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-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-511 **Course Title:** Laboratory Work in Photonics

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

Course Outlines: Mode-field diameter, bend loss and cut-off wavelength of a single mode fiber, numerical aperture, and refractive index profile of a multi-mode fiber, refractive index profiling of a planar waveguide by prism coupling method, acousto-optic effect, electro-optic effect, Characterization of light emitting diode, laser diode, photo-voltaic solar cell, photodetectors, and optocoupler, thin films deposition by thermal evaporator and spin coating, thin film characterization by spectro-photometer, optical time domain reflectometry.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-513 **Course Title:** Optical Electronics

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

Course Outlines: Anisotropic medium, wave and ray refractive indices, index ellipsoid, fundamentals of lasers, lasers rate equations, resonator cavity, Q-switching and mode locking, solid state lasers, gas lasers, fiber lasers, semiconductor lasers, salient features of optical fibers, electro-optic effect, longitudinal and transverse configurations, acousto-optic effect, RamanNath and Bragg diffraction, acousto-optic devices, nonlinear optical effects, second harmonic generation, frequency conversion, optical parametric amplifier, self-focussing, self-phase modulation, stimulated Raman and Brillouin scattering.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-555 **Course Title:** Optical Communication System

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

Course Outlines: Analogue vs digital communication, Elements of digital communication system, Communication channels (Wireline, Fiber-optic, Wireless, Underwater acoustic and storage channels) and their characteristics, Mathematical models for communication channels, Digital modulation and demodulation schemes, Introduction to quantum communication.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-559 **Course Title:** Photonic Sensors

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

Course Outlines: Basics of photonic sensors, characteristics and performance parameters, Basic optical sensors and interrogation scheme, Evanescent waves and plasmonic sensors, Fiber optic sensors: FBGs and LPGs, interferometric sensors, gyroscope, Distributed sensors, reliability issues in photonic sensing, Enhanced sensor schemes, Quantum sensing and metrology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-561 **Course Title:** Silicon Photonics

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

Course Outlines: Metal Oxide Semiconductor (MOS) Transistors (Qualitative analysis and review), CMOS Processing Technology and its relevance to photonic devices and circuits, Silicon Photonic waveguides with focus in SOI platform, Coupling of light from- and to photonic waveguides, Resonant and Non-resonant Passive Devices, Active Silicon Photonic Devices.

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.