Exchange.	7
	Total	**38**

Text Books:
1. Atul Kahate, Cryptography and Network Security, 4th Edition,2019
2. William Stallings, Cryptography and Network Security: Principles and Practices, 7th Edition,2019 .

References:
1. Nina Godbole and Sunit Belapure, Cyber Security, 1st edition, 2019.

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8IIOT04 Professional Elective -V (ii) DIGITAL IMAGE PROCESSING

Course Requisite: 4IIoT02 Introduction to Signal Processing.
Course Objectives:
1. Fundamentals of digital Image and transform methods used in digital image processing
2. Image enhancement and Image restoration techniques used in digital image processing
3. Image compression methods and Segmentation used in digital image processing.

Course Outcomes:
On completion of this module the student will be able to:

1. Understand the general terminology of digital image processing.
2. Explore various types of images, intensity transformations and spatial filtering.
3. Elaborate the Fourier transform for restoration in frequency domain.
4. Explore the methodologies for image Compression.
5. Comprehend the knowledge of image segmentation in Digital image processing.
6. Elaborate the video processing and its applications.

	Subject: DIGITAL IMAGE PROCESSING	L
UNIT I	**Digital Image Fundamentals:** Introduction to digital image processing: Digital Image Fundamental, Elements of Visual Perception, Simple Image Model, Sampling and Quantization, Basic Relationships between Pixel Imaging Geometry, Gray scale image representation.	7
UNIT II	**Image Enhancement:** Basic Techniques, Enhancement by point processing, Spatial Filtering, Enhancement in Frequency domain, histogram based processing, homomorphic filtering.	6
UNIT III	**Image Restoration:** Degradation model, Inverse filtering, Weiner (CNS) filtering Restoration in Spatial domain, Basic morphological concept, morphological principles, binary morphology, Basic concepts of erosion and dilation.	7
UNIT IV	**Image Compression:** Fundamentals, Image compression models, Elements of Information theory, Lossy and predictive methods, vector quantization, Huffman coding, and lossless compression, compression standards.	6
UNIT V	**Image Segmentation**: Detection of discontinuities, Edge Linking and boundary detection, Threshold, Regional oriented Segmentation.	6
UNIT VI	**Fundamentals of Video Processing** : Applications of Digital image processing, Time-Varying Image Formation model, fundamentals of Three-Dimensional Motion Model, Sampling of Video signals in spatial domain, formats of video signals.	7
	Total	**39**

Text Books:
1. Gonzalez and Woods, “Digital Image Processing”, Addison / Wesley.
2. A. K. Jain, “Digital Image Processing”, PHI.

References:
1. Sanjay Sharma, “Digital Image Processing”, S. K. Katariya& Sons, New Delhi.
2. William K. Pratt, “Digital Image Processing”, 3rd ed., John Wiley and Sons Publications.

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8IIoT04 Professional Elective -V: (iii) Robotics

Course Pre-requisite:

1SA3 Applied Physics
1A1 Applied Mathematics-I
5IIOT03 Python Programming
5IoT04 PE(iv)Data Structure and Algorithm

Course Objectives:
1. To introduce the functional elements of Robotics and Understand the Basics of Robotics
2. To impart knowledge on the direct and inverse kinematics and Learn the Working Components of Robot
3. To introduce the dynamics and control of manipulators and Develop Path Planning Techniques for Robots
4. To introduce concept of dynamics and Control of Robotic Systems in Industry.

Course Outcomes:
After completion of the course students will able to
1. Understand basic concept of Robotics.
2. Explore instrumentation systems and its applications for Components used in Robotics.
3. Elaborate Robot Kinematics and Dynamics.
4. Explore path planning techniques in Robotics.
5. Explain the dynamics and control in robotics industries.
6. Elaborate the applications of Robotics in different industrial environments.

