INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-501 **Course Title:** Numerical Analysis and Computational Techniques

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

Course Outlines: Review of computer programming. Linear system of simultaneous equations, nonlinear algebraic equation, curve fitting, roots of transcendental equation, interpolation, data analysis and statistics. Finite difference method, Numerical integration and differentiation, Monte-Carlo simulation, ordinary differential equation, partial differential equation methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-503 **Course Title:** Fabrication and Characterization Techniques

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

Course Outlines: Lithographic techniques: Patterning, various kinds of resists, Spin Coating, Thermodynamics of Material Growth, Kinetics and Nucleation; Grain growth, Physical Vapor Deposition: Evaporation, Pulsed Laster Deposition, Nano-fabrication Techniques: Bottom-up and top-down approaches, Electrospinning, Sol-Gel. Dry and wet etching techniques. Structural characterization: X-ray Diffraction, X-ray Reflectivity, RHEED, Microstructural characterization: Optical Microscopy: Scanning Electron Microscopy, Atomic Force Microscopy, Transmission Electron Microscope, Electrical and Transport Characterization, Chemical characterization, Thermal characterization, Optical Characterization: Ellipsometer, Spectrometric characterization: IR, Raman and X-ray photo spectrometer.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-505 **Course Title:** Laboratory Work in Solid State Electronic Materials

L-T-P: 0-0-6 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Four Probe Technique for resistivity measurement, Mapping and analysis of the resistivity of thin films and bulk samples, Ionic conductivity measurement of solid state materials, Hall coefficient of n- and p- type semiconductors, Dielectric constant, Curie temperature of ferroelectric material, Verification of Bragg's condition by X-ray diffractometer, Thermoluminescence study in alkali halides crystals, solar cell characteristics, magnetoresistance of semiconductors, coercivity, saturation magnetization and retentivity of ferromagnetic materials, laser diode characteristics, superconductivity measurements, Determination of Lande's 'g' factor, C-V characteristics of various solid-state devices and materials

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-507 **Course Title:** Semiconductor Device Physics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Physics of Semiconductors; P-N junction, Metal-Semiconductor junction and Bipolar Junction Transistors; Field Effect Transistors: Junction Field Effect Transistor, Metal Semiconductor Field Effect Transistor, High Electron Mobility Transistors, Metal Oxide Semiconductor Field Effect Transistors (Ideal and real MOS capacitors, Threshold Voltage, C-V curve, Current-Voltage Characteristics of Enhancement Mode MOSFET); Tunnel Devices: Tunnel Diode, MIS tunnel devices, MIM tunnel diodes, Hot Electron Transistors, Resonant Tunneling Diodes; IMPATT Diodes, BARITT Diode, TUNNETT Diode; Single Electron Transistors .

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-509 **Course Title:** Science and Technology of Thin Films

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

Course Outlines: Vacuum components and systems, Thin film deposition techniques, Physical vapour Deposition Techniques including Sputtering, Pulsed Laser Deposition, Molecular Beam Epitaxy and Chemical Vapour deposition, different methods to study structural, Chemical, Electrical and Magnetic properties of thin films, Applications of thin films.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHL-544 **Course Title:** Thin film technology

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outline: Review of thin films preparation, Thin film devices: Thermoelectric sensors, Multi-Junction Converters, Infrared sensors, flow sensors, power generators, microcoolers. Magnetic devices: magneto-resistive sensors, magneto-strictive actuators, MRAM, STT-RAM, Photonic devices: optical isolators and circulators, generating and detecting Thz, Microelectronics: Integrated and superconducting circuits.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHL-548 **Course Title:** Semiconductor Micro-Electronic Technology

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outline: Crystal growth and epitaxy, thermal oxidation of silicon, including Deal- Grove Model. Vacuum science and technology. CVD technique for deposition of dielectric thin film. Optical and non-optical lithography, nanolithography, wet and dry etching. Doping of semiconductors, ion implantation. Integrated devices fabrication and their characteristics.

Department of Physics: Proposed STAR Courses

FOR PG

Subject Code: PH-xxx PHT-501 Course Title: **Advanced Materials for Energy Harvesting and Storage**
L-T-P: **3-0-0** Credits: 3 Subject Area: STAR Course

Outline: 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

Subject Code: PH-xxx PHT-502 Course Title: **Functional Materials**
L-T-P: **3-0-0** Credits: 3 Subject Area: STAR Course

Outline: 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.

FOR UG

Subject Code: PH-xxx PHT-503 Course Title: **Fundamentals of Nanoscience and Technology**
L-T-P: **3-0-0** Credits: 3 Subject Area: STAR Course

Outline: 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.

FOR UG/PG

Subject Code: PH-xxx PHT-504 Course Title: **Computational Science with Python**
L-T-P: **2-0-2** Credits: 3 Subject Area: STAR Course

Outline: 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)

Subject Code: PH-xxx PHT-505 Course Title: **Quantum Simulations**
L-T-P: **2-0-2** Credits: 3 Subject Area: STAR Course

Outline: 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 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.