UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO IV SEMESTERS (FULL TIME)

M.TECH. LASER AND ELECTRO OPTICAL ENGINEERING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	LO9116	Mathematical Physics For Optical Engineering	3	1	0	4
2	LO9111	Radiation Sources and Detectors	3	0	0	3
3	LO9112	Laser Theory	3	0	0	3
4	LO9113	Laser Engineering	3	0	0	3
5	LO9114	Laser Applications	3	0	0	3
6	LO9115	Electromagnetic Theory and applications	3	1	0	4
PRACTICAL						
7	LO9117	Laser Laboratory I	0	0	4	2
		TOTAL	**20**	**0**	**4**	**22**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	LO9121	Photonic Materials and Devices	3	0	0	3
2	LO9122	Nonlinear Optics	3	0	0	3
3	LO9123	Optical Fiber Communication	3	0	0	3
4	OC9151	Integrated Optics	3	0	0	3
5	E1	Elective I	3	0	0	3
6	E2	Elective II	3	0	0	3
PRACTICAL						
7	LO9127	Laser Laboratory II	0	0	4	2
		TOTAL	**18**	**0**	**4**	**20**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E3	Elective III	3	0	0	3
2	E4	Elective IV	3	0	0	3
3	E5	Elective V	3	0	0	3
PRACTICAL						
4	LO9135	Project Work – Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	LO9141	Project Work – Phase II	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDIT TO BE EARNED FOR THE AWARD OF DEGREE = 69

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1	LO9151	Fiber optic sensors	3	0	0	3
2	LO9152	Holography and Speckle	3	0	0	3
3	LO9153	Medical Application of Lasers	3	0	0	3
4	LO9154	Materials processing by lasers	3	0	0	3
5	OC9158	Optical Computing	3	0	0	3
6	LO9155	Nonlinear Fiber Optics	3	0	0	3
7	LO9156	Remote Sensing by Lasers	3	0	0	3
8	LO9157	Laser Spectroscopy	3	0	0	3
9	LO9158	Mini project	3	0	0	3
10		Special Elective	3	0	0	3

LO9116 MATHEMATICAL PHYSICS FOR OPTICAL ENGINEERING

L T P C
3 1 0 4

AIM

To prepare the students to apply mathematics in real Physics problems

OBJECTIVE:

To make the students understand the basic mathematical functions necessary for applying them in real Physics problems.

UNIT I VECTORS AND TENSORS 10

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 10

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 8

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 10

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 APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS 7

Classification -methods of solving linear ODE and PDEs -separation of variables -wave equation -Laplace equation -nonlinear PDEs -approximation methods for nonlinear differential equations --Painleve analysis for PDEs -AKNS, bilinear and BT methods - applications.

L: 45 +T:15

REFERENCES:

1. E. Kreyszig. "Advanced engineering mathematics" (81h Edition). John-Wiley & Sons.. Inc., New York (1999).
2. M.D. Greenberg. "Advanced engineering mathematics", Pearson Education, New Delhi (2002).
3. K. F. Riley, M.P. Hobson and S.J. Bence. "Mathematical methods for physics and engineering", Cambridge Univ. Press, Cambridge. (1998).
4. L.W. Couch., "Digital and analog communication systems", Pearson Education, New Delhi (2001). .
5. W-Lauterborn. T. Kurz and M. Wiesenfeldt., "Coherent optics and applications", Springer. Berlin (1995).
6. M. Lakshmanan and S. Rajasekar. .'Nonlinear dynamics: Integrability, chaos and patterns", Springer. Berlin (2003).

LO9111 RADIATION SOURCES AND DETECTORS

L T P C
3 0 0 3

AIM:

To educate the students the importance of radiation sources and detectors

OBJECTIVE:

To teach the Physics of radiation from different sources in different signals of electromagnetic spectrum.
To teach the principle involved in fabrication of different radiation detectors.

UNIT I SOURCES OF RADIATION 12

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 8

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 7

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.

L: 45

REFERENCES:

1. White H.E., 'Introduction of Atomic Spectra', McGraw Hill, International Students Edition, 1985.
2. Barrow G.M., 'Molecular Spectroscopy', McGraw Hill, Kugakusha, New Delhi, 1982.
3. *Keyes R.J., '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, UK, 1993.
6. Dereniak E.L. and Crowe D.G., 'Optical Radiation Detectors', John Wiley, New York, 1984.
7. Endel UIGA, ‘Optoelectronics’, Prentice Hall Inc. New Jersey, 1995.
8. Bhattacharya B.P., ‘Semiconductor and Optoelectronic Devices’, Prentice Hall, 1996.
9. Sze S.M., “High Speed Semiconductor Devices”, John Wiley, 1990.

