ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.TECH. LASER AND ELECTRO OPTICAL ENGINEERING
REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To prepare students to excel in research or to succeed in Laser & Electro-optical engineering profession through global, rigorous post graduate education.
II. To provide students with a solid foundation in Mathematics, Physics of Lasers and optical devices, and Electro-optical engineering fundamentals required to apply the principles for optical engineering design.
III. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the optical engineering domain.
IV. To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to apply laser and electro-optical engineering aspects.
V. To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Students will demonstrate knowledge of mathematics, electromagnetics, laser theory, principles and applications, optical materials and opto-electronics.
2. Students will demonstrate knowledge of Electro-Optics, Fiber Optics Sensors, Integrated Optics, Photonic Devices and Nonlinear Optics.
3. Students will demonstrate an ability to identify, formulate and solve optics and laser related problems.
4. Students will demonstrate an ability to design and conduct optics and laser experiments, analyze and interpret data.
5. Students will demonstrate an ability to design a system, component or process as per needs and specifications.
6. Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
7. Students will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
8. Students will demonstrate knowledge of professional and ethical responsibilities.
9. Students will be able to communicate effectively in both verbal and written form.
10. Students will show the understanding of impact of laser and electro-optical engineering aspects for practical applications. Further, they will develop confidence for self education and ability for life-long learning.

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓			✓						
II		✓		✓	✓	✓	✓			
III				✓	✓	✓	✓			
IV							✓	✓	✓	
V			✓	✓				✓	✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	SEM 1	Electromagnetic Theory and Applications	✓									
		Laser Engineering and Applications			✓		✓					
		Materials for Optical Devices	✓									
		Optoelectronics	✓				✓					
		Principles of Optics and Lasers	✓									
		Mathematical Physics for Optical Engineering	✓									
		Laser Laboratory I	✓			✓		✓			✓	
	SEM 2	Electro-Optics Theory and Applications		✓	✓	✓		✓				
		Fiber Optics Sensors		✓	✓	✓		✓				
		Integrated Optics and Photonic Devices		✓								
		Nonlinear Optics		✓	✓	✓						
		Elective I										
		Elective II										
		Laser Laboratory II		✓	✓	✓	✓	✓			✓	
YEAR 2	SEM 3	Elective III										
		Elective IV										
		Elective V										
		Project Work Phase I			✓	✓	✓		✓	✓		✓
		Technical Seminar and Report Writing								✓	✓	
	SEM 4	Project Work Phase II			✓	✓	✓		✓	✓		✓

ANNA UNIVERSITY, CHENNAI
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CURRICULA AND SYLLABI

SEMESTER - I

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	LO 7101	Electromagnetic Theory and Applications	PC	4	4	0	0	4
2.	LO 7102	Laser Engineering and Applications	PC	3	3	0	0	3
3.	LO 7103	Materials for Optical Devices	PC	3	3	0	0	3
4.	LO 7105	Optoelectronics	PC	3	3	0	0	3
5.	LO 7106	Principles of Optics and Lasers	PC	3	3	0	0	3
6.	LO 7104	Mathematical Physics for Optical Engineering	FC	4	4	0	0	4
PRACTICALS								
7.	LO 7111	Laser Laboratory I	PC	4	0	0	4	2
			TOTAL	**24**	**20**	**0**	**4**	**22**

II SEMESTER

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	LO 7201	Electro Optics Theory and Applications	PC	3	3	0	0	3
2.	LO 7202	Fiber Optics Sensors	PC	3	3	0	0	3
3.	LO 7203	Integrated Optics and Photonic Devices	PC	3	3	0	0	3
4.	LO 7204	Nonlinear Optics	PC	3	3	0	0	3
5.		Elective I	PE	3	3	0	0	3
6.		Elective II	PE	3	3	0	0	3
PRACTICALS								
7.	LO 7211	Laser Laboratory II	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

III SEMESTER

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective III	PE	3	3	0	0	3
2.		Elective IV	PE	3	3	0	0	3
3.		Elective V	PE	3	3	0	0	3
PRACTICALS								
4.	LO 7311	Technical Seminar and Report Writing	EEC	2	0	0	2	1
5.	LO 7312	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**23**	**9**	**0**	**14**	**16**

IV SEMESTER

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	LO 7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS:70

FOUNDATION COURSES (FC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Mathematical Physics for Optical Engineering	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Electromagnetic Theory and Applications	PC	4	4	0	0	4
2.		Laser Engineering and Applications	PC	3	3	0	0	3
3.		Principles of Optics and Lasers	PC	3	3	0	0	3
4.		Materials for Optical Devices	PC	3	3	0	0	3
5.		Optoelectronics	PC	3	3	0	0	3
6.		Electro-Optics Theory and Applications	PC	3	3	0	0	3
7.		Fiber Optics Sensors	PC	3	3	0	0	3
8.		Integrated Optics and Photonic Devices	PC	3	3	0	0	3
9.		Nonlinear Optics	PC	3	3	0	0	3
10.		Laser Laboratory I	PC	4	0	0	4	2
11.		Laser Laboratory II	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	LO 7001	Digital Holography	PE	3	3	0	0	3
2.	LO 7002	Fabrication of Optical Devices	PE	3	3	0	0	3
3.	LO 7003	Fourier Optics and Signal Processing	PE	3	3	0	0	3
4.	LO 7004	Holography and Speckle	PE	3	3	0	0	3
5.	LO 7005	Laser Spectroscopy	PE	3	3	0	0	3
6.	LO 7006	Low Dimensional Structures and Lasers	PE	3	3	0	0	3
7.	LO 7007	Materials Processing by Lasers	PE	3	3	0	0	3
8.	LO 7008	Medical Applications of Lasers	PE	3	3	0	0	3
9.	LO 7009	Nanophotonics	PE	3	3	0	0	3
10.	LO 7010	Nonlinear Fiber Optics	PE	3	3	0	0	3
11.	LO 7011	Optical Computing and Signal Processing	PE	3	3	0	0	3
12.	LO 7012	Optical Displays and Storage Devices	PE	3	3	0	0	3
13.	LO 7013	Optical Switching and Networks	PE	3	3	0	0	3
14.	LO 7014	Quantum Optics	PE	3	3	0	0	3
15.	LO 7015	Radiation Sources and Detectors	PE	3	3	0	0	3
16.	LO 7016	Remote Sensing by Lasers	PE	3	3	0	0	3
17.	LO 7017	Ultrafast Optics	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Technical Seminar and Report Writing	EEC	2	0	2	0	1
2.		Project Work Phase I	EEC	12	0	0	12	6
3.		Project Work Phase II	EEC	24	0	0	24	12

LO 7101 ELECTROMAGNETIC THEORY AND APPLICATIONS L T P C
4 0 0 4

OBJECTIVE:

- To educate the students the importance of electromagnetic radiation

UNIT I PROPAGATION OF ELECTROMAGNETIC WAVES 9

Introduction – Maxwell's equations – plane waves in a dielectric – Poynting vector – complex notation – wave propagation in lossy medium.

UNIT II REFLECTION AND REFRACTION OF ELECTROMAGNETIC WAVES 9

Interface of two homogeneous nonabsorbing dielectrics – total internal reflection and evanescent waves – reflection and transmission by a film – extension of two films – interference filters – periodic media – presence of absorbing media: reflection and transmission.

UNIT III WAVE PROPAGATION IN ANISOTROPIC MEDIA 9

Introduction – double refraction – polarization devices – plane waves in anisotropic media – wave refractive index – ray refractive index – ray velocity surface – index ellipsoid – phase velocity and group velocity

UNIT IV ELECTROMAGNETIC ANALYSIS- SIMPLE OPTICAL WAVEGUIDE 9

Introduction – classification of modes for planar waveguide – TE modes in a symmetric step index planar waveguide – TM modes – relative magnitudes – power – radiation modes – excitation – Maxwell's equations in inhomogeneous media.

UNIT V ANALYSIS OF OPTICAL WAVEGUIDES 9

Quasimodes in planar structure – leakage of power from the core – determination of propagation characteristics – calculation of bending loss – optical fiber – numerical aperture – modal analysis for step index and parabolic index medium – multimodes – modes in an asymmetric planar waveguide – Ray analysis – WKB analysis – coupled mode theory.

TOTAL: 60 PERIODS

OUTCOME:

- **The students will understand how Maxwell's electromagnetic wave equations are derived** from the basic laws of Physics. Also they will learn to apply electromagnetic wave equations in different media and to analyze the interaction.

REFERENCES:

1. A. Ghatak and K. Thiagarajan, Optical electronics, Cambridge University Press, (2013).
2. M.N.O. Sadiku, Elements of electromagnetics, Oxford Univ. Press., New York (2014).
3. Fawwaz T. Ulaby, Eric Michielssen, Umberto Ravaioli, Fundamentals of applied electromagnetics, Prentice Hall., New York (2014).
4. Ammon Yariv, Quantum Electronics, (3rd Edition), Wiley India Pvt. Ltd., New Delhi(2012).
5. G. P. Agrawal, Nonlinear fiber optics, Elsevier, Oxford (2013).
6. David J. Griffiths, Introduction to Electromagnetics, Pearson Education, (2013).

LO 7102 LASER ENGINEERING AND APPLICATIONS L T P C
3 0 0 3

OBJECTIVE:
Educating the students about fabrication and configuration of different lasers

UNIT I GAS LASERS 9
Electrical discharge mechanism – Gas discharge processes, Glow discharge, RF discharge, Hollow cathode discharge and pulsed discharge- Selective Excitation processes in gas discharges-Excitation mechanism - Power supplies for pulsed and CW gas lasers – He-Ne laser, Copper vapour laser, Argon-ion laser, He-Cd laser, He-Se laser. Excitation mechanism - Nitrogen laser - Carbon-dioxide laser - Gas dynamic laser - Excimer laser - Chemical laser - X-ray laser - Free electron laser.

UNIT II SOLID STATE, SEMICONDUCTOR AND LIQUID LASERS 9
Pumping mechanism - Arc lamp - Diode pumping - Cavity configuration - Ruby laser - Nd:YAG; Nd:Glass; Er doped laser, Ti - Sapphire laser – fiber laser - Fiber Raman laser. Intrinsic semiconductor laser - Doped semiconductor - Conduction for laser actions – Injection laser - Threshold current – Homojunction – Hetrojunction. Double hetro- junction lasers - Quantum well laser - Distributed feedback laser - Liquid lasers - Organic dyes - Pulsed-CW dye laser - Threshold condition - Configuration - Tuning methods.

