INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Chemistry

Subject Code: CYT-501 **Course Title:** Computational Approaches to Catalysis & Reaction Design

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Quantum chemistry: Hartree-Fock theory, basis sets, correlated ab initio methods, configuration interaction, MP2 theory, Coupled-cluster methods, multi-reference methods, density functional theory, semi-empirical methods, solids and periodic models. Geometry optimization: features of potential energy surfaces, geometry optimization methods, geometry optimization with quantum chemical methods, transition states and reaction paths. Rate constant and Equilibria, statistical thermodynamics and equilibrium, transition state theory, homogeneous and heterogeneous catalysis, computational-based examples to understand catalysts role in reactions, screening of catalytic reactions to find best catalyst.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of Department/Centre: Department of Humanities and Social Sciences

Subject Code: HST-501 **Course Title:** Statistical Application for Behavioral and Social Research

L-T-P: 2-1-0 **Credits:** 03 **Subject Area**: STAR

Course Outlines: Descriptive & Inferential Statistics, Measures of central tendency and variability, Standard Scores and the Normal Curve, Statistical Inference and its application, Correlation; Simple Linear Regression, Multiple Regression Analysis, Analysis of Variance, Experimental methods and analysis, Principal component analysis and Exploratory Factor analysis, Confirmatory factor analysis; Use of statistical packages.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Hydrology

Subject Code: HYT-501 **Course Title:** Data Analysis and Numerical Modelling

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course outlines: Introduction to data analysis; Basic concepts of probability and statistics; Probability distributions and their applications; Frequency analysis, Risk and uncertainty in hydroclimatic analysis; Hypothesis testing and nonparametric test; Time series analysis; Regression analysis; Data visualization; Review of differential equations in water resources, Introduction to numerical methods; Finite difference approximation of first and second order derivatives, Forward, backward and central difference methods; explicit, implicit and Crank Nicholson schemes, numerical errors, stability and convergence criteria, Basics of Finite element methods; Iterative methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHT-506 **Course Title:** Superconducting Qubits-based Quantum Computing

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course outlines: Quantum states in Hilbert space, EPR paradox, Schrödinger wave equation and its incompleteness, Superposition, entanglement, Quantum Confinement, Fundamentals of Superconductivity, Cooper pairs, and Josephson tunneling. Bits and Qubits, Josephson Quantum dot-junction-based Superconducting quantum qubits, charge qubits, flux qubits and phase qubits, Transmon qubit, and hybrid qubits. Quantum circuits Quantum gates X-gate (bit flip, Not), Z-gate (phase flip), H-gate and T gate, controlled-NOT, qubits gates and quantum Circuits, Shor's Algorithm, and Grover's Algorithm code, Superconducting qubits-based quantum computers fabrication, advantages based on coherence time, operation fidelities and Error's correction, Di-Vincenzo Criteria, Possible array of Superconducting Quantum Qubits, and Challenges ahead in Quantum computing.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Water Resources Development and Management

Subject Code: WRT-501 **Course Title:** Artificial Intelligence (AI) & Machine Learning (ML) for Water Resources

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to AI & ML, Systems and Modeling, Statistics and Data Analysis, Probability theory and Distribution, Search Algorithm, Gradient Decent, Genetic Algorithm, Model Development, Types of Regression Models, Classification, Parameters Estimation, Building Linear Neural Models, Feed Forward, Multilayer Perceptron, Sensitivity and Uncertainty Analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Polymer and Process Engineering

Subject Code: PET-501 **Course Title:** Polymers for Advanced Applications

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Importance of plastics in modern society; biodegradability: myths and reality; polymers in healthcare and safety; polymers as a safe, hygienic medium for packaging foods and food products; polymer: materials for national security; fuel-efficient modern automobiles- contribution of polymer; resource conservation land, water, forests, and energy, recycling of plastics and integrated waste management.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Polymer and Process Engineering

Subject Code: PET-502 **Course Title:** Membrane Fabrication & Applications

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Fundamentals of membranes and applications, preparation of polymeric and inorganic membranes and fabrication of membrane modules, polymeric membranes for MF, UF, RO, FO processes, and gas separation; Influence of polymeric solution thermodynamics on membrane performance; Sintering, stretching, track-etching, template leaching, interfacial polymerization, phase inversion; Characteristics of membrane material and products; Membrane Processes: Pressure driven and osmosis membrane processes for water and gas separation, large scale application of RO; High tech applications of membrane.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/ CENTRE: Centre for Nanotechnology

Subject Code: NTT-501 **Course Title:** Technology of Nanoscale Devices

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to nanotechnology and nanoscale devices; basics of nanoscale electronic and optoelectronic devices; nanotechnology for solar cells, light emitting diodes, photodetectors, field effect transistors, etc; single electron transistors; low dimensional carbon-based devices; nanomaterials-based sensors: physical, chemical and biological; nanodevices for healthcare; nanotechnology inspired IoT and artificial intelligence.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/ CENTRE: Centre for Nanotechnology