	Subject: Robotics	L
Unit I	INTRODUCTION TO ROBOTICS Basics - Types - Mobility - Terrain - Components Classification and Performance Characteristics	6
Unit II	WORKING COMPONENTS FOR ROBOTS Drives-basic concepts of Electric-Hydraulic and Pneumatic Drives, Tactile sensors, Proximity and Range Sensors, Acoustic Sensors, Segmentation, Feature Extraction, introduction to Object Recognition.	7
Unit III	ROBOT KINEMATICS AND DYNAMICS Kinematics of Manipulators, Rotational, Translation and Transformation, Homogeneous Transformation, Inverse Kinematics - Linearization of Robot Dynamics.	6
Unit IV	PATH PLANNING Definition, Joint space technique, Use of p-degree polynomial, Cubic polynomial-Cartesian space technique, Parametric descriptions, Straight line and circular paths, Position and orientation planning.	7

Unit V	DYNAMICS AND CONTROL Lagrangian mechanics, 2DOF Manipulator, Lagrange Euler formulation, Dynamic model, Manipulator control problem, Linear control schemes, PID control scheme.	6
Unit VI	APPLICATION OF ROBOTS Industrial Automation, Robots for Nuclear-Thermal and Chemical Plants, Typical Examples of Automated Industries.	6
	Total	**38 hrs**

Text Books:

1. R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2. JohnJ.Craig ,Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.

References:

1. Ashitava Ghoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press, Sixth impression, 2010.
2. K. K.AppuKuttan, Robotics, I K International, 2007.
3. Edwin Wise, Applied Robotics, Cengage Learning, 2003.
4. R.D.Klafter,T.A.Chimielewski and M.Negin, Robotic Engineering–An Integrated Approach, Prentice Hall of India, New Delhi, 1994.
5. B.K.Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers,Chennai, 1998.
6. S.Ghoshal, "Embedded Systems & Robotics" Projects using the 8051 Microcontroller", Cengage Learning, 2009.
7. M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.
8. Mikell P. Groover, "Industrial Robotics: Technology, Programming and Applications", 2012, 2nd Edition, McGraw-Hill Publishers.
9. John J.Craig, "Introduction to Robotics, Mechanics and Control", 2010, 3rd Edition, Pearson Education.

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8IIoT04 Professional Elective -: (iv) COMPUTER GRAPHICS

Course Prerequisite: 4IIoT03 Operating System,
5IIoT03 Python Programming
5IIoT04 (iv)Data Structure and Algorithm

Course Objectives:

1. To make students aware of basics of Computer Graphics and outline various 2D, 3D geometric transformations and viewing.
2. To introduce curves in computer graphics.
3. To enrich students with the knowledge and practical skills required to create and manipulate hierarchical 3D models using modern modeling techniques and tools.

Course Outcomes:

After completion of the course students will able to

1. Understand basics of graphics hardware and software.
2. Explore Geometric transformations on 2D objects.
3. Comprehend the knowledge of Geometric transformations on 3D objects.
4. Demonstrate visible surface detection methods used in computer Graphics.
5. Elaborate various models for color and shading in Computer Graphics.
6. Demonstrate the contribution of interactive simulation in hierarchical modeling.

	Subject: Computer Graphics	**L**
Unit I	**Introduction to computer graphics & graphics systems** Overview of computer graphics, storage tube graphics display, Raster scan display. Points & lines, Line drawing algorithms, DDA algorithm, fill algorithm, boundary fill algorithm, flood fill algorithm	7
Unit II	**2D transformation** Basic transformations: translation, rotation, scaling, Matrix representations & homogeneous coordinates, transformations between coordinate systems, reflection shear, Transformation of points, lines, parallel lines, intersecting lines.	7
Unit III	**3D transformations** Translation, rotation and scaling transformations. Rotation about an arbitrary axis in space, reflection through an arbitrary plane, general parallel projection transformation; clipping, viewport clipping.	7
Unit IV	**Curves** Curve representation, surfaces, designs, Bezier curves, B-spline curves, end conditions for periodic B-spline curves, rational B-spline curves.	6
Unit V	**Color& shading models** Light & colour model, interpolative shading model, Flat shading, Phong shading, Gouraud shading, Lambert lighting model, Phong lighting model, Blinn-Phong lighting model.	7

Unit VI	**Hierarchical Modelling** Basic Modelling Concepts, Modelling Packages, General Hierarchical Modelling Methods, Hierarchical modelling using OpenGL display List	6
	Total	**40 hrs**

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Text Book: Donald Hearn and Pauline Baker, "Computer Graphics with OpenGL", Fourth Edition, Pearson Education, 2013.

Reference Books:

1. F.S. Hill, "Computer Graphics using OpenGL", Third Edition, Pearson Education, 2006.
2. John F. Hughes, Andries van Dam, Morgan McGuire, David F. Sklar, James D. Foley, Steven K. Feiner, Kurt Akeley, "Computer Graphics- Principles and practice", Third Edition in C, Pearson Education, 2013.

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