Indian Institute of Technology Kanpur

COURSES OF STUDY

2025

Indian Institute of Technology Kanpur
KANPUR-208016

PHOTONIC SCIENCE AND ENGINEERING

BT/BS – MT (PG Part – Category B) (*from other departments*)		Template No. LTP-1		
COURSES	7th	8th	9th	10th
	PG-1 [09] (PSE601A)	PG-3 [09] (PSE604A)	M.Tech. Thesis [36]	M.Tech. Thesis [36]
	PG-2 [09] (PSE602A)	PG-4 [09] (PSE605A)		
	18	18	36	36

MINIMUM CREDIT REQUIREMENT IN M.TECH PART FOR GRADUATION:

PG Component : 36 Credits
Thesis Component : 72 Credits

REMARKS:

1) All courses to be taken with the permission of Supervisor/ DUGC Convener.
2) Course credits and Thesis credits mentioned under the dual degree template are only for the M.Tech. part of the programme. In addition to these credits, students are required to follow and complete all their graduation requirements for their UG programme.
3) Upto 36 OE credits may be used from the parent department's BT/BS minimum requirements to fulfil requirements for the dual degree programme. These will be waived from the parent department's BT/BS programme requirements and counted towards PG requirements.

IDP in PSE

Course ID	Course Title	Credits L-T-P-D-[C]	Content
PSE600	INTRODUCTION TO PROFESSION & COMMUNICATION	1-0-0-0-3	Communicating science and technology: Introduction to the profession; Nature and philosophy of science and technology; Knowing the audience and their needs; Scientific Writing: Identifying the key Point; Putting the work in context – Introduction and literature survey; Designing the writing flow; Developing a good paragraph; Common types of arguments; Importance of the title and abstract; Plagiarism and Academic Integrity: Importance of academic integrity; What is plagiarism and self-plagiarism; Responsibilities of authors and their rights; Forms and standards; Aids to check and avoid plagiarism; Primacy of credit in the scientific community; Current Research Trends in Photonics: Summarize various research activities within the IDP; Career Choices: Aptitude Challenges and Opportunities: Academia; R&D labs in private and government firms; Interdisciplinarity; Changing track; Start up.
PSE601	INTRODUCTION TO PHOTONICS	3-0-0-0-9	Photonics deals with light generation, amplification, guiding, manipulation, and detection for harvesting information. This course introduces some of the fundamental aspects of photonics excluding generation and detection. Course Topics: Maxwell Equations, Wave Equations, Dielectric Media, Constitutive Relations Electromagnetic Waves- Gaussian Beams, Absorption and Dispersion Spatial and Temporal Coherence Boundary conditions, Fresnel's equations and coefficients, Brewster and critical angles, Total internal reflection, Evanescent waves, ATR Polarization, Crystal optics and Optics of

			Anisotropic Media Interference and Interferometers: Fabry Perot Electro-optics, Acousto-optics and modulators Fourier transform, optical Fourier transform and introduction to Diffraction Dielectric Waveguides – conditions for propagation, modes, dispersion, field distribution Suggested topics for photonics applications, if time permits, will include: Photonic devices in brief: Beam splitter, Waveplates, Optical Isolator, Wavelength Switches, Fabry Perot Filters, Bragg Mirrors, Micro-ring Resonators.
PSE602	PRINCIPLES OF LASERS AND DETECTORS	3-0-0-0-9	This course provides an introduction to the fundamental principles governing the operation and design of coherent light sources and detection tools. Course Topics: Introduction to light sources, Lasers, principle of lasing Optical cavities, longitudinal, transverse modes, Stability Interaction of radiation with matter, Spontaneous emission Absorption and stimulated emission, line broadening mechanisms Population inversion, absorption and gain coefficients Pumping schemes (Rate equation based Lasing model) Three- and four- level lasers CW and pulsed lasers, Q-switching and mode-locking Detection of optical radiation: Photomultiplier tubes, semiconductor photodiodes, avalanche photodiodes, Single photon detectors, dark current, thermal noise, shot noise Measurement systems: Spectroscopy (Spectral and Temporal measurement systems), CCD, monochromater, pulse width measurement.
PSE603	NUMERICAL METHODS IN OPTICS	3-0-0-0-9	To train a student to be able to numerically model problems related to optical phenomena. Each of the topics listed below will be accompanied by case studies related to optics. Some suggested case studies are: Ray Tracing using Matrix methods, Design of optical systems, Vectorial Wave propagation, Beam propagation, Anisotropic media, Modal description. Course Topics: Introduction to MATLAB/MATHMATICA type platform Linear algebra: matrices, matrix inversion; QR, Singular value decomposition, systems of equations, eigenvalues, eigenvectors, orthonormalization, condition number Laplace and Fourier transforms Vector calculus, Cartesian tensors Ordinary differential equations, series solution, Fourier series, Special functions Iterative and direct methods for linear algebraic equations; generalized inverses, least squares Numerical differentiation and integration; Numerical solution of 1st and second order ODEs, Runge-Kutta method, stability, stiff systems Partial differential equations, second order equations, classification, separation of variables, Sturm-Liouville theory Numerical solution of linear PDEs by the method of finite differences, stability Interpolation; Regression analysis Laplace equation, Poisson equation, Heat equation, Wave equation, Telegraph equation Complex variable theory Taylor series expansion, Taylor series approximation, applications such as linearization, root finding Signal processing fundamentals, time domain and frequency domain statistics, Convolution and Correlation, DFT applications.

