COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Technology – International School of Photonicss M.Tech Opto Electronics and Laser Technology – Outcome Based Education Syllabus – Approved – Orders issued

CONFERENCE SECTION

No.Conf.II/2941/1/AC-Technology/2020 Dated, Kochi-22, 22.10.2020

Read: Item No.1(f.5) of the Minutes of the meeting of the Academic Council held on 08.07.2020

ORDER

The Academic Council at its meeting held on 08.07.2020 along with the recommendations of the Standing Committee resolved to approve vide item read above, the revised course structure and Outcome Based Education Syllabus of M.Tech Opto Electronics and Laser Technology course offered at the International School of Photonics with effect from 2020 as in appendix.

Orders are issued accordingly.

Dr.MEERA V.
REGISTRAR

To

1. Dr.C.K Aanandan, Dean, Faculty of Engineering and Professor (Rtd), Department of Electronics, CUSAT, Kochi-22
2. The Director, International School of Photonics, CUSAT, Kochi-22
3. The Controller of Examinations/Joint Registrar (Academic)/Assistant Registrar (Academic)
4. Academic A, C/Exam E, B/Exam Confidential Sections
5. Day file/Stock file/File copy

rv/6

INTERNATIONAL SCHOOL OF PHOTONICS (ISP)

COURSE STRUCTURE AND SYLLABI OF

Master of Technology
(Optoelectronics and Laser Technology)

COCHIN UNIVERSITY OF

SCIENCE AND TECHNOLOGY

KOCHI - 682 022

2020

CONTENTS

M.Tech

Course Structure

Semester I

Course code	Paper	Core/ Elective	Credits	Marks
20-441-0101	Modern Optics	C	4	100
20-441-0102	Laser Technology	C	4	100
20-441-0103	Optoelectronics	C	4	100
20-441-0104	Lab Course I	C	3	100
Any One Elective				
20-441-0105	Advanced Engineering Physics	E	3	100
20-441-0106	Digital Communication	E	3	100
	Total for Semester 1		**18**	**500**

Semester II

Course code	Paper	Core/Elective	Credits	Marks
20-441-0201	Fibre Optics & Applications	C	4	100
20-441-0202	Lab course II	C	3	100
20-441-0203	Mini Project, Seminar	C	2	100

Any 3 electives				
20-441-0204	Laser Applications	E	3	100
20-441-0205	Optical Communication Technology	E	3	100
20-441-0206	Non linear Optics OSP & OC.	E	3	100
20-441-0207	Biophotonics	E	3	100
20-441-0208	Laser Spectroscopy	E	3	100
20-441-0209	Science and Technology of Plasma	E	3	100
	Total for Semester II		**18**	**600**

Semester III

Course code	Paper	Core/Elective	Credits	Marks
20-441-0301	Project	C	15	300
20-441-03XX	Open Elective*	E	3	100
	Total Semester III		**18**	**400**

*Management for Scientists and Engineers offered by School of Management Studies OR Any interdisciplinary Electives offered in the MOOC platform

Semester IV

Course code	Paper	Core/Elective	Credits	Marks
20-441-0401	Project	C	18	400
	Total for the programme		**72**	**1900**

M.Tech. (OE&LT)
Detailed Syllabus

SEMESTER I
20-441-0101 MODERN OPTICS

.

Course Outcomes

On successful completion of this course, students should be able to:

1. explain the propagation of light in conducting and non-conducting media (understand level)
2. understand reflection/transmission behaviour of light interacting with a dielectric interface (understand level)
3. analyze the polarization state of a beam of light (analyze level)
4. use the principles of wave motion and superposition to explain the physics of polarization, dispersion, interference and diffraction. (apply level)
5. describe the operation of optical devices, including, polarisers, retarders, modulators, inteferometers, difraction gratings. (understand level)
6. have an understanding of light coherence, the coherent properties of light from various sources, and the measurement of degrees of coherence (understand level)
7. use Fourier transform theory to predict and interpret imaging under various Fourier transform filtering conditions.(apply level)

MODULE I

Electromagnetic theory: Maxwell's equations, Energy density and momentum of the electromagnetic field, Poynting's theorem, Boundary conditions on an interface. Reflection, refraction and total internal reflection. Reflection and refraction of polarized waves on an interface. Electromagnetic waves in a conducting medium.Polarisation: Birefringence, Polarisation ellipse, Different polarization states, Stokes parameters and their measurements. Jone's vectors and matrices.