LO9112 LASER THEORY

L T P C
3 0 0 3

AIM:
To make the students understand the principles of lasers

OBJECTIVE:
To teach the students the basic theory of lasers, importance of optical resonators and different methods of laser beam control.

UNIT I 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- Line Broadening mechanisms.

UNIT II INTERACTION OF LIGHT WITH MATTER 9
Population inversion - Threshold condition - Gain profile – super-radiance Laser - Rate equation for 3 level and 4 level systems - conditions for CW and pulsed laser action.

UNIT III OPTICAL RESONATORS 9
General considerations - Laser resonators - Fox and Li theory - Fresnel number Photon representation of cavity properties of a cavity - Plane and spherical mirror cavities - general conditions of stability - lens sequence - matrix treatment of thin lens sequence - confocal resonator - Gaussian beam propagation - Multimode oscillation - Degeneracy.

UNIT IV GAIN AND SATURATION EFFECTS 9
Theory of Gain saturation - Gain narrowing - Effect of Gain saturation on modes - Power output - Single mode operation - Mirror transmission and power optimization - Hole burning effects - Lamb dip - Gain saturation amplifiers with hole burning and cross relaxation - mode pulling and pushing.

UNIT V Q-SWITCHING, MODE LOCKINGAND COHERENCE OF LASER 9
Theory of Q-switching and experimental methods - Theory of Mode locking and experimental methods - cavity dumping - Spatial and Temporal coherence - Auto and mutual correlation function - Analytical treatment of Visibility.

REFERENCES

1. Ammon Yariv, Quantum Electronics, John Wiley & Sons, Inc., New York, 1989.
2. J. Verdeyen, Laser Electronics, Prentice Hall, 1989.
3. O.Svelto, Laser Physics, Plenum Press, New York, 1982.
4. A.Ghatak & K.Thiagarajan, Optical Electronics, Cambridge University, 1994.

LO9113 LASER ENGINEERING

L T P C
3 0 0 3

AIM:
To educate the students with different methods of laser fabrication.

OBJECTIVE:
To teach the students the principle and working of different types of lasers.
To teach the physics of spatial and temporal beam control.

UNIT I LOW POWER 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.

UNIT II HIGH POWER GAS LASERS 9

Excitation mechanism - Power supplies - Nitrogen laser - Carbon-dioxide laser - Gas dynamic laser - Excimer laser - Chemical laser - X-ray laser - Free electron laser.

UNIT IV SOLID STATE LASERS 9

Pumping mechanism - Arc lamp - Diode pumping - Cavity configuration - Ruby laser - Nd:YAG; Nd:Glass; Er doped laser, Ho:YLF laser, Alexandrite laser - Ti - Sapphire laser - Colour center laser - Fiber Raman laser.

UNIT IV SEMICONDUCTOR AND LIQUID LASERS 9

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 V ULTRA SHORT PULSE GENERATION AND MEASUREMENT 9

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

REFERENCES

1. R.B. Laud - Lasers and Non linear optics. New Age International (P) Ltd. Publishers, New Delhi. (1996).
2. Pike High Power Gas Lasers, Institute of Physics, London. (1976).
3. Walter Koechner - Solid State Lasers Engineering, Springer Verlag, New York. (1992).
4. J. Verdeyen - Laser Electronics,. Prentice Hall, London. (1989).
5. F.J. Durate and L.W. Hilman - Dye Lasers Principles With Applications, Inc Academic Press, New York. (1990).

LO9114 LASER APPLICATIONS

L T P C
3 0 0 3

AIM:
To teach the physics of various applications of lasers

OBJECTIVE:
To educate the students with various applications of lasers and laser instrumentation.

UNIT I METROLOGICAL APPLICATIONS 10
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 - Holographic and speckle interferometry.

UNIT II 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.

UNIT III SPECTROSCOPIC APPLICATIONS 9
Photochemical reactions - Steady and excited state techniques - Comparison of one photon and Multiphoton effect and its applications – Photo ionization – Photo isomerism - Isotope separation - Laser fusion – Laser trapping of atoms and cooling.