PSE604	PHOTONIC SYSTEMS AND APPLICATIONS	3-0-0-0-9	Number of industrial and scientific applications related to photonics is growing rapidly across various disciplines. The basic courses in the first semester related to generation and transmission of photons deal with fundamental principles. The present course focuses on design issues for various applications/devices of photonics. Design of lasers, its tuning system and design of beam transmission components are discussed specific to different practical applications. Course Topics: Principles and Applications of Solid-State Laser Systems: Laser diode Structures, Mechanism of photon emission in semiconductor laser, Tunable semiconductor diode laser, rare earth doped lasers, Nd-Glass/Nd-Yag/Er- doped/Vd-Yag Lasers, Transition metal lasers, Ruby/Ti-Saphire lasers, High Power Diode lasers, DPSS Lasers, Quantum cascade Laser. Principles and Applications of Liquid and Gas Laser Systems: Dye laser, Tunable Lasers, Frequency stabilization, Tuning Techniques, Ar + lasers, He-Ne laser, CO2 lasers. Nonlinear optics: Parametric processes, Phase matching, Nonlinear optical processes, SHG, Chirped pulse amplifier, parametric amplifier. Photonics Applications in Medicine and Surgery: Laser Tissue Interaction, Turbid media, Depth of penetration, Thermal and optical properties of tissue, Heat dissipation by blood flow, Diagnostic application of lasers, Dosimetry Photon Transport theory, Measurement of tissue properties, Double integrating sphere. Laser Applications in Material Processing: Laser matter interaction, non-Fourier thermal transport, Ablation, Laser induced plasma, Laser micromachining, Microfabrication, Direct-write patterning, Laser CVD, Texturing, Joining, Annealing, Scribing Optical measurements: thin film measurements, Temperature and concentration measurements, Stresses, Flow imaging, Biomedical diagnostics, Optical Tomography Entertainment: CD Rom, Video Projection, Laser shows Special Topics: Plasmonics, Photonic crystals, Optical antennas, Photonic metamaterials, nanophotonics
PSE605	PHOTONICS LAB TECHNIQUES	1-0-6-0-9	This course will help develop experimental skill of the students in the areas of optics and photonics. An eclectic mix of about ten experiments would be undertaken by the students in the semester from the given list, apart from demonstration experiments and laboratory visits. Course Topics: 1. Electro-optic effect using LiNbO3 crystal 2. Acousto-optic modulator 3. Study of effects of loss, dispersion, amplifier noise on 10Gbps links 4. 40Gbps QAM modulation and coherent demodulation 5. Nonlinearities in fiber: Four-wave mixing, Raman scattering etc. 6. SHG generation and OPO using Nd: Yag laser 7. OPO using BBO crystal 8. Fresnel and Fraunhofer Diffraction 9. He-Ne laser beam parameters

			10. Laser diode characteristics: L-I characteristic, beam profile measurement, modes and spectrum using FP cavity 11. Michelson interferometer: setup, refractive index measurement 12. Nd: YAG laser characteristics 13. Fiber Mach-Zehnder interferometer 14. Holography 15. Loss and dispersion characterization of WDM optical components – Coupler, Circulator, EDFA, Filter, and single-mode fibers. Demonstration experiments and Research Lab visits are meant to familiarize students with CELP facilities and various research activities of the faculty members.
PSE607	SPECIAL TOPICS IN PHOTONICS	3-0-0-0-9	This course provides flexibility to individual faculty members to offer new courses in the areas of their research interest. For example, the following course content was offered in Spring 2020 in the domain of quantum optics: (1) Quick recap of Quantum mechanics: Particle wavefunction (probability density), Schrodinger equation, Operators, Commutators, Eigenfunctions and eigenvalues of Hermitian operators, Orthogonality and complete set, time-evolution of eigenstates and a general wavefunction, Simple Harmonic Oscillator, Dirac Notation (bra-ket algebra), Perturbation theory; (2) Semi-classical interaction of electromagnetic field (classical) with matter (quantized): Interaction Hamiltonian, Transition rates, Fermi-'s Golden rule, Two-level model of an atom, Density matrix and Bloch equations, Rabi frequency, Spontaneous decay, lineshape in fluorescence, Seminal experiments; (3) Quantization of electromagnetic field (light): Single-mode and multi-mode quantized field (light); (4) Classical and non-classical states of light: Interferometry experiments, Beam-splitters, single-photon based devices; (5) Quantum mechanical interaction of electromagnetic field (quantized) with matter (quantized): Interaction Hamiltonian, Cavity QED.
PSE 701/702	PG Seminar Course I or II	0-0-0-0	Familiarizing the PSE PG students on the current themes and progress as presented by their colleagues, and in the process would learn best practices in creating and delivering subject matter presentations in a clear and concise way.
PSE699	MTech Thesis credits		Research
PSE799	PhD Thesis credits		Research
PSE899	MS Thesis credits		Research