Fifth Semester					
Theory					
Sl. No.	Category	Subject Code	Subject Name	L-T-P	Credit
1	PCC-6	22CT5PC01T	Formal Language and Automata Theory	3-0-0	3
2	PCC-7	22CT5PC02T	Operating System	3-0-0	3
3	PCC-8	22CT5PC03T	Python Programming	3-0-0	3
4	PEC-2	Professional Elective-2:			
		22CT5PE01T/ 22CT5PE02T/ 22CT5PE03T/ 22CT5PE04T/ 22CT5PE05T/ 22CT5PE06T/ 22CT5PE07T/ 22CT5PE08T/	Knowledge Discovery and Data Mining/ Advance Computer Architecture/ Mobile App Development/ Artificial Intelligence/ Introduction to Graph Theory Wireless Sensor Network Blockchain Technology Soft Computing	3-0-0	3
5	OEC-1	Open Elective-1:(For CST Students)			
		22ME5OE01T 22ME5OE02T 22EC5OE01T 22EC5OE02T 22CE5OE01T 22EE5OE01T 22EE5OE04T	Engineering Management Micro Electro-Mechanical Systems (MEMS) VLSI Design Microprocessor and Interfacing Building Services and Maintenance Renewable Energy Systems Introduction to Electrical Properties of Materials	3-0-0	3
		Open Elective-1: (For OtherBranch Students)			
		22CT5OE01T	Introduction to Python Programming		
6	OEC-2	Open Elective-2: (ForCST Students)		3-0-0	3
		22ME5OE03T 22ME5OE04T 22EE5OE02T 22EE5OE03T 22CE5OE03T 22EC5OE03T 22EC5OE04T	Smart and Intelligent Materials Nanoscience and Technology Sensor and Instrumentation Smart Grids Geo-Environmental Engineering Embedded System Design Radar System Engineering		
		Open Elective-1: (For Other Branch Students)			
		22CT5OE02T	Database Management System		

7	MC	Mandatory Course:		3-0-0	0
		22CM5MC01T 22CM5MC02T	Constitution of India/ Essence of Indian Tradition Knowledge		
Total Credit (Theory)					18
Practical					
1	PCC-6	22CT5PC01L	PCC Lab-6: Formal Language and Automata Theory Laboratory.	0-0-2	1
2	PCC-7	22CT5PC02L	PCC Lab-7: Operating System Laboratory	0-0-2	1
3	PCC-8	22CT5PC03L	PCC Lab-8:Python Programming Laboratory.	0-0-2	1
4	PSI	22CM5PS01L	Summer Internship / Summer Training / MOOC Certification	0-0-2	1
Total Credit (Practical)					4
Total Semester Credit					22

22CT5PC01T	Formal Language and Automata Theory(3-0-0)	3Credits

Course Objective

1. Identify different formal language classes and their relationships.
2. Design grammars and recognizers for different formal languages.
3. Prove or disprove theorems in automata theory using its properties.
4. Determine the decidability and intractability of computational problems.

Module-1: **[8 Hrs]**

Alphabet, string, Language, Finite representation of Language. Finite Automata: Deterministic & Non Deterministic Finite Automaton. Language accepted by DFA & NFA, ƐNFA. Equivalence of NFA and DFA, constructing NFA to equivalent DFA.Myhill-Neroda Theorem, Equivalent states & Minimized DFA, Examples.

Module-2: **[10 Hrs]**

Grammar: Representation, Language generated by a grammar, Chomsky Hierarchy, Context Free Grammar, Normal Forms – CNF/GNF. Regular Language & Closure Properties of RL. Identifying Non-regular language: Using Pigeonhole principle and using A pumping Lemma. Regular Expression. Language associated with Regular Expression & associated operators, Closure Properties. Regular Grammar.Equivalence of Regular Language, Arden's theorem, Regular expression and Regular Grammar.

Module-3: **[7 Hrs]**

Pushdown Automata. Language accepted by PDA (by going to final state & emptying stack). Context-free grammar to PDA.Pumping Lemma for CFL.Closure properties and decision algorithm for CFL.

Module-4: **[7 Hrs]**

Turing machine.Turing machine as language acceptors. Single tape and multitape Turing machines. Nondeterministic Turing machine, Universal Turing machine and Linear Bounded Automata.Rice's Theorem (No Proof).

Module-5: **[8 Hrs]**

Computability and decidability.The Turing machine halting problem.Turing machine models and complexity classes.Cook's theorem (No Proof). Some NP problems and their language representation: SAT, 3-SAT, Graph colorability, Hamiltonian Cycle, Vertex Cover Problem..

Course Outcome:

1. Able to understand the concept of abstract machines and their power to recognize languages.

2. Able to employ finite state machines for modeling and solving computing problems.
3. Able to design context-free grammars for formal languages.
4. Able to distinguish between decidability and undecidability.
5. Able to gain proficiency with mathematical tools and formal methods.

TEXTBOOKS:

1. An Introduction to Finite Languages and Automata – Peter Linz, Jones &Berlett, Fifth Edition, 2011
2. Introduction to Automata Theory, Languages, and Computation– Hopcroft, Ullman, Addison Wesley, 3rd Edition, Indian Reprint 2011

Reference Books:

1. Introduction to the Theory of Computation – Michael Sipser, Thompson, 2nd Edition, 2012
2. introduction to Languages and the Theory of – John Martin, McGrawhill, Second Edition, Indian Reprint 2013.

Digital Learning Resources

Course Name	Theory of Automata, Formal Languages and Computation
Course Link	https://nptel.ac.in/courses/106/106/106106049/
Course Instructor	Prof.KamalaKrithivasan, IIT Madras

22CT5PC02T	Operating System(3-0-0)	3 Credits

COURSE OBJECTIVES:

1. Recognize the concepts and principles of operating systems.
2. Provide comprehensive introduction to understand the underlying principles, techniques, and approaches which constitute a coherent body of knowledge in operating systems.
3. Teach understanding how the various elements that underlie operating systems interact and provide services for execution of application software.

Module-1: **[10 Hrs]**

Overview of operating systems: computer system organization, computer system architecture, operating system operations. Need of Process/Memory/Storage Management, Protection and security, Distributed systems, Real-Time Embedded Systems. Operating systems services, User-Operating System Interface, System calls and its types, operating system structure.

Process Concept: Process Scheduling; Operations on Processes; Interprocess Communication; Thread; Multithreading models.

Module-2: **[10 Hrs]**

Scheduling Criteria, Algorithms (FCFS, SJF, SRTF, Round Robin, Priority, Multi-level Queue and Feedback Queue), Thread scheduling.

The Critical-section problem, Peterson's Solution, Synchronization Hardware, Semaphores, Classical problems of synchronization, monitors.

Module-3: **[14 Hrs]**

System model; Deadlock Characterization; Methods for Handling Deadlock (Deadlock prevention, detection, and Avoidance, recovery);

Swapping; Contiguous memory allocation; Paging; Structure of the page table; Segmentation;

Virtual memory, demand paging, Copy-on-write, page-Replacement algorithms (FIFO, LRU, LFU, Optimal Page Replacement).

Module-4: **[6 Hrs]**

File Concept: Access Methods, Directory Structure, FileSystem Mounting, File Sharing and Protection. File system structure, File System Implementation, Directory Implementation, Allocation Methods. Overview of Mass-storage structure, disk structure, disk attachment, disk scheduling, swap-space management.

Course Outcome:

1. Identify basic components of operating system.
2. Conceptualize synchronization amongst various components of a typical operating system.
3. Understand and simulate activities of various operating system components.
4. Correlate basic concepts of operating system with an existing operating system.

TEXTBOOK:

1. Abraham Silberschatz, Peter Baer Galvin & Greg Gagne - "Operating System Concepts", 8th edition, John Wiley & Sons

REFERENCE BOOKS:

1. William Stallings - "Operating Systems - Internals and Design Principles", 5th edition, Pearson.
2. Charles Crowley - "Operating Systems: A Design-Oriented Approach", Tata McGraw Hill Co., 1998 edition.
3. Andrew S. Tanenbaum - "Modern Operating Systems", 2nd edition, 1995, PHI (Prentice Hall of India).

Digital Learning Resources

Course Name	Operating System Fundamentals
Course Link	https://nptel.ac.in/courses/106/105/106105214/
Course Instructor	Prof.SantanuChattopadhyay IIT Kharagpur

22CT5PC03T	Python Programming (3-0-0)	3 Credits

Course Objective:

1. Identify/characterize/define a problem.
2. Design a program to solve the problem.
3. Create executable code.
4. Read most Python code and write basic unit tests.

Module-1: [10Hrs]

Features and History of python, Literal constants, variables and identifiers, data types,Inputoperations,comments,reservewords,indentation,operatorsandexpression operations on strings go, other data types, conditional branching statements, loop structures, break, continue, pass, else.

Functions definition, function call, variable scope and lifetime, return statement, more on defining functions, lambda functions, recursive functions, modules, packages in python, globals(), locals()and reload().

Module-2: [10Hrs]

Concatenating, appending and multiplying strings, string formatting operator, built in string methods and functions, slice operation, ord() and chr(), in and not in operations, comparing strings, iterating strings,stringmodule,match(),search() and sub(),findall()and finditer().

File handling: filepath, types of files, opening and closing files, reading and writing files, file position, renaming and deleting files, directory methods.

Data structures: sequence,lists, functional programming, tuple, sets, dictionaries

Module-3: [10Hrs]

Classes and objects: class methods and self-arguments, the _init_(), class variable and object variable, _del_(),public and private data members, calling a class method from another class method, built-in functions to set, get and delete class attributes ,Inheritance, types, composition or containership, abstract classes or interfaces

Operator overloading: implementing Operator overloading, reverse adding, overriding _getitem_()and_setitem_()methods,overridingtheinoperator,overloadingthemiscfunctions

Module-4: [10Hrs]

Error and exception handling: handling exceptions, multiple exception blocks, multiple exceptions in a single block, except block without exception, else clause, raising an exception, instantiating

exceptions, handling exceptions in invoked functions, built-in and user-defined exceptions, the finally block, predefined cleanup action

Demonstration of NumPy, Tensor Flow, and JAX.Demonstration of ML libraries like PyTorch, Keras, and Trax, and Demonstration of graph plotting using Matplotlib.

