Appendix - V (I)

INTERNATIONAL SCHOOL OF PHOTONICS (ISP)

COURSE STRUCTURE AND SYLLABI
of
Master of Technology (Optoelectronics and Laser Technology)

COCHIN UNIVERSITY OF
SCIENCE AND TECHNOLOGY

KOCHI - 682 022

2024

Program Specific Outcomes (MTech OE&LT))

PSO1: Acquire knowledge in the principles of light-matter interactions and photonics related areas of physics.

PSO2: Enhance knowledge in sub-domains of laser physics, fibre optics, optoelectronics and optical communications through specific courses.

PSO3: Develop proficiency in experimentation, data acquisition and interpretation in advanced topics of laser technology and optical communication technology.

PSO4: Execute major project in advanced topics of photonics to acquire skills in solving complex problems.

PSO5: Familiarise with modern equipment and complex tools employed in photonics and optoelectronics.

PSO6: Foster skills in processing scientific data and its presentation.

PSO7: Address the societal needs through outreach programmes and extension activities.

SCHEME

M.Tech Optoelectronics and Laser Technology (2024 Admission onwards)

Semester I

Sl. No	Course Code	Course Title	Core /Elective	Credits	L-T-P	CA	ESE	Total marks
1	24-441-0101	Modern Optics	C	4	3-1-0	50	50	100
2	24-441-0102	Laser Technology	C	4	3-1-0	50	50	100
3	24-441-0103	Optoelectronics	C	4	3-1-0	50	50	100
4	24-441-0104	Lab 1	C	2	0-0-4	100		100
5	24-441-0105	Literature Review	C	1	1-0-0	100		100
6	24-441-0106	Research Methodology (MOOC)	C	3	3-0-0	0	100	100
7	24-441-010X	Elective I	E	3	3-0-0	50	50	100
			Total	21		450	250	700

Elective I

24-441-0107: Advanced Engineering Physics

24-441-0108: Digital Communication

24-441-0109: Nonlinear Optics

Semester II

Sl. No	Course Code	Course Title	Core/ Elective	Credits	L-T-P	CA	ESE	Total marks
1	24-441-0201	Fibre Optics & Applications	C	4	3-1-0	50	50	100
2	24-441-0202	Optical Communication Technology	C	4	3-1-0	50	50	100
3	24-441-020X	Elective II	E	3	3-0-0	50	50	100
4	24-441-0203	Lab 2	C	3	0-0-6	100		100
5	24-441-0204	Seminar	C	1	1-0-0	100		100
6	24-441-0205	Minor Project	C	2	0-0-4	100		100
			Total	17		450	150	600

Elective II

24-441-0206: Advanced Laser Technology

24-441-0207: Nonlinear Optics

24-441-0208: Nano-Biophotonics

Semester III

Sl. No	Course Code	Course Title	Core/ Elective	Credits	L-T-P	CA	ESE	Total marks
1	24-441-0301	Project and Viva	C	10	0-0-20	300		300
2	24-441-030X	Elective III	E	3	3-0-0	50	50	100
3	24-441-0302	Open Elective (MOOC)	E	3	3-0-0	0	100	100
4	24-441-0303	Internship	C	2		100		100
			Total	18		250	250	600

Elective III

24-441-0304: Laser Spectroscopy

24-441-0305: Computational photonics

Internship

Students have to complete an internship of 2 credits (60 Hours of work) before the beginning of Semester IV.

Semester IV

Sl. No	Course Code	Course Title	Core/ Elective	Credits	L-T-P	CA	ESE	Total marks
1	24-441-0401	Project and Viva	C	18	0-0-36		500	500
			Total	18			500	500

24-441-0101 Modern Optics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the propagation of light in conducting and non-conducting media	Understand	5	
CO2	Understand reflection/transmission behaviour of light interacting with a dielectric interface	Understand	5	
CO3	Describe the operation of optical devices, including, polarisers, retarders and modulators	Understand	5	6
CO4	Have an understanding of light coherence, the coherent properties of light from various sources, and the measurement of degrees of coherence	Understand	4	4
CO5	Analyze the polarization state of a beam of light	Analyze	4	4
CO6	Use the principles of wave motion and superposition to explain the physics of polarization, dispersion, interference and diffraction	Apply	4	4
CO7	To compare the effects of Fraunhoffer and Fresnel diffraction	Analyze	6	4
CO8	Apply matrix methods for analysing ray propagation	Apply	4	
CO9	Describe the concept of wavefront distortion	Understand	4	4
CO10	Use Fourier transform theory to predict and interpret imaging under various Fourier transform filtering conditions.	Apply	4	4
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1				
CO2	3	3	1				
CO3	3	3	1				
CO4	3	3	1				
CO5	3	3	1			2	
CO6	3	3	1			2	
CO7	3	3	1			2	
CO8	3	3	1			1	
CO9	3	3	1			1	
CO10	3	3	1			1	

3-High; 2-Medium; 1-Low

Module I

Light in bulk matter, scattering and absorption, dispersion, transmission and index of refraction, Fresnel's equations, boundary conditions on an interface, complex refractive index, evanescent wave, refraction at spherical surfaces, thin lens combinations, aspherical mirrors, lens systems, analytical ray tracing, matrix methods, superposition of waves, standing wave, phase and group velocities, propagation of light waves in a dielectric, dispersion equation, electromagnetic waves in a conducting medium.

Module II

Interference of light: conditions for interference, Fresnel – Arago Laws, interference of mutually coherent beams, Young's double slit experiment, effects of finite coherence length, interference in dielectric films, film thickness measurement by interference, multiple beam interference, Michelson's interferometer, Mach-Zehnder interferometer, Fabry- Perot interferometer, Interference filters, variable input frequency Fabry- Perot interferometer, mode suppression with an etalon, Sagnac effect, Sagnac interferometer. Coherence – temporal coherence and line width, partial coherence, spatial coherence width.

Module III

Polarisation: Generation of polarised light, mathematical representation of polarised light, jones vectors, polarisers, Jones matrices, birefringence, polarisation ellipse, retarders, optical activity, different polarization states, Stokes parameters and their measurements, optical modulators-photoelasticity, Faraday effect, Kerr and Pockels effects, electro optic modulation, magneto optic effects, magneto optic liquid crystal variable retarder.

Module IV

Theory of Diffraction: Kirchoff's theorem. Fresnel- Kirchoff integral formula and its application to diffraction problems. Fraunhofer and Fresnel diffraction: Fraunhofer diffraction by single slit, double slit, multiple slits, rectangular aperture, circular aperture, resolution of imaging systems, diffraction grating, Fresnel diffraction: free propagation of a spherical wave, the vibration curve, circular apertures, circular obstacles, Fresnel zone plate, Fresnel integrals. Matrix methods in ray propagation, rays in a lens-like medium, Propagation of beams, Gaussian beam propagation. ABCD law, focussing of Gaussian beams.

Module V

Elements of Fourier optics: Fourier transforms, one and two dimensional transforms, transform of a cylinder function, lens as a Fourier transform element, concept of spatial frequencies, effect of lens on a wave front, Fourier transform spectroscopy, theory of imaging, elements of adaptive optics, principles of adaptive optics, wave front distortion, wave front sensors, wave front reconstruction (qualitative treatment).

References

1. Optics, Eugene Hecht, A.R. Ganesan, Pearson Education, 4th Edition, 2016 (text).
2. Introduction to Optics, Frank L. Pedrotti, S.J., Leno M. Pedrotti, Leno S. Pedrotti, Pearson, 3rdEdition, 2012 (Text).
3. Optics, Ajoy Ghatak, Tata McGraw Hill, 3rd edition, 2005
4. Fundamentals of Photonics, Saleh and Teich, Wiley India Pvt. Ltd., 2nd edition, 2012.
5. Optical Physics, Ariel Lipson, Stephen G. Lipson, and Henry Lipson, Cambridge University Press, 4th Edition, 2011
6. Modem Optics, R.D. Guenther, John Wiley, 1990.
7. Quantum Electronics, Amnon Yariv, Academic Press, 1998.
8. Principles of optics, Bom and Wolf Cambridge University Press,1981.
9. Adaptive optics in Astronomy, Francois Roddier, Cambridge University Press, 2004.
10. Wave Optics and applications, R S Sirohi, Orient Longmann, 2001.

24-441-0102 Laser Technology

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain different electron oscillator models	Understand	6	
CO2	Describe emission and absorption of radiation	Understand	6	
CO3	Describe the requirements for laser action	Understand	8	
CO4	Describe rate equations and solve them for different level-system	Evaluate	8	
CO5	Identify the requirements for pulse shortening techniques	Analyze	6	
CO6	Describe techniques for q-switching and mode-locking	Evaluate	6	
CO7	Predict the stability of lasers	Apply	6	
CO8	Explain the generation of higher order modes	Understand	6	
CO9	Identify different lasers for a particular application	Analyze	6	
CO10	Review safety requirements of lasers	Understand	2	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1				
CO2	3	3	1				
CO3	3	3	1				
CO4	3	3	1			3	
CO5	3	3	1				
CO6	3	3	1		2	2	
CO7	3	3	1				
CO8	3	3	1				
CO9	3	3	1				
CO10	3	3	1				

3-High; 2-Medium; 1-Low

Module I

Electron Energy Levels in atoms, Molecular vibrations, molecular rotations, Energy bands in solids, Electron oscillator model-classical and quantum, Spontaneous emission, absorption, thermal radiations-Planck's radiation law, emission and absorption of narrowband light, Line

Broadening mechanisms - Collisional broadening, Doppler broadening, Absorption and gain coefficients.

Module 2
Gain and feedback, Threshold, photon rate equations, population rate equations, three-level and four level laser scheme, pumping three and four level lasers, saturation, small signal gain and saturation, spatial hole burning, spectral hole burning, lamb dip, frequency pulling, obtaining single mode oscillation, laser line width, polarization and modulation, frequency stabilization, laser at threshold.

Module 3
Rate equations for intensities and populations, relaxation oscillations, Q-switching, methods of Q-switching, Multimode laser oscillation, phase-locked oscillators, mode-locking, amplitude - modulated mode locking, frequency-modulated mode locking, methods of mode-locking, amplification of short pulses, amplified spontaneous emission, ultrashort light pulses.

Module 4
Ray matrix, resonator stability, paraxial wave equations, Gaussian beams, ABCD matrix for Gaussian beams, Gaussian Beam modes, Hermite-Gaussian and Laguerre-Gaussian beams, Diffraction by an aperture, diffraction theory of resonators, Beam quality, Unstable resonators for high-power lasers, Bessel beams.

Module 5
Electron-impact excitation, Excitation transfer, He-Ne laser, rate equation model in He-Ne laser, CO_2 electric discharge lasers, gas-dynamic lasers, Chemical lasers, excimer lasers, dye lasers, optically pumped solid state lasers, fiber amplifiers and lasers, ultra short and super intense pulses.

References

1. Laser Physics, Peter W Milonni and Joseph H Eberly, Wiley, 2010 (Text)
2. Laser Fundamentals, W T Silfvast, Second Edition, Cambridge University Press, 2008 (Text)
3. Principles of Lasers, O Svelto, Fourth Edition, Springer, 1998
4. Lasers, Anthony E Siegman, University Science Books, 1986
5. Lasers - Fundamentals and Applications, K Thyagarajan and A Ghatak , Springer, 2010

24-441-0103 Optoelectronics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Analyze the energy band structure of semiconductors to differentiate between direct and indirect bandgap materials	Understand	5	0
CO2	Design basic circuits utilizing semiconductor principles, evaluating dynamic resistance and capacitance in pn junctions	Apply	5	0
CO3	Evaluate LED materials, structures, and efficiencies to optimize luminous flux characteristics for various applications	Analyze	6	0
CO4	Apply LED principles in optical fiber communications, designing circuits for efficient data transmission	Apply	6	0
CO5	Apply the Shockley-Ramo theorem to assess external photocurrent in various photodetectors, considering noise characteristics	Apply	6	0
CO6	Analyze the characteristics and applications of advanced photodetector technologies, such as avalanche photodiodes and pin photodiodes	Evaluate	7	0
CO7	Assess the efficiencies and structures of various sensors and solar cells, optimizing performance for specific applications	Analyze	8	0
CO8	Apply principles of absorption, emission, and luminescence spectroscopy in material analysis and characterization	Apply	5	0
CO9	Apply principles of optical computing, including QSD arithmetic and symmetric coding, in designing efficient computational systems	Apply	6	0
CO10	Design optical logic gates, backplane buses, and memory cells for implementing optical computing architectures, optimizing for speed and efficiency	Apply	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1				
CO2	3	3	1				
CO3	1	3	3				
CO4	1	3	3				
CO5	3	3	1				
CO6	1	3	3		2	2	
CO7	3	3	1				
CO8	3	3	1				
CO9	1	1	3				
CO10	1	1	3				

3-High; 2-Medium; 1-Low

Module I

Review of semiconductor concepts and energy bands, Semiconductor statistics, Extrinsic semiconductors, Direct and indirect bandgap semiconductors, pn Junction principles, pn junction reverse current, pn junction dynamic resistance and capacitances, recombination lifetime, pn junction band diagram, Heterojunctions.