UNIT III ULTRA SHORT PULSE GENERATION AND MEASUREMENT 9

Nano second pulse generation- Pico,nano,femto and atto second pulse generation - Q-switching: methods - Cavity damping - Mode locking – Configurations – Methods of detection and measurement of ultrashort pulses.

UNIT IV METROLOGICAL APPLICATIONS 9
CW and Pulsed laser beam characteristics and its measurements- Beam focusing effects-spot size-Power and Energy density Measurements-Distance measurement - Interferometric techniques – Calibration Methods -LIDARS - Theory and different experimental arrangements - Pollution monitoring by remote sensing - Applications - Laser gyroscope.

UNIT V MATERIAL PROCESSING 9
Models for laser heating - Choice of a laser for material processing - Laser welding, drilling, machining and cutting - Laser surface treatment - Laser vapour deposition - Thin film applications.

TOTAL: 45 PERIODS

OUTCOME:
- The students will explain the engineering principles and working of different types of lasers and their applications.

REFERENCES:

1. R.B. Laud. Lasers and Non linear optics. New Age International (P) Ltd. New Delhi. (2011).
2. Walter Koechner. Solid State Lasers Engineering. Springer Verlag, New York. (2010).
3. J. Verdeyen. Laser Electronics. Prentice Hall (1994).
4. Alphan Sennaroglu. Photonics and Laser Engineering: Principles, Devices, and Applications. McGraw-Hill Professional (2010)
5. K.R.Nambiar. Lasers: Principles, Types and Applications. New Age International (P) Ltd. Publishers, New Delhi. (2009).

LO 7103 MATERIALS FOR OPTICAL DEVICES L T P C
3 0 0 3

OBJECTIVE:
Educating the students to understand about various materials available for fabricating optical devices

UNIT I OPTICAL PROCESSES 9
Refractive index and dispersion – transmission, reflection and absorption of light – glass and amorphous materials – optical material for UV and IR. Semiconductors: electron-hole pair formation and recombination – absorption in semiconductors – radiation in semiconductors – Augur recombination- photoluminescence – electroluminescent process – choice of LED materials.

UNIT II LASER CRYSTALS 9
Spectroscopy of laser crystals – laser crystals for high gain – crystal growth and characterization.

UNIT III OPTICS OF ANISOTROPIC CRYSTALS 9
Biaxial, uniaxial crystals – double refraction – index ellipsoid – optical activity – nonlinear optical crystals – liquid crystals – photorefractive materials – theory of photorefractivity – application of photorefractive materials.

UNIT IV SEMICONDUCTORS 9
Band gap modification by alloying optical properties of quantum well, quantum wire and quantum dot structures – photonic band gap (PBG) materials – growth of PBG materials – light transmission in PBG materials.

UNIT V OPTICS OF THIN FILMS 9
Reflection, transmission and absorption in thin films – antireflection (AR) coating: single layer AR coating – double layer AR coatings – multilayer AR coatings – inhomogeneous AR coatings. Reflection coatings: metal reflectors – all dielectric reflectors. Interference filters: edge filters – band pass filters – Fabry-Perot filters – multicavity filters – thin film polarizers – beam splitters – thin film optical integrated structures and devices.

TOTAL: 45 PERIODS

OUTCOME:
- The students will explain the principles of optical properties of materials and device applications.

REFERENCES:

1. Pallab Bhattacharya, Semiconductor optoelectronic devices. PHI Pvt. Ltd., New Delhi (2009).
2. B.E.A. Saleh and M.C. Teich. Fundamentals of photonics. Wiley India Pvt Ltd. (2012)
3. Walter Koechner. Solid State Lasers Engineering. Springer Verlag, New York (2010).
4. R.W. Munn and C.N. Ironsid. Nonlinear optical materials. Springer, Berlin (2013).
5. George I. Stegeman and Robert A. Stegeman. Nonlinear Optics: Phenomena, Materials and Devices. Wiley, New Jersey (2012).
6. Ammon Yariv. Quantum Electronics. Wiley India Pvt. Ltd., New Delhi (2012).
7. A. Ghatak and K. Thiagarajan. Optical electronics. Cambridge University Press (2013).
8. Mark Fox. Optical properties of solids. Oxford University Press (2010).

LO 7105 **OPTOELECTRONICS** **L T P C**
3 0 0 3

OBJECTIVE:
Educating the students the basics of semiconductor optoelectronics

UNIT I REVIEW OF SEMICONDUCTOR DEVICE PHYSICS 9
Energy bands in solids, the E-k diagram, Density of states, Occupation probability, Fermi level and quasi Fermi levels, p-n junctions, Schottky junction and Ohmic contacts. Semiconductor optoelectronic materials, Bandgap modification, Heterostructures and Quantum Wells.

UNIT II SEMICONDUCTOR PHOTON SOURCES 9
Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier. Electroluminescence. The LED: Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics; direct current modulation. Quantum-well lasers; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL); Laser diode arrays.Semiconductor optical amplifiers (SOA), SOA characteristics and their applications.

UNIT III SEMICONDUCTOR PHOTODETECTORS AND SOLAR CELLS 9
Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Noise in photodetection; Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance. Photo-transistors and CCDs – Noise in photodetectors – photovoltaic device principles – PN junction photovoltaic characteristics – temperature effects – solar cells materials, devices and efficiencies.

UNIT IV OPTOELECTRONIC MODULATION AND SWITCHING DEVICES 9
Analog and digital modulation – Franz-Keldysh and Stark effect modulators – quantum well electo-absorption modulators. Optical switching and logic devices: self-electro-optic device – bipolar controller-modualtor – switching speed and energy.

UNIT V OPTOELECTRONIC INTEGRATED CIRCUITS 9
Hybrid and monolithic integration – applications of Optoelectronic Integrated Circuits (OEICs) – materials and processing for OEICs – integrated transmitters and receivers – guided wave devices – optical interconnects.

TOTAL: 45 PERIODS

OUTCOME:
- The students will explain about the principles of semiconductors, optical processes in semiconductors and working of optoelectronic devices.

REFERENCES:

1. Pallab Bhattacharya. Semiconductor optoelectronic devices.PHI Pvt. Ltd. New Delhi (2009).
2. S.O. Kasap. Optoelectronics and photonics. Pearson, New Delhi (2013).
3. C.R. Pollock. Fundamentals of optoelectronics. Irwin, Chicago (1995).
4. J. Wilson. Optoelectronics: An Introduction. Prentice-Hall (1997).
5. Ammon Yariv. Quantum Electronics. Wiley India Pvt. Ltd. New Delhi (2012).
6. A. Ghatak and K. Thiagarajan. Optical electronics. Cambridge University Press (2013).
7. B.E.A. Saleh and M.C. Teich. Fundamentals of photonics. Wiley India Pvt Ltd. (2012)
8. Jasprit Singh. Semiconductor optoelectronics: Physics and Technology. McGraw-Hill (1995).
9. E. Rosencher, B.Vinter and P. G. Piva. Optoelectronics. Cambridge University Press (2002).

LO 7106 PRINCIPLES OF OPTICS AND LASERS **L T P C**
3 0 0 3

OBJECTIVE:
Teaching the students about the principles of optics and lasers

UNIT I APPLIED OPTICS 9
Wave equation – linearly polarized waves – circularly and elliptically polarized waves – physics of lenses – types of lenses – two beam interference – multiple reflections from a plane parallel film – modes of the Fabry-Perot cavity – spatial and temporal coherence – propagation and diffraction of a Gaussian beam.

UNIT II RADIATION IN A CAVITY 9
Black body radiation - Modes of oscillation - Einstein coefficients - relation between the absorption coefficients and Einstein coefficients - Lifetime of excited state- decay of excited states, Line Broadening mechanisms – quantum mechanical description of radiating atoms, molecules in gas, liquid & solid phase, selection rules for atoms and molecules, Spectral notation.

UNIT III INTRODUCTION TO LASERS 9
Condition for producing laser - population inversion, gain and gain saturation – saturation intensity - Threshold condition – requirements for obtaining population inversion – 2,3 and 4 level systems – steady state and transient population processes – variation of laser power around threshold – optimum output coupling conditions for CW and pulsed laser action.

UNIT IV CAVITY OPTICS AND LASER MODES 9
Requirements for a resonator – gain and loss in a cavity – resonator as an interferometer – longitudinal modes – wavelength selection in multiline lasers – single frequency operation – characterization of resonator – resonator stability for Guassian beams – common cavity configurations. Spatial energy distributions: Transverse modes and limiting modes – resonator alignment – gain and saturation effects.

UNIT V Q-SWITCHING, MODE LOCKING AND COHERENCE OF LASERS 9
Concept of Q-switching and experimental methods – intracavity switches – energy storage in laser media – pulse power and energy – cavity dumping - Theory of Mode locking and experimental methods - Spatial and Temporal coherence - Auto and mutual correlation function - Analytical treatment of Visibility.

TOTAL: 45 PERIODS

OUTCOME:
- The students will discuss the basic theory of optics, lasers, importance of optical resonators and different methods of laser beam control.

REFERENCES:

1. K. Thyagarajan and A. Ghatak. Lasers: Fundamentals and applications. Springer, New York (2010).
2. Ammon Yariv. Quantum Electronics. Wiley India Pvt. Ltd., New Delhi (2012).
3. J. Verdeyen. Laser Electronics. Prentice Hall, (1994).
4. O.Svelto. Laser Physics. Springer, New York (2010).
5. Mark Steven Csele. Fundamentals of light sources and lasers. Wiley Interscience, New Jersey (2004).

LO 7104 MATHEMATICAL PHYSICS FOR OPTICAL ENGINEERING L T P C
4 0 0 4

OBJECTIVE:
To prepare the students to apply mathematics in real Physics problems

UNIT I VECTORS AND TENSORS 12
Gauss divergence theorem – Stokes's theorem – Green's theorem – applications to electromagnetic field – definition of tensors – algebra of Cartesian tensors – outer product contraction and quotient theorems – Kronecker & Levi-Civita tensors – example – applications in physics – crystal optics.

UNIT II PROBABILITY AND RANDOM VARIABLES 12
Introduction -sets -probability and relative frequency -random variables -cumulative distribution functions and probability density functions -ensemble average and moments - binomial, poisson, uniform, Gaussian and sinusoidal distributions -functional transformations of random variables - multivariate statistics -central limit theorem (statement and applications) - power spectral density -- dc and rms values for ergodic random processes.

UNIT III FOURIER TRANSFORMATIONS AND APPLICATIONS 12
Fourier series -Fourier transform and spectra -Parseval's theorem -Dirac delta function – unit step function -two dimensional signals -Fresnel & Fraunhofer diffraction -examples FT by lens– point source -single slit, double slit-circular aperture -cosine grating - coherent optical filtering - holographic filters - discrete Fourier transform.