Course Outcome:

1. To understand why Python is a useful scripting language for developers.
2. To learn how to design and program Python applications.
3. To learn how to use lists, tuples, and dictionaries in Python programs.
4. To learn how to identify Python object types.

Textbooks

1. **Python Programming**, ReemaThareja, Oxford Publications
2. **Learning Python**, Mark Lutz, O'Reilly

Reference Books:

1. **Statistics and Machine Learning in Python Release 0.1**, EdouardDuchesnay, Tommy Löfstedt
2. **Python Data Analytics**, Fabio Nelli, Apress

Digital Learning Resources

Course name	Programming Data Structures and Algorithms in Python
Course Link	https://nptel.ac.in/courses/106/106/106106145/
Course Instructor	Prof.MadhavanMukund, Chennai Mathematical Institute

22CT5PE01T	Knowledge Discovery and Data Mining(3-0-0)	3Credits

Course Objectives

1. Identify the scope and necessity of Data Mining and Knowledge Discovery.
2. To understand various tools of Data Mining and their techniques to solve real-time problems.
3. To develop ability to design various algorithms based on data mining tools.
4. To develop further interest in research and design of new Data Mining techniques.

Module-1: [12Hrs.]

Knowledge Discovery in Databases (KDD) process: data integration, mining, and interpretation of patterns in large collections of data. Overall Architecture, Data Warehouse Database Sourcing, Data pre-processing techniques: Acquisition, Clean-up & Transformation Tools, Metadata data mining techniques for classification, regression, clustering, deviation detection, and association analysis; and evaluation of patterns mined from data.

Module-2: [10Hrs.]

Data Warehousing Component, Defining Features, data warehouses and data marts, overview of the components, metadata in the data warehouse. OLAP in the Data Warehouse: Demand for Onlineanalyticalprocessing,needformultidimensionalanalysis,OLAPdefinitionsandrules,OLAPcharacteristics,majorfeatures,dimensionalanalysis,hypercube.Drill-downandroll-up,slice-and-diceorrotation,OLAPmodels,overviewofMOLAPmodel,ROLAPmodel,ROLAPversusMOLAP.

Module-3: [12Hrs.]

Data Mining Basics: What is Data Mining, Data Mining Defined, The knowledge discovery process, OLAP versus data mining, data mining and the data warehouse, Major Data Mining Techniques, Cluster detection, decision trees, memory-based reasoning, link analysis, neural networks, DataMiningApplications,Benefitsofdataminginginindustry,bankingandfinance

Module-4 [6Hrs.]

Web mining: classifying webpages, extracting knowledge from the web, mining the World Wide Web, Spatial Data Mining, Multimedia Data Mining, Text Mining.

Course Outcome:

1. Identify and distinguish data mining applications from other IT applications
2. Describe data mining algorithms
3. Describe applicability of data mining
4. Suggest appropriate solutions to data mining problems

5. Analyze data mining algorithms and techniques
6. Work as a team in solving challenging data mining problems

TEXTBOOKS:

1. Jiawei Han, MichelineKamber, and Jian Pei - "Data Mining: Concepts and Techniques", Third Edition, Elsevier.
2. Data Warehousing, Data Mining & OLAP by Alex & Stephen, McGraw Hill.

Reference Books:

1. VikramPudi& P. Radha Krishna, Data Mining, Oxford University Press.
2. ReemaThareja, Data Warehousing, Oxford University Press.

Digital Learning Resources

Course Name	Data Mining
Course Link	https://nptel.ac.in/courses/106/105/106105174/
Course Instructor	Prof.PabitraMitra, IIT Kharagpur

22CT5PE02T	Advance Computer Architecture(3-0-0)	3Credits

Course Objective:

1. To make students know about the Parallelism concepts in Programming.
2. To give the students an elaborate idea about the different memory systems and buses.
3. To introduce the advanced processor architectures to the students.
4. To make the students know about the importance of multiprocessor and multicomputers.
5. To study about dataflow computer architectures.

Module-1: **[10Hrs.]**

Evolutionofarchitectures,RISCandCISCarchitectures,introductiontoParallelism,Flynn'sClassificatio n, Basic concepts of pipelining, linear & non-linear pipelining, data hazards, control hazards, and structural hazards, Techniques for overcoming or reducing the effects of various hazards.

Module-2: **[8Hrs]**

Instruction-level parallelism (ILP): Concepts of instruction-level parallelism, Techniques for increasing ILP; Superscalar, super pipelined, and VLIW processor architectures; SPARC and ARM processors; Array Processor and Vector Processors.

Module-3: **[10Hrs]**

Interconnection Networks: Network Topologies, Static Networks: 1D linear array, 2D ring, star, mesh, 2D mesh, 2D torus, 3D mesh, Hypercube: 3D & 4D Hypercube. Dynamic Networks: crossbar, Single-stage, multistage network: Clos, Benes, & Baseline network. Multiprocessor system interconnection, Multistage & combining networks.

Module-4: **[6Hrs]**

Distributed Memory Architecture, UMA, NUMA, Memory Interleaving, Multiprocessor cache Memory, Cache Consistency model, Directory-based cache coherence, Software distributed shared memory.

Module-5: **[6Hrs]**

Multi-scalar architecture, Multi-core Architectures, Multi-core Interconnect, Dynamic Core architectures, GPU-GPU Architecture, CPU-GPU Integration.

Course Outcome:

1. Demonstrate concepts of parallelism in hardware/software.
2. Discuss memory organization and mapping techniques.
3. Describe architectural features of advanced processors.
4. Interpret performance of different pipelined processors.
5. Explain dataflow in arithmetic algorithms.
6. Development of software to solve computationally intensive problems.

Text Books:

1. Kai Hwang, "Advanced Computer Architecture: Parallelism, Scalability, Programmability", 3rd Edition, McGraw-Hill, 2016.
2. K. Hwang and F. A. Briggs, "Computer Architecture and Parallel Processing", 2nd Edition, McGraw-Hill Education.
3. Flynn, Michael J., "Computer Architecture: Pipelined and Parallel Processor Design", Jones and Bartlett Publishers, ©1995.
4. [An Introduction to Multi-core Architectures, Multi-core Interconnect, Dynamic Core architectures](http://www.digimat.in/nptel/courses/video/106103183/106103183.html) [Last accessed on 08/05/2019].

5. [Introductory CUDA Technical Training Courses](https://developer.nvidia.com/educators/existing-courses-IntroductoryCUDATechnicalTrainingCourses) [Last accessed on 08/05/2019].
6. [A brief review of CUDA](https://nptel.ac.in/courses/106102114/27) [Last accessed on 08/05/2019].

Digital Learning Resources

Course Name	Advance Computer Architecture
Course Link	NPTEL::Computer Scienceand Engineering -NOC:Advancedcomputer architecture
Course Instructor	Prof.SmrutiR.Sarangi,IIT Delhi

Course Name	Advance Computer Architecture
Course Link	NPTEL::ComputerScienceandEngineering-NOC:AdvancedComputer Architecture
Course Instructor	Prof.JohnJose, IITGuwahati

22CT5PE03T	Mobile App Development (3-0-0)	3Credits

22CT5PE04T	Artificial Intelligence(3-0-0)	3Credits

Course Objective:

1. To learn the concepts of Artificial Intelligence.
2. To learn the methods of solving problems using Artificial Intelligence.
3. To introduce the concepts of Expert Systems and their design procedures.

Module-1:[12Hrs]

Intelligence and AI, Agents, Model of different types of agent: reactive, deliberative, goal-driven, utility-driven, and learning agents, Environment, Properties of Environment, State Space, Knowledge, Rationality, Turing Test. Search Techniques - definition and importance, uninformed search - DFS, BFS, iterative deepening, iterative broadening, depth-limited search, Issues in design of heuristics, Best First search, A* and AO* search, Hill climbing, Simulated Annealing, Constraint Satisfaction Problem, 8-puzzle problem, Cryptoarithmetic problem.

Module-2:[10Hrs]

Adversarial Search, Game Playing, min-max search, alpha-beta pruning.Knowledge Representation in AI, Logic - propositional, predicate, First Order Logic.Normal forms.Modus Ponens & Modus Tollens, Theorem Proving, Principle of Resolutions, Non-Monotonic Reasoning. Semantic Net, Frame.

Module-3:[12Hrs]

Planning and its importance. Classical & partial order planning, Conditional Planning. Uncertainty, types of uncertainty, Probabilistic Reasoning - joint distribution reasoning, Bayesian networks, learning, explanation-based learning, induction learning - Decision Tree, statistical learning - Bayesian learning, expectation maximization, hidden Markov model, closed world problems.

Module-4:[6Hrs]

Expert Systems – Design Techniques, components, Problem and knowledge domain, Knowledge engineering approach, error in design of expert system, lifecycle of expert system, MYCIN and DENDRAL – an expert system.

Course Outcome:

1. Ability to comprehend AI & ES to analyze and map real-world activities to digital world.
2. Ability to identify problems that are amenably solved by AI methods.
3. Ability to design and carry out an empirical evaluation of different AI algorithms.

Text Books:

1. Knight & Rich - "Artificial Intelligence", McGraw Hill, 3rd Edition.
2. N.J. Nilson - "Principles of Artificial Intelligence", 2nd Edition, Narosa Publishing.