Subject Code: NTT-502 **Course Title:** Quantum Materials

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to quantum materials; quantum confinement and low dimensional materials; 1D, 2D, and 0D materials; topological insulators and van der Waals heterojunctions; materials for spintronics; quantum hall effect; quantum effect in low-dimensional magnetic systems; superconducting materials.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/ CENTRE: Centre for Nanotechnology

Subject Code: NTT-503 **Course Title:** AI and ML for Nanotechnology

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Data analysis, Python programming and visualization, regression and dimensional reduction of properties at nanoscale, machine learning for nanosensors, supervised learning for selection of nanomaterials, optimization for nanodevices, explainable AI in nanobiotechnology, and capstone project.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Electrical Engineering

Subject Code: EET-501 **Course Title:** Electric Drive for Modern Transport Systems

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Electric traction, overhead supply system, substation, locomotive converter and drivemotors, high speed traction system and drivers, hyper loop/vacuum tube transportation system.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Electrical Engineering

Subject Code: EET-504 **Course Title**: Data Structures

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Hardware and software implementations of data structures, existing data structures and related operations Link List, Stack, recursion, converting a recursive procedure to a non-recursive procedure. Simple queue, de-queue, input restricted and output restricted de-queue. Tree, its creation, BST, traversal algorithms, heap tree, MST, Graph, Its traversal. Table Hash function and hashing, collision and collision resolving methodologies. Searching & Sorting Algorithms and their Complexity.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Electrical Engineering

Subject Code: EET-507 **Course Title:** Control Theory and its Applications in Renewable Energy Systems

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to Renewable Energy (RE), Modelling of renewable energy sources such as Solar, Wind, Hydro, and Biomass from a control theoretical point of view. Fractional order modelling of RE, Model Identification techniques for Renewable Energy Systems, Control challenges in Integration of Renewable energy, Classical control for renewable energy systems, Model-based control system design, Advanced control for Renewable Energy Systems, Simulation studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Electrical Engineering

Subject Code: EET-509 **Course Title**: Embedded System Design using FPGA

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Digital devices and verification tools. Abstraction levels. Combinational and sequential circuits. PLDs, General FPGAs, Design Development flow, Combinational/Sequential circuits design and verification with HDL. Data-path and Control-path. FSM and ASM with Datapath. HDL design of processor, I/O. SRAM interface with time constraints. General purpose soft-core processor: Architecture, Interfacing, Interrupt handling, Assembly Code Development. FPGA Implementation: Constraint file development, synthesis and implementation of combinational, sequential, programmed processor.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Electrical Engineering

Subject Code: EET-502 **Course Title:** Electric Vehicle Systems

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Fundamentals of EV systems, Types and architecture of EVs, powertrain components and sizing, motor and speed control methods, type and management of energy storage systems (ESS), types of batteries used, battery sizing, BMS and its topologies, vehicle charging methods, standards, converters used in EVs, vehicle communication.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF CENTRE: Centre of Excellence in Disaster Mitigation and Management

Subject Code: DMT-501 **Course Title:** AI/ML for Disaster Management

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to AI/MLs, Classification and Clustering, Supervised and Unsupervised Learning, Decision Trees, Random Forest, Principal Component Analysis (PCA), Support Vector Machines, K-Nearest Neighbors, Logistic Regression, Gradient Boosting, Bayesian Networks, Ensemble Methods, Neural Networks, Deep Learning (CNN, RNN), Reinforcement Learning. Natural Language Processing (NLP), NLP application in Disaster Studies. Exploratory Data Analysis: Python for Data Analytics, Libraries like PyTorch, Keras. R Programming language: Dplyr, Tidyr, Lubricate packages.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Hydro and Renewable Energy

Subject Code: HRT-501 **Course Title:** Modeling of Turbulence in Turbines

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction and Origin of Turbulence; Theories, Correlation, Kolmogrov Hypothesis, PDF; Scaling analyis Turbulent Kinetic Energy and scaling analysis; Mathematical Modeling; Introduction to CFD Governing Equations, Introduction to FDM, FVM; Discretization Schemes, Convective and Diffusive terms; Introduction to Turbines, Types and parts of turbines; Challenges, Meshing, Running CFD cases; Implementation in software using case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Hydro and Renewable Energy

Subject Code: HRT-503 **Course Title:** Modeling and Stability Analysis of DC-DC Converters

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Linear system theory, Fourier and Laplace transforms, Transfer functions; Electrical circuit in laplace domain, transient and steady state response; Bode plots, stability criteria using phase and gain margin, control loops; Modeling of DC-DC converter, steady-state representation, circuit averaging; Designing close loop control of DC-DC converter, slope compensation, RHP zero; Stability of close loop system, type-I, II, III compensation networks; Practical aspects of controller design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Hydro and Renewable Energy