UNIT IV SPECIAL FUNCTIONS 12
Beta and Gamma functions -Legendre, Bessel, Hermite and Lagurre polynomials - generating functions -recurrence relations, orthogonal relations, associated polynomials and their properties - confluent hyper geometric functions and their properties.

UNIT V DYNAMICAL SYSTEMS 12
Linear and nonlinear oscillators – autonomous and non-autonomous systems – classification of equilibrium points – bifurcations and chaos – chaos in a model laser system – linear and nonlinear dispersive waves – Nonlinear Schrodinger equation in optical fibers - solitary wave solutions and basic solitons, Nonlinear Schrodinger equation: envelope soliton, Hiroto's method, IST method. Numerical analysis: Euler method and 4^{th} order Runge-Kutta method for solving differential equations –finite difference and finite element analysis methods for solving partial differential equations.

TOTAL: 60 PERIODS

OUTCOME:
The students will explain the basic mathematical methods including dynamical systems theory for applying them in real Physics problems.

REFERENCES:

1. E. Kreyszig. Advanced engineering mathematics. Wiley-India, New Delhi (2011).
2. Peter V.O'Neil. Advanced engineering mathematics. Cengage (2012).
3. M.D.Greenberg. Advanced engineering mathematics. Pearson, NewDehli (2009).
4. K. F. Riley, M.P. Hobson and S.J. Bence. Mathematical methods for physics and Engineering. Cambridge Univ. Press, NewDelhi (2010).
5. Leon W. Couch. Digital and analog communication systems. Pearson Education, New Delhi (2013).
6. W-Lauterborn. T. Kurz and M. Wiesenfeldt. Coherent optics and applications. Springer. Berlin (1995).
7. M. Lakshmanan and S. Rajasekar. Nonlinear dynamics: Integrability, chaos and patterns. Springer. Berlin (2003).
8. M.Lakshmanan and K. Murali. Chaos in nonlinear oscillators: Controlling and Synchronization. World Scientific, Singapore (1996).

LO 7111 **LASER LABORATORY - I** **L T P C**
0 0 4 2

OBJECTIVE:
To carry out different diffraction and interference based experiments using optical devices and lasers.

Any ten experiments

1. Measurement of Brewster angle and the refractive index of a transparent material.
2. Studies on lenses
3. Study of magneto-optic rotation and magneto-optic modulation.
4. Kerr Effect Study
5. Measurement of Spatial and Temporal Coherence
6. Fraunhofer Diffraction Experiments
7. Fourier Filtering Experiments
8. Effect of Polarization on Interference
9. Acoustical Modulator
10. Gas laser design
11. Transversely Pumped Dye Lasers
12. Longitudinally Pumped Dye Lasers
13. Holographic Recording and Reconstruction
14. Speckle Photography
15. Construction of an optical phototransistor switch
16. Construction of low-intensity, high-intensity LED circuits.
17. Study of white, high-intensity red and IR light on a phototransistor and a photovoltaic cell.
18. Construction of optical transmitter and receiver circuits.`
19. Fiber Communication Installation Procedure
20. Setting up of Fiber Optic Analog Link
21. Setting up of Fiber Optic Digital Link
22. Measurement of Losses in Optical Fiber
23. Measurement of Numerical Aperture
24. Time Division Multiplexing of Signals

TOTAL: 60 PERIODS

OUTCOME:
The students will demonstrate the principles of diffraction, interference and fiber optics.

LO 7201 **ELECTRO OPTICS THEORY AND APPLICATIONS** **L T P C**
3 0 0 3

OBJECTIVE:
Educating the students to understand about electro-optics and its applications

UNIT I CRYSTAL OPTICS **9**
Point group and space group – matrix representation of symmetry operations – the effect of crystal symmetry in crystal properties – Neumann's principle – tensors – first-order electro-optical tensor - piezo-optical and elasto-optical tensors – dielectric description of a crystal - double refraction – polarization devices – crystal structures of $LiNBO_3$, KDP and $BaTiO_3$.

UNIT II PROPAGATION OF ELECTROMAGNETIC WAVES 9

Wave equation in isotropic material – wave equation in anisotropic materials – aniso-tropic materials – index ellipsoid – propagation in uniaxial and biaxial crystals – birefringence – wavel plates and compensators – optical activity.

UNIT III GROWTH OF ELECTRO-OPTIC AND ACOUSTO-OPTIC MATERIALS 9

Growth of single crystals – Electro-optic crystals – acousto-optic crystals – magneto-optic crystals – photorefractive crystals – Techniques for growing single crystals – zone refining technique – growth of molecular crystals.

UNIT IV ELECTRO AND ACOUSTO OPTICS 9

The electro-optic effect (EOE)– linear and quadratic electro-optic effect – physical properties of electro-optic coefficients – retardation – EOE based amplitude and phase modulation – EOE in KDP and cubic crystals – integrated optical modulators. Elastooptic effect – acousto-optic interactions – Bragg diffraction in an anisotropic medium – Raman-Nath diffraction – surfact acoustooptics – magneto optic effect – magneto-optic Kerr effect – Franz-Keldysh effect.

UNIT V OPTICAL MODULATORS 9

Electro-optic(EO) light modulators – electro-optic Fabry-Perot modulators – bistable EO devices. EO based beam deflection – Q-swtiching. Acousto-optic (AO) modulators – AO deflectors – AO tunable filters.The photoeleastic effect – Bragg diffraction of light by acoustic waves.Electro-absorption modulators.

TOTAL: 45 PERIODS

OUTCOME:

The students will explain the principles of electro-optics, modulators, switches and their uses.

REFERENCES:

1. C.C.Davis. Lasers and Electro-optics: Fundamentals and Engineering. Cambridge Univ.Press, Cambridge (2014).
2. Walter Koechner. Solid State Lasers Engineering. Springer Verlag, New York (2010).
3. R.W. Munn and C.N. Ironsid. Nonlinear optical materials. Springer, Berlin (2013).
4. J.A.K. Tareen and T.R.N. Kutty. A basic course in crystallography. University Press (2000).
5. T. S. Narasimhamurty. Photoelastic and Electro-Optic Properties of Crystals. Springer, Berlin (2012).
6. H.L. Bhat. Introduction to Crystal Growth: Principles and Practice. CRC Press, Boca Raton (2015).
7. Ammon Yariv. Quantum Electronics. Wiley India Pvt. Ltd., New Delhi (2012).
8. A. Ghatak and K. Thiagarajan. Optical electronics. Cambridge University Press (1994).
9. Amnon Yariv and Pochi Yeh, Optical waves in crystals: Propagation and control of laser radiation. Wiley (2002).

LO 7202 FIBER OPTIC SENSORS L T P C

3 0 0 3

OBJECTIVE:

To tutor the students the basic concepts and practices of fiber optics, optical communication and sensors

UNIT I FIBER OPTICS 9

Total internal reflection - Phase shift & attenuation during total internal reflection - Hybrid modes - cutoff frequencies - meridinal rays & skew rays - different types of fibers.

UNIT II CHARACTERISTICS AND FABRICATION OF OPTICAL FIBERS 9

Dispersion - Fiber attenuation, absorption loss & scattering loss measurement - Optical Time Domain Reflectometer (OTDR) and its uses - Interferometric method to measure fiber refractive index profile. Fiber materials - Fiber fabrication- fiber optic cables design - fiber connectors - fiber splices - Lensing schemes for coupling improvements.

UNIT III OPTICAL FIBER COMMUNICATION AND NETWORKS 9

Elements of an optical fiber communication system – optical sources -–Surface Emitting, edge emitting and superluminescent LEDs – Optical Detectors: Pin photodiodes – Avalanche photodiodes – Multiplexers: wavelength division multiplexing - Electrooptic and Acoustooptic modulation - Coherent optical fiber communication system - ASK, FSK and PSK modulated waveforms - heterodyne and homodyne detections. Local Area Networks - Bus, ring and star topologies - optical fiber regenerative repeater - optical amplifiers - basic applications. Passive components – Couplers – Multiplexing and De-multiplexing.

UNIT IV INTENSITY AND POLARIZATION SENSORS 9

Intensity sensor: Transmissive concept - Reflective concept - Microbending concept - Transmission and Reflection with other optic effect - Interferometers - Mach Zehnder - Michelson - Fabry-Perot and Sagnac – Phase sensor: Phase detection - Polarization maintaining fibers. Displacement and temperature sensors: reflective and Microbending Technology - Applications of displacement and temperature sensors.

UNIT V INTERFEROMETRIC SENSORS 9

Pressure sensors: Transmissive concepts -Microbending - Intrinsic concepts - Interferometric concepts – Applications. Flow sensors: Turbine flow meters - Differential pressure flow sensors - Laser Doppler velocity sensors - Applications - Sagnac Interferometer for rotation sensing. Magnetic and electric field sensors: Intensity and phase modulation types – applications.

TOTAL: 45 PERIODS

OUTCOME:

The students will acquire knowledge in fundamentals of fiber optics, communication equipments, construction and working of optical communication networks including sensor applications.

REFERENCES:

1. Eric Udd and W.B. Spillman (Eds.). Fiber optic sesnsors: An introduction for engineers and scientists. Wiley (2011).
2. Allen H. Cherin. An Introduction to Optical Fibers. McGraw Hill Inc., Tokyo (1995).
3. John M. Senior. Optical Fiber Communications. Prentice Hall International Ltd., London (1992).
4. Govind P. Agrawal. Fiber Optic Communication Systems. John Wiley & Sons Inc., New York (1997).
5. Gerd Keiser. Optical fiber Communications. McGraw Hill Inc. Tokyo (1995).
6. C.M. Davis. Fiber Optic Sensor Technology Hand Book. Dynamic Systems, Reston Virginia (1992).
7. D.A.Krohn. Fiber Optic Sensors - Fundamentals and Applications. Instrument Society of America, U.S.A (1988).
8. Bishnu P. Pal (Ed.). Fundamentals of fiber optics in telecommunication and sensor systems. John Wiley & Sons (1993).

LO 7203 INTEGRATED OPTICS AND PHOTONIC DEVICES **L T P C**
3 0 0 3

OBJECTIVE:
To teach the students the fundamentals and applications of integrated optics

UNIT I OPTICAL AMPLIFIERS 9
Concepts – principles of optical amplification – optical amplifiers: general considerations – semiconductor optical amplifier – applications – advantages and drawbacks – EDFAs – optical fiber amplifiers – coherent sources for IO – MQW – photonic switching principles.