Reference Books:

1. Russel&Norvig - "Artificial Intelligence: A Modern Approach", 2nd Edition, Pearson.
2. D.W. Patterson - "Introduction to Artificial Intelligence and Expert Systems", Prentice Hall.
3. Joseph Giarratano, Gary Riley - "Expert Systems: Principles and Programming".

Digital Learning Resources

CourseName	Artificial Intelligence and Expert Systems
CourseLink	://nptel.ac.in/courses/106106126/
CourseName	ArtificialIntelligence
CourseLink	https://nptel.ac.in/courses/106/105/106105079/
CourseInstructor	Prof.P.Dasgupta,IITKharagpur

22CT5PE05T	**Introduction to Graph Theory(3-0-0)**	**3 Credits**
22CT5PE06T	**Wireless Sensor Network(3-0-0)**	**3 Credits**
22CT5PE07T	**Blockchain Technology(3-0-0)**	**3 Credits**
22CT5PE08T	**Soft Computing(3-0-0)**	

Open Elective -1 (For CST Branch Students)

Course Code: 22ME5OE01T	Course Name: Engineering Management	L-T-P 3- 0-0	Credit 3

Course Objectives:

1. To provide an introduction to Engineering Management and exposure to forecasting methods, namely qualitative & quantitative methods .
2. Impart knowledge on the Aggregate Planning and Materials Requirement Planning?
3. Understand the principles/methods of Scheduling and Sequencing.
4. Understand the Maintenance Planning and Control and the methods for reliability improvement?
5. Impart knowledge on the Modern concepts/ techniques in operations management and Supply Chain management.

Syllabus

Module – I **[8 hours]**

Management and Organizations, Management process: Definition, planning organizing, directing, controlling, coordinating, types of management. Organization Definition, planning, design and development, types of organizations. Management planning and control: Classical, new classical and modern principles. General Management, scientific management, engineering, management, systems management.Planning: Procedures, resources and constraints, objectives, goals, policies and procedures. Control: Setting of reference or standards, appraisal or evaluation, monitoring and controlling, types of control.

Module – II **[7 hours]**

Human resource planning and management: selection, recruitment, training, retraining, skill development, competence development, promotion and career development, participative management, trade unions, and collective bargaining, Management of Physical Resources Plant: site selection procedures, factors affecting selection. Layout-types and relative merits and demerits, Maintenance-Objectives, different types of associated decisions, strategies for effective maintenance, computer applications. Material : Functions, objectives, planning and control including inventory models with or without storage costs, price break(excluding dynamic and probabilistic considerations). Different classes of inventory.Material Requirement Planning (MRP).

Module – III **[8 hours]**

Financial management: Introduction to standard forms of financial statements, i.e., balance-sheet, profit and loss, and income statement. Fixed and current asset items. Fixed and current liability items. Linkage of two successive balance-sheets through income or profit and loss statement. Funds flow statement. Financial ratios and their implications. Managerial economics: Concepts, theory of production, marginal productivity and cost. Introduction to theory of firm.

Module – IV **[7 hours]**

Quality management: Quality definition, quality planning, quality control and quality management, Total quality management, ISO 9000 systems, simple quality control techniques like control charts and acceptance sampling. Marketing management consumer behavior, market research, product design and development pricing and promotion.

Module – V **[10 Hours]**

Project management: Introduction. Concept of a project, project management concepts, project simulation, cost or project and means of financing, economic evaluation criteria of the project, project implementation, project planning, scheduling and monitoring, project control (PERT, CPM techniques including crashing). Project evaluation.

Information technology and management. Role of information, management information system and decision support system, Information technology-introduction to e-business, e-commerce and integration tools like enterprise resource planning (ERP).

Course Outcomes:

1. Acquire a sound knowledge on the principles of Operations Management .
2. Use forecasting methods, principles/methods of scheduling and Sequencing, methods of maintenance planning and control, concepts/ technique supply chain management for Engineering Management.
3. Select and use an appropriate principles/methods/ techniques/ modern concepts with reference to given application/situation in the mechanical systems/ project management and finance
4. Develop and implement new ideas/ modern concepts with reference to given application/situation for best manufacturing practices.
5. Preparation and ability to engage in independent and lifelong learning in the context of technological change in Engineering Management

Text Books:

1. Engineering Management, A K Gupta, S. Chand Publishing
2. Engineering Management: Meeting the Global Challenges, C. M. Chang, Second Edition, CRC Press, Taylors & Francis Group

Reference Books:

1. Engineering Management, A. S. Chauhan, R. S. Vaishwanar, Neetu Jain, Jain Brothers Publications
2. Engineering Management, Fraidoon Mazda, Pearson Edition

The Practice of Engineering Management, Patrick D. T. O'Connor, Wiley–Blackwell.

Course Code: 22ME5OE02T	Course Name: Micro Electro-Mechanical Systems (MEMS)	L-T-P 3- 0-0	Credit 3

Course Objectives:

1 Learning fundamental concepts for design of micro-electromechanical devices (MEMS), including mechanical and thermal behavior of materials and structures, transduction principles, transducer design, and modeling.
2 Learn about the current and future trends of MEMS in the industry. Types of MEMS devices, their application areas.
3 Acquire comprehensive knowledge of micro fluidic devices.
4 Learn different techniques for fabrication of MEMS devices, materials used and their properties.
5 Learn analytical/mathematical modeling of a MEMS device. Gain knowledge on capabilities of different tools used in the industry.

Syllabus

Module-I **[7 hours]**

Introduction to MEMS

History of micro system technology, overview of commercial MEMS products, future trends, Case study, Micro-fabrication basics and materials used. Miniaturization : Moore's law, Effects of scaling: on mechanical strength, heat transfer, vibrational and magnetic characteristics. Benefits and limitations of the materials and miniaturization.

Module-II **[8 hours]**

MEMS types, application areas

Mechanical Transducer: Inertial Sensors (Accelerometer, Gyroscope), Pressure Sensors, Flow Sensors, Force Sensors (SPM), Magnetic Transducers: Magnetic Field Sensors, Magnetic Actuators, Proximity sensor;

Chemical/Biological Transducers : Gas sensor, Thermal Transducers: Thermometers, IR Sensors; Applications of MEMS: smart homes, electrical systems, material transport, condition monitoring, biomedical prosthesis.

Packaging of MEMS devices : Standard Packages, Packaging Concepts, Packaging Examples

Module-III **[7 Hours]**

Microfluidics:

Fundamentals of fluid mechanics, Basic components of a micro-fluidic system, Micro flows, Micro pumps, Capillarity and Surface Tension, Micro pumping methods, Micro dispensers, Micro

nozzles

Module-IV **[7 hours]**

Materials and Fabrication techniques of MEMS

Properties of materials used in MEMS fabrication : silicon, polymers, metals, ceramics. Their structure and properties. Structure of silicon and other materials (polymers), Silicon wafer processing, Bulk micro machining and Surface micro machining, Wafer-bonding. Thin-film deposition, Lithography, wet etching and dry etching.

Module-V **[9 hours]**

Modeling of MEMS structures

System modeling of MEMS : Analytical vs Numerical Modeling, Lumped Element modeling, Finite element modeling; MEMS simulation packages : MEMS pro, MEMS+, SUGAR, Coventor, SoftMEMS, COMSOL etc. Demonstration of MEMS pro-Ansys integration

Course Outcomes:

1 Understand the operation of micro devices, micro systems and their applications.
2 Select whether the particular situation requires the use of a MEMS device. If required, select an appropriate device.
3 Analyze a chemical/biological system to select the right microfluidic device.
4 Apply knowledge of physical, chemical and biological principles to engineer MEMS devices using different materials and techniques. Select appropriate MEMS fabrication techniques for a particular design and application.
5 Apply knowledge of MEMS analysis to evaluate suitability of MEMS designs for particular applications. Select a suitable tool for a

Text Books:

1 Smart Material Systems and MEMS:Design and Development Methodologies, Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Wiley, 2006
2 MEMS & Micro systems Design and Manufacture, Tai Ran Hsu, Tata McGraw Hill, New Delhi, 2002

Reference Books:

1 MEMS Sensors, Design and Application, Siva Yellampalli, IntechOpen, 2018
2 MEMS : Design and Fabrication, Mohamed Gad-el-Hak, CRC Press, 2005
3 Microsystem Design, Stephen D. Senturia, Springer US, 2001

Course Code: 22EC5OE01T	Course Name: VLSI Design	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1 To understand the concept of VLSI Design Methodology, Design Flow, fabrication steps of NMOS as well as CMOS process and MOSFET the static and switching behavior of MOS Inverter.
2 To understand the design and working of combinational and sequential MOS circuits.
3 To understand the concept of semiconductor memories.
4 To understand the concept of Layout of CMOS Digital Circuits, DRC, LVS and RCX

Syllabus

Module-I **[8 Hours]**

Introduction, Historical perspective, VLSI Design methodologies, VLSI Design Flow, Design Hierarchy, Design Styles, CAD Technology .

Fabrication of MOSFETS, Fabrication processes, NMOS Fabrication, CMOS n-well process, Layout Design rules, Stick Diagrams, Full Custom Mask Layout Design.

MOS Transistor, Review of structure and operation of MOSFET (n-MOS enhancement type), CMOS, MOSFET V-I characteristics, MOSFET scaling and small geometry effects, MOSFET capacitances.

Module-II **[10 Hours]**

MOS Inverters:

Basic NMOS inverters, characteristics, inverters with resistive load and with n-type MOSFET load, CMOS inverter and characteristics.

MOS inverters: Switching characteristics and interconnect effects: Delay time definitions and calculation, inverter design with delay constraints, estimation of parasitic switching power dissipation of CMOS inverters.

Module- III **[8 Hours]**

Combinational MOS logic circuits: CMOS logic circuits, state style, complex logic circuits, pass transistor logic.