Subject Code: HRT-504 **Course Title:** Quantitative Investigations of Flows

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Properties of Fluids, Basic of Experimental Methods, Introduction to Hydrodynamics, Aerodynamics and Multiphase Flows, Types of Wind Tunnels, Cavitation Tunnels and Flumes, Instrumentation, Fundamentals of Flow Visualization, Visualization Techniques, Velocity, Temperature and Pressure Measurement Techniques, Measurement Techniques for Special Flow, Free Surface Flow and Multiphase Flow, Advance in the field of Flow Measurement e.g. Quantum Dots, Accuracy and Uncertainty Analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Paper Technology

Subject Code: PPT-501 **Course Title:** Pulp, Paper & Packaging

L-T-P: 3-0-0 **Credits:**3 **Subject Area:** STAR

Course outlines: Pulping methodology, mechanical and chemical pulping, chemical recovery process, bleaching sequences, bleaching chemicals, chlorine-free bleaching, stock preparation, paper properties, refining, paper making, wet end and dry end operations, recycling of secondary fiber, pulp quality control, paper packaging systems, packaging applications, sustainable packaging practices, life cycle analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Paper Technology

Subject Code: PPT-502 **Course Title:** Environmental Control

L-T-P: 3-0-0 **Credits:**3 **Subject Area:** STAR

Course outlines: Environmental issues, IPPC directive, Environmental action programs, Eco-Management and Audit Scheme (EMAS), Environmental Impact Assessment, effluent monitoring, Process modifications, air quality management, effluent treatment, waste management.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Applied Mathematics and Scientific Computing

Subject Code: AMT-501 **Course Title:** Deep Learning

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to Artificial Intelligence-historical development and motivation, Perceptron model and Multilayer Perceptron (MLP) models, Introduction to Tensorflow and Keras, Convolution Neural Networks, Recurrent Neural Networks, Generative AI.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF Department/Center/School: Department of Management Studies

Subject Code: BMT-501 **Course Title:** Industrial Internet of Things

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outline: **Introduction to IIoT** - Defining the IIoT, IIoT Applications and Use Cases, **Technical Foundations of IIoT-** IoT Devices and Sensors, Data Collection and Processing, **IIoT Platforms and Architecture-**Platforms and Middleware, IIoT Security and Privacy, **Business Implications of IIoT**- Business Models and Value Creation, Organisational Transformation, **Strategic Considerations and Future Trends-** Strategic Alignment of IIoT, Emerging Trends and Future Outlook, case studies

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF Department/Center/School: Management Studies

Subject Code: BMT-502 **Course Title:** Data, Models and Decisions

L-T-P: 3-0-0 **Credits: 3** **Subject Area: STAR**

Course Outlines: Introduction to Decision Analysis: Illustrations of decision problems; Supplier Selection: Diversification, risk mitigation, reliability; Spot Markets: Coupling, Aggregate supply and demand curves, price signals; Logistics and Transportation: Travelling Salesman problem, Vehicle Routing Problem; Production Planning: Pure Strategies, Mixed Strategies; Scheduling and Routing: Queues, Johnson's RUle; Data Envelopment Analysis: Efficiency Measures; Discrete Event Simulation; Decision Making under uncertainty.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF Department/Center/School: Department of Management Studies

Subject Code: BMT-503 **Course Title: AI Applications in Marketing**

L-T-P: 3-0-0 **Credits: 3** **Subject Area: STAR**

Course Outlines: Introduction to AI in Marketing: The Marketer's challenge; Nature, scope, understanding of basics of AI; AI history; AI themes; Types of AI, benefits and limitations of AI; Machine Learning; New Technologies- IoT, AR, VR, Mixed Realities, Developing Marketing Strategies and Plans using AI: Role of AI in value delivery process; Designing AI marketing strategy; Building sustainable competitive advantage using AI; Using AI for segmentation, targeting and positioning, AI For Marketing Research: AI for standardization, personalization and relationalization, network and networks effect; Using AI in product strategy- development, design and differentiation, managing services- virtual assistants, chatbots, service robots and other AIs; pricing strategies – pitfalls of pricing algorithms; marketing channel management- new and hybrid channels, managing retailing- online versus in-store -hybrid shopping experiences, Ethics in AI: Ethical Concerns in using AI: concerns about privacy, potential for bias, concerns about appropriateness; the risks of using AI: fairness, transparency and management of self-learning algorithms; AI and workforce; Building accountability in AI and Four phase approach to implementing AI.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of Department: Metallurgical and Materials Engineering

Subject Code: MTT-501 **Course Title:** Materials for Sustainability

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course outlines:

Sustainability concepts and metrics, Materials life cycle, circular economy and their relationship, Sustainable materials, Case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Physics

Subject Code: PHT-501 **Course Title:** Advanced Materials for Energy Harvesting and Storage

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Basics of energy conversion processes (thermoelectric, piezoelectric, photovoltaic, hydroelectric, etc.), Materials for energy harvesting and storage, covering synthesis, characterization. Hydroelectric cells, dielectrics, quantum dots, perovskite solar cells, and supercapacitors, batteries. Role of nanostructures in enhancing energy storage performance. Flexible and wearable energy devices

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Physics

Subject Code: PHT-502 **Course Title:** Functional Materials

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Functional materials are materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli (temperature, electric/magnetic field, etc.) and are therefore applied in a broad range of technological devices for example in memories, displays and telecommunication. This course aims to provide students with a detailed understanding of a range of functional materials, including magnetic and superconducting materials, ferroelectric materials, semiconductor materials and 2D materials. These are a rapidly emerging class of materials that exhibit novel physical properties and find applications in a wide range of fields such as catalysis, electronic devices, actuators and sensors.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Physics

Subject Code: PHT-503 **Course Title:** Fundamentals of Nanoscience and Technology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Nanoscience, Nanotechnology, Fundamentals, Principles, Applications, Nanostructures, Quantum Mechanics, Materials Science, Characterization Techniques, Fabrication Methods, Nanomaterials, Nanoelectronics, Self-assembly, Surface Science, Nanoengineering, Quantum Dots, Carbon Nanotubes, Nanosensors, Energy Applications, Environmental Implications, Ethical Considerations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Physics

Subject Code: PHT-504 **Course Title:** Computational Science with Python

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Programming in Python, Variables and Array, Control structure, basic numerical algorithms covering interpolation, integration, differentiation, ODE and PDE solvers, Dense linear algebra (numpy), Sparse linear algebra (scipy), Plotting, Symbolic computing (sympy), Data processing (pandas), Machine learning basics (Regression)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Physics

Subject Code: PHT-505 **Course Title:** Quantum Simulations

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Basics of quantum computing applied to simulating physical systems. Coding quantum computers for solving some eigenvalue problems in many-body systems with an adequate introduction to the relevant algorithms, encodings, and transformations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Computer Science and Engineering

Subject Code: CST-501 **Course Title:** Programming in C/C++

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to Programming, Fundamentals of C: Literals, Keywords, Variables, Constants, data types, Operators, Expressions, Control Structure: if-else, switch case, loop structure, for loop, while loop, do-while loop. Arrays, String. Functions, Recursion. Structures and Union. Pointers: Memory and Pointers, Pointer Arithmetic, Dynamic Memory Allocation. C++ v/s C: Re-iterating control structures, arrays, strings, functions and pointers in C++, References, class, constructor, object, Access Specifiers and Modifiers. Object-oriented Concepts: Encapsulation, Abstraction, Polymorphism, Inheritance, Sub-classes, Static vs Dynamic Binding, Exception Handling.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Mechanical & Industrial Engg.

Subject Code: MIT-501 **Course Title:** Value Engineering

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Fundamental concepts, definitions, value analysis, value management, historical perspective, Functions: Classification of functions, types of functions, functional analysis, FAST diagrams, Functional Cost Analysis, examples and case studies, Techniques of value engineering, Value engineering job plan, systematic implementation of principles of value engineering, applications of the principles in product and process design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
NAME OF DEPARTMENT/CENTRE/SCHOOL: Civil Engineering

Subject Code: CET-504 C**ourse Title:** Introduction to the Theories of Inelasticity

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to inelasticity, Physical basis of plasticity, Tensile test and Bauchinger effect, Structure of phenomenological plasticity theories, Yield criteria, Geometry of yield surfaces, Levy-Mises equations, Flow rules, Plastic potentials, Consistency condition, Internal variables, Isotropic and Kinematic Hardening, Drucker's stability postulate, Maximum plastic dissipation, Maximum plastic work, Associativity, Convexity, Normality, Uniqueness, Introduction to computational inelasticity, return mapping algorithm, principle of virtual work, Finite element formulation of 1-D plasticity, Viscoelastic behavior of materials, Creep, Relaxation, Viscoelastic models: Kelvin-Voigt, Maxwell, Standard linear solid, Physics of damage, Definition of damage variables, Effective stress concept, Isotropic damage and its formulation, Effects of isotropic damage on elastic fields, Finite element formulation of brittle and quasi-brittle damage.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
NAME OF DEPARTMENT/CENTRE/SCHOOL: Civil Engineering

Subject Code: CET-505 C**ourse Title:** Engineering Design Optimization and Reliability

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to Design Optimization, Optimal Design Problem Formulation, Graphical Optimization and Basic Concepts, Optimum Design Concepts: Optimality Conditions, Optimal Design with MATLAB, Numerical Methods for Unconstrained Design Optimization, Numerical Methods for Constrained Design Optimization, Practical Applications of Optimization, Genetic Algorithm for Optimum Design, Multi-objective Optimum Design Concepts and Methods, Fundamentals of probability theory, Common probabilistic models, General component reliability, First-order second-moment methods, First and Second-order reliability method, Importance measures and parameter uncertainty, Sampling techniques, Surrogate Modelling, Development of reliability based design codes, System reliability

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Electronics & Communication Engg.

Subject Code: ECT-504 **Course Title:** Applications of RF Technology in Defence and Space Applications

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Syllabus: Unit 1: Foundation – Transmission Line Theory, Smith Chart, Network Analysis using Sparameters, Impedance Matching. 12 Hours

Unit 2: Power Combiners for Defence and Space Applications – Rectangular Waveguide, Corporate, Radial Combiner, E-plane Sectoral, and Magic T combiners. 10 Hours

Unit 3: Antennas for Defence and Space Applications – Microstrip Patch Antenna, Waveguide Horn Antenna, Antenna Arrays 8 Hours

Unit 4 : Filters for Defence and Space Applications – Stepped Impedance Low Pass Filters. Band Pass Filters, Tunable Band Pass Filters, Multi-Functional Filters 6 Hours

Unit 5: Optimization Techniques – Linear and Aggressive Space Mapping Technique 6 Hours

INDIAN INSTITUTE OF TECHNOLOGY

NAME OF DEPARTMENT/CENTRE/SCHOOL: ELECTRONICS & COMMUNICATION ENGG.

Subject Code: ECT-501 **Course Title:** Inference and Learning Algorithms

L-T-P: 3-0-0 **Credits: 3** **Subject Area: STAR**

Course Outlines:

- **Review of Probability Theory:** Bayes theorem, Random variables, Probability Distributions, Moments, Conditional Expectation, Entropy, Kullback-Leibler Divergence, Data Processing Inequality.

- **Review of Optimization Theory** – Convex sets and functions, Duality, Kharush-Kuhn-Tucker (KKT) Optimality Conditions, Fixed point method for solving KKT conditions

- **Maximum Likelihood Inference:** Maximum Likelihood (ML) criterion, Sufficient Statistics, Neyman Factorization theorem, Asymptotic consistency of ML estimation.

- **Bayesian Inference:** Maximum Aposteriori Probability (MAP) estimation, Sequential Bayesian Inference.

- **Inference in presence of latent variables:** Expectation Maximization (EM), EM algorithm as Majorization Minimization, Gaussian Mixture Model.

- **Variational Inference**: Majorization Minimization, Mean Field Approximation, Evidence Lower Bound (ELBO).

- **Sparse Inference:** Sparse Signal Model**,** Sparse solutions of linear systems**,** Sparse Linear Regression

- **Inference in Graphical models:**Graphical models, Factor Graphs, Sum-Product Algorithm, Message-Passing over Factor Graphs.

- **Inference using Maximum Entropy Principle:** Exponential Family Distributions , Maximum Entropy Method.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Mathematics

SubjectCode:MAT-501 **Course Title**: Computational Methods for AI and ML

L: 2 **T:** 1 **P:** 0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Direct and iterative solvers for linear system of equations, ordinary least square and minimum normed solutions for rectangular system of equations, linear regression, eigenvalues and eigenvectors of a matrix, spectral decomposition, singular value decomposition, low-rank approximation, principal component analysis, linear discriminant analysis, tensor decomposition algorithms, gradient calculus, maxima and minima, Jacobian and Hessian matrices, positive and negative definite matrices, various loss functions, gradient descent, numerical algorithms for constrained and unconstrained optimization of nonlinear loss functions, introduction to probability, conditional probability and Bayes theorem, Gaussian distribution, maximum likelihood estimation and maximum a priori estimation in case of linear regression.

Indian Institute of Technology Roorkee

Name of Deptt./Centre/School: Centre for Transportation Systems

Name of Department/Centre/School: Centre for Transportation Systems (CTRANS)

Subject Code: TST-501 **Course Title**: Sustainable Transportation Systems

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Sustainability and Transportation; Life Cycle Assessment; Transport Externalities; Active Mobility; Public Transport; Multi-Modal Freight Transport; Sustainable Fuel Sources; Electric Mobility; Case Studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Biosciences and Bioengineering

Subject Code: BET-501 **Course Title:** Bioinformatics

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines:

Introduction of Linux and Python programming, Algorithm and Data Structures, Object Oriented Programming, Health Informatics, Sequence Analysis, Structural Informatics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Earthquake Engineering

Subject Code: EQT-501 **Course Title:** High Performance Scientific Computing

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outline:

Overview of scientific computing and its importance, Challenges in high-performance computing, Shared memory vs. distributed memory architectures, Open MP for shared-memory parallelism, Compiler optimization, Loop optimization, Algorithms for problem solving (equation solvers, eigen value decomposition, singular value decomposition, fast fourier transforms, etc.).