MODULE II

Coherence: Young's double slit, double slit with an extended source, Michelson's interferometer, Mach-Zehnder interferometer, Multiple beam interference, Fabry- Perot interferometer, Resolving power, Free spectral range and Finesse ofFabry- Perot interferometer. Interference filters. Variable input frequency Fabry- Perot interferometer, Mode suppression with an etalon, Sagnac effect, Sagnac interferometer.

Theory of Partial coherence: Spatial and temporal coherence. Coherence length and coherence time. Degree of coherence, Fourier transform spectroscopy. Intensity interferometry, Hanbury Brown - Twiss interferometer.

MODULE III

Ray propagation: Rays in a medium. Matrix methods in ray propagation. Translation, Reflection and Refraction matrices, Thick lens and Thin lens matrices, Ray path in an inhomogeneous medium. Ray vector and ray matrices.Lens wave guide. Rays in a lens-like medium. Propagation of beams, Gaussian beam propagation. ABCD law. Focussing of Gaussian beams. Hermite Gaussian Beams.

MODULE IV

Theory of Diffraction: Kirchoff's theorem. Fresnel- Kirchoff integral formula and its application to diffraction problems. Fraunhofer and Fresnel diffraction. Fraunhofer diffraction by single slit, double slit, multiple slits, diffraction grating, circular aperture. Fresnel diffraction, Fresnel zones, Fresnel integrals./ Spatial filters.

MODULE V

Elements of Fourier optics: Concept of spatial frequencies, Effect of lens on a wave front, Lens asaFouriertransform element.Fouriertransform Spectroscopy, Theory oflmaging.

Elements ofAdaptive optics: Principles ofAdaptive optics, Wave front distortion, wave front sensors, wave front reconstruction (qualitative treatment only)

REFERENCES

Optics E.Hecht Pearson Edn (4th Ed) 2004

Introduction to Optics, Frank L. Pedrotti, S.J., Leno M. Pedrotti, Leno S.Pedrotti, Pearson, (3rdEdition), 2012

Optics, Ajoy Ghatak, Tata McGraw Hill， 3rd edition, 2005

Fundamentals ofPhotonics - Saleh and Teich Wiley Intsc (2007)

Modem Optics - R.D, Guenther， John Wiley (1990)

Quantum Electronics - AmnonYariv, Academic Press (1998)

Principles of optics - Bom and Wolf Cambridge University Pres (1981)

Adaptive optics in Astronomy - Francois Roddier (Ed). Cambridge University (1999) Wave Optics and applications-R S Sirohi, Orient Longmann (2001)

20-441-0102 LASER TECHNOLOGY

Course Outcomes

On successful completion of the course, the student will be able to:

1. describe Einstein's treatment of absorption and emission of radiation (understand level)
2. describe the conditions required for laser action(understand level)
3. describe laser media with rate equations and solve them(evaluate level)
4. predict the stability of laser cavity (apply level)
5. identify the behavior and functionality of different lasers(analyze level)
6. identify a laser for a particular application(analyze level)
7. review the safety requirements of lasers(understand level)

MODULE I

Radiative decay of Excited states of isolated atoms- Spontaneous emission, decay rate, radiative transition probability - Electron as a classical radiating harmonic oscillator- collisional decay-Emission broadening processes- homogeneous and inhomogeneous broadening -Quantum mechanical description of radiating atoms –Cavity Radiation- number of cavity modes- Rayleigh Jeans Formula-Planck's law of cavity radiation-relationship between cavity radiation and blackbody radiation-Einstein's A and B coefficients- Absorption and Emission cross sections.

MODULE II

Absorption and Gain on a homogenously and inhomogeneously broadend radiative transitions - Gain coefficients and stimulated emission cross sections - Population inversion-Saturation intensity-Development and growth of a laser beam - exponential growth factor- threshold requirements for a laser - Laser gain saturation - laser beam growth beyond saturation intensity - optimization of laser power - laser output fluctuations - Inversions and two level sytems- steady state inversions in three and four level systems - pumping pathways.

MODULE III

Fabry-Perot Resonator - Fabry-Perot cavity modes - longitudinal laser cavity modes - mode number-Transverse Laser cavity modes with plane parallel and curved mirrors- transverse mode spatial distributions- mode frequencies - Gaussian shaped transverse modes - mode characteristics - stable curved mirror cavities - ABCD Matrices - resonator stability - stability diagram - paraxial wave equations - Gaussian beams – Hermite-Gaussian and Laguerre-Gaussian beams - Unstable resonators

MODULE IV

Q-switching - Methods of Q-switching - Multimode laser oscillations - phase locked oscillators - mode locking - Methods of mode-locking - Pulse shortening techniques - Self-phase modulation - pulse shortening or lengthening using GVD - Pulse compression with grating and prism - ultrashort-pulse laser and amplifier system, Ring cavity