Sequential logic circuit – Introduction, SR latch, clocked latch & flip-flop circuits, CMOS D latch and edge triggered flip-flop**.**

Module-IV **[6 Hours]**

Semiconductor Memories: Introduction, Read Only Memory Circuits, Static Read-Write Memory (SRAM) Circuits, Dynamic Read-Write Memory (DRAM) Circuits.

Module-V **[8 Hours]**

Layout concepts and examples of CMOS Inverter, 2-Input NAND Logic Gate, 2-Input NOR Logic Gate, 2:1 Multiplexer using Transmission Gate, D-Latch using Transmission Gate, Concept of DRC, LVS and RCX.

Course Outcomes:

After completion of the course, the student will be able to

1 Analyze the characteristic of MOSFET, understand the fabrication steps, design CMOS inverters, calculate the dimension of MOSFETs for delay and inverter threshold voltage.
2 Design combinational and sequential circuits using CMOS technology and verify their functionalities.
3 Analyze the memory cells and verify its functionality
4 Analyze the layout and verification of CMOS integrated circuits.

Text Books:

1 CMOS Digital Integrated Circuits: Analysis and Design, Sung-Mo Kang, Yusuf Leblebici and Chul Woo Kim, 4th Edition, Tata McGraw-Hill Publishing Company Limited, 2015.
2 VLSI Design, Debaprasad Das, 2nd Edition, Oxford University Press, 2015, New Delhi.

Reference books:

1. CMOS VLSI design a circuits and systems perspective, Neil H. E. weste, David Harris and Ayan Banerjee, 4th Edition, Pearson Education, 2015.
2. Digital Integrated Circuits– A Design Perspective, Jan M. Rabaey, AnanthaChandrakasan and BorivojeNikolic, 2nd Edition, PHI Learning, 2016, New Delhi
3. Basic VLSI Design, Douglas A. Pucknell and K. Eshraghian, 3rd Edition, PHI Learning, 2009, New Delhi

Digital Learning Resources:

Course Name	CMOS Digital VLSI Design
Course Link	https://nptel.ac.in/courses/108/107/108107129/
Course Instructor	Prof. SudebDasgupta | IIT Roorkee

Course Name	Digital VLSI Design
Course Link	https://nptel.ac.in/courses/108/103/108103108/
Course Instructor	Prof. ChandanKarfa | IIT Guwahati

Subject Code:	Subject Name:	L-T-P:	Credit:
22EC5OE02T	**Microprocessor and Interfacing**	3-0-0	3

Course objectives:

1. Understand the main components and working principle of the Intel 8086 microprocessor and its programming
2. Understand the Memory organization, interfacing and the interrupt concept of 16-bit microprocessor
3. To make the interfacing of the I/O devices using programmable interfacingdevices
4. To enable the students to understand the basic components and working principle of the Intel 32-bit processor80386

Syllabus:

Module-1 **[10Hours]**

8086 Microprocessor:

Introduction: Overview of Microcomputer organization.

Intel 8086 Microprocessor: Introduction, 8086 Programmer's model: Register organization, **Hardware Architecture**: Bus interface unit (BIU), Execution unit (EU), Pipelined operation, physical address generation and Memory segmentation.

8086 Pin description: Common, Minimum and maximum mode Pin and Signals, Bus cycle and System configuration.

Module-II **[8 Hours]**

8086 Memory Interfacing and Interrupt technique:

8086 Memory Interfacing: External Memory addressing, EPROM and RAM interface with 8086.

8086 Interrupt: Interrupt Processing, sources of interrupt in 8086, Interrupt Instructions, Interrupt types, IVT, Hardware Interrupts and Interrupt priorities.

Module-III **[8 Hours]**

8086 Instruction set and programming:

8086 Addressing modes, Instruction set: data transfer, arithmetic, bit manipulation, branch and processor control, assembler directives and programming

Module-IV **[10 Hours]**

Peripheral interfacing and its programming:

Introduction to basic I/O interface, I/O interfacing techniques in 8086.

Interfacing devices: 8255 PPI, 8254 Timer, 8251 USART, ADC-0808/0809, and DAC-0800 interfacing using PPI.

Module-V **[10 Hours]**

32-bit Microprocessor 80386:

Salient features of 80386, Architecture and Signal Description of 80386. Register Organization of

80386, Hardware Memory organization 80386 Memory management: Real mode, Segment translation, protected mode, Memory paging mechanism and Virtual 8086Mode

Course Outcomes:

After completion of the course, the student will be able to

1 Gain deep knowledge on 8086 microprocessor architecture and pin and signals and demonstrate the memory interfacing and illustrate the use ofinterrupts.

2 Identify the addressing modes and illustrate the different classification and functions of 8086 microprocessor instructions and apply the knowledge in assembly language programming.

3 Illustrate the design aspect of I/O interface and Design and development of interfacing various I/O devices using programmable peripheral devices with the 8086 microprocessor.

4 Study and understand the architecture and memory management system of 80386 advancedmicroprocessors.

Text Books:

1 A. K. Ray and K. M. Bhurchandi, **"**Advanced Microprocessors andPeripherals**",** 3rd Edition, Tata McGraw Hill Education,2000, New Delhi.

2 Walter A Triebel and Avtar Singh, "The 8088 and 8086 Microprocessors, Programming, Interfacing, Software, Hardware and Applications", 4th edition, Pearson Education, 2014, Noida

Reference Books:

1 Barry B. Brey, *The Intel Microprocessors, Architecture, Programming and Interfacing*, 8th Edition, Pearson Education, 2009,Noida

2 Doughlas.V.Hall, *Microprocessor and Interfacing : Programming and Hardware*, 2nd Edition, McGraw Hill, 1992,Noida

3 Yu-chengliu and Glenn a. Gibson, *Microcomputer Systems: The 8086/8088 Family Architecture, Programming & Design***-**, 2ndEdition, Prentice Hall of India, 2007, New Delhi

Digital Learning Resources

Course Name	Microprocessors and interfacing
Course Link	https://nptel.ac.in/courses/108/103/108103157/
Course Instructor	Prof. Shaik Rafi Ahmed, Department of Electronics and Electrical Engineering, IIT Guwahati

Course Code: 22EE5OE01T	Course Name: Renewable Energy Systems	L-T-P 0	3- 0-	Credit 3

Course Objectives:

The program is expected to enable the students to

1 Design and develop innovative products and services in the field of Renewable Energy.
2 Keeps abreast with the latest technology and tool set.
3 Communicate effectively to propagate ideas and promote team work
4 Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

Syllabus

Module-I [4 Hours]

Introduction: Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Quality of Energy: Measure of Quality of energy, Identification of potential energy resources in terms of their quality. Dependency of Efficiency of energy conversion on Quality of energy. Cogeneration, Dispersed or Distributed generation.

Module-II [8 Hours]

Energy from Sun: Sun- earth Geometric Relationship, Solar radiation geometry, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Sunpath diagram and evaluation of insolation quality at a location using Sunpath, Solar Thermal Energy Applications.

Solar Thermal Energy Collectors: Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish – Stirling Engine System, Working of Stirling or Brayton Heat Engine, Solar Collector Systems into Building Services, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooing, Solar Cookers, Solar pond.

Module-III [7 Hours]

Solar Photovoltaic Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Equivalent Circuit of a PV Cell, Impact of parameters of PV cell performance, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Maximum Power Point Tracking (MPPT), MPPT algorithms: P&O, Incremental Conductance, Efficiency of Solar Cells, Photovoltaic Panels, Shading & Mitigation techniques, Applications of Solar Cell Systems.

Module-IV [10 Hours]

Wind Energy Conversion System (WECs): Energy content in wind, extractible content of energy through WECs. Types of wind turbines with respect to axis of rotation (Horizontal & vertical axis wind turbine), working principle (lift and drag type) etc.

Airfoil terminology - Blade element theory - Blade design - Rotor performance and dynamics-

Balancing technique (Rotor &Blade), significant parameters determining efficiency of WECs, Pitch angle, No of blades, solidity, Tip Speed ratio.
Constant speed Constant frequency - Variable speed variable frequency - Up wind-Down wind - Stall control-Pitch control - Gear coupled generator type - Direct generator drive/PMG/Rotor excited sync generator.

Module-V **[10 Hours]**

Integrated Energy Systems: Systems aspects of Integration: voltage effect, thermal effects, fault level, islanding. Stand alone systems: Network voltage and system efficiency, Case studies of standalone system. Hybrid energy systems ans its economic evaluation.Technological aspects of power electronic systems connection to the grid. Hybrid and integrated energy systems, total energy concepts and waste heat utilization, Energy modeling to optimize different systems

Course Outcomes:

1. Appraise the need and possibility of extracting solar energy and converting into electrical energy using PV cell.
2. Design and analyze stand-alone and grid connected PV system.
3. Describe the dynamics of wind turbine and electrical generator.
4. Select and design suitable configuration of the wind energy conversion system based on application.
5. Suggest, design and analyze hybrid energy systems.

Text Books:

1. Non-conventional Energy Sources by G. D. Rai, KhannaPublishers.
2. Renewable Energy by Boyle, Godfrey Oxford University Press.
3. Renewable Energy SystemsDesignand Analysis with Induction Generators, by M. Godoy Simoes, Felix A. Farret, CRC press.
4. Micro-grid: A Conceptual Solution, Robert Lasseter, Paolo Piagi, PESC2004, June 2004.

Reference Books:

1. Renewable Energy Resources byJohnTwidell and Tony Weir, Taylor Francis Group.
2. Renewable Energy Sources for fuels and Electricity by Laurie Barrtom, Island Press.