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF CENTRE: Centre for Space Science and Technology

Subject Code: SST-501 **Course Title**: Space Exploration and Applications

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outline:

History of Space exploration, Societal applications of Space Science and Technologies, India's Space Programme, Space Materials, Fabrication Techniques for Spacecraft Structures, Payload, Launch Vehicle and Ground Systems, Satcom and Navigation Systems, Policies and Economics for Space, Offshoots of Space Technology, Materials and Technology for Future Space Missions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: DEPARTMENT OF DESIGN

Subject Code: DET-501 **Course Title:** User Experience and Interface Design

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines:

Introduction to UX-UI design; Five elements of UX; UX design approaches; User research processes, ethnography, task analysis user interviews, card sorting, eye-tracking, etc.; Deliverables of UX; Information architecture; Prototype design; Atomic design model; Usability testing; Visual communication design of interface, typography, colour theory, design trends and design systems; UI animations and transitions; Case studies and best practices.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-501 **Course Title:** Advanced Materials for Energy Harvesting and Storage

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Basics of energy conversion processes (thermoelectric, piezoelectric, photovoltaic, hydroelectric, etc.), Materials for energy harvesting and storage, covering synthesis, characterization. Hydroelectric cells, dielectrics, quantum dots, perovskite solar cells, and supercapacitors, batteries. Role of nanostructures in enhancing energy storage performance. Flexible and wearable energy devices.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-503 **Course Title:** Fundamentals of Nanoscience and Technology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Nanoscience, Nanotechnology, Fundamentals, Principles, Applications, Nanostructures, Quantum Mechanics, Materials Science, Characterization Techniques, Fabrication Methods, Nanomaterials, Nanoelectronics, Self-assembly, Surface Science, Nanoengineering, Quantum Dots, Carbon Nanotubes, Nanosensors, Energy Applications, Environmental Implications, Ethical Considerations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-504 **Course Title:** Computational Science with Python

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Programming in Python, Variables and Array, Control structure, basic numerical algorithms covering interpolation, integration, differentiation, ODE and PDE solvers, Dense linear algebra (numpy), Sparse linear algebra (scipy), Plotting, Symbolic computing (sympy), Data processing (pandas), Machine learning basics (Regression)**.**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-505 **Course Title:** Quantum Simulations

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Basics of quantum computing applied to simulating physical systems. Coding quantum computers for solving some eigenvalue problems in many-body systems with an adequate introduction to the relevant algorithms, encodings, and transformations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Mechanical and Industrial Engineering

Subject Code: MIT-501 **Course Title:** Value Engineering

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Fundamental concepts, definitions, value analysis, value management, historical perspective, Functions: Classification of functions, types of functions, functional analysis, FAST diagrams, Functional Cost Analysis, examples and case studies, Techniques of value engineering, Value engineering job plan, systematic implementation of principles of value engineering, applications of the principles in product and process design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Mathematics

Subject Code: MAT-501 **Course Title:** Computational Methods for AI and ML

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Direct and iterative solvers, least square and minimum normed solutions, linear regression, spectral decomposition, singular value decomposition, low-rank approximation, principal component analysis, linear discriminant analysis, tensor decomposition algorithms, gradient calculus, Jacobian and Hessian matrices, positive and negative definite matrices, various loss functions, gradient descent, numerical algorithms for nonlinear loss functions, conditional probability and Bayes theorem, Gaussian distribution, maximum likelihood estimation and maximum apriori estimation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF CENTRE: Centre for Transportation Systems

Subject Code: TST-501 **Course Title**: Sustainable Transportation Systems

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Carbon footprint of transportation systems; Life cycle analysis; Sustainability Concepts in transportation planning; Strategies for sustainable transportation; Challenges and opportunities for sustainability transportation systems; Active mobility; Public transport planning; Sustainable freight transport; Multi-modal integration; Sustainable fuel sources; Electric mobility adoption and charging infrastructure planning; Water based transport; Case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Biosciences & Bioengineering

Subject Code: BET-501 **Course Title:** Bioinformatics

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction of Linux and Python programming, Algorithm and Data Structures, Object Oriented Programming, Health Informatics (Telemedicine, Mobile Apps, Medical Image Analysis), Biological webservers/databases and their usage, Sequence Analysis, Structural Informatics

NDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Earthquake Engineering

Subject Code: EQT-501 **Course Title:** High Performance Scientific Computing

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Overview of scientific computing and its importance, Challenges in high-performance computing, Shared memory vs. distributed memory architectures, OpenMP for shared-memory parallelism, Compiler optimization, Loop optimization, Algorithms for problem solving (equation solvers, eigenvalue decomposition, singular value decomposition, fast fourier transforms.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Chemical Engineering

Subject Code: CHT-501 **Course Title:** Computational Fluid Dynamic with Tools

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to the computational fluid dynamics (CFD) – Governing equations for Mass, Momentum and Energy; Discretization methods: finite-volume, finite-element, finite-difference; Accuracy, conservation, convergence and stability concepts for all the discretization methods; CFD solutions using first principles (e.g. MSExcel, Python/ MATLAB); Commercial and open source codes for the CFD problems; Application of data-driven approximation techniques in CFD.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Paper Technology

Subject Code: PPT-501 **Course Title:** Pulp, Paper & Packaging

L-T-P: 3-0-0 **Credits:**3 **Subject Area:** STAR

Course outlines: Pulping methodology, mechanical and chemical pulping, chemical recovery process, bleaching sequences, bleaching chemicals, chlorine-free bleaching, stock preparation, paper properties, refining, paper making, wet end and dry end operations, recycling of secondary fiber, pulp quality control, paper packaging systems, packaging applications, sustainable packaging practices, life cycle analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Paper Technology

Subject Code: PPT-502 **Course Title:** Environmental Control

L-T-P: 3-0-0 **Credits:**3 **Subject Area:** STAR

Course outlines: Environmental issues, IPPC directive, Environmental action programs, Eco-Management and Audit Scheme (EMAS), Environmental Impact Assessment, effluent monitoring, Process modifications, air quality management, effluent treatment, waste management.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Applied Mathematics and Scientific Computing

Subject Code: AMT-501 **Course Title:** Deep Learning

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to Artificial Intelligence-historical development and motivation, Perceptron model and Multilayer Perceptron (MLP) models, Introduction to Tensorflow and Keras, Convolution Neural Networks, Recurrent Neural Networks, Generative AI.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydro and Renewable Energy

Subject Code: HRT-501 **Course Title:** Modeling of Turbulence in Turbines

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction and Origin of Turbulence; Theories, Correlation, Kolmogrov Hypothesis, PDF; Scaling analyis Turbulent Kinetic Energy and scaling analysis; Mathematical Modeling; Introduction to CFD Governing Equations, Introduction to FDM, FVM; Discretization Schemes, Convective and Diffusive terms; Introduction to Turbines, Types and parts of turbines; Challenges, Meshing, Running CFD cases; Implementation in software using case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydro and Renewable Energy

Subject Code: HRT-502 **Course Title:** System Dynamics Modelling

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Purpose and concepts of system dynamics; Structure and behavior of dynamic systems; Building theory with causal loop diagrams (CLDs); Conceptualization and policy analysis with CLDs; Stocks and flows; First-order systems; Positive feedback and exponential growth; Negative feedback and exponential decay; Multiple loop systems; Nonlinear first-order systems; Modeling S-shaped growth; Delays; Structure and behavior of material delays vs. information delays; Modeling decision making; Case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPARTMENT: Department of Hydro and Renewable Energy

Subject Code: HRT-503 **Course Title:** Modeling and Stability Analysis of DC-DC Converters

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Linear system theory, Fourier and Laplace transforms, Transfer functions; Electrical circuit in laplace domain, transient and steady state response; Bode plots, stability criteria using phase and gain margin, control loops; Modeling of DC-DC converter, steady-state representation, circuit averaging; Designing close loop control of DC-DC converter, slope compensation, RHP zero; Stability of close loop system, type-I, II, III compensation networks; Practical aspects of controller design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Hydro and Renewable Energy

Subject Code: HRT-504 **Course Title:** Quantitative Investigations of Flows

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Properties of Fluids, Basic of Experimental Methods, Introduction to Hydrodynamics, Aerodynamics and Multiphase Flows, Types of Wind Tunnels, Cavitation Tunnels and Flumes, Instrumentation, Fundamentals of Flow Visualization, Visualization Techniques, Velocity, Temperature and Pressure Measurement Techniques, Measurement Techniques for Special Flow, Free Surface Flow and Multiphase Flow, Advance in the field of Flow Measurement e.g. Quantum Dots, Accuracy and Uncertainty Analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CET-504 **Course Title:** Introduction to the Theories of Inelasticity

L-T-P: 3-0-2/2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to inelasticity, Tensile test and Bauschinger effect, Structure of phenomenological plasticity theories, Yield criteria, Levy-Mises equations, Flow rules, Plastic potentials, Consistency condition, Internal variables, Isotropic and Kinematic Hardening, Drucker's stability postulate, Computational inelasticity, FE formulation of 1-D plasticity, Viscoelastic models, Physics of damage, Isotropic damage, FE formulation of damage.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CET-505 **Course Title:** Engineering Design Optimization and Reliability

L-T-P: 3-0-2/2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Fundamentals of design optimization: formulation, graphical methods, and optimality, Numerical methods for constrained/unconstrained optimization and implementation, Genetic algorithms and multi-objective optimization concepts, Practical applications and surrogate modelling for efficiency, Introduction to reliability-based optimization and design codes, emphasizing essential probabilistic models and system reliability.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Management Studies