UNIT IV BIOMEDICAL APPLICATIONS 10
Biological effects of laser radiation - Applications of scattered laser light - Thermal and Non Thermal applications - Biostimulation Laser Imaging of tissues - Fluorescent Life time Imaging - Optical Coherence Tomography (FLIM- OCT) - Laser hazards and control.

UNIT V LASER INSTRUMENTATION 7
Bar code reader – Compact Disc-- Laser Doppler Velocimetry – Laser Printing.

REFERENCE

1. Arecchi, F.T., Laser Handbook, Vol.2, North Holland Publication, 1974.
2. Lidder, R.E., McGraw Hill, London, Fundamental and Applied Laser Physics, John Wiley, New York, 1985.
3. *Duley., W.W, Laser Processing and Analysis of Materials, Plenum Press, New York, 1983.
4. J.Wilson & J.F.B. Hawkes, Opto Electronics - An Introduction, Prentice Hall, 1992.
5. A.J. Welch and M.J.C.Van Gamert, Optical Thermal Response of Laser Irradiated Tissue, Plenum Press, New York, 1995.
6. William M.Stem, Laser Material Processing, Springer-Verlag, Berlin, 1988

LO9115 ELECTROMAGNETIC THEORY AND APPLICATIONS

L T P C
3 1 0 4

AIM:
To educate the students the importance of electromagnetic radiation.

OBJECTIVE:
To teach the students how Maxwell's electromagnetic wave equation are derived from basic laws of Physics.
To apply electromagnetic wave equation in different media and analyze the interaction.

UNIT I PROPAGATION OF ELECTROMAGNETIC WAVES 8
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 10
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 7
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 10
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 10
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.

L: 45 +T: 15

REFERENCES:

1. A.Ghatak and K.Thyagarajan, " Optical electronics", Cambridge Univ. Press, New Delhi, (2002)
2. M.N.O. Sadiku, "Elements of electromagnetics", Oxford Univ. Press., New York (2001).
3. F.T. Ulaby, "Fundamentals of applied electromagnetics", Prentice Hall., New York (2001).
4. A. Yariv, "Quantum electronics", Wiley, New York (1989).
5. G. P. Agrawal, "Nonlinear fiber optics", Academic., San Diego (2003).
6. David J. Griffiths, " Introduction to Electromagnetics", Pearson Education, 2002.

LO9117 LASER LABORATORY - I

L T P C
0 0 4 2

1. Brewster Angle Determination
2. Faraday Effect Study
3. Kerr Effect Study
4. Measurement of Spatial and Temporal Coherence
5. Fraunhofer Diffraction Experiments
6. Fourier Filtering Experiments
7. Effect of Polarization on Interference
8. Acoustical Modulator
9. Nitrogen Laser Power Supply Construction
10. Laser Power Supply Construction
11. Carbon dioxide Laser Power Supply Construction
12. Nitrogen Laser Study
13. Transversely Pumped Dye Lasers
14. Longitudinally Pumped Dye Lasers
15. Holographic Recording and Reconstruction
16. Speckle Photography
17. Fiber Communication Installation Procedure
18. Setting up of Fiber Optic Analog Link
19. Setting up of Fiber Optic Digital Link
20. Measurement of Losses in Optical Fiber
21. Measurement of Numerical Aperture
22. Time Division Multiplexing of Signals

Total: 60

LO9121 PHOTONIC MATERIALS AND DEVICES

L T P C
3 0 0 3

AIM:
To educate the students understand about photonic materials and devices.

OBJECTIVE:
To teach the students about different types of photonic materials and their uses as devices.

To apply the principles of semiconductors to photonic devices and to tutor the students about the fabrication techniques and characterization of various photonic devices.

UNIT I SEMICONDUCTOR PHYSICS 7
Band gaps, density of states, materials, optical and electronic properties, carrier generation and recombination, mobility and diffusion, low dimensional structures, quantum wells, wires and dots, heterostructures.

UNIT II OPTICAL PROCESSES IN SEMICONDUCTORS 10
Electron-Hole formation and recombination – absorption in semiconductors – effect of electric field on absorption – absorption in quantum wells and the quantum-confined Stark effect – Kramer-Kroning relations – radiation in semiconductors – deep level transitions – auger recombination – Luminescence from quantum wells – measurement of absorption and luminescence spectra – time resolved photoluminescence.

UNIT III MATERIALS GROWTH & FABRICATION 10
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 IV DEVICES 13
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.