Digital Learning Resources:

Course Name	Solar, Wind and Biomass Energy Systems
Course Link	https://nptel.ac.in/courses/103/103/103103206/
Course Instructor	Prof. R. Anandalakshmi Prof. VaibhavVasantGoud, Department of Chemical Engineering, IIT Guwahati

CourseName	Solar &WindEnergy
CourseLink	https://nptel.ac.in/courses/103/107/103107157/
CourseInstructor	Prof. P. Mondal, Department of Chemical Engineering, IIT Roorkee
CourseName	Energy Resources
CourseLink	https://www.youtube.com/watch?v=cZSYukWvpsE
CourseInstructor	Prof. RanganBenarjee, Department of Energy Science &Technology, IIT Bombay
CourseName	Design of Photo voltaic system
CourseLink	https://www.youtube.com/watch?v=hr2sId412zU&list=PLuv3GM6-gsE2KyXoBTQ6lbrwn22Z3SiVm&index=2
CourseInstructor	Prof. L. Umanand, Department of Electronic System Engineering, IISc, Bangalore

Subject Code: 22EE5OE04T	Subject name: Introduction to electrical Properties of materials	L-T-P: 3-0-0	Credit: 3

Course Objectives:

1. To understand the conducting properties of metal.
2. To give knowledge about semiconductor materials.
3. To give knowledge about the insulating materials and their applications.
4. To acquire the knowledge about the dielectric materials.
5. To have knowledge about magnetic materials.
6. To have knowledge about special purpose materials.

Syllabus

Module-I **[8 Hours]**

Conductivity of Metal: Introduction, factors affecting the resistivity of electrical materials, motion of an electron in an electric field, Equation of motion of an electron, current carried by electrons, mobility, energy levels of a molecule, emission of electrons from metals, thermionic emission, photo electric emission, field emission.

Module-II **[6 Hours]**

Dielectric Properties: Introduction, effect of a dielectric on the behaviour of a capacitor, polarization, the dielectric constant of monatomic gases, frequency dependence of permittivity.

Module-III **[9 Hours]**

Dielectric losses, significance of the loss tangent, dipolar relaxation, frequency and temperature dependence of the dielectric constant.Dielectric properties of polymeric system, ionic conductivity in insulators, insulating materials, Ferro-electricity, piezoelectricity.

Module-IV **[10 Hours]**

Magnetic properties of Materials: Introduction, Classification of magnetic materials, diamagnetism, para-magnetism, ferromagnetism, magnetization curve, the hysteresis loop, factors affecting permeability and hysteresis loss, common magnetic materials, magnetic resonance. Superconductivity and its origin, Zero resistance and Meissner Effect, critical current density.

Module-V **[10 Hours]**

Semiconductors: Energy band in solids, conductors, semiconductors, and insulators, types of semiconductors, impurity type semiconductor, diffusion, the Einstein relations, hall effect, thermal conductivity of semiconductors, electrical conductivity of doped materials.

Course Outcomes:

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

1. Understand the various kinds of materials and their applications in ac and dc fields.
2. Understand the conductivity of superconductivity of materials.
3. Explain the electrical properties of different materials and metallic behavior of materials on the basis of band theory.
4. Explain the properties and applications of all kind of magnetic materials.

5 Explain the properties of electrical conducting and insulating materials.

6 Assess a variety of approaches in developing new materials with enhanced performance to replace existing materials.

Text Books:

1 C. S. Indulkar and S. Thiruvengadam, S., “An Introduction to ElectricalEngineering

2 Kenneth G. Budinski, “Engineering Materials: Prentice Hall of India, NewDelhi

3 ELECTRICAL PROPERTIES OF MATERIALS, 9th Edition (L. Solymer, Donald Walsh,R. R .A.Syms)

4 Electrical and Electronic Engineering Materials by SK Bhattacharya, Khanna Publishers, NewDelhi.

Reference Books:

1. Electrical Engineering Materials Adrianus J Dekker, Phi LearningPublishers.

2. Introduction to Electrical Engineering Materials 4th Edn. 2004 Edition by Indulkar C, S. Chand & Company Ltd-NewDelhi.

Digital Learning Resources:

Course Name	Processing of Semiconducting Materials
Course Link	http://nptel.ac.in
Course Instructor	Dr. PallabBanerji,Department of Metallurgy and Material Science,IITKharagpur.

Open Elective -1 for other branch students

Subject Code: 22CT5OE01T	Subject Name: Introduction to Python Programming	L-T-P:3-0-0	Credit:3

Course Objective:

1. Identify / characterize / define a problem.
2. Design a program to solve the problem.
3. Create executable code.
4. Read most Python code and write basic unit tests.

Module- 1 **[10Hrs]**

Features and History of Python, Literal constants, variables and identifiers, data types, Input operations, comments, reserved words, indentation, operators and expressions, operations on strings, other data types, conditional branching statements, loop structures, break, continue, pass, else. Functions in Python.

Module- 2 **[10Hrs]**

Concatenating, appending, and multiplying strings, formatting operator, built-in string methods and functions, slice operation, ord() and chr(), in and not in operations, comparing strings, iterating strings, string module, match(), search() and sub(), findall() and finditer().
Data structures: sequence, lists, functional programming, tuple, sets, dictionaries.

Module-3 **[10Hrs]**

Class and Objects: class methods and self arguments, the __init__() method, class variable and object variable, __del__() method, public and private data members, calling a class method from another class method, built-in functions to set, get, and delete class attributes.
Inheritance, types, composition or containment, abstract classes or interfaces.
Operator overloading: implementing operator overloading, reverse adding, overriding __getitem__() and __setitem__() methods, overriding the in operator, overloading the miscellaneous functions.

Module- 4 **[10Hrs]**

Error and Exception handling:handling exceptions, multiple exception blocks, multiple exceptions in a single block, except block without exception, else clause, raising an exception,instantiatingexceptions,handlingexceptionsininvokedfunctions,builtinanduserdefinedexceptions,thefinallyblock,predefinedcleanupaction.

Course Outcome:

1. To understand why Python is a useful scripting language for developers.
2. To learn how to design and program Python applications.
3. To learn how to use lists, tuples, and dictionaries in Python programs.
4. To learn how to identify Python object types.

Text Books:

Python programming, ReemaThareja, Oxford publications. Learning Python, Mark Lutz, O'Reilly.

Reference Books:

Statistics and Machine Learning in Python Release 0.1, EdouardDuchesnay, Tommy Löfstedt,
Python Data Analytics, Fabio Nelli, Apress.

Digital Learning Resources

Course Name	Programming Data Structures and Algorithm in Python
Course Link	https://nptel.ac.in/courses/106/106/106106145/
Course Instructor	Prof.MadhavanMukund, Chennai Mathematical Institute

Open Elective -2 (For CST Branch Students)

Course Code: 22ME5OE03T	Course Name: Smart and Intelligent Materials	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1 To study different type of smart material and its application.
2 Understand in details on the shape memory material and Chromogenic materials.
3 Understand the details of smart polymer and its application.
4 To study about smart hydrogels and its properties.
5 Understanding of smart material and its application in aerospace engineering.

Syllabus

Module-I **[7 hours]**

Smart materials and structures: System intelligence- components and classification of smart structures, common smart materials and associated stimulus-response, Application areas of smart systems **Ferroelectric materials:** Piezoelectric materials- piezoelectric effect, Direct and converse, parameter definitions, Piezoceramics, Piezopolymers, Piezoelectric materials as sensors, Actuators and bimorphs

Module-II **[7 hours]**

Shape memory materials: Shape memory alloys (SMAs), Shape memory effect, Martensitic transformation, One way and two-way SME, training of SMAs, binary and ternary alloy systems, Functional properties of SMAs

Chromogenic materials: Thermochromism, Photochromism, Electrochromism, Halochromism, Solvatochromism- principle and design strategies

Module-III **[7 hours]**

Smart polymers: Thermally responsive polymers, Electroactive polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Molecular imprinting using smart polymers, Approaches to molecular imprinting, Drug delivery using smart polymers

Module-IV **[7 hours]**

Smart hydrogels: Synthesis, Fast responsive hydrogels, Molecular recognition, Smart hydrogels as actuators, Controlled drug release, Artificial muscles, Hydrogels in microfluidics

Module-V **[7 hours]**

Smart systems for space applications: Elastic memory composites, Smart corrosion protection coatings, Self-healing materials, Sensors, Actuators, Transducers, MEMS,

Deployment devices, Molecular machines

Course Outcomes:

1 On successful completion of this course students will be able:
2 Characterize and evaluate smart materials for specific applications.
3 Inspect the theory of shape memory alloy material and chromogenic materials.
4 Understand the structure of smart polymer and its application to engineering problems.
5 Examine the properties of smart hydrogels.
6 Design advanced materials for aerospace, biological, nuclear and high temperature applications.

Text Books:

1 Engineering Analysis of Smart Material Systems, D.J. Leo, Wiley 2007.
2 Smart Materials and New Technologies in Architecture, M. Addington, D.L. Schodek, Elsevier 2005.
3 Shape Memory Materials, K. Otsuka, C.M. Wayman (Eds.), Cambridge University Press, 1998.
4 Smart Materials and Structures, M.V. Gandhi, B. S. Thompson, Chapman & Hall, 1992.

Reference Books:

1 Processes, and Methods Technology, M. Schwartz, New Materials, CRC Press, 2006.
2 Made to Measure: Materials for the 21stCentury, P. Ball, Princeton University Press, 1997.
3 Smart Polymers: Applications in Biotechnology and Biomedicine, Galaev, B. Mattiasson (Eds.), 2nd ed., CRC Press, 2008.
4 Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems , N. Yui, R. J. Mrsny, K. Park (Eds.), CRC Press, 2004.

Course Code: 22ME5OE04T	Course Name: Nanoscience and Technology	L-T-P 3- 0-0	Credit 3

Course Objectives:

1 Learn about the background on Nanoscience and nanomaterials.
2 Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment
3 Recognize the different functionalities of nonamaterials.
4 Understand the fundamentals of Biomimetic nanomaterials and its application.
5 Understand the different applications of nanomaterials.