Subject Code: BMT-501 **Course Title:** Industrial Internet of Things

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to IIoT - Defining the IIoT, IIoT Applications and Use Cases, Technical Foundations of IIoT- IoT Devices and Sensors, Data Collection and Processing, IIoT Platforms and Architecture-Platforms and Middleware, IIoT Security and Privacy, Business Implications of IIoT-Business Models and Value Creation, Organisational Transformation, Strategic Considerations and Future Trends- Strategic Alignment of IIoT, Emerging Trends and Future Outlook, case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Management Studies

Subject Code: BMT-502 **Course Title:** Data, Models and Decisions

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to Decision Analysis: Illustrations of decision problems; Supplier Selection: Diversification, risk mitigation, reliability; Spot Markets: Coupling, Aggregate supply and demand curves, price signals; Logistics and Transportation: Travelling Salesman problem, Vehicle Routing Problem; Production Planning: Pure Strategies, Mixed Strategies; Scheduling and Routing: Queues, Johnson's RUle; Data Envelopment Analysis: Efficiency Measures; Discrete Event Simulation; Decision Making under uncertainty.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Management Studies

Subject Code:BMT-503 **Course Title:** AI Applications in Marketing

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Nature, scope, understanding of basics of AI; AI themes; Types of AI; Developing Marketing Strategies and Plans using AI; Designing AI marketing strategy; AI For Marketing Research: Using AI in product strategy; managing services; pricing strategies and pitfalls; marketing channel management; Ethics in AI; the risks of using AI.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Management Studies

Subject Code: BMT-504 **Course Title:** Organization Behaviour For Technology based Organizations

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Dynamics in organization, contributing discipline to OB, Leadership: Theories, Models, types of Leadership, success stories in technology based organisations. Motivation; Theories, Models, Success stories. Organizational Change Models; Reasons, elements of change, Models, Stress Management; Stress Life cycle, Sources of stress in technology based organisations, Theories of stress. Conflict Management in in technology based organisations; Consequences, causes, types of conflict, conflict handling intentions, Outcomes of conflict. Leadership, Team Building; Types of teams, Team culture, Effective Team Work. Organization Culture in Technology based Organisations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF CENTRE: Centre for Space Science and Technology

Subject Code: SST-501 **Course Title:** Space Exploration and Applications

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: History of Space exploration, Societal applications of Space Science and Technologies, India's Space Programme, Space Materials, Fabrication Techniques for Spacecraft Structures, Payload, Launch Vehicle and Ground Systems, Satcom and Navigation Systems, Policies and Economics for Space, Offshoots of Space Technology, Materials and Technology for Future Space Missions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Computer Science and Engineering

Subject Code: CST-501 **Course Title:** Programming in C/C++

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Fundamentals of C: Literals, Keywords, Variables, Constants, data types, Operators, Expressions, Control Structure: if-else, switch case, loop structure, for loop, while loop, do-while loop. Arrays, String. Functions, Recursion. Structures and Union. Pointers: Memory and Pointers, Pointer Arithmetic, Dynamic Memory Allocation. C++ v/s C: Re-iterating control structures, arrays, strings, functions and pointers in C++, References, class, constructor, object, Access Specifiers and Modifiers. Object-oriented Concepts: Encapsulation, Abstraction, Polymorphism, Inheritance, Sub-classes, Static vs Dynamic Binding, Exception Handling.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DST-501 **Course Title**: Analysis of Dam Instrumentation Data

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Types of Instruments used in the dams and catchments, Basics of time series analysis, Synthetic data generation, Time domain analysis of the data, Frequency domain analysis of the data, Applications of AI & ML in Dam Engineering, Flow forecasting using Artificial Neural Networks (ANN), Fuzzy Logic and Genetic Algorithms.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Architecture and Planning

Subject Code: ART-502 **Course Title:** Fundamentals of Town Planning

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Definitions and basic concepts, Urban, rural and regions; Town planning in ancient and historic ages; Multi Level planning and governance structure in India, Legal provisions of Planning; Principles of town planning: Land use planning, Development plan/ Master plan, Neighbourhood planning; Planning tools and techniques: surveys, zoning, development controls, Planning Concepts: Industrial townships; Smart City, Sustainable City, Critical infrastructures and Urban renewal; Transportation and mobility; Disaster resilience in urban planning; Role of technology; Participatory planning and role of stakeholders; Future of Planning; Discussion and case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Design

Subject Code: DET-501 **Course Title:** User Experience and Interface Design

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** STAR

Course Outlines: Introduction to UX-UI design; Five elements of UX; UX design approaches; User research processes, ethnography, task analysis user interviews, card sorting, eye-tracking, etc.; Deliverables of UX; Information architecture; Prototype design; Atomic design model; Usability testing; Visual communication design of interface, typography, colour theory, design trends and design systems; UI animations and transitions; Case studies and best practices.