Module II

Light-emitting diodes: Principles, Homo junction and hetero junction LEDs, Quantum well LEDs, LED materials and structures, LED efficiencies and luminous flux, Basic LED characteristics, LEDs for optical fibre communications, Phosphors and white LEDs, LED electronics, Semiconductor lasers.

Module III

Principle of the pn Junction photodiode, Shockley-Ramo theorem and external photocurrent, Absorption coefficient and photodetector materials, Quantum efficiency and responsivity, The pin photodiode, Avalanche photodiode, Heterojunction photodiodes, Schottky junction photodetector, Phototransistors, Photoconductive detectors, Basic photodiode circuits, Noise in photodetectors.

Module IV

Image sensors: CMOS and CCD

Photovoltaic devices: Solar cells, Basic principles, Operating current and voltage, and Fill factor, Equivalent circuit of a solar cell, Solar cell structures and efficiencies.

Optical spectroscopy: Absorption spectroscopy, Emission spectroscopy, Luminescence spectroscopy.

Module V

Optical computing: QSD arithmetic, Symmetric coding, Optoelectronic implementation, Artificial neural networks, Optical implementation of neural networks, Optical architecture for pattern association, Optical logic gates, Optical backplane buses, Binary memory cell and Optical switches.

References

1. Optoelectronics and Photonics: Principles and Practices (Second Edition), S O Kasap, Pearson 2023 (Text)
2. Optoelectronic Devices and Systems (Second Edition), S C Gupta, PHI Learning Pvt Ltd 2015 (Text)
3. Optoelectronics Sensors and Instrumentation, M K Ghosh, Ed-Tech New Delhi 2018.
4. Semiconductor Optoelectronic Devices (second edition), Pallab Bhattacharya, Pearson 2017.

24-441-0105 Literature Review

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Articulate a focused research question or topic, guiding the literature review effectively.	Apply	2	0
CO2	Conduct systematic searches for relevant literature using academic databases and other scholarly sources.	Apply	2	0
CO3	Evaluate the credibility, relevance, and quality of sources, ensuring the reliability and validity of the literature review.	Evaluate	4	0
CO4	Organize literature based on themes and synthesize information to identify patterns, trends, contradictions, and gaps in the research.	Analyze	3	0
CO5	Write coherent, well-structured literature reviews with accurate citations using the APS style, ensuring adherence to academic integrity standards.	Create	4	0
	Total Number of Hours		15	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1			1	2	1	3	1
CO2			1	2	1	3	1
CO3			1	2	1	3	2
CO4			1	2	1	3	1
CO5			1	2	1	3	2

3-High; 2-Medium; 1-Low

A literature review is an essential component of academic research, providing a comprehensive overview and analysis of existing literature relevant to the topic of study. Here are the key steps and components required for a literature review:

1. Define your research question or topic: Clearly articulate the focus of your literature review. What specific aspect of the subject are you exploring?
2. Search for relevant literature: Conduct comprehensive searches using academic databases, libraries, online journals, and other sources to identify relevant literature. Use appropriate keywords and search terms related to your topic.
3. Evaluate sources: Critically evaluate the credibility, relevance, and quality of the sources you find. Consider factors such as the author's expertise, publication date, peer-review status, and methodology.
4. Organize the literature: Categorize the literature based on themes, concepts, theories, or methodologies relevant to your research question. Develop a clear organizational structure for your review.

5. Summarize key findings: Provide concise summaries of the main findings, arguments, and conclusions of each source. Highlight key points that contribute to your understanding of the topic.
6. Identify gaps in the literature: Analyze the existing literature to identify areas where further research is needed or where there are gaps in knowledge. This can help justify the significance of your own research.
7. Synthesize and analyze: Synthesize the information from the various sources to identify patterns, trends, contradictions, and debates within the literature. Offer your analysis and interpretation of the existing research.
8. Write the literature review: Write a coherent and well-structured review that includes an introduction, body paragraphs organized around key themes or concepts, and a conclusion that summarizes the main findings and implications of the literature.
9. Cite sources properly: Make sure to cite all sources properly using the APS citation style ([1] Author(s), "Title of the paper," Journal Abbreviation, volume number, page range (year)). Accurate citation is crucial for avoiding plagiarism and giving credit to the original authors.
10. Check for plagiarism: Utilize the plagiarism check tool available in the University library to ensure originality. Append a certificate of plagiarism with the review report to demonstrate adherence to academic integrity standards.
11. Revise and edit: Review your literature review carefully, revising for clarity, coherence, and accuracy. Edit for grammar, punctuation, and formatting errors to ensure your review meets academic standards.

Follow these steps to create a thorough and well-structured literature review that contributes to the existing body of knowledge on your chosen topic.

24-441-0107 Advanced Engineering Physics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand crystal structure and its correlation with material properties and electronic transitions in periodic crystals.	Understand	5	0
CO2	Differentiate between Fermions and Bosons and their statistical distribution.	Understand	5	0
CO3	Apply Schrödinger equation and Dirac algebra in the presence of various external potentials and the harmonic oscillator system.	Apply	6	0
CO4	Understand various quantum effects in materials	Understand	8	0
CO5	Construct Hamiltonians and solve eigenvalue problems in the presence of perturbations	Apply	6	0
CO6	Analyze transition probabilities in perturbative systems using Fermi's Golden rule	Analyze	6	0
CO7	Apply Maxwell's equations and the concept of harmonic oscillator to quantize electromagnetic radiations	Analyze	4	0
CO8	Understand coherent and squeezed light and the interaction of radiation with matter	Understand	8	0
CO9	Understand the basic principles of Raman spectroscopy	Understand	6	0
CO10	Analyze rotational and vibrational spectra of molecules.	Analyze	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	3			1	
CO2	3	3	1			1	
CO3	3	3	3			1	
CO4	3	3	1			1	
CO5	3	3	1			1	
CO6	3	3	3			1	
CO7	3	3	1			1	
CO8	3	3	1			1	
CO9	3	3	3			1	
CO10	1	3	3			1	

3-High; 2-Medium; 1-Low

Module 1

Concepts of crystal structure, crystal planes, Miller indices, Bravais lattices, reciprocal lattices, the concept of Brillouin zones, zone boundary, Bosons and Fermions, Fermi-Dirac and Bose-Einstein distribution, bonding in crystals, Blöch theorem, band theory.

Module 2

Concept of basis and base vectors, Dirac algebra, operators in quantum mechanics, Hermitian and Unitary operators, wave-particle duality, uncertainty relations, Schrödinger equations, particle in a box, quantization of energy levels, harmonic oscillator, electrons in periodic potential, origin of energy bands in solids, the concept of the potential barrier, quantum effects in two dimensional, One dimensional, and zero-dimensional materials.

Module 3

Particle in spherically symmetric potential, spin angular momentum, concept of degenerate and non-degenerate perturbation theory, time-dependent perturbation, Stark effect, Fermi's golden rule, radiative transition rate, selection rules.

Module 4

Maxwell's equations, electromagnetic spectrum, quantization of electromagnetic field, Number states, coherent and squeezed light, interaction of electromagnetic radiation with matter.

Module 5

Rotational spectra of diatomic molecules, intensity of spectral lines, non-rigid rotator, vibrational spectra of diatomic and polyatomic molecules, anharmonic oscillator, diatomic vibrating-rotator. quantum and classical theory of Raman spectroscopy.

References

1. Concepts of Modern Physics (Ninth Edition), Arthur Beiser and Shobhit Mahajan, McGraw Hill Education, 2009
2. Solid State Physics (Third Edition), M A Wahab, Narosa Publications, New Delhi, 2015.
3. Quantum Optics, Mark Fox, Oxford University Press, New York, 2006.
4. Introduction to Solid State Physics (Eighth Edition), Charles Kittel, Wiley, 2012.
5. Solid State Physics (Third Edition), David Ashcroft and Mermin, CENGAGE Learning, 2003.
6. Introduction to Quantum Mechanics, J. Griffiths David, Pearson, 2015.
7. Modern Quantum Mechanics, J. J. Sakurai and Jim Napolitano, Cambridge University Press, 2017.
8. Introductory Quantum Optics (First Edition), Christopher Gerry and Peter Knight, Cambridge University Press, 2004.
9. Fundamentals of Molecular Spectroscopy (Fourth Edition), C N Banwell, McGraw Hill Education,(2017).

24-441-0108 Digital Communication

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concepts of sampling, scaling and digital systems.	Analyze	6	0
CO2	Identify the importance of pulse shaping and minimum bandwidth requirement.	Analyze	6	0
CO3	Understand the basics of equalization and synchronization techniques.	Understand	6	0
CO4	Analyze a basic PCM system and interpret the performance parameters of its various modified schemes.	Analyze	6	0
CO5	Understand the concept of Information theory, Entropy and Mutual Information.	Understand	6	0
CO6	Use the concepts of information theory and coding for mathematical modelling and analysis of communication systems.	Apply	6	0
CO7	Familiarize with the different types of errors found while transmitting data.	Understand	6	0
CO8	Discuss the significance and performance analysis of error detection and correction strategies employed in digital communication systems.	Understand	6	0
CO9	Understand the significance of 5G in mobile networks and familiarize with the uses and applications.	Understand	6	0
CO10	Study the core and access networks of the 5G Mobile network and compare it with previous generation mobile networks.	Understand	6	0
	Total Numbers of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1			1	
CO2	3	1	1			1	
CO3	3	1	1			1	
CO4	3	1	1			1	
CO5	3	1	1			1	
CO6	3	1	1			1	
CO7	3	1	1			1	
CO8	3	1	1			1	
CO9	3	1	1			1	
CO10	3	1	1			1	

3-High; 2-Medium; 1-Low

Module I
Digital Signals and Systems: sampling, scaling, spectral analysis of band pass digital signals, Digital PAM, PFM, PPM signals, binary PAM formats, digital systems, band-limited digital PAM systems, bandwidth considerations, Line coding, binary error probabilities, regenerative repeaters, eye diagram, Nyquist pulse shaping.

Module II
Equalization, Synchronization and Modulation, equalization, synchronization techniques, Carrier, symbol/bit and frame synchronization, digital CW (Continuous Wave) modulation, PCM (Pulse Code Modulation), PCM generation and reconstruction of multiplexing PCM signals, DPCM, Adaptive DPCM, DM and its drawbacks, Adaptive Delta Modulation, Amplitude, Phase and Frequency modulation methods.

Module III
Information theory, concept of amount of information and its properties, applications of information theory, average information, entropy, effective complexity, coding to increase average information per bit, Hartley Shannon's Theorem, channel capacity, bandwidth, S/N trade-off, data compression.

Module IV
Error Detection and Correction, types of errors, error detection techniques, simple parity check, 2D parity check, checksum, cyclic redundancy check, error correction techniques, error correcting codes, block code, convolutional code, cyclic code, hamming code, parity code, repetition code, forward and backward error, correction methods, Automatic Retransmission Query (ARQ) Systems, performance of ARQ systems.

Module V
5G, uses of 5G, underlying technologies that make up 5G, radio access network, core network, 5G working, comparison of 5G with previous generation mobile networks, applications of 5G, vision of 6G.

References

1. Communication Systems, A B Carlson, 5th edition, McGraw Hill, 2011.
2. Principles of Communication Systems, Herbert Taub, Donald Schilling & Gautam Saha, 4th edition, McGraw Hill, 2017.
3. Digital Communication, Nishanth Nazimudeen, 1st edition, Cengage, 2018.
4. Principles of Digital Communication, Das, Mullick, and Chatterjee, 1st edition, Wiley Eastern and Halstead Press, 1986.
5. Communication Systems, Simon Haykin, 4th edition, John Wiley & Sons, 2001.
6. Key 5G Physical Layer Technologies, Enabling Mobile and Fixed Wireless Access, Douglas H. Morais, 2nd Edition, 2021.

Semester II

24-441-0201 Fibre Optics and Applications

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the theory of propagation of light in an optical fibre	Understand	4	
CO2	Solve wave equations and explain electromagnetic fields of guided modes	Apply	4	
CO3	Analyze the formation of modes in a planar optical wave guide	Analyze	6	4
CO4	Examine single mode and multimode optical fibers and classify optical fibers based on their refractive index profiles	Analyze	4	6
CO5	Compare different types of pulse broadening mechanisms in optical fibers	Understand	4	
CO6	Distinguish between the loss mechanisms in optical fibers and to compute various losses	Analyze	4	2
CO7	Categorize different techniques to provide optical connections in fibers	Analyze	4	4
CO8	Practice the use of various standard optical fiber connectors and couplers	Apply	4	6
CO9	Compare the sensitivity of various fibre Bragg gratings	Understand	5	4
CO10	Analyze the functioning of optical fiber sensors that use amplitude, phase, frequency and polarization type modulation schemes	Analyze	6	4
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1			1	
CO2	3	1	1			1	
CO3	3	2	1			1	
CO4	3	1	1			1	
CO5	3	1	1			1	
CO6	3	3	1			1	
CO7	3	3	1			1	
CO8	3	3	1			1	
CO9	3	3	1			1	
CO10	3	1	1			1	

3-High; 2-Medium; 1-Low

Module I

Optical wave guides: Historical development, ray theory of propagation, electromagnetic theory of wave propagation, characteristics of planar wave guides, TE and TM modes in planar wave guide, number of guided modes, optical fibre, types of fibers, step index and graded index fibers, characteristics of optical fibre, mode analysis: weakly guiding fibre approximation, LP modes, single mode fibre, cut- off wave lengths, spot size, mode coupling, elements of coupled mode analysis.

Module II

Transmission characteristics of optical fibers: Attenuation, absorption losses, fiber bend losses, linear scattering losses, nonlinear scattering losses, stimulated Raman and stimulated Brillouin scattering, Optical fiber amplifiers: Erbium doped fiber amplifier, amplifier modelling, Dispersion: Phase and group velocities, material dispersion, intra-modal dispersion and wave guide dispersion, overall fibre dispersion, dispersion management, dual mode fibers, dispersion modified fibers, specialty optical fibers, photonic crystal fibers, guiding by effective index, guiding by photonic bandgap, polarization maintaining fibers, solitons.

Module III

Optical fiber measurements: Attenuation measurements, dispersion measurements (time domain and frequency domain), measurements of NA, fiber diameter and refractive index profile, interferometric method, near field scanning method, measurements of cut-off wavelength, mode filed diameter, insertion loss. Field measurements: Optical time domain reflectometer (OTDR), Testing of optical fiber systems, effects of changing pulse width.

Module IV

Optical fibers and cables: Fabrication of optical fiber, fiber material requirements, Fiber drawing: Liquid phase methods, vapour phase deposition techniques, cable design, optical fiber connection: joints and couplers, fiber splices, fusion splices, mechanical splices, fiber connectors, expanded beam connectors, single mode fiber optic components, fiber couplers, wavelength division multiplexers, fiber polarisation controllers, source to fibre and fibre to fibre coupling, coupling losses, i/p, o/p couplers, cabling standards, system components, cabling tools.

Module V

Periodic interaction in wave guides, coupled mode equations, power coupling between modes, directional couplers, grating input- output couplers, contra-directional coupling, fibre Bragg grating, long- period fiber Bragg Grating, fabrication of fibre gratings. Optical fibre sensors: Intensity modulation sensors, phase modulation sensors, temperature, pressure, chemical and rotation sensors, fibre optic gyroscopes, evanescent wave sensors, polymer optical fiber-based sensing, Integrated optical devices: Couplers, OSA, Lenses.

References

1. Title Optical fiber communication, G. Keiser, McGraw Hill Education, 5th Edition, 2017 (text).
2. Understanding fiber optics, J Hecht, Laser Light Press, 5th Edition, 2016.
3. Introduction to fiber optics, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press, 2017 (text).
4. Optical Fiber Communications: Principles and Practice, 3rd edition, John M. Senior, Pearson Education India, 2010.
5. Fundamentals of Fibre Optics in Telecommunication and Sensor Systems, B.P. Pal., New Age Publishers, 1992.
6. Fibre Optic Sensors - Principles and Applications, B. D. Gupta, New India Publishing, 2006.
7. Fibre Optic Communication Systems, 3rd Edition - G.P. Agrawal, John Wiley & Sons, 2002.
8. Integrated Optics, R. G. Hunsperger. Springer Verlag, 1998.

24-441-0202 Optical Communication Technology

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe the properties and advantages of optical guided communication	Understand	5	
CO2	Identify the various components of the optical fiber communication system. and explain the importance of integrated optical systems.	Understand	5	
CO3	Describe the working of LEDs and laser diodes.	Understand	7	
CO4	Explain various external modulation methods for coherent communication.	Understand	8	
CO5	Describe the operation of optical receivers including the types of preamplifiers.	Understand	7	
CO6	Design and prepare optical power loss/gain budget with various line coding.	Apply	8	
CO7	Distinguish semiconductor optical amplifier and erbium doped fiber amplifier.	Understand	5	
CO8	Calculate gain and power conversion efficiency of an optical amplifier.	Apply	5	
CO9	Describe various optical network topologies and its performance.	Understand	5	
CO10	Explain the concepts such as RF over fiber, solitons and optical CDMA.	Understand	5	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1			1	
CO2	3	1	1			1	
CO3	3	3	1			1	
CO4	3	1	1			1	
CO5	3	1	1			1	
CO6	3	3	2			1	
CO7	3	3	1			1	
CO8	3	3	2			1	
CO9	3	1	1			1	
CO10	3	1	1			1	

3-High; 2-Medium; 1-Low

Module I

Unguided optical communication system, transmission parameters, beam divergence, atmospheric attenuation, guided wave communication, merits of optical fiber communication systems, basic network information rates, time evolution of fiber optic systems, elements of optical fiber transmission link/repeaters, integrated optics, active and passive components, opto-mechanical switches, all optical switches.

Module II
Optical Transmitter: LED - Modulation bandwidth, Emission Pattern, Need for Laser Diodes, Single Longitudinal Mode Lasers, Photon Lifetime, Semiconductor Laser Rate equation, steady state solution, LI characteristics, Output power from laser, Modulation response of LD,Chirp, Noise in Lasers- Relative Intensity Noise, Phase noise, Effect of noise on different modulation schemes, External Modulation- generation of OOK, BPSK, QPSK and 16QAM

Module III
Optical receiver operation, Error sources, Receiver configuration, Fourier transform representation, Digital receiver performance calculations, Preamplifier types, High impedance bipolar transistor amplifiers, trans-impedance amplifier, Analog receivers.