Syllabus

Module-I **[10 hours]**

General introduction and theory of nanomaterials- History of nanomaterials; Size and shape dependent properties and their uniqueness; Energy at nanoscale - surface characteristics and electrostatic and steric stabilization - Quantum confinement - zero dimensional, one dimensional and two dimensional nanostructures

Module-II **[8 hours]**

Synthesis of nanomaterials- Introduction to nanoparticle synthesis – top-down and bottom up approaches - physical nanofabrication techniques (PVD, MBE, CVD, self-assembly, lithographic techniques etc.) and wet chemical methods for the synthesis of zero dimensional one dimensional and two dimensional nanostructures-metal nanoparticles, quantum dots, nanoclusters, nanowires and rods, thin films

Module-III **[12 hours]**

Functional nanomaterials- Synthesis, properties and applications of organic, inorganic, hybrid nanomaterials – core-shells, nanoshells, self-assembled nanostructures, superlattices, nanoceramics metallic, polymeric and ceramic nanocomposites, nanoporous materials, nanofluids, nanolayers and carbon based nano materials - Occurrence, production, purification, properties and applications of fullerene, carbon nanotube, graphene, carbon onion, nanodiamond and films

Module-IV [8 hours]

Biomimetic nanomaterials - Introduction to biomimetics, mimicking mechanisms found in nature, synthesis and applications of bioinspirednanomaterials and self-assemblies

Module- V [8 hours]

Applications of nanomaterials- Application of nanomaterials in healthcare, biosenors, coatings environment, catalysis, agriculture, automotives, sensors, electronics, photonics, information technology, quantum computing, energy and aerospace sectors.

Course Outcomes:

1 To develop a foundational knowledge of the Nanoscience and related fields.
2 Apply their learned knowledge to develop Nanomaterial's.
3 Evaluate the different functional properties of nanomaterials.
4 Understand the details about Biomimetic nanomaterials and its application.
5 Utilize the knowledge of nanomaterial in solving engineering problems.

Text Books:

1 Nanoscale Materials in Chemistry, K. J. Klabunde and R.M. Richards (Eds.), 2nd Edn., John Wiley & Sons, 2009.
2 Nano: The Essentials, T. Pradeep, McGraw-Hill (India) Pvt Limited, 2008.
3 Handbook of Nanotechnology, BharatBhushan, Springer, 2007.

Reference Books:

1 Nanostructured Materials: Processing Propertiesand Applications, Carl C. Koch (Ed.), William Andrew Inc., 2007.
2 Carbon Materials and Nanotechnology, Anke Krueger, Wiley-VCH Verlag GmbH & Co. KGaA, 2010.
3 Nanostructures and Nanomaterials Synthesis, Cao, G., Properties, and Applications, Imperial College Press, 2004.
4 Characterization of nanophase materials, Wang, Z. L., (Ed.), Wiley-VCH Verlag GmbH, 2000.
5 Nanotechnology for the Energy Challenge. Garcia-Martinez, J., (Ed.), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2009.
6 Handbook of Nanoscience, Engineering, and Technology, Goddard III W.A., et. al.,(Ed.), Taylor & Francis Group, 2007.
7 Hybrid Nanomaterials: Synthesis, Characterization, and Applications, B.P.S. Chauhan(Ed), Wiley-VCH Verlag GmbH, 2011.
8 Bioinspired Intelligent Nanostructured Interfacial Materials, J. Lei andF.Lin, World Scientific Publishing Company, 2010.

Biomimetic and BioinspiredNanomaterials, Challa S. S. R. Kumar (Ed.) Wiley-VCH Verlag GmbH, 2010.

Course Code:	Course Name:	L-T-P:	Credit:
22EE5OE02T	Sensor and Instrumentation	3- 0- 0	3

Course Objectives: The students will

1. Understand the concepts of measurement technology
2. Theylearnthevarioussensorsusedtomeasurevariousphysicalparameters.
3. Theywilllearnthefundamentalsofsignalconditioninganddataacquisition.
4. Learn how to use virtual instrumentation for measurement.

Syllabus:

Module-I [8 hours]

Sensors & Transducer: Definition, Classification & selection of sensors, Elements of a general measurement system: Static Characteristics: systematic characteristics, statistical characteristics, calibration; Dynamic characteristics of measurement systems: transfer functions of typical sensing elements, step and frequency response of first and second order elements, and dynamic error in measurement systems.

Module-II [8 hours]

Measurement of displacement using Potentiometer, LVDT & Optical Encoder, Measurement of force using strain gauge, Measurement of pressure using LVDT based diaphragm & piezoelectric sensor

Module-III [8 hours] Signal Conditioning Elements: Deflection bridges: design of resistive and reactive bridges,push- pull configuration for improvement of linearity and sensitivity. Amplifiers:Operational amplifiers-ideal and non-ideal performances, inverting, non-inverting and differential amplifiers, instrumentation amplifier, filters. A.C. carrier systems, phase sensitive demodulators and its applications in instrumentation

Module-IV [10 hours]

Virtual Instrumentation: Graphical programming techniques, Data types, Advantage of Virtual Instrumentation techniques, Concept of WHILE & FOR loops, Arrays, Clusters &graphs,Structures: Case, Sequence & Formula nodes, need of software based instruments for industrial automation.

Module- V [4 hours]

Data Acquisition Methods: Basic block diagram, Analog and Digital IO, Counters, Timers,

Types of ADC: successive approximation and sigma-delta, Types of DAC: Weighted Resistor and R-2R Ladder type, Use of Data Sockets for Networked Communication

Course Outcomes: After completion of the course, the student will be able to

1. Applytheuseofsensorsformeasurementofdisplacement,forceandpressure.
2. Employ commonly used sensors in industry for measurement of temperature, position, accelerometer, vibration sensor, flow and level.
3. Demonstrate the use of virtual instrumentation in automation industries.
4. Identify and use data acquisition methods.
5. Comprehend intelligent instrumentation in industrial automation.

Text Books:

1. J.P. Bentley, Principles of Measurement Systems- 3rd edition, Pearson Education, New Delhi,2007.
2. JovithaJerome,Virtual Instrumentation Using LabVIEW,PHI Learning Pvt. Ltd., New Delhi-1100012010

Reference Books:

1 Introduction to Measurement and Instrumentation- A.K. Ghosh (3/e), PHI Learning,New Delhi, 2009.

2 Patranabis D, Sensors and Transducers, 2nd Edition, PHI, New Delhi, 2010

Digital Learning Resources:

Course Name	Sensor and Transducer
Course Link	https://nptel.ac.in/courses/108/108/108108147/ https://nptel.ac.in/courses/108/105/108105064/
Course Instructor	Dr. HardikJeetendraPandya, Department of Electronic Systems Engineering, IISc Bangalore Prof. AlokBarua, Department of Electrical Engineering, IIT Kharagpur.

Course Code: 22EE5OE03T	Course Name: Smart Grids	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1 To understand the basic concepts, components, and architecture of smart grid.
2 To understand the various measurement technologies in smart grid.
3 To educate the importance of renewable energy in smart grid.
4 To know about battery technology and energy storage.
5 To brief about the role of electric vehicles in smart grids.

Syllabus:

Module-I **[12 hours]**

Introduction to Smart Grid:

Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, smart-grid activities in India, differences between traditional grid and smart grid.

Module-II **[7 hours]**

Concept of Microgrids:

Introduction to the concept of microgrid, the overview of the structure and architecture of microgrid with brief control, operational aspects.Recent pilot microgrid projects and their outcomes.

Module-III **[8 hours]**

Control of Smart Power Grid System:

Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System –Reactive Power Control in Smart Grid

Module-IV **[7 hours]**

Energy Storage Systems:

Batteries, Super Conducting Magnetic Energy Storage System, Pumped Hydro, Compressed Air Energy Storage, Flywheel, Ultra capacitors.

Module- V **[8 hours]**

Domain Name System (DNS)

Phasor Measurement Units: Importance of PMUs, Phasor Measurement Units and Phasor Data Concentrators. Wide Area Monitoring: WAMS concept, data collection, WAMS architecture, advanced data processing, optimal placement of PMUs.

Course Outcomes:

After completion of the course, the student will be able to:

1. Understand the features of Smart Grid.
2. Understand the basic concepts of microgrid and characteristics of energy storage devices.
3. Understand the concepts of phasor measurements in power system.
4. Analyze the power system behavior using synchronized phasor measurements.

Text Books:

1 Smart Grids, Infrastructure, Technology and Solutions, S. Borlase, CRC Press, 1st Edition, 2013.
2 Microgrids Architecture and Control, N. D. Hatziargyriou, IEEE Press Series, John Wiley & Sons Inc, 1st Edition, 2013.
3 Wide Area Monitoring of Interconnected Power Systems, A. R. Messina, IET publisher, 1st Edition, 2015.

Reference Books:

1 Synchronized Phasor Measurements and Their Applications, Arun G. Phadke, James S. Thorp, Springer International Publishing AG, 2nd Edition, 2017.
2 Design of Smart Power Grid Renewable Energy Systems, Ali Keyhani, Wiley-IEEE, 2011.
3 The Smart Grid: Enabling Energy Efficiency and Demand Response, Clark W. Gellings, CRC Press, 2009.
4 Smart Grid: Infrastructure, Technology and Solutions, Stuart Borlase, CRC Press.
5 Smart Grid: Technology and Applications, JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Wiley.
6 The Advanced Smart Grid: Edge Power Driving, Andres Carvallo, John Cooper, Artech House Publishers, July 2011.

Digital Learning Resources:

CourseName	IntroductiontoSmartGrid
CourseLink	https://nptel.ac.in/courses/108/107/108107113/
CourseInstructor	Prof.NPPadhy&Prof. PremalataJena,Departmentof Electrical Engineering,IITRoorkee

Course Code: 22CE5OE03T	Course Name: Geo-Environmental Engineering	L-T-P 3- 0-0	Credit 3

Course Objectives:

1 To know the sub-surface contamination, geosynthetics types and its application.
2 To gain comprehensive knowledge solid and hazardous waste management.
3 To provide knowledge on contaminant transport.
4 To understand about the remediation techniques.
5 To know the basic concept of landfill design.

Syllabus

Module-I [8 hours]

Introduction: Scope, importance, waste generation, subsurface contamination. Geo-synthetics: Types of manufacturing functions, applications, and economics.

Module-II [8 hours]

Solid and Hazardous Waste Management: Classification of waste, Characterization of solid wastes, Environmental Concerns with waste, Waste management strategies.

Module-III [8 hours]

Contaminant Transport: Transport process, Mass transfer process, Bioremediation, Phytoremediation.

Module-IV [8 hours]

Remediation Techniques: Objectives of site remediation, various active and passive methods, Soil washing, Emerging remediation technologies.

Module- V [8 hours]

Landfills: Types of landfills, Site Selection, Waste Containment Liners, Leach ate collection system, Cover system, Gas collection system

Course Outcomes:

After completion of the course the student can:

1. Understand surface contamination, geosynthetic types and its function.

2. Analyze the classification of waste and waste management strategies.
3. Identify contaminant transport mechanisms in soils.
4. Understand the principles of soil treatment techniques.
5. Get idea about different landfill concepts.

Text Books:

1 K.R.ReddyandHDSharma,"*GeoenvironmentalEngineering:SiteRemediation,wastecontainment,andemergingwastemanagementtechnologies*",JohnWilley,NewJersey,USA

2 RN.Yong, "*Geo Environmental Engineering: Contaminated Ground :Fate of Pollutions and Remediation*"., Thomson Telford , London, UK

Reference Books:

1 LNReddyandH.I.Inyang, "*GeoenvironmentalEngineering:PrinciplesandApplications*",MarcelDek , New York,USA

2 R.W. Sarsby, "Environmental Geotechnics", Thomson Telford, London, UK

Digital Learning Resources:

CourseName	Geo-EnvironmentalEngineering
CourseLink	https://nptel.ac.in/courses/105/102/105102160/
CourseInstructor	Prof.ManojDatta,DepartmentofCivilEngineering,IITDelhi

Course Code: 22EC5OE03T	Course Name: Embedded System Design	L-T-P 3- 0- 0	Credit 3

Course Objectives:

1. To get the knowledge of the Embedded technology and its utility to the society.
2. Understanding the architecture and programming of embedded processor (ARM or FPGA) or microcontroller
3. Familiarization with the embedded computing platform design and analysis.
4. To acquire the knowledge in interfacing protocols and related Hardwires.

Syllabus

Module-I [10 hours]

Introduction to Embedded Systems:

Hardware and Software Concepts: Embedded Systems, Application and characteristics of Embedded System, Overview of Processor and Hardware Units in Embedded System, Embedded Software into a system, Introduction to Embedded System Design, Introduction to Embedded System Architecture.

System-on-Chip, NoC, Embedded Hardware Modeling and Design: System-on-chip (SoC),Network-on-chip (NoC), Levels of Hardware modeling, Embedded Hardware Design and Development.

Module-II [8 hours]

8051, AVR ATmega and ARM Microcontrollers:

Microcontrollers, AVR Microcontrollers, ARM processor –based system Design

Sensors, A/D–D/A Converters, Actuators and Interfacing:

Sensors, A/D–D/A Converters, Actuators, interfacing Techniques, Network Embedded System, Internet-Enable Systems-Network Protocols, Wireless and Mobile System Protocols

Module-III [8 hours]

Real-Time Operating System (RTOS) and Real-Time task scheduling:

RTOS: concepts, types of Real time Task and their characteristics, task scheduling, Feature of RTOS, device driver, interrupts and Service mechanism

Module-IV **[8 hours]**

IoT System- System Architecture and Design:

IoT, Internet connectivity and IoT connectivity, Edge computing Architecture and Application, IoT communication module Protocols, Rapid prototype designing using open source Boards.

Module- V **[8 hours]**

EMBEDDED AI- System Architecture and Design:

Artificial Intelligence Embedded AI hardware and Software Development, Embedded AI Application

Course Outcomes: After completion of the course, the student will be able to

1 Design an embedded system application
2 Implement the peripheral interfacing.
3 Use system design techniques to develop firmware
4 Develop embedded system solution to automation and IoTs Application.

Text Books:

1. K. V. SHIBU, *Introduction to Embedded Systems*, McGraw Hill Publication Company Limited, 2009, New Delhi.

Reference Books:

1. Raj Kamal, *Title Embedded Systems*, 4th Edition, McGraw Hill Publication Company Limited, 2020, New Delhi.
2. David E. Simon, Addition Wesley, *An Embedded Software Primer*, Wiley, 1999, New Delhi.
3. K. Short, *Embedded Microprocessor Systems Design: An Introduction Using the Intel 80C188EB*, Prentice Hall,1998, ISBN-10 : 0132494671,ISBN-13 :978-0132494670.

Digital Learning Resources:

Course Name	Embedded System Design
Course Link	https://nptel.ac.in/courses/106/105/106105159/
Course Instructor	Prof. AnupamBasu, Department of Computer Science and Engineering, IIT Kharagpur

Course Code: 22EC5OE04T	Course Name: Radar System engineering	L-T-P 3- 0-0	Credit 3

Course Objectives:

1 To learn the basics of RADAR fundamentals and familiarization with various components of Transmitter and receiver.
2 To understand the concept of radar signal and its processing techniques under ambiguity conditions.
3 To learn about different types of RADARs and their operational principles.
4 To understand basic detection theory and tracking principles of radar systems.

Syllabus

Module-I [10 hours]

Introduction to Radar:
Basic radar, maximum unambiguous range, building blocks of radar, simple form of radar equation, Block diagram of Radar transmitter, Radar frequencies, Applications to radar and related Problems.

Radar Equation:
Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise and SNR, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets - sphere, cone-sphere), Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment). Related Problems.

Module-II [8 hours]

CW and Frequency Modulated Radar:
Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Measurement Errors, Multiple Frequency CW Radar.

Module-III [10 hours]

MTI and Pulse Doppler radar:
Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double

Cancellation, Staggered PRFs. Range Gated Doppler Filters. MTI Radar Parameters, Limitations to MTI Performance. Non-coherent MTI, MTI versus Pulse Doppler Radar.

Module-IV **[7 hours]**

Tracking Radar:

Tracking with Radar-Types of Tracking Radar Systems, Monopulse Tracking-Amitude Comparison Monopulse (one-and two-coordinates), Phase Comparison Monopulse. Sequential Lobing, Conical Scan Tracking, Block Diagram of Conical Scan Tracking Radar, Tracking in Range, Comparison of Trackers**.**

Module- V **[8 hours]**

Radar Receiver:

Block Diagram of Radar Receiver & Radar Displays - A-scope and PPI.

Modern Radars:

Height Finding Radars, Synthetic Aperture Radar, Airborne Radar, Secondary Surveillance Radar.

Course Outcomes:

1. After completion of the course, the student will be able to:
2. Demonstrate the understanding of radar fundamentals and various factors affecting the detection process.
3. Differentiate between various types of radar based on their working principles and field of application.
4. Familiarize with different displays and their applications on a real-time basis.
5. Analyze radar signals and various building blocks affecting it, and also the detection process by applying different target-centric tracking principles.
6. Understand the concepts of Phasor measurements in power system.

Text Books:

1 Merrill I. Skolnik, Introduction to Radar Systems, Third Edition, Tata McGraw-Hill, 2001, New Delhi.

Reference Books:

1. Radar Principles, Byron Edde, Technology, Applications, First Edition, Pearson Education, 2007, New Delhi.
2. Radar Design Principles, Nathanson, Second Edition, McGraw-Hill, 1991, New York.
3. Radar Principles, Peyton Z. Peebles, First Edition, Wiley, 1998, New York.
4. Principles of Modern Radar: Basic Principles, Mark A. Richards, James A. Scheer, William A. Holm, First Edition, Scitech Publishing, 2013, Raleigh, North California.

Digital Learning Resources:

Course Name	Radar System Engineering
Course Link	https://nptel.ac.in/courses/108/107/108107113/
Course Instructor	Prof.N P Padhy& Prof. PremalataJena, Department of Electrical Engineering, IIT Roorkee

Open Elective -2 for other branch students

Subject Code: 22CT5OE02T	Subject Name: Database Management System	L-T-P: 3-0-0	Credit: 3

Objectives

1. To learn data models, conceptualize, and depict a database system using ER diagram.
2. To understand the internal storage structures in a physical database design.
3. To know the fundamental concepts of transaction processing techniques.

Module I: (5 hours)

Introduction: Purpose of Database System – Views of data – data models, database management system, three-schema architecture of DBMS, components of DBMS.

E/R Model - Conceptual data modelling - motivation, entities, entity types, attributes, relationships, relationship types, E/R diagram notation, examples.

Module II: (10 hours)

Relational Model: Relational Data Model - Concept of relations, schema-instance distinction, keys, referential integrity and foreign keys, relational algebra operators.

SQL - Introduction, data definition in SQL, table, key, and foreign key definitions, update behaviors. Querying in SQL, notion of aggregation, aggregation functions, group by and having clauses, embedded SQL.

Module III: (7 hours)

Database Design: Dependencies and Normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, minimal covers.

Definitions of 1NF, 2NF, 3NF, and BCNF, decompositions and desirable properties of them, algorithms for 3NF and BCNF normalization, 4NF, and 5NF.

Module IV: (10 hours)

Transactions: Transaction processing and Error recovery - concepts of transaction processing, ACID properties, concurrency control, locking based protocols for CC, error recovery and logging, undo, redo, undo-redo logging and recovery methods.

ModuleV: (8hours)

Implementation Techniques: Data Storage and Indexes - file organizations, primary, secondary index structures, various index structures-hash-based, dynamic hashing techniques, multi-level indexes, B+trees.