MODULE V

Laser Systems: General description, laser structure, excitation mechanism and applications of the following lasers- He-Ne, Argon ion, He-Cd, CO_2, Excimer, Nitrogen, X-ray plasma laser, FEL, Organic dye laser, Ruby, Nd:YAG, Nd:Glass, Alexandrite, Ti:Sapphire, OPO, Fiber lasers, DPSS, Semiconductor lasers

References:

Laser Fundamentals, W T Silfvast, Cambridge University Press
Lasers - Fundamentals and Applications, Thyagarajan and Ghatak , Springer, 2010
Laser Physics, P W Milonni and J H Eberly, John Wiley and Sons, 2010
Principles of Lasers - O Svelto, Fourth Edition, Springer, 1998
Lasers - Anthony E Siegman, University Science Books, USA, 1986

20-441- 0103 OPTO ELECTRONICS

Course Outcomes

On successful completion of the course the students will be able to

1.recall the properties of Photons and Electrons and recognise their applications in optoelectronic devices. (Remember level)
2.classify LED and laser diode structures and their applications (Understand level)
3.differentiate the types of optical modulators and their applications (Analyze level)
4.categorise different luminescence mechanisms involved in the modern display devices (Analyze level)
5.compare the modes of operations and characteristics of different optoelectronic detectors. (Evaluate level)

MODULE I

Origin and Nature of light, Properties and measurement of light Photons and Electrons Basic semi conductors, PN junction, carrier recombination and diffusion, injection efficiency, hetero junction, internal quantum efficiency, External quantum efficiency, double hetero junction, quantum wells and super lattices.

MODULE II

Opto electronic devices, Optical modulators, modulation methods and modulators, transmitters, optical transmitter circuits, LED and laser diodes, LED Power and efficiency, double hetero structure LED, LED structures, LED characteristics, Organic LEDs, Principle of OLED, Multilayer OLED, Structure and characterization.

MODULE III

Modulation of light, Optical Modulators Fanz Keldysh and Stark effect modulators Quantum well electro absorption modulators electro optic effect, EO materials, Kerr modulators, scanning and switching, self electro optic devices, MO devices, AO devices, AO modulators.

MODULE IV

Display devices, Luminescence Types Photoluminescence, PL display Electron luminescence, EL display, LED display, drive circuitary, plasma panel display, liquid crystals, properties, LCD displays, numeric displays.

MODULE V
Photo detectors, thermal detectors, photoconductors, photon devices, PMT, photodiodes, photo transistors, noise characteristics of photo-detectors, PIN diode, APD design and characteristics, CCD, Solar cells.

REFERENCES:

Semiconductor optoelectronic devices — Pallab Bhattacharya(Prentice Hall of India, 2009)
Fibre Optics and Opto-electronics, R P Khare (Oxford University Press, 2004)
Opto electronics-Thyagaraj an and Ghatak, Cambridge Uni, Press (1997)
Optoelectronic Devices and systems S C Gupta, PHI (2005)
Solis State Electronic Devices Ben G Streetman and Sanjay Banerjee, PHI 5th Edition (2003)
Opto electronics -An introduction - J Wilson and J F B J iS Hawkers.(Prentice-Hall India, 1996)

20-441- 0105 ADVANCED ENGINEERING PHYSICS

After completing this course, the students will be able to:

1. Identify and correlate structure property relationship in various crystal phases (*Understand level*)
2. Predict the nature of electronic transitions in periodic crystals (*Understand level*)
3: ApplySchrödinger equation and Dirac algebra in the presence of various external potentials (*Apply level*)
4. Solve the Schrödinger equation for harmonic oscillator. (*Apply level*)
5. Construct Hamiltonians and solve eigen value problems in the presence of perturbations (*Apply level*).
6. Analyze transition probabilities in perturbative systemsusing Fermi's Golden rule (*Analyze level*).
7.ApplyMaxwell's equations and the concept of harmonic oscillator to quantize electromagnetic radiations (*Apply level*)
8. Interpret rotational, vibrational, electronic and Raman spectroscopic data (*Apply level*).
9. Analyze UV-Vis, IR and Raman spectra of given samples (*Analyze level*)

Module 1

Concepts of crystal structure, Symmetry elements, Group theory, Group theory in the classification of crystals, Bravais lattices, Reciprocal lattices, Concept of Brillouin zones, Zone boundary, Crystal directions, Crystal planes, Miller indices, Bonding in crystals, Band theory, Energy bands, Density of states, Fermi surface.