UNIT V CHARACTERIZATION 5
Measurements using lenses, monochromators, spectrometers, grating, mirrors, lock-in amplifiers – characterization of photodiodes, LEDs and laser diodes – modulation of lasers – rate equations.

REFERENCES:

1. P. Bhattacharya, “Semiconductor optoelectronic devices”, Prentice-Hall India, New Delhi (2003).
2. B.E.A. Saleh and M.C. Teich., “Fundamentals of photonics”, John Wiley., New York (1991).
3. J. Singh, “Optoelectronics: An introduction to materials and devices”, Mc-Graw-Hill Co., New York (1996).
4. S.O.Kasap, “Optoelectronics and photonics: Principles and practices”, Prentice-Hall, New York (2001).
5. T.P. Pearsall, “Photonics essentials: An introduction to experiments”, Mc-Graw-Hill Professional, New York (2002).

LO9122 NONLINEAR OPTICS

L T P C
3 0 0 3

AIM:
To make the students understand the theory of nonlinear optics.

OBJECTIVE:
To teach the students the principles of nonlinear optics and origin of optical nonlinearities. To analyze various types of nonlinearities in 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 8
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 10
Stimulated scattering processes – Stimulated Brillouin scattering – Phase conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS – Stimulated Rayleigh - Wing Scattering.

REFERENCES:

1. Robert W. Boyd, “Non-linear Optics”, Academic Press, London, 1992. (Units II and IV)
2. .A.Yariv, Opto Electronics, Third Edition, John Wiley and Sons , New York , 1990. (Unit II)
3. P.N.Butcher and D.Cotter, “The Elements of Nonlinear Optics”, Cambridge Univ. Press, New York, 1990. (Unit I & V)

LO9123 OPTICAL FIBER COMMUNICATION

L T P C
3 0 0 3

AIM:
To tutor the students the basic concepts and practices of fiber optics and optical communication.

OBJECTIVE:
To educate the students the fundamentals of fiber optics and make him learn about equipment, construction and working of optical communication networks.

UNIT I FIBER OPTICS 8
Total internal reflection - Phase shift & attenuation during total internal reflection - Hybrid modes - cutoff frequencies - meridinal rays & skew rays - different types of fibers.

UNIT II TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS 8
Dispersion - Fiber attenuation, absorption loss & scattering loss measurement - Optical Time Domain Reflectometer (OTDR) and its uses - Interferometric method to measure fiber refractive index profile.

UNIT III OPTICAL FIBERS CABLES & CONNECTORS 8
Fiber materials - Fiber fabrication- fiber optic cables design - fiber connectors - fiber splices - Lensing schemes for coupling improvements.

UNIT IV METHODS OF MODULATION AND DETECTION 11
Elements of an optical fiber communication system – optical sources- Injection laser – Homojunction and Heterojunction lasers – Fiber lasers – 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 - Basic coherent receiver model - heterodyne and homodyne detections.

UNIT V OPTICAL FIBER COMMUNICATION NETWORKS 10
Local Area Networks - Bus, ring and star topologies - optical fiber regenerative repeater - optical amplifiers - basic applications - Low speed industrial optical fiber networks – principles of WDM – passive components – Couplers – Multiplexing and De-multiplexing.

REFERENCES:

1. Allen H. Cherin, An Introduction to Optical Fibers, Mc Graw Hill Inc., Tokyo, 1995.
2. John M. Senior, Optical Fiber Communications, Prentice Hall International Ltd., London 1992.
3. Govind P. Agrawal, Fiber Optic Communication Systems, John Wiley & Sons Inc., New York, 1997.
4. Gerd Keiser, Optical fiber Communications, McGraw Hill Inc. Company, Tokyo, 1995

OC9151 INTEGRATED OPTICS

L T P C
3 0 0 3

AIM:
To teach the students the fundamentals and applications of integrated optics.

OBJECTIVE:
To provide the information in a way that the student can understand the principle of optical amplifiers, waveguides and construction and working of integrated circuits.

To discuss the various applications of integrated circuits.

UNIT I OPTICAL AMPLIFIERS 10
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 10
Applications of coupled mode theory – theory of gratings in waveguide structures – WDM MUX/DEMUX – guided wave control – electrooptic, acoustooptic, magnetooptic, thermooptic and nonlinear optical effects – fabrication of optical waveguides in glass, Lithium Niobate substrates.

UNIT III OPTICAL INTEGRATED CIRCUITS 10
Microfabrication techniques in optical integrated circuits – guided wave excitation and waveguide evaluation – passive waveguide devices – functional optical waveguide devices.