Outcomes

1. Ability to Install, configure, and interact with a relational database management system (RDBMS).
2. Ability to master the basics of SQL and construct queries using SQL.
3. Ability to design and develop a large database with optimal query processing.

Books:

1. A.Silberschatz,HenryF.Korth,andS.Sudharshan,“DatabaseSystemConcepts”,7thEd,Tata McGrawHill,2019.

2. C.J.Date,A.KannanandS.Swamynathan,“AnIntroductiontoDatabaseSystems”,8thed,PearsonEducation,2006 Ramez Elmasri and Shamkant B. Navathe, “Fundamentals of Database Systems”, 7th Edition, Pearson/Addisionwesley,2016.
3. RaghuRamakrishnan,“DatabaseManagementSystems”,ThirdEdition,McGrawHill,2003.

Digital Learning Resources:

Course Name: Fundamentals of Database Systems
Course Link: Fundamentals of Database Systems - NPTEL
Course Instructor: Dr. Arnab Bhattacharya, IIT Kanpur

Course Name: Introduction to Database Systems
Course Link: Introduction to Database Systems - NPTEL
Course Instructor: Prof. P. Sreenivasa Kumar, IIT Madras

Mandatory Course

22CM5MC01T	Constitution of India (3-0-0)	0Credits

Course Objective:

1. This course acquaints students with the constitutional design of state structures and institutions, and their actual working over time.
2. The course traces the embodiment of some of these conflicts in constitutional provisions, and shows how these have played out in political practice.

Module-1: Introduction to the Indian Constitution [10Hrs]
Preamble & its Philosophy
Salient Features of Indian Constitution

Module-2: Key Concepts [10Hrs]
Citizenship - Methods of acquiring & losing, Fundamental Rights & Fundamental Duties
Directive Principles of State Policy

Module-3: Union Government: Organization, Powers & Functions [10Hrs]
Legislature: Union Parliament
Executive: President, Vice-President, Prime Minister & Council of Ministers
Judiciary: Supreme Court

Module-4: State Government: Organization, Powers & Functions [10Hrs]
State Legislature - Composition & Powers
State Executive: Governor, Chief Minister & Council of Ministers - Powers & Functions
State Judiciary: High Court - Composition & Powers

Course Outcome:

1. Able to understand the historical background of the constitutional making and its importance for building a democratic India, the structure of Indian government, the structure of state government, and the local administration.

2. Able to apply the knowledge on Directive Principles of State Policy and the knowledge in strengthening of the constitutional institutions like CAG, Election Commission, and UPSC for sustaining democracy.

3. Able to analyze the history and features of the Indian Constitution, the roles of Governor and Chief Minister, the role of State Election Commission, the decentralization of power between central, state, and local self-government. Able to evaluate the Preamble, Fundamental Rights and Duties, ZillaPanchayat, block level organization, various commissions such as SC/ST/OBC and Women's commissions.

Text Books:

1. D.D. Basu, *An Introduction to the Constitution of India*, Prentice Hall, New Delhi. (Latest Edition)

2. M.V. Pylee, *An Introduction to the Constitution of India*, Vikas, New Delhi, 1998.

3. A.G. Noorani, *Constitutional Questions in India: The President, Parliament and the States*, Oxford University Press, Delhi, 2000.

4. J.C. Johari, *Indian Political System*, Anmol Publishers, New Delhi, 1996.

5. V.D. Mahajan, *Constitutional Development and National Movement in India*, S. Chand and Co, New Delhi, 1986.

22CM5MC02T	Essence of Indian Tradition Knowledge(3-0-0)	0 Credits

Course Objectives:

1. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the importance of roots of knowledge system.
2. To make the students understand the traditional knowledge and analyze it and apply it to their day-to-day life.

Module 1: [8 hours]

Introduction to traditional knowledge: Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, Indigenous Knowledge (IK), characteristics, traditional knowledge vis-a-vis indigenous knowledge, traditional knowledge Vs western knowledge.

Module2:[6hours]

Protection of traditional knowledge: The need for protecting traditional knowledge. Significance of TK protection, value of TK in global economy.Role of government to harness TK.

Module3:[8hours]

Legal frameworks related to traditional knowledge: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act), The Biological Diversity Act 2002 and Rules 2004, the Protection of Traditional Knowledge Bill, 2016.

Module4:[8hours]

Traditional knowledge and intellectual property: Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge.

Module5:[10hours]

Traditional Knowledge in Different Sectors: Traditional knowledge and engineering, Traditional medicine systems, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of the environment, Management of biodiversity, Food security of the country and protection of TK.

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

1. Identify the concept of Traditional knowledge and its importance.
2. Explain the need and importance of protecting traditional knowledge.
3. Illustrate the various enactments related to the protection of traditional knowledge.
4. Interpret the concepts of Intellectual Property to protect the traditional knowledge.
5. Explain the importance of Traditional knowledge in Agriculture and Medicine.

Textbooks:

1. *Traditional Knowledge System in India* by AmitJha, 2009.
2. *Traditional Knowledge System in India* by AmitJha, Atlantic Publishers, 2002.
3. *Knowledge Traditions and Practices of India* by KapilKapoor and Michel Danino.

Practical

22CT5PC01L	Finite Language Automata Theory Lab	1Credits

Course Objective:

1. To model, compare and analyze different computational models and define Finite Automaton.
2. To explain the relationship between different languages and automata.
3. To understand the relation between Context-free Languages and PDA.
4. To learn how to design PDA as acceptor and TM as Calculators.

Laboratory Experiments:

1. Building Finite Automaton from Language (DFA & NFA)
2. Converting from NFA to DFA
3. Minimization of DFA
4. Converting from Regular Expression to NFA
5. DFA to Regular Expression and Regular Grammar
6. Design of Context-Free Grammar & Construction of Parse Tree, Transforming Context-Free Grammar into Chomsky Normal Form
7. Building Push-Down Automaton
8. Building Turing Machine

Course Outcome:

1. Analyze and design finite automata, regular languages and equivalence among them.
2. Create finite automaton from regular expression also able to generate Regular Expression from Finite Automaton.
3. Differentiate and design different forms of Context-Free Grammar.
4. Analyze and design the different types of automata like push down automaton, linear bounded automata and Turing machine.

Text Books:

1. An Introduction to Finite Languages and Automata - Peter Linz, Jones & Bartlett, Fifth Edition, 2011.
2. Introduction to Automata Theory, Languages, and Computation - Hopcroft, Ullman, Addison Wesley, 3rd Edition, Indian Reprint 2011.
3. Introduction to the theory of computation - Michael Sipser, Thomson, 2nd Edition, 2012.
4. Introduction to Languages and the Theory of Computation - John Martin, McGrawhill, Second Edition, Indian Reprint 2013.

22CT5PC02L	OPERATING SYSTEM LAB	1Credits

Course Objective:

1. To introduce Basic Linux general purpose Commands.
2. To learn network Linux commands.
3. To learn shell script.
4. To learn different programming languages in Linux editor environment and implement different Operating system algorithm.
5. To learn about file management and different types of permission setup.
6. To understand how system processes work and how to manage them.

Laboratory Experiments:

1. Practice with UNIX commands(File management, Process Management, User Management, String searching and manipulation, Administrative Commands)
2. Basics of Shell Scripting, Conditional Blocks and Loop
3. Array, String, Function in Shell Script
4. Process Creation using Fork and exec
5. Inter-process Communication using Named Pipe
6. Process Synchronization Using Semaphore
7. Simulation of CPU Scheduling Algorithms(FCFS, SJF, RR)
8. Simulation of Deadlock Prevention Algorithms(Banker's Algorithm)
9. Simulation of Page Replacement Algorithms(FIFO, LRU)
10. Simulation of Disk Scheduling Algorithms

Course Outcome:

1. Experiment with Unix commands and shell programming.
2. Able to implement algorithm for process and File system management with system calls.
3. Able to implement and analyse the performance of different algorithm of Operating Systems like CPU scheduling algorithm, page replacement algorithms, deadlock avoidance, detection algorithms and so on.

Text Books:

1. J. N. Spillal, V. Kratika, Raj A, Basics of OS, UNIX and SHELL Programming, BPB Publication, 2017
2. Abraham Silberschatz, Peter Bear Galvin & Greg Gagne “Operating System Concepts”, 8th edition, John Wiley & Sons

22CT5PC03L	Python Programming Laboratory (0-0-2)	1Credits

Lab Objectives:

1. To write, test, and debug simple Python programs.
2. To implement Python programs with conditionals and loops.
3. Use functions for structuring Python programs.
4. Represent compound data using Python lists, tuples, and dictionaries.
5. Read and write data from/to files in Python.

Lab Outcomes:

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

1. Write, test, and debug simple Python programs.
2. Implement Python programs with conditionals and loops.
3. Develop Python programs step-wise by defining functions and calling them.
4. Use Python lists, tuples, dictionaries for representing compound data.
5. Read and write data from/to files in Python.

Laboratory Experiments:

1. Basic Python programming with selection and loop control statement.
2. Types of functions, lambda function, and use of recursion in Python programming.
3. Implementation of list, tuple, set, dictionary.
4. Implementation of string using string inbuilt functions.
5. File handling operations using Python programming.
6. Implementation of real-world entities using the OOPs concept.
7. Implementation of inheritance, abstract class, and interfaces.
8. Implementation of operator overloading and method overriding.
9. Exception handling using Python.
10. Demonstration on NumPy and graph plotting using Matplotlib.

Course Outcome:

1. Analyze and design finite automata, regular languages, and equivalence among them.
2. Create finite automata from regular expression also able to generate Regular Expression from Finite Automata.
3. Differentiate and design different forms of Context-Free Grammar.
4. Analyze and design the different types of automata like pushdown automata, linear bounded automata, and Turing machine.