Link power budget, Rise time budget, Link line coding, NRZ codes, RZ codes, Block codes, Coherent Systems, Balanced Detection, Phase and Polarisation Diverse Coherent Detection, Digital Signal Processing for compensation of phase noise, frequency offset, chromatic dispersion, polarisation mode dispersion. Homodyne and Hetrodyne detection. Multiplexing schemes, TDM, WDM concepts and components, Operational principles of WDM, Passive components, 2 x 2 fiber coupler, Fiber grating filters, Tunable filters, System consideration and tunable filter types

Module IV
Optical amplifiers, general applications and amplifier types, semiconductor optical amplifiers, External pumping, Amplifier gain, Erbium doped fiber amplifiers, Amplification mechanism, EDFA architecture, EDFA power conversion efficiency and gain, Amplifier noise.

Module V
Optical networks, Network topologies, Performance of passive linear busses, Performance of star architectures, SONET/SDH, Transmission formats and speeds, Optical interfaces, SONET/SDH rings, SONET/SDH networks, Nonlinear effects on network performance, Solitons, Optical CDMA, Ultrahigh capacity networks, RF over fiber.

References

1. Optical Fibre Communication - G Keiser, McGraw Hill(4th Ed), 2006 (Text)
2. OpticalFibre Communications - JM Senior(Prentice Hall India 1994) (Text)
3. Introduction to Fiber-Optic Communications, Rongquing Hui, Academic Press (2019) (Text)
4. Fibre Optic Communication - C Agarwal (Wheeler, 1993)
5. OpticalFibre Communication Systems- J Gowar(Prentice Hall, 1995).
6. Fibre Optic Communication -J Palais (Prentice Hall International 1988).
7. Optical networks: A practical perspective Kumar N Sivarajan and Rajeev Ramaswami, MarcourtAsia, 2010
8. WDM systems and networks: Modeling, simulation, design and engineering, N. Antoniades, G. Ellinas, and I. Roudas, Springer, 2012 (ISBN 978-1-4614-1092-8).

24-441-0206 Advanced Laser Technology

CO	**CO Statement**	**CL**	**Class Hrs**	**Lab Hrs**
CO1	Explain different mechanisms for ultra-short pulse generation	Understand	6	
CO2	Describe techniques for pulse shaping	Understand	6	
CO3	Describe the cavity modes	Understand	8	
CO4	Describe ABCD matrix analysis	Evaluate	8	
CO5	Explain various pulse compression techniques	Understand	6	
CO6	Describe measurement techniques for compressed pulses	Evaluate	6	
CO7	Describe propagation of attosecond light pulses	Understand	6	
CO8	explain the stabilization of carrier-envelope phase	Understand	6	
CO9	identify different models for attosecond pulse generation and detection	Analyze	6	
CO10	review safety requirements of ultra high intensity lasers	Understand	2	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1		1	1	
CO2	3	3	1		1	1	
CO3	3	3	1		1	1	
CO4	3	3	1		1	1	
CO5	3	3	1		1	1	
CO6	3	3	1		1	1	
CO7	3	3	1		1	1	
CO8	3	3	1		1	1	
CO9	3	3	1		1	1	
CO10	3	3	1		1	1	

3-High; 2-Medium; 1-Low

Module I

Characteristics of femtosecond light pulses-pulse propagation-interaction with linear optical elements- generation of phase modulation- beam propagation- Femtosecond optics - dispersion of interferometric structures, focusing element, elements with angular dispersion-GVD-pulse shaping with resonant particles-nonlinear, nonresonant optical processes

Module II

Superposition of cavity modes- cavity modes and modes of a mode-locked laser- basic elements and operations of a fs laser- circulating pulse model - evolution of the pulse energy - pulse shaping in intracavity elements - cavity modes and ABCD matrix analysis - cavity with a Kerr Lens - Synchronous mode-locking, hybrid mode-locking - mode-locking based on nonresonant nonlinearity - Ti-Sapphire laser.

Module III

Amplified spontaneous emission - Nonlinear refractive index effects - Chirped pulse amplification - amplifier design -Optical parametric chirped pulse amplification - pulse compression - pulse shaping through spectral filtering - Intensity autocorrelation - nonlinear optical processes for measuring femtosecond pulse correlations - single shot measurements - Frequency resolved optical gating(FROG) - Spectral Phase interferometry for Direct Field Reconstruction(SPIDER).

Module IV

Mathematical description of attosecond optical pulses - propagation of attosecond pulse in linear dispersive media - Carrier envelope phase and dispersion - Group velocity dispersion, Group Delay dispersion, pulse broadening and compression - stabilization of the carrier-envelope phase of oscillators.

Module V

Attosecond pulse generation - Three step model - Long and Short trajectories - chirp of attosecond pulses - Tunneling ionization and multiphoton ionization - isolated attosecond pulse generation - Complete Reconstruction of attosecond bursts (CRAB) - measurement of temporal a single harmonic pulse - side bands - reconstruction of attosecond beating by interference of two-photon transition (RABBIT)

References

1. Ultrashort Laser Pulse Phenomena, Jean-Claude Diels and Wolfgang Rudolph, Second Edition, Academic Press, 2006 (Text)
2. Fundamentals of Attosecond Optics, Zenghu Chang, CRC Press, 2011 (Text)
3. Principles of Lasers, O Svelto, Fifth Edition, Springer, 2010
4. Lasers, Anthony E Siegman, University Science Books, 1986
5. Lasers - The Power and Precision of Light, Jean-Claude Diels and Ladan Arissian, WILEY-VCH Verlag GmbH & Co, 2011

24-441-0109/24-441-0207 Nonlinear Optics

CO	CO Statement	CL	Class Hrs	Lab Hrs	PSO
CO1	Utilize the concepts of nonlinear susceptibilities to predict frequencies generated by nonlinear optical processes.	Apply	7	0	1,2
CO2	Explain Miller's Rule, Symmetries of nonlinear susceptibilities and index contraction method	Understand	5	0	1,2
CO3	Analyze the theory of second order nonlinear effects such as Second Harmonic Generation, Sum Frequency Generation, Difference Frequency Generation, Optical Parametric Oscillations and Frequency Up/Down Conversion	Analyze	6	0	1,2
CO4	Understand the principles of Phase-matching, index matching and Quasi Phase Matching conditions.	Understand	6	0	1,2
CO5	Explain the concepts of Third order nonlinearity-third order susceptibility tensor, Degenerate four wave mixing	Understand	7	0	1,2
CO6	Explain the theory behind Optical Phase Conjugation and its applications in image processing and distortion correction.	Apply	5	0	1,2
CO7	Explain the theory of nonlinear scattering mechanisms.	Understand	7	0	1,2
CO8	Understand the theories related to Self Focusing , Self Induced Transparency, and the propagation of optical solitons.	Understand	5	0	1,2
CO9	Explain the theory of nonlinear absorption processes - Saturable Absorption, Reverse Saturable Absorption, Two photon Absorption and its applications.	Understand	7	0	1,2
CO10	Analyze the theory of nonlinear Fabry-Perot etalon, optical bistability and its applications.	Analyze	5	0	1,2
	Total Number of Hours		60	0	

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1			1	
CO2	3	3	1			1	
CO3	3	3	1			1	
CO4	3	3	1			1	
CO5	3	3	1			1	
CO6	3	3	1			1	
CO7	3	3	1			1	
CO8	3	3	1			1	
CO9	3	3	1			1	
CO10	3	3	1			1	

3-High; 2-Medium; 1-Low

Module 1

Historical Overview of Nonlinear Optics, Non-linear polarization, physical origin of non-linear optical coefficients- Classical Anharmonic Oscillator Model, Miller's Rule, susceptibility tensors, Symmetries of nonlinear susceptibilities, Index contraction, d-matrix., Parametric and Non-parametric processes.