UNIT IV ACTIVE IOC AND HYBRID OICS 8
Integrated semiconductor sources, detectors and active switches on substrates – optoelectronic integrated circuits – recent trends in optical integrated circuits.

UNIT V APPLICATIONS OF OPTICAL INTEGRATED CIRCUTIS 7
Optical switches – A/D converters – RF spectrum analyzers – convolvers – correlators – modulators – integrated optic sensors.

L: 45

REFERENCES:

1. D.K. Mynbaev and L.L. Scheiner, “Fiber-optic communications technology”, Pearson Education, New Delhi (2001).
2. H. Nishihara, M. Haruna and T. Suhara, “Optical integrated circuits”, McGraw Hill Book Co., Tokyo (1989).
3. B.E.A. Saleh and M.C. Teich., “Fundamentals of photonics”, John Wiley., New York (1991).
4. G. Keiser, “Optical fiber communications”, McGraw Hill.,New Delhi., (1983).
5. P.Bhattacharya, “Semiconductor optoelectronic devices”., Prentice-Hall India., New Delhi, (1998).
6. A.Ghatak and K.Thyagarajan, “ Optical electronics”, Cambridge Univ. Press, New Delhi, (2002).

LO9127 LASER LABORATORY II

L T P C
0 0 4 2

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 (nano second)
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. Speckle Interferometry - Out of Plane Displacement
12. Speckle Shear Interferometry
13. Laser Doppler Interferometry (LDV)
14. Stimulated Raman Scattering
15. Stimulated Brillouin Scattering
16. Phase Conjugation
17. Optical Modulation - Fiber Optics Communication
18. Laser Speckle Optometer
19. Laser Effects on Human Cell
20. Tumour Diagnosis using Lasers

Total: 60

LO9151 FIBER OPTIC SENSORS

L T P C
3 0 0 3

AIM:
To teach the students the principle, working and applications of fiber optic sensors.

OBJECTIVE:
To impart knowledge to the students about the concepts of fiber optic sensors.

To explore the functioning and applications of fiber optic sensors in various fields.

UNIT I INTRODUCTION TO OPTICAL FIBERS 9
Refraction and Total Internal Reflection - Meridional rays - Skew rays - Bent Fibers - Mechanisms of Attenuation - Evanescent waves - Cross coupling - Mode patterns - Types of fibers.

UNIT II INTENSITY AND PHASE MODULATED SENSORS 9
Transmissive concept - Reflective concept - Microbending concept - Intrinsic concept - Transmission and Reflection with other optic effect - Interferometers - Mach Zehnder - Michelson - Fabry-Perot and Sagnac - Phase detection - Polarization - Maintaining fibers

UNIT III DISPLACEMENT AND TEMPERATURE SENSORS 9
Displacement sensors based on the reflective technology and Microbending Technology - Applications of displacement sensors - Temperature Sensors - Reflective concept - Microbending – Interferometric & Luminescence concepts - Applications.

UNIT IV PRESSURE AND FLOW SENSORS 9
Pressure sensors - Transmissive concepts -Microbending - Intrinsic concepts - Interferometric concepts - Applications - Turbine flow meters - Differential pressure flow sensors - Vortex Shedding Flow sensor - Laser Doppler velocity sensors - Applications - Sagnac Interferometer for rotation sensing.

UNIT V MAGNETIC AND ELECTRIC FIELD SENSORS 9
Magnetic field sensors - Intensity and phase modulation types - Electric field - Intensity and phase modulation types - Applications

REFERENCES:

1. Frederich C. Allard (Ed.), 'Fiber Optics Hand Book', McGraw Hill Publishing Company, New York, 1990.
2. C.M. Davis et al, 'Fiber Optic Sensor Technology Hand Book', Dynamic Systems, Reston, Virginia, 1992.
3. Krohn D.A., 'Fiber Optic Sensors - Fundamentals and Applications', Instrument Society of America, U.S.A, 1988.

LO9152 HOLOGRAPHY AND SPECKLE

L T P C
3 0 0 3

AIM:

To introduce the principles of holography and speckle

OBJECTIVE:

To teach the theory of holography
To teach how experimentally holograms and specklegrams could be recorded and reconstructed
To introduce the concept of holographic interferometry and its applications

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 Cyrstals - 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

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)

REFERENCES:

1. Robert K. Erf, 'Holographic Non-destructive Testing', Academic press, New York & London, 1974.
2. Vest C.M, '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. Sirohi R.S. Ed., 'Speckle Meterology', Marcel Dekker, New York, 1993.