UNIT II OPTICAL WAVEGUIDES AND INTEGRATED CIRCUITS 9
Applications of coupled mode theory – theory of gratings in waveguide structures – guided wave control – electrooptic, acoustooptic, magnetooptic, thermooptic and nonlinear optical effects – fabrication of optical waveguides in glass, Lithium Niobate substrates. Microfabrication techniques in optical integrated circuits – guided wave excitation and waveguide evaluation – passive waveguide devices – functional optical waveguide devices.

UNIT III ACTIVE OPTICAL INTEGRATED CIRCUITS AND APPLICATIONS 9
Integrated semiconductor sources, detectors and active switches on substrates – optoelectronic integrated circuits – recent trends in optical integrated circuits. Optical switches – A/D converters – RF spectrum analyzers – convolvers – correlators – modulators – integrated optic sensors.

UNIT IV PHOTONIC MATERIALS GROWTH & FABRICATION 9
Types of photonic materials – growth methods – nucleation – homogeneous – heterogeneous – LEC technique – epitaxy - growth of photonic materials by LPE, VPE, MBE, MOCVD, Plasma CVD, photochemical deposition. Interfaces and junctions - interface quality, interdiffusion and doping. Quantum wells and bandgap engineering (examples of structures).Post-growth processing (patterning by photolithography, contacting, annealing).

UNIT V PHOTONIC DEVICES 9
Photodiodes: current-voltage equation – operation-spectral response – quantum efficiency – response time – diffusion time – drift – capacitance of diodes, measurement – photoconductivity – LEDs: electroluminescent process – choice of LED materials – device configuration and efficiency – structures – device performance – manufacturing process – defects and reliability – laser diode: junction laser operating principles – threshold current – heterojunction lasers – distributed feedback lasers – quantum well lasers – surface emitting lasers – rare-earth doped lasers – device fabrication – mode locking.

TOTAL: 45 PERIODS

OUTCOME:
- The students will gain information in a way that the they can understand the principle of optical amplifiers, waveguides and construction and working of integrated circuits.

REFERENCES:

1. H. Nishihara, M. Haruna and T. Suhara. Optical integrated circuits. McGraw Hill Book Co., Tokyo (1989).
2. Robert G. Hunsperger. Integrated optics: Theory and technology. Springer (2010).
3. Theodor Tamir (Ed.). Guided-wave optoelectronics. Springer-Verlag (2012).
4. D.K. Mynbaev and L.L. Scheiner. Fiber-optic communications technology. Pearson Education, New Delhi (2001).
5. G. Keiser. Optical fiber communications. McGraw Hill. New Delhi. (1983).
6. P.Bhattacharya. Semiconductor optoelectronic devices. Prentice-Hall India., NewDelhi, (1998).
7. A.Ghatak and K.Thyagarajan. Optical electronics. Cambridge Univ. Press, New Delhi, (2002).
8. B.E.A. Saleh and M.C. Teich. Fundamentals of photonics. John Wiley., New York (1991).
9. Larry A. Coldren, Scott W. Corzine and Milan L. Mashanovitch, Diode laser and photonic integrated circuits", Wiley (2012)

LO 7204 **NONLINEAR OPTICS** **L T P C**
3 0 0 3

OBJECTIVE:
To make the students understand the theory of nonlinear optics

UNIT I ORIGIN OF OPTICAL NONLINEARITIES 9
Effects due to quadratic and cubic polarization – Response functions – Susceptibility tensors – Linear, second order and n^{th} order susceptibilities – Wave propagation in isotropic and crystalline media – The index ellipsoid.

UNIT II SECOND HARMONIC GENERATION (SHG) AND PARAMETRIC OSCILLATION 9
Optical SHG – Phase Matching – Experimental verification – Parametric oscillation – Frequency tuning – Power output and pump saturation – Frequency up conversion – Materials.

UNIT III THIRD ORDER NONLINEARITIES 9

Intensity dependent refractive index – Nonlinearities due to molecular orientation – Self-focusing of light and other self-action effects - Optical phase conjugation – Optical bistability and switching - Pulse propagation and temporal solitons.

UNIT IV ELECTRO –OPTIC AND PHOTOREFRACTIVE EFFECTS 9
Electro-optic effects – Electro-optic modulators - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in Photorefractive materials.

UNIT V STIMULATED SCATTERING PROCESSES 9
Stimulated scattering processes – Stimulated Brillouin scattering – Phase conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS – Stimulated Rayleigh - Wing Scattering.

TOTAL: 45 PERIODS

OUTCOME:
The students will explain the principles of nonlinear optics and origin of optical nonlinearities.They will also analyze various types of nonlinearities in optics.

REFERENCES:

1. Robert W. Boyd. Non-linear Optics. Academic Press, London (2008).
2. Y.V.G.S.Murti and C.Vijayan. Essentials of Nonlinear Optics. Wiley (2014).
3. Peter E. Powers. Fundamentals of nonlinear optics. CRC Press (2011).
4. Geoffrey New. Introduction to nonlinear optics. Cambridge University Press (2011).
5. Alan Newell and Jeremy Moloney. Nonlinear optics. Westview Press (2003).
6. Amnon Yariv and Pochi Yeh. Optical waves in crystals: Propagation and control of laser radiation. Wiley (2002).
7. Paul N.Butcher and David Cotter. The Elements of Nonlinear Optics. Cambridge Univ. Press, New York (1991).

LO 7211 **LASER LABORATORY II** **L T P C**
0 0 4 2

OBJECTIVE:
To educate the students to carry out experiments on optical computing, holography, nonlinear optics and optical modulators.

ANY TEN EXPERIMENTS

1. Planar Dye laser
2. Distributed Feedback Dye Laser
3. Tuning of Dye Laser using Grating
4. Tuning of Dye Laser using DFDL Arrangement
5. Measurement of Ultrashort Pulses
6. Dye Laser Gain Measurement
7. Holographic Interferometry - Double Exposure in NDT
8. Holographic Interferometry - Time Average - Vibration Analysis
9. Real Time Holography
10. Contour Holography
11. Digital holography: Matlab simulations
12. Basic operations of computation by light
13. Speckle Interferometry - Out of Plane Displacement
14. Speckle Shear Interferometry
15. Laser Doppler Interferometry (LDV)
16. Stimulated Raman Scattering
17. Stimulated Brillouin Scattering
18. Phase Conjugation
19. Fiber Communication Installation Procedure
20. Setting up of Fiber Optic Analog Link
21. Setting up of Fiber Optic Digital Link
22. Nonlinear optics: Optical Z-scan
23. Nonlinear optics: Eclipse type Z-scan
24. Nonlinear optics: Optical limiting
25. Bistable optical devices
26. Laser Speckle Optometer
27. Laser Effects on Human Cell
28. Tumour Diagnosis using Lasers
29. CCD based experiments

TOTAL: 60 PERIODS

OUTCOME:
The students will demonstrate the experimental techniques in the concepts of optical computing, holography, nonlinear optics and optical modulators.

LO 7001 **DIGITAL HOLOGRAPHY** **L T P C**
3 0 0 3

OBJECTIVE:
To study about the generation of digital holograms and its applications

UNIT I COMPUTER GENERATED HOLOGRAMS 9
Introduction – mathematical preliminaries – Fourier transform – phase transformation of a spherical lens - principles of holography – numerical reconstruction – separation of virtual image, real image and DC-term – recording digital holograms. Digital holography for bulk image acousto-optical reconstruction: Main assumptions – system architecture – computer simulations – modeling and color image processing.

UNIT II DIGITAL HOLOGRAPHIC MICROSCOPY 9
Introduction – diffraction theory – hologram formation and wavefront reconstruction -reconstruction algorithms – direct method- phase shifting method: image formation – measurement of surface shape and deformation - instruments – applications.

UNIT III OPTICAL RECONSTRUCTION 9
Introduction – compensating aberrations – controlling numerical reconstructions – controlling reconstructions in MWDH compensating chromatic aberrations – application of digital holography for investigation and testing of MEMS structures. Comparative digital holography – encryption of information with digital holography – synthetic apertures.

UNIT IV INTERFEROMETRY AND SPECKLE METROLOGY 9
General principles – deformation measurement – shape measurement – measurement of refractive index variations – distant measurements – data compression and decompression. Electronic speckle pattern interferometry – digital shearography – digital speckle photography.

UNIT V THREE DIMENSIONAL DISPLAYS 9
Computer generated holograms for white light reconstruction – wide-angle computer generated holograms for 3D display – optical scanning holography – 3D display projection system – 3D display and information processing based on integral imaging – autostereoscopic, partial pixel, spatially multiplexed and 3D display technologies.

TOTAL: 45 PERIODS

OUTCOME:
Outline the concept of mathematics, computer programming, physics, technology and applications of digital holography. Course will cover the basic concepts of digital hologram generation, holographic interferometry, microscopy and three-dimensional display techniques.

REFERENCES:

1. Ulf Schnars and Werner Jueptner. Digital holography. Springer,Berlin (2005).
2. Ting-Chung Poon. Digital Holography and Three-Dimensional Display: Principles and Applications. Springer, Berlin (2010).
3. Leonid Yaroslavsky. Digial holography and digital image processing: Principles, methods and algorithms. Kluwer (2004).
4. Pascal Picart and Jun-chang Li. Digital holography. Wiley (2012).
5. Anand Asundi. Digital Holography for MEMS and Microsystem Metrology. Wiley (2011).

LO 7002 FABRICATION OF OPTICAL DEVICES **L T P C**
3 0 0 3

OBJECTIVE:
To educate the students the importance optical devices

UNIT I NEW APPROACHES IN NANOPHOTONICS 9
Near-Field Optics-Aperture near-field optics - Apertureless near-field optics -Near-field scanning optical microscopy (NSOM or SNOM):- SNOM based detection of plasmonic energy transport- SNOM based visualization of waveguide structures- SNOM in nanolithography- SNOM based optical data storage and recovery.

UNIT II QUANTUM-CONFINED MATERIALS 9
Materials: -Optical properties- Non-linear optical properties - Quantum dots -Structure –Cores - Shells: - Coating:- Fabrication - Inks and pigments -Patterning of thin films / lithography- Optical lithography- E-beam Lithography- X-ray Lithography - Nanoimprint lithography and soft lithography.

UNIT III PLASMONICS 9
Total internal reflection and evanescent waves: - Plasmons and surface plasmon resonance (SPR): Attenuated total reflection -Grating SPR coupling- Optical waveguide SPR coupling- SPR dependencies and materials - Plasmonics and nanoparticles -Applications of metallic nanostructures -Plasmonic waveguiding and photonic circuit elements -SPR based harmonic generation: - Light generation.

UNIT IV PHOTONIC CRYSTALS 9
Important features of photonic crystals - Presence of photonic bandgap - Anomalous Group Velocity Dispersion -Anomalous Refractive Index Dispersion -Microcavity-Effect in Photonic Crystals-Fabrication of photonic crystals -Colloidal self assembly:- Gravity sedimentation:- Cell method:- Two-photon-lithography - Photosensitive materials -E-Beam lithography- Defects in photonic crystals- Photonic Crystal Laser - PC based LEDs - Photonic crystal fibers (PCFs).

UNIT V PHOTONIC DEVICES 9
Laser Diodes - Quantum well lasers - Quantum cascade lasers - Cascade surface-emitting photonic crystal laser - Quantum dot lasers - Quantum wire lasers –LEDs - White LEDs based on quantum dots -LEDs based on nanotubes- LEDs based on nanowires - LEDs based on nanorods: - Quantum well infrared photodetectors – Single electron transistors and quantum computing - White LEDs – quantum well and wires

TOTAL: 45 PERIODS

OUTCOME:
- The students will explain the physics and technology of various optical devices and fabrication of different optical devices.

REFERENCES:

1. Mitsuo Fukuda. Optical Semiconductor Devices. Wiley series in microwaves and optical engineering, Kai Chang (Ed.) (1999).
2. Jia-Ming Liu. Photonic Devices. Cambridge University Press (2005)
3. E. Fred Schuber. Light Emitting Diodes. Cambridge University Press (2005)
4. Harry J. Levinson. Principles of Lithography. SPIE Press (2005)
5. P. Rai-Choudhury. Handbook of Microlithography, Micromachining and Microfabrication: Micromachining and microfabrication. SPIE (1997).

LO 7003 FOURIER OPTICS AND SIGNAL PROCESSING L T P C
3 0 0 3

OBJECTIVE:
To make the students to understand the concepts of Fourier optics and their applications in optical information processing

UNIT I SIGNALS AND SYSTEMS 9
Fourier analysis in two dimensions: Fourier transform - separable functions – Fourier-Bessel transforms. Linear and space-invariant systems. Sampling theory:Shannon-Nyquist sampling theorem – space-bandwidth product – discrete Fourier transform from continuous transform – periodic convolution.

UNIT II DIFFRACTION THEORY 9
Scalar diffraction – monochromatic fields and irradiance – optical path length and field phase representation – Rayleigh-Sommerfeld formulation – angular spectrum of plane waves- Fresnel approximation – Fraunhofer approximation – Fraunhofer diffraction patterns – Fresnel diffraction calculations.

UNIT III COHERENT OPTICAL SYSTEMS 9
Thin lens as a phase transformation – Fourier transforming properties of lenses and image formation by lens – frequency response of a diffraction-limited system under coherent and incoherent illumination – aberrations and their effects – comparison of coherent and incoherent imaging – super-resolution.

UNIT IV WAVEFRONT MODULATION 9
Wavefront modulation with photographic film : physical processes of exposure, development and fixing – film in an incoherent optical system – film as coherent optical system – modulation transfer function. Spatial light modulators: liquid crystals – spatial light modulators using liquid crystals – magneto-optic spatial light modulators – quantum well spatial light modulators and acousto-optic spatial light modulators. Diffractive optical elements: Binary optics – types of diffractive optics.

UNIT V OPTICAL INFORMATION PROCESSING 9
Abbe-Porter experiment – phase contrast microscopy and other simple applications. Coherent image processing: vanderLugt filter – joint-transform correlator – character recognition – invariant pattern recognition – image restoration – data processing from synthetic aperture radar – acousto-optic signal processing – discrete analog processors.

TOTAL: 45 PERIODS

OUTCOME:
- The students will learn discuss Fourier transform, diffraction theory and the principles of analog optical information processing.

REFERENCES:

1. J.W. Goodman. Introduction to Fourier optics. Mc-Graw Hill, New Delhi (2005).
2. O.K.Ersoy. Diffraction, Fourier optics and imaging. John Wiley & Sons, New Jersey (2007).
3. E.G.Stewart. Fourier optics: an introduction. Dover Publications, (2004).
4. J.B. Breckinridge and D.G. Voelz. Computational Fourier optics: A MATLAB tutorial. Society of Photo Optical (2011).
5. T.C.Poon and Partha P. Banerjee. Contemporary optical image processing with MATLAB. Elsevier (2001).

LO 7004 HOLOGRAPHY AND SPECKLE L T P C
3 0 0 3

OBJECTIVE:
To introduce the principles of holography and speckle

UNIT I OPTICAL HOLOGRAPHY 9
General theoretical Analysis - Types of Holograms - Requirements to record and reconstruct holograms - Experimental techniques - Recording materials - Silver halide - Dichromated Gelatin - Ferroelectric Crystals - Inorganic Photochromatic Materials - Thermo plastic Materials - Photoresists

UNIT II HOLOGRAMS FOR DISPLAY 9
360^0 holograms - Double sided holograms - Holographic stereograms - Rainbow Holograms - Colour Holography - Volume Reflection Holograms - Multicolour Rainbow Holograms - Holographic Optical elements - Holographic Scanners

UNIT III HOLOGRAPHIC INTERFEROMETRY 9
Theoretical Analysis of Double Exposure - Real-Time and Time-averaged Interferometric Techniques - Contour holography - Sandwich Holography - Double Pulsed Holography - Acoustical and Microwave Holography

UNIT IV APPLICATIONS OF HOLOGRAPHY IN ENGINEERING AND MEDICINE 9
Measurement of displacement, deformation, strain, stress and bending movements for opaque and transparent objects - Holographic NDT - Holography in Biology and Medicine – holographic data storage.

UNIT V SPECKLE PHOTOGRAPHY AND INTERFEROMETRY 9
In-plane and out-of-plane translations – Pointwise and whole field analysis - Time averaged Speckle Photography - Speckle Interferometry - Speckle Shear Interferometry -displacements and strain measurements - Electronic speckle pattern Interferometry(ESPI)

TOTAL: 45 PERIODS

OUTCOME:
The students will demonstrate about how experimentally holograms and specklegrams could be recorded and reconstructed. Further they will learn about the concept of holographic interferometry and its applications.

REFERENCES:

1. Robert K. Erf. Holographic Non-destructive Testing. Academic press, New York & London (1974).
2. C.M.Vest. Holographic Interferometry. John-Wiley & Sons Inc., Canada (1979).
3. Hariharan. Optical Holography. Academic Press, New York (1983).
4. Robert K. Erf. Speckle Meterology. Academic press, New York (1978).
5. R.S.Sirohi (Ed). Speckle Meterology. Marcel Dekker, New York (1993).

LO 7005 **LASER SPECTROSCOPY** **L T P C**
3 0 0 3

OBJECTIVE:
To educate the students about the basic principles of laser spectroscopy

UNIT I BASIC PRINCIPLES 9
Comparison between conventional Light Sources and Lasers – Saturation – Excitation methods: Single-step excitation – Multistep excitation – Multi-photon absorption - Detection Methods: Fluorescence – Photoionization – Collisional ionization – field ionization – Laser wavelength setting.

UNIT II DOPPLER – LIMITED TECHNIQUES 9
Absorption measurements – Intra-cavity absorption measurements – Absorption measurements on excited states – Level labeling – Two-photon absorption measurements – Opto-Galvanic spectroscopy – Single atom detection – Opto-acoustic spectroscopy – Optical double resonance and level-crossing experiments with laser excitation.

UNIT III TIME-RESOLVED SPECTROSCOPY 9
Generation of short optical pulses – generation of ultrashort optical pulses – Measurement techniques for Optical Transients: Transient – Digitizer - Boxcar – Delayed coincidence– Streak-camera & Pump-probe techniques. Basics of lifetime measurements – Methods of measuring radiative properties – linewidth measurements – ODR and LC – Beam foil techniques – Beam laser techniques – Time resolved spectroscopy with pulsed lasers – Phase-shift method and emission method – The hook method – Quantum-Beat spectroscopy.

UNIT IV HIGH RESOLUTION SPECTROSCOPY 9
Spectroscopy on collimated atomic beams: Detection through fluorescence - detection by photoionization - detection by the recoil effect - detection by magnetic deflection. Saturation spectroscopy and related techniques - Doppler-free two-photon absorption - spectroscopy of trapped ions and atoms.

UNIT V APPLICATIONS OF LASER-SPECTROSCOPY 9
Diagnostics of combustion processes: Background - Laser-induced fluorescence and related techniques - Raman spectroscopy - coherent anti-stokes Raman scattering - Velocity measurements. Laser remote sensing of the atmosphere: Optical heterodyne detection - long path absorption techniques - LIDAR techniques. Laser-induced fluorescence and Raman spectroscopy in liquids and solids: Hydrospheric remote sensing - monitoring of surface layers. Laser-induced chemical processes: Laser-induced chemistry - laser isotope separation - spectroscopic aspects of lasers in medicine.

TOTAL: 45 PERIODS

OUTCOME:
The students will gain knowledge about the fundamentals of spectroscopy, different types of spectroscopy and applications of laser spectroscopy.

REFERENCES:

1. S. Svanberg. Atomic and Molecular Spectroscopy. Springer Verlag, Germany (1992).
2. J. R. Lakowicz. Principles of Fluorescence Spectroscopy. Kluwer Academic/Plenum Publishers, New York (1999).
3. Z. Wang and H. Xia. Molecular and Laser Spectroscopy. Springer Series in Chemical Physics, Vol.50 (1991).

LO 7006 LOW-DIMENSIONAL STRUCTURES AND LASERS L T P C
3 0 0 3

OBJECTIVE:
To educate the students understand the consequences for the electronic and optical properties of materials when carriers are confined in two, one and zero dimensional systems

UNIT I LENGTH SCALES AND LOW DIMENSIONALITY 9
Electronic transport in 1,2 and 3 dimensions- Quantum confinement, energy – subbands, quantum wells, quantum wires, quantum dots. Effective mass, Drude conduction and mean free path in 3D-ballistic conduction, phase coherence lengthand quantized conductance in 1D- Epitaxial growth of semiconductors: Molecular beamepitaxy -Gas epitaxy from metal-organics–Nanolithography - Self-organization of quantum dots and quantum wires.

UNIT II ELECTRICAL PROPERTIES 9
Density of energy states in low-dimensional electronic systems - Statistics of charge carriers in low-dimensional systems - Evolution from the discrete to the continuous spectra in quantization direction for low-dimensional systems for different dimensions Quasi-low dimensional systems - 2D and 3D shielding Electrons in quantum semiconductor structures: an introduction;-Electrons in quantum semiconductor structures: more advanced systems and methods

UNIT III OPTICAL PROPERTIES 9
Phonons in low-dimensional semiconductor structures; -Localization and transport -Electronic states and optical properties of quantum wells -Optical properties of low dimensional systems (transition rules, polarization etc). Transport properties of 2D and 1D systems. Quantized conductance with Landauer-formalism.Scattering phenomena in 1D. Devices based on quantum phenomena and Coulomb blockade. Nonlinear optics in low-dimensional semiconductors.

UNIT IV LASER OSCILLATIONS AND OPTICAL RESONATORS 9
Threshold condition, Steady state and transient operation – Rate equations; Relaxation oscillation, Spectral and spatial hole burning, Frequency pulling and Lamb dip, Properties of laser beams. Gaussian beams and their properties, Optical resonators, General modes and resonances, Mode selection, Mode volume, Resonators for high power and high energy laser.

UNIT V SEMICONDUCTOR LASERS 9
(Condition for gain, gain spectrum, threshold current, double heterostructures, quantum well laser, quantum dot laser) - Light modulation using semiconductor quantum structures. (Excitons, Quantum Confined Stark Effect)- . High electron mobility transistor (HEMT). (Mobility, modulation doping) - Quantum Hall effect (Resistance standard)- High speed heterostructure devices-Multiple-Micro-Cavity (MMC) lasers, Deeply Etched Distributed Bragg Reflector (DBR) lasers, Coupled Cavity (CC) lasers, Distributed Reflector (DR) lasers, and Membrane lasers.

TOTOAL: 45 PERIODS

OUTCOME:
- The students will explain the physics and technology of various nano based lasers, preparation and fabrication of low dimension based lasers, Low-Dimensional Semiconductor Structures and quantum heterostructures.

REFERENCES:

1. Keith Barnham. Low-Dimensional Semiconductor Structures: Fundamentals and Device Applications. Cambridge Press (2008).
2. J.Singh. Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill (1994).
3. J.F.Wilson & J.Hawkes. Optoelectronics, an Introduction. Prentice and Hall (1988).
4. J.H.Davies. The Physics of Low-dimensional Semiconductors: An Introduction. Cambridge University Press (1997).
5. O.Svelto. Principles of Lasers. Plenum press, New York (1998).
6. P.W.Milonni and J.H.Eberly. Lasers. Willey Inter Science (1988).

LO 7007 MATERIALS PROCESSING BY LASERS L T P C
3 0 0 3

OBJECTIVE:
To educate the students about the applications of lasers in materials processing.

UNIT I INDUSTRIAL LASER SYSTEMS 9
High power laser systems - Focusing optics - Steering optics - Mechanisms - Overview of industrial lasers - CW &pulsed - Q-switched and Mode locking – fiber laser – disk laser.

UNIT II THERMAL PROCESSES IN INTERACTION ZONE 9
Depth of penetration with respect to laser energy density - Reflectivity of Metals with respect to wavelength - Rate of heating and cooling - Maximum temperature rise and depth of hardened layer - Different gases used during laser materials processing - Operational parameters in laser materials processing - Key hole effect – heat affected zone.

UNIT III SURFACE TREATMENT 9
Surface modification- surface cladding - surface alloying - Hard facing - Shock hardening - shock peeling - laser parameters for surface alloying - process variables - Beam profiles - Different methods to obtain desired penetration depths - Experimental set-up.

UNIT IV LASER WELDING, DRILLING AND CUTTING 9
Advantages of laser processing versus conventional methods – material parameters for welding/drilling/cutting – dependence of lambda, pulse width, repetition rate and factors influencing the parameters. Recent developments – hybrid welding. Cooling parameters for welding processes – gas shielding.

UNIT V PRE-PROCESSING AND PROCESSING PARAMETERS 9
Annealing , quenching effects – basic thermodynamics of material processing and preparation – laser heads, geometry, selection cutting nozzle – copper and Teflon cone design. Laser assisted process – powder feeding – wire feeder, plasma interaction – pulse shaping – gas dynamics – microstructure checking and analysis – viewing optics – CCD recording. Marking and galvo interaction.

TOTAL: 45 PERIODS

OUTCOME:
The students will gain knowledge about industrial laser systems and interaction of laser radiation with matter.

REFERENCES:

1. J.Wilson and J.F.B. Hawkes. Optoelectronics - An Introduction. Prentice Hall of India Pvt. Ltd., New Delhi (1996).
2. J.F.Reddy. High Power Laser Applications. Academic Press (1977).
3. Ian W. Boyd. Laser Processing of Thin Films and Microstructures. Springer – Verlag (1987).
4. W.W.Duley. Laser Processing and Analysis of Materials. Plenum Press, New York (1983).
5. U.A.Rykalni and A.Kokona. Laser and Electron Beam Material Processing Hand Book. MIR Publishers (1987).

LO 7008 MEDICAL APPLICATIONS OF LASERS

LO 7008	**MEDICAL APPLICATIONS OF LASERS**	**L T P C**
		3 0 0 3

OBJECTIVE:
To guide the students in different applications of lasers in the medical field

UNIT I FUNDAMENTALS OF LASER-TISSUE INTERACTION 9
Laser Characteristics as applied to medicine and biology - Laser tissue interaction – Photophysical process - Photo biological process - Absorption by biological systems - Different types of interaction - Thermal photochemical (one photon and multiphoton) - Electromechanical - Photoablative processes

UNIT II PHOTOBIOLOGY AND MEDICAL LASERS 9
Study of biological functions - Microradiation of cells - optical properties of tissues (normal and diseased state) - Experimental methods to determine the reflectance, absorption, transmittance and emission properties of tissues - Laser systems in medicine and biology - Nd:YAG, Ar ion, CO_2, Excimer, N_2, Gold Vapour laser - Beam delivery and measuring systems

UNIT III THERMAL APPLICATIONS 9
Surgical applications of lasers - Sterilization - hermostasis - Cancer Liver stomach gynecological surgeries - Performance evaluation - Lasers in Opthalmology - Dermatology and Dentistry – Cosmetic Surgery.

UNIT IV NON THERMAL APPLICATIONS 13
Trace element detection - Laser induced fluorescence studies - Cancer diagnosis - Photo radiation therapy of tumours - Lasers in endoscopy – Lasers in laproscopy - Lasers in trapping of cells and genetic engineering - Bio simulation - Holographic and speckle application of lasers in biology and medicine.

UNIT V SAFETY REGULATIONS 5
Protection standards for lasers - Safety regulation - Specific precautions- Medical surveillance.

TOTAL: 45 PERIODS

OUTCOME:
- The students will discuss about laser tissue interaction, photobiology and thermal and non-thermal applications of lasers.

REFERENCES:

1. S. S. Martellucci and A.N.Chester. Laser Photobiology and Photomedicine. Plenum Press, New York (1985).
2. R. Pratesi and C.A.Sacchi. Lasers in Photomedicine and Photobiology. Springer verlag, West Germany (1980).
3. J.A.S.Carruth and A.L. Mckenzie. Medical Lasers Science and Clinical Practice. Adam Hilger Ltd., Bristol (1991).
4. T. Kaluylu and M.Tsukakoshi. Laser Microradiation of cells. Harward Academic publishers, New York. (1990).

LO 7009 **NANOPHOTONICS** **L T P C**
3 0 0 3

OBJECTIVE:

- To make the students to understand the concepts of nanophotonics

UNIT I PHOTONIC PROPERTIES OF NANOMATERIALS 9

Photon absorption – photon emission – photon scattering – metals: permittivity and the free electron plasma – extinction coefficient of metal particle – colours and uses of gold and silver particles. Semiconductors: Tuning the band gap of nanoscale semiconductors – the colours and uses of quantum dots – nanoscale interactions of electronic interactions - lasers based on quantum confinement. Optical luminescence and fluorescence from direct, bandgap semiconductor nanoparticles - carrier injection - polymer-nanoparticle LED's and solar cells – electroluminescence - doping nanoparticles - Mn-ZnSe phosphors - light emission from indirect semiconductors - light emission from Si nanodots – CNT.

UNIT II PHYSICS OF PHOTONIC CRYSTALS 9

Maxwell's Equations - Bloch's Theorem - Photonic Band Gap and Localized Defect States-Transmission Spectra - Nonlinear Optics in Linear Photonic Crystals - Guided Modes in Photonic Crystals Slab. Photonic crystal optical circuitry - 1-D Quasi Phase Matching - Nonlinear Photonic Crystal Analysis – Nonlinear photonic crystals – photonic crystal fibers – photonic crystal sensor.Materials: $LiNbO_3$, Chalcogenide Glasses, etc, Wavelength Converters,

UNIT III NEAR-FIELD INTERACTION AND MICROSCOPY 9

The limits of light: conventional optics – near filed optics – theoretical modeling of near-field nanoscopic interactions – near-field microscopy – near field studies in quantum dots, single-molecule spectroscopy and nonlinear optical processes – apertureless near-field spectroscopy and microscopy – nanoscale enhancement of optical interactions – time-and-space-resolved studies of nanoscale dynamics. Optical tweezers.

UNIT IV PLASMONICS 9

Introduction: Plasmonics - merging photonics and electronics at nanoscale dimensions - single photon transistor using surface Plasmon - nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots,–plasmonic wave guiding – applications of metallic nanostructures.

UNIT V NANOPHOTONICS FOR BIOTECHNOLOGY AND NANOMEDICINE 9

Near-field bioimaging – nanoparticles for optical diagnostics and targeted therapy – semiconductor quantum dots for bioimaging – up-converting nanophores for bioimaging – biosensing.polariton guiding by subwavelength metal grooves. Subwavelength aperture plasmonics – plasmonic wave guiding – applications of metallic nanostructures.

TOTAL: 45 PERIODS

OUTCOME:

The students will explain the effects of interaction of photons with matter and their ensuing applications

REFERENCES:

1. Paras N. Prasad. Nanophotonics. Wiley-Interscience (2004).
2. Sergey V. Gaponenko. Introduction to nanophotonics. Cambridge University Press, Cambridge (2010).
3. Ben Rogers, S. Pennathur and J. Adams. Nanotechnology: Understanding small systems. CRC Press, Boca Raton (2008).
4. Klaus D. Satller. Handbook of Nanophysics-6: Nanoelectronics and nanophotonics, Taylor & Francis Group (2010)
5. V.V. Klimov. Nanoplasmonics. Taylor & Francis Group (2011).

LO 7010 **NONLINEAR FIBER OPTICS** **L T P C**
3 0 0 3

OBJECTIVE:
To make the students understand the fundamentals of nonlinear fiber optics with a special emphasis on optical communication

UNIT I FIBER NONLINEARITIES 9
Introduction - Nonlinear Refraction - Maxwell's Equations - Fiber Modes - Eigen value Equations - Single Mode Condition - Nonlinear pulse Propagation - Higher Order Nonlinear Effects.

UNIT II GROUP VELOCITY DISPERSION AND PHASE MODULATION 9
Gaussian Pulse - Chirped Gaussian Pulse - Higher Order Dispersions - Changes in Pulse Shape – Self Phase Modulation (SPM) induced Spectral Broadening - Non-linear Phase Shift - Effect of Group Velocity Dispersion - Self Steepening - Application of SPM- Cross Phase Modulation (XPM) - Coupling between Waves of Different Frequencies - Non-linear Birefringence - Optical Kerr Effect - Pulse Shaping.

UNIT III OPTICAL SOLITONS AND DISPERSION MANAGEMENT 9
Soliton Characteristics - Soliton Stability - Dark Solitons – Other kinds of Solitons - Effect of Birefringence in Solitons - Solitons based Fiber Optic Communication System (Qualitative treatment) – Demerits - Dispersion Managed Solitons (DMS).

UNIT IV SOLITON LASERS 9
Non-linear Fiber Loop Mirrors - Soliton Lasers - Fiber Raman Lasers - Fiber Raman Amplifiers - Fiber Raman Solitons - Erbium doped fiber amplifiers.

UNIT V APPLICATIONS OF SOLITONS 9
DMS for single channel transmission – WDM transmission - Fiber Gratings- Fiber Couplers – Fiber Interferometers – Pulse Compression – Soliton Switching – Soliton light wave systems.

TOTAL: 45 PERIODS

OUTCOME:
- The students gain knowledge about nonlinear fiber optics and fundamentals of soliton dynamics.

REFERENCES:

1. Govind P. Agrawal. Nonlinear Fiber Optics. Academic Press, New York (1995).
2. Y.V.G.S.Murti and C.Vijayan. Essentials of Nonlinear Optics. Wiley (2014).
3. A. Hasegawa and M. Matsumoto. Optical Solitons in Fibers. Springer, Berlin (2003).
4. Govind P. Agrawal. Applications of Nonlinear Fiber Optics. Academic Press, New York (2001).
5. M. Lakshmanan and S. Rajasekar. Nonlinear Dynamics: Integrability, Chaos and Patterns. Springer, Berlin (2003).
6. Y. S. Kivshar and Govind Agrawal. Optical Solitons : From Fibers to Photonic Crystals. Academic Press, New York (2003).

LO 7011 OPTICAL COMPUTING AND SIGNAL PROCESSING **L T P C**
3 0 0 3

OBJECTIVE:

- To introduce the concept of optical computing and the signal processing

UNIT I FOURIER OPTICS AND IMAGE PROCESSING 9

A short history of the Field of Optical Computing – Fourier Optics – Correlation and Convolution – Fourier Transform with lenses – Grating filters – Complex transform filters – Fourier holograms – Optical image processing.

UNIT II OPTICAL COMPUTING WITH SPATIAL LIGHT MODULATOR (SLM) 9

Introduction – Liquid crystal light valve – Micro channel Spatial Light Modulator – Numerical optical computing basics – Logic gates using SLMs – Flip-flops – Optical binary temporal integrator – optical circuits – Optical switching network – Optical matrix computations – Optical matrix vector multiplier – Matrix-Matrix Multiplier – Optical implementation of Matrix-vector multiplier.

UNIT III OPTICAL SWITCHING DEVICES 9

Types of switching devices – some requirements of switching devices – Networks – Role of optical switching – Implications of optical switching – Circuit switches – Four port Directional coupler switches and switch matrices – active path optical switches with electrical control – optical logic devices for switching – The electronics-optics interface – A self routing wideband switching matrix.

UNIT IV OPTICAL INTERCONNECTIONS 9

Introduction – Types of optical interconnections – Specific properties of optical interconnections – Power requirements of optical interconnections – Fan-in and Fan-out properties of Optical interconnections – Multistage interconnections.

UNIT V OPTICAL NEURAL NETWORKS 9

Optical computing and neural networks – Optical linear neural nets – Non-linear neural networks – Auto associative and self-organizing networks – Recent advances.

TOTAL: 45 PERIODS

OUTCOME:

- The students will explain about optical computing and application of Fourier optics in image processing.

REFERENCES:

1. Mohammad A. Karim and Abdul A.S. Awwal. Optical Computing – An Introduction. John Wiley & Sons (2003).
2. Alistair D. McAulay. Optical Computer Architectures. John Wiley & Sons (1991).
3. Dror G. Fritelson. Optical Computing. The MIT Press (1988).
4. B.S. Wherrett, and F.A.P. Toole. Optical Computing", Heriot-Watt University, Edinburgh, (1988).
5. Henri H. Arsenault et al. Optical Processing and Computing. Academic Press, London (1989).

LO 7012 OPTICAL DISPLAYS AND STORAGE DEVICES L T P C
3 0 0 3

OBJECTIVE:
To study about the principles of optical displays and optics based data storage devices

UNIT I VISUAL SYSTEM, COLOUR VISION AND COLORIMETRY 9
Introduction – evolution of display technologies – eye anatomy and eye optics – visual performance of the eye – models of visual performance and photometry. Colour vision and colorimetry: colour vision basics – colour matching – colour systems and spaces – colorimetry. Holographic optical elements – optical holography.

UNIT II 2D DISPLAY TECHNOLOGY 9
Display system interfaces and performance parameters – CRT displays – Transmissive displays, reflective displays, transreflective displays – emissive displays. Flat panel displays: AMLCD, LCOS, Plasma, OLED – projection systems – new display technologies: high dynamic range display – bidirectional displays – projection displays - enriched colour display. Display metrology: display performance measurement and calibration – display evaluation – colour management and calibration.

UNIT III BINOCULAR VISION AND 3D DISPLAY TECHNOLOGY 9
Binocular vision and perception basics – 3D display principles and techniques: Basics, spatial stereoscopic displays – autostereoscopic displays – light-field displays – computer generated holograms – 3D media encoding. Near-Eye displays (NEDs): Eye physiology – brightness and power consumption – technologies for NEDs – examples – optical design – laser displays – holographic image generation for NEDs – optical combiners – contact lens displays – adaptive displays and eye tracking – image integration.

UNIT IV DIGITAL VIDEO DISPLAY 9
General principles – interlaced versus progressive video signals and displays – differences between displaying video and graphics. Digital video deinterlacing/interlacing: Algorithms imported from graphics – vertical-temporal deinterlacing – film source – field rate conversion – display of graphics on interlaced displays. Digital image display: standard and high definition television formats – integrating video data with digital processing parameters.

UNIT V OPTICAL DATA STORAGE SYSTEMS 9
Overview – basics of optical storage – theoretical aspects of phase-change alloys – thermal modeling of phase-change recording – data recording characteristics – recording media. Optical data media formats – materials for optical data storage - Holographic data storage – applications.

TOTAL: 45 PERIODS

OUTCOME:
Discuss the concept of physics, technology and applications of optical displays and optical information storage devices.

REFERENCES:

1. Rolf R. Hainich and Oliver Bimber. Displays: Fundamentals and applications. CRC Press (2011).
2. Lindsay MacDonald and A.C. Lowe (Eds.). Display systems: Design and applications. Wiley (1997).
3. G. Berbecel. Digital image display: Algorithms and implementation. Wiley (2003).
4. E.R. Meinders, A.V. Mijiritskii, Liesbeth van Pieterson and M. Wuttig. Optical data storage: Phase-changing media and recording. Springer (2006).
5. Demetri Psaltis, G. T. Sincerbox and A.M. Glass. Holographic data storage. Springer (2000).

LO 7013 OPTICAL SWITCHING AND NETWORKS L T P C
3 0 0 3

OBJECTIVE :

- To make the students to understand the fundamentals of optical switching and networks.

UNIT I OPTICAL SYSTEM COMPONENTS AND NETWORK DESIGN 9

Optical System Components: Filters, Couplers, Isolators, attenuators, amplifiers, Circulators, repeaters, combiners – modems – Add Drop Multiplexers (ADM) – optical switches (Electro-optical, mechanical & photonic) – optical line termination – optical network unit – optical network termination. Transmission System Engineering: System model, Power penalty - transmitter, receiver, crosstalk, dispersion – soliton systems - Wavelength stabilization -Overall design considerations.

UNIT II OPTICAL NETWORK ARCHITECTURES 9

Introduction to Optical Networks: Multiplexing techniques – second-generation optical networks – optical layer – transparency – optical packet switching - SONET / SDH, optical transport network – framing – Ethernet – IP – multiprotocol label switching – resilient packet ring – storage-area networks.

UNIT III WAVELENGTH ROUTING NETWORKS 9

WDM Network Elements; Optical line terminals – optical line amplifiers – optical add/drop multiplexers – optical crossconnects - WDM Network Design - Cost tradeoffs, Virtual Topology Design, Routing and wavelength assignment, Statistical Dimensioning Models.

UNIT IV PACKET SWITCHING AND ACCESS NETWORKS 9

Photonic Packet Switching – OTDM, Multiplexing and Demultiplexing, Synchronisation, Header Processing, Buffering, Burst Switching, Testbeds; Access Networks.

UNIT V NETWORK MANAGEMENT AND SURVIVABILITY 9

Control and Management – Network management functions – optical layer services and interfacing – layers within the optical layer – multivendor interoperability - Configuration management, Optical safety, Service interface; network Survivability- Protection in SONET / SDH and IP Networks, Optical layer Protection, Interworking between layers.

TOTAL: 45 PERIODS

OUTCOME :

- The students will discuss about different types of optical components and their uses in designing optical switches and networks.

REFERENCES:

1. Rajiv Ramaswami and Kumar N. Sivarajan. Optical Networks : A Practical Perspective. Elsevier (2010)
2. Vivek Alwayn. Optical network design and implementation. Cisco Press (2004).
3. Steven Shepard. Optical networking crash course. McGraw-Hill (2008)
4. Robert C. Elsenpeter. Optical networking: A begineer's guide. McGraw-Hill (2001)
5. L. Harte and D. Eckard. Introduction to optical communication, lightwave technology, fiber transmission and optical networks. Althos Publishing (2005).
6. C. Siva Ram Moorthy and Mohan Gurusamy. WDM Optical Networks : Concept, Design and Algorithms. Prentice Hall of India (2002).
7. Biswanath Mukherjee. Optical WDM Networks. Springer (2006).

LO 7014 QUANTUM OPTICS L T P C
3 0 0 3

OBJECTIVE:
To study about the science of light and its interaction with matter which requires quantum mechanics to describe it

UNIT I PHOTON STATISTICS 9
Formalism of quantum mechanics – radiative transitions in atoms. Introduction to photon statistics – photon-counting statistics – coherent light: Poissonian photon statistics – classification of light by photon statistics – super-Poissonian light – sub-Possonian light – theory of photodetection – shot noise photodiodes – Observation of sub-Poissonian photon statistics.

UNIT II PHOTON ANTIBUNCHING (PA) 9
Introduction – Hanbury Brown-Twiss experiments and classical intensity fluctuations – second order correlation function – Hanbury Brown-Twiss experiments with photons – photon bunching and antibunching – experimental demonstrations of PA – single photon sources.

UNIT III COHERENT STATES AND SQUEEZED LIGHT 9
Light waves as classical harmonic oscillator – phasor diagrams and field quadratures – light as quantum harmonic oscillator – vacuum field – coherent states – shot noise and number-phase uncertainty – squeezed states – detection – generation of squeezed states – quantum noise in amplifiers – Quantum theory of Hanbury Brown-Twiss experiments.

UNIT IV ATOM-PHOTON INTERACTIONS 9
Resonant light-atom interactions: Preliminary concepts – time-dependent Schrodinger equation – weak-field limit – strong-field limit – Bloch sphere. Atoms in cavities: Optical cavities – atom-cavity coupling (weak and strong coupling). Cold atoms: laser cooling – Bose-Einstein condensation – atom lasers.

UNIT V QUANTUM INFORMATION PROCESSING 9
Quantum cryptography: Classical cryptography – basics of quantum cryptography – quantum key distribution – system errors – single photon sources – experiments. Quantum computing: Quantum bits – quantum logic gates – decoherence and error correction – applications of quantum computers – experiments. Entangled states and quantum teleportation: Entangled states – generation of entangled photon pairs – single-photon interference experiments – Bell's theorem – principles of teleportation – experiments.

TOTOAL: 45 PERIODS

OUTCOME:
Explain the concept of physical principles involved in the light interaction of matter through quantum mechanics. The technology and application of quantum optics in information processing and cryptography will be covered.

REFERENCES:

1. Mark Fox. Quantum optics. Oxford University Press (2006).
2. C.Gerry and P.Knight. Introductory quantum optics. Cambridge University Press (2004).
3. D.F. Walls and G. J. Milburn. Quantum optics. Springer (2010).
4. M.O. Scully and M. Suhail Zubairy. Quantum optics. Cambridge University Press (1997).
5. G.S. Agarwal. Quantum optics. Cambridge University Press (2013).
6. R. Loudon. The quantum theory of light. Oxford University Press (2000).

LO 7015 RADIATION SOURCES AND DETECTORS

L T P C
3 0 0 3

OBJECTIVE:
To educate the students the importance of radiation sources and detectors

UNIT I SOURCES OF RADIATION 9

Basic radiative transfer - Radiance and radiometric quantities - The angular range – Radiometric – Photometric units and their relationship – geometrical radiation transfer - Radiant intensity and their profiles – Lambertian – point – exponent profiles - Optical transfer function – Numerical aperture - Sources - Natural and luminescent sources of radiation., blackbody radiation - Infrared, Ultraviolet, Visible radiation sources - radiometric measurements and calibration.

UNIT II SPECTROSCOPY AND OPTICAL DEVICES 9

Electromagnetic spectrum – Wave and quantum aspects - Atomic, molecular and vibrational spectroscopy - Electronic, vibrational and rotational transitions - Selection rules – IR, VIS, UV radiation - Absorption & Emission Spectroscopy - Devices – Materials for reflection and transmission - Reflective losses and their reduction - Different types of filters and their applications.

UNIT III DETECTOR CHARACTERISTICS 9

Basic detector mechanisms - radiometric instruments and detector interfaces - Photon detection process – Photon effects – Thermal effect – wave interaction effect – Noise in radiation detectors – Figure of merit - Spectral response – Responsivity – Noise equivalent power – Detectivity – Frequency response – Response time – Negative Electron Affinity (NEA) - Optical receivers - preamplifiers.

UNIT IV CONVENTIONAL DETECTORS 9

Photomultipliers, microchannel analyzer, photoresistors, photodiodes, nonselective detectors - Thermal and photoemissive detectors - Photoconductive and photovoltaic detectors, performance limits. Photographic, thermoplastic materials - Sensitivity, time and frequency response - eye and vision, photographic film - Camera tubes.

UNIT V MODERN DETECTORS 9

Hybrid photodetectors - Imaging detectors - solid-state arrays, video, Detector electronics, detector interfacing - Different CCD cameras- Digital camera – Optical Multichannel Analyzer – Monochromator – Photo transistors – Photo thyristors – Triac - Box-car Averager – Integrating Sphere – Streak Camera.

TOTAL: 45 PERIODS

OUTCOME:
The students will explain physics of radiation from different sources in different signals of electromagnetic spectrum. Further, they will understand the principle involved in fabrication of different radiation detectors.

REFERENCES:

1. H.E.White. Introduction of Atomic Spectra. McGraw Hill International Students Edition (1985).
2. G.M.Barrow. Molecular Spectroscopy. McGraw Hill, Kugakusha, New Delhi (1982).
3. R.J.Keyes. Optical and Infrared Detectors. Topics in Applied Physics, Springer Verlag (1977).
4. Jurgen R.Meyer- Arendi. Introduction to Classical and Modern Optics. Prentice Hall of India Pvt.Ltd. (1988).
5. Roger M.Wood. Optical Materials. The Institute of Materials, London (1993).
6. E.L.Dereniak and D.G.Crowe. Optical Radiation Detectors. John Wiley, New York, (1984).
7. U.I.G.A.Endel. Optoelectronics. Prentice Hall Inc. New Jersey (1995).
8. B.P.Bhattacharya. Semiconductor and Optoelectronic Devices. Prentice Hall (1996).
9. S.M.Sze. High Speed Semiconductor Devices. John Wiley (1990).

LO 7016 **REMOTE SENSING BY LASERS** **L T P C**
3 0 0 3

OBJECTIVE:
To teach the students understand the basic principles of remote sensing by lasers

UNIT I ECOSYSTEM 9
Atmosphere - Hydrosphere - Biosphere Main feature contents - Dynamical Variation - their influence on human life - Changes in ecosystem by natural and anthropogenic causes

UNIT II SOURCES AND DETECTORS FOR REMOTE SENSING 9
CO_2 , N_2 , Dye, Ar-ion, Excimer Lasers - Optical Telescopes - Light collection filtering receivers - diodes and PMT - Sensitivity Limit.

UNIT III PRINCIPLES AND DESIGN OF SYSTEMS 9
Scattering form LIDAR Equations – DIAL equations – Fluorescent form – analysis and interpretation of LIDAR signals – spectral rejection of laser backscattered radiation – Differential absorption detection limiter – Raman scattering.

UNIT IV ATMOSPHERIC POLUTION AND SURVEILLANCE 9
Pollution Source Monitoring - Detection limit - Source Detector Characteristics - Detection of OH ion SO_2, CO_2, CO, NO, N_2O, methane, ethylene in industrial environment, green House gases detection - Ozone Depletion Study.

UNIT V HYDROSPHERIC LIDAR APPLICATION 9
LIF by UV Laser - Laser Fluorosensor - Oil Slick, Chlorophyll - Laser Phytoplankton mapping - Study on Shoals - Coral reefs.

TOTAL: 45 PERIODS

OUTCOME:
The students will explain the basics of remote sensing.

REFERENCES:
1. Piemental. Analytical Applications of Lasers. Wiley Interscience (1986).
2. E.D.Hinckley. Laser Monitoring of Atmospheric. Springer- verlag, New York (1976).
3. R.M.Measures. Laser Remote Sensing. Wiley Interscience, New York (1984).

LO 7017 **ULTRAFAST OPTICS** **L T P C**
3 0 0 3

OBJECTIVE:
To study about the physics and technological applications of ultrashort laser pulses.

UNIT I ULTRAFAST PULSE GENERATION 9
Introduction – laser basics – short pulse generation via mode-locking – active mode-locking: frequency domain treatment – passive-mode locking with saturable absorbers – solid state model locking using the optical Kerr effect – solidstate mode locking including phase effects.

UNIT II ULTRASHORT PULSE MEASUREMENT 9

Introduction – electric filed autocorrelation – intensity auto correlation – electric field-cross correlation and spectral interferometry – chirped pulses and measurement in the time-frequency domain – frequency-resolved optical gating – characterization of noise and jitter.

UNIT III DISPERSION AND DISPERSION COMPENSATION 9

Introduction – group velocity dispersion – temporal dispersion based on angular dispersion – dispersion with grating and prism sequences – dispersion properties of lenses – dispersion properties of mirror structures – measurement of group velocity dispersion – frequency dependent storage time.

UNIT IV ULTRAFAST NONLINEAR OPTICS 9

Propagation equation for nonlinear refractive index media – self-phase modulation – pulse compression and solitons – higher order propagation effects: delayed nonlinear index and Raman scattering – higher-order propagation effects: delayed nonlinear index and Raman scattering – soliton effects in mode-locked lasers with fast self-amplitude modulation – mode locked frequency combing.

UNIT V ULTRAFAST SPECTROSCOPY 9

Ultra short pulse amplification – Fourier transform pulse shaping – space-time duality and temporal imaging – ultrafast spectroscopy: degenerate pump-probe transmission measurements – coherent short pulse spectroscopy –dephasing phenomena – impulsive stimulated Raman scattering.

TOTAL: 45 PERIODS

OUTCOME:

Explain the concept of physics, technology and applications of ultrashort laser pulses.Course will coverthe basic concepts of ultrafast laser pulse generation, mode-locking, higher-order effects and spectroscopy.

REFERENCES:

1. A. Weiner. Ultrafast optics. Wiley (2009).
2. J.-C. Diels and W. Rudolph. Ultra short laser phenomena. Academic Press (2006).
3. S. Watanabe and K. Midorikawa (Eds.). Ultrafast optics V. Springer (2007).
4. M.E. Fermann, A.Galvanauskas and G.Sucha (Eds.). Ultrafast lasers: Technology and applications. Marcel Dekker, New York (2003).
5. H. Ishikawa. Ultrafast all-optical signal processing devices. Wiley (2008).