Module 2

Propagation of EMW through nonlinear media, Coupled amplitude equations for second-order processes $\chi^{(2)}$, Phase Matching conditions, Quasi Phase Matching (QPM) , second harmonic generation, sum and difference frequency generation, optical parametric processes (OPA and OPO), Frequency Up/Down conversion.

Module 3

Third order nonlinearity: Third order susceptibility tensor, Degenerate four wave mixing , Phase conjugate optics- properties of phase conjugate light,Generation of phase conjugate light, FWM in optical Kerr media, coupled mode formulation, Resonators with OPC mirror, Imaging through distorting medium.

Module 4

Nonlinear scattering processes - Stimulated Raman Scattering (SRS)-Quantum mechanical description of Raman scattering, Raman cross section and gain, SRS described by non-linear polarization, Anti Stokes Raman Scattering, Coherent Antistokes Raman Scattering (CARS).

Self action effects- intensity dependent refractive index, Self-focusing effect, Self-induced transparency- pulse area theorem.

Module 5

Nonlinear absorption- Two photon Absorption (TPA), Multiphoton absorption, Applications of nonlinear absorption, saturable and reverse saturable absorbers, Z-scan theory of closed aperture and open aperture scan. Nonlinear Fabry- Perot etalon (NLF), NLF as a computing element, Optical Bistability, Optical logic gates.

References

1. Hand book of Nonlinear optics-Richard L Sutherland, (Second Edition), Marcel Dekker Inc,(2003) (Text).
2. Nonlinear optics- Robert W Boyd, Academic Press, Elsevier, Inc (Third Edition) (2008), (Text).
3. Photonics, Elemental and Devices- V V Rampal, Wheeler Publishing (1992).
4. Lasers and Nonlinear optics- B B Laud, Wiley Eastern 3rd Edition, (2004).
6. Optical Electronics in Modern Communications (5th Edition), A Yariv, Oxford University Press, (1997).
7. Nonlinear Optics- Y R Shen, John Wiley Sons (1991).
8. Nonlinear Fibre Optics- Govind P Agarwal, Academic Press, 4th Edition(2007).
9. Quantum Electronics- A Yariv, John Wiley Sons (1975).
10. Fundamentals of Photonics, B E A Salch, M C Teich, John Wiley Sons, 2nd edition (2007).
11. Physics of nonlinear optics-Guang S He and Song H Lie, world scientific , London (1999).
12. Fundamentals of Nonlinear Optics, P.E.Powers , CRC Press(2011).

24-441-0208: Nano-Biophotonics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the basic theory and science of interaction of light with cells and tissues	Understand	8	
CO2	Understand different light delivery systems	Understand	6	
CO3	Understand fundamentals of optical imaging	Analyze	6	
CO4	Understand different optical imaging techniques	Understand	8	
CO5	Analyze different optical biosensors	Analyze	6	
CO6	Understand flow cytometry	Understand	5	
CO7	Understand photodynamic therapy	Understand	4	
CO8	Understand different tissue engineering techniques using light	Understand	6	
CO9	Understand optical tweezers and analyze its applications	Analyze	5	
CO10	Understand use of materials like quantum dots for bioimaging	Understand	6	
	Total Numbers of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1		1	1	
CO2	3	3	1		1	1	
CO3	3	3	1		1	1	
CO4	3	3	1		1	1	
CO5	3	3	1		1	1	
CO6	3	3	1		1	1	
CO7	3	3	1		1	1	
CO8	3	3	1		1	1	
CO9	3	3	1		1	1	
CO10	3	3	1		1	1	

3-High; 2-Medium; 1-Low

Module I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers, human eve and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides. Optical coherence Tomogaphy, Spectral and time-resolved imaging. Fluorescence, resonance energy transfer imaging, nonlinear optical imaging.

Module II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, darkfield and differential interference contrast microscopy, Florescence, confocalandmultiphoton microscopy.

Applications of bio-imaging; Bio-imaging probes and fluoropores, imaging of microbes, cellular imaging and tissue imaging

Module III

Optical Biosensors: Florescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, planer waveguides, evanescentwaves, interferometric and surface plasmon resonance.

Flow Cytometry: basis, fluro chromes for flow cytometry, DNAanalysis.

Module IV

Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, applications of photodynamic therapy, two photon photodynamic therapy. Tissue engineeringusing light; contouring and restructuring of tissues using laser, laser tissue regeneration, femtosecond laser surgery.

Module V

Laser tweezers and laser scissors: design of Laser tweezers and laser scissors, optical trapping using non Guassian optical beam, manipulation of single DNA molecules, molecular motors, laser for Genomics and Proteomics, semi conductor Quantum dots for bio imaging, Metallicnano-particles and nano-rods for bio-sensing, Photonics and biomaterials: bacteria as bio- synthezers for photonics polymers.

References

1. Introduction to bio-photonics- P.N. Prasad Wiley Interscience (2003)
2. Biomedical Photonics -A handbook - editor Tuan.Vo Dinh (CRC Press) (2002)

Semester III

24-441-0304 Laser Spectroscopy

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the Advantages of Lasers in Spectroscopy	Understand	5	
CO2	Compare various experimental techniques in high sensitivity laser spectroscopic techniques.	Understand	7	
CO3	Compare techniques such as photoacoustic and optothermal spectroscopies	Understand	7	
CO4	Describe the advantages of using lasers in fluorescence spectroscopy.	Understand	5	
CO5	Explain the experimental techniques in nonlinear optical spectroscopic techniques.	Understand	6	
CO6	Illustrate the techniques of nonlinear and laser Raman spectroscopy.	Understand	6	
CO7	Comprehend the concepts of optical pumping spectroscopy.	Understand	6	
CO8	Describe the mechanism of double resonance spectroscopy.	Understand	6	
CO9	Summarize the concept of time-resolved spectroscopy	Understand	7	
CO10	Explain LIBS and its applications.	Understand	5	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	3	1		1	1	
CO2	3	3	1		1	1	
CO3	3	3	1		1	1	
CO4	3	3	1		1	1	
CO5	3	3	1		1	1	
CO6	3	3	1		1	1	
CO7	3	3	1		1	1	
CO8	3	3	1		1	1	
CO9	3	3	1		1	1	
CO10	3	3	1		1	1	

3-High; 2-Medium; 1-Low

Module I
Advantages of lasers in spectroscopy, High-Sensitivity Methods of Absorption Spectroscopy, Frequency Modulation, Intra-cavity Laser Absorption Spectroscopy, Cavity Ring-Down Spectroscopy, Fluorescence Excitation Spectroscopy.

Module II
Photoacoustic Spectroscopy, Optothermal Spectroscopy, Ionization Spectroscopy – photoionization, collision-induced and field ionization, Sensitivity of ionization Spectroscopy
Thermal lens spectroscopy, dual and single beam techniques.
Laser induced fluorescence spectroscopy, experimental aspects of LIF.

Module III
Nonlinear spectroscopy, saturation spectroscopy, experimental schemes, Multiphoton spectroscopy, two-photon absorption spectroscopy, Doppler-Free Multiphoton Spectroscopy.

Laser Raman Spectroscopy, Experimental Techniques of Linear Laser Raman Spectroscopy, Nonlinear Raman Spectroscopy, Coherent Anti-Stokes Raman Spectroscopy, Resonant CARS.

Module IV
Optical Pumping and Double-Resonance Techniques, Optical Pumping,Optical–RF Double-Resonance Technique, Optical–Microwave Double Resonance, Optical–Optical Double Resonance.

Module V
Time resolved laser spectroscopy, Measurement of Ultrashort Pulses, Streak Camera,Optical Correlator for Measuring Ultrashort Pulses, FROG Technique, SPIDER Technique, Lifetime Measurement with Lasers, Spectroscopy in the Pico-to-Attosecond Range, Applications.
Laser Induced Breakdown Spectroscopy, factors affecting laser ablation and laser induced plasma formation, Double pulse LIBS, Femtosecond LIBS, Resonant LIBS, Applications.

References

1. Laser Spectroscopy Vol. 2 Experimental Techniques, Wolfgang Demtröder, Springer Berlin Heidelberg (2008)(Text)
2. *Anal. Chem.* 2013, 85, 2, 640–669
3. Handbook of laser induced breakdown spectroscopy, David A. Cremers, Leon J. Radziemski, Wiley (2013)(Text)
4. Laser Spectroscopy: Vol 1 Basic Principles, Wolfgang Demtröder, Springer (2008)(Text)
5. Thermal Lens spectroscopy, Mladen Franko, Chieu D. Tran, Wiley (2010)
6. Photoacoustics and Photoacoustic Spectroscopy, Allan Rosencwaig, John Wiley & Sons Inc; Volume 57 ed. edition (1980)

24-441-0305 Computational Photonics

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Recall Maxwell's equations, constitutive relations, and boundary conditions.	Understand	6	0
CO2	Describe the dielectric function of materials using Drude model, and understand electromagnetic radiation.	Understand	6	0
CO3	Understand analytical methods for solving Laplace's equation and numerical techniques for solving differential equations.	Understand	6	0
CO4	Describe numerical methods for solving differential equations related to photonic systems.	Understand	6	0
CO5	Understand cavity modes and propagation of waves in periodic media.	Understand	6	0
CO6	Analyze the structure of periodic media in order to predict the wave propagation in it.	Analyse	6	0
CO7	Understand numerical methods for solving differential equations.	Understand	6	0
CO8	Apply numerical methods for solving problems in photonics.	Apply	6	0
CO9	Understand the electromagnetic response of antenna elements and nanophotonic structures.	Understand	6	0
CO10	Utilize numerical methods for calculating the response of simple optical systems.	Apply	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3				2	1	
CO2	3				2	1	
CO3	3				2	1	
CO4	3				2	1	
CO5	3				2	1	
CO6	3				2	1	
CO7	3				2	1	
CO8	3				2	1	
CO9	3				2	1	
CO10	3				2	1	

3-High; 2-Medium; 1-Low

Module I
Maxwell equation, constitutive relations, boundary conditions, electromagnetic waves, waves in vacuum and in absorbing media. Dielectric function, dielectric function of metals and Drude model. Radiation, Poynting vector and power.

Module II
Computational methods in Photonics. Analytical methods. Laplace equation and its solutions. Solutions to Laplace equation in rectangular and spherical coordinates. Examples of solving electrostatic systems using Laplace equation. Mie Theory.

Module III
Cavities and cavity modes. Waveguides and modes, basics of waveguide theory. Wave propagation in layered media, Transfer matrix method. Photonic crystal structures and band-gap engineering.

Module IV
Numerical techniques for solving differential Equations. Euler's and Runge Kutta methods. Discretization methods, Integration methods, Time-stepping methods.. Finite difference method. Solving Laplace equation using finite difference method.

Module V
Electromagnetic response of nanoscale systems. Antenna effects in nanoscale systems: nanoantennas. Plasmonic and dielectric antennas. Computational modelling of plasmonic structures. Finite difference and finite element methods in photonics. Boundary conditions, discretization, meshing, convergence testing.

References

1. Introduction to Electrodynamics, David J. Griffiths, Prentice Hall of India.
2. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley, 1998 (Text).
3. Antenna Theory: Analysis and Design, Constantine A. Balanis, 4th Ed. Wiley 2016 (Text).
4. Principles of Nano Optics, Bert Hecht and Lukas Novotny, Cambridge University Press, 2012 (Text).
5. Introductory Methods of Numerical Analysis, 5th Ed., S. S. Sastry, Prentice Hall of India, 2012 (Text).
6. Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House, 1995 (Text).
7. Nanophotonics, Paras N. Prasad, Wiley-Interscience, 2004 (Text).
8. The Mathematical Theory of Finite Element Method, Susanne C. Brenner and L. Ridgway Scott, Springer-Verlag New York Inc., 2007 (Text).
9. Introductory Methods of Numerical Analysis, 5th Edition, S. S. Sastry, Prentice Hall of India, Delhi, 2022 (Text).