LO9153 MEDICAL APPLICATION OF LASERS

L T P C
3 0 0 3

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

OBJECTIVE:
To provide the information in a way that the student can learn about laser tissue interaction, photobiology and thermal and non-thermal applications of lasers and create awareness about the safety of lasers.

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.

REFERENCES:

1. Martellucci. S. S., and Chester. A.N., 'Laser Photobiology and Photomedicine' Plenum Press, New York, 1985.
2. Pratesi. R., and Sacchi. C.A., 'Lasers in Photomedicine and Photobiology', Springer verlag, West Germany, 1980.
3. Carruth JAS & AL Mckenzie, 'Medical Lasers Science and Clinical Practice', Adam Hilger Ltd., Bristol, 1991.
4. Kaluylu. T, Tsukakoshi. M, 'Laser Microradiation of cells', Harward Academic publishers, New York, 1990.

LO9154 MATERIALS PROCESSING BY LASERS

L T P C
3 0 0 3

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

OBJECTIVE:
To endow the students with knowledge about industrial laser systems and interaction of laser radiation with matter and applications of lasers in various materials processing like cutting, welding, surface treatment etc.

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 locked.

UNIT II THERMAL PROCESSES IN INTERACTION ZONE 15
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.

UNIT III SURFACE TREATMENT 7
Surface modification:- surface cladding - surface alloying - Hard facing - Shock hardening - laser parameters for surface alloying - process variables - Beam profiles - Different methods to obtain desired penetration depths - Experimental set-up.

UNIT IV LASER WELDING 7
Different modes of laser beam welding - Comparison between laser beam and electron beam welding - Influence of different parameters - Absorptivity - Welding speed - Focussing conditions - Advantages and limitations of laser welding - Laser welding of industrial materials - Recent developments in laser welding techniques

UNIT V LASER CUTTING AND DRILLING 7
Laser energy density for cutting and drilling - Melt flashing mechanism - Various assisting gases and their importance - Advantages of laser cutting - Laser instrumentation for cutting and drilling - Factors affecting cutting rates - Effect of laser pulse energy on diameter and depth of drilled hole.

REFERENCES:

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

OC9158 OPTICAL COMPUTING

L T P C
3 0 0 3

AIM:

To introduce the concept of optical computing

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OBJECTIVE:

To teach different branches of optical computing such as Fourier optics, image processing, optical switching, optical neural network etc.

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) 10

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 8

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

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REFERENCES:

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

LO9155 NONLINEAR FIBER OPTICS

L T P C
3 0 0 3

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

OBJECTIVE:
To tutor the students about nonlinear fiber optics and fundamentals of soliton dynamics. To apply the principles of solitons in optical communication, pulse compression, soliton switching etc.

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 10
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 8
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.

REFERENCES:

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

LO9156 REMOTE SENSING BY LASERS

L T P C
3 0 0 3

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

OBJECTIVE:
To instruct the students about the basics of remote sensing.

To make the students gain knowledge of ecosystem and design of laser remote sensing systems and equipment required for remote sensing.

UNIT I ECOSYSTEM 8
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 6
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 6
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 POLLUTION AND SURVEILLANCE 15
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 10
LIF by UV Laser - Laser Fluoresensor - Oil Slick, Chlorophyll - Laser Phytoplankton mapping - Study on Shoals - Coral reefs.

Total: 45

REFERENCES:

1. Piemental, 'Analytical Applications of Lasers', Wiley Interscience, 1986.
2. Hinckley E.D., 'Laser Monitoring of Atmospheric', Springer, verlag, New York, 1976.
3. Measures R.M., 'Laser Remote Sensing', Wiley Interscience, New York, 1984. * Text Book.

LO9157 LASER SPECTROSCOPY

L T P C
3 0 0 3

AIM:
To educate the students about the basic principles of laser spectroscopy.

OBJECTIVE:
To endow the students with the knowledge of the fundamentals of spectroscopy and about different types of spectroscopy and applications of laser spectroscopy in various fields.

UNIT I BASIC PRINCIPLES 10
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 7
Absorption measurements – Intra-cavity absorption measurements – Absorption measurements on excited states – Level labelling – 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 10
Generation of short optical pulses – generation of ultrashort optical pulses – Measurement techniques for Optical Transcients: 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 8
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 10
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.

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.