Module 2

Familiarization of Matrix algebra, Concept of basis vectors, Dirac algebra, Operators in quantum mechanics, Hermitian and Unitary operators, Dirac delta function, General uncertainty principle, Schrödinger equations, Particle in a box, Quantization of energy levels, Quantum effects intwo dimensional, One dimensional, and Zero dimensional materials, Electrons in periodic potential, Blöch Theorem, Potential barrier, Harmonic oscillator, Krönig-Penney Model.

Module 3

Particle in spherically symmetric potential, Hamiltonian of two interacting particles, Rigid rotator, Eigen values and eigen vectors of angular momentum, Concept of spin, Perturbation theory, Stark effect and Zeeman effect, Fermi's golden rule, Radiative transition rate, Selection rules.

Module 4

Maxwell's equations, Electromagnetic spectrum, Quantization of electromagnetic field, Interaction of electromagnetic radiation with matter.

Module 5

Rotational spectra of diatomic molecules, Intensity of spectral lines, Non-rigid rotator, Vibrational spectra of diatomic and polyatomic molecules, Anharmonic oscillator, Diatomic vibrating-rotator, Quantum and classical theory of Raman spectroscopy, Pure rotational Raman spectra, Vibrational Raman spectra.

References:

1.Concepts of Modern Physics, Arthur Beiser andShobhit Mahajan, McGraw Hill Education, 9th Edn, 2009
2.Solid State Physics, M A Wahab, Narosa Publications, New Delhi, 3rd Edn, 2015.
3.Introduction to Solid State Physics, Charles Kittel, Wiley, 8th Edn, 2012.
4.Solid State Physics, David Ashcroft and Mermin, CENGAGE Learning, 3rd Edn, 2003.
5.Introduction to Quantum Mechanics, J. Griffiths David,Pearson, 2015.
Modern Quantum Mechanics, J. J. Sakurai and Jim Napolitano, Cambridge University Press, 2017.
7.Introductory Quantum Optics, Christopher Gerry and Peter Knight 1st Edn, Cambridge University Press, 2004.
8.Fundamentals of Molecular spectroscopy, C N Banwell, McGraw Hill Education; Fourth edition (2017),

20-441-0106 DIGITAL COMMUNICATION

Course Outcome:

After completing the course students will be able to

1. Identify the importance of pulse shaping and minimum bandwidth requirement. (Analyze level)
2. Analyze a basic PCM system and interpret the performance parameters of its various modified schemes. (Analyze level)
3. Use the concepts of information theory and coding for mathematical modelling and analysis of communication systems. (Apply level)
4. Discuss the significance and performance analysis of error detection and correction strategies employed in digital communication systems.(Understand level)
5. Differentiate specific types of Digital CW modulation in terms of mathematical models.(Analyze level)
6. Develop a technique for spectral analysis of bandpass digital signals. (Create level)

MODULE I

Digital signals and systems, Digital PAM signals, binary PAM formats, line coding, bandlimited digital PAM systems,bandwidth considerations, Power spectra of discrete PAM signals, binary error probabilities, regenerative repeaters, eye diagram, Nyquist pulse shaping, equalisation, synchronization techniques, bit and frame synchronization.

MODULE II

Pulse code modulation, PCM generation and reconstruction of multiplexing PCM signals, DPCM,Adaptive DPCM; DMand its drawbacks, Adaptive delta modulation.

MODULE III

Information Theory, concept of amount of informationand its properties, average information, entropy, coding toincrease average information per bit, HartleyShannon's Theorem, Channel Capacity, Band Width, S/Ntrade-off.

MODULE IV

Error Detection and Correction - Repetition and Parity Check Codes,Convolutional Codes – Convolutional Encoding,Automatic Retransmission Query (ARQ) Systems, performance of ARQ systems.

MODULE V

Digital CW modulation, spectral analysis of band pass digital signals, amplitude-phase and frequency modulation methods.

REFERENCES:

1. COMMUNICATION SYSTEMS fifthedition, A B Carlson (McGraw Hill),2011
2. PRINCIPLES OF COMMUNICATION SYSTEMS fourth edition, Herbert Taub & Donald Schilling & Gautam Saha(McGraw Hill),2017
3. DIGITAL COMMUNICATION first edition, Nishanth Nazimudeen (Cengage), 2018
4. PRINCIPLES OF DIGITAL COMMUNICATIONfirst edition, Das, Mullick, Chatterjee (Wiley Eastern and Halstead Press),1986
5. COMMUNICATION SYSTEMS fourth Edition, Simon Haykin (John Wiley & Sons), 2001

SEMESTER II

20-441- 0201 FIBRE OPTICS AND APPLICATIONS

Course Outcomes:

At the end of the course the student should be able to

1. explain the theory of propagation of light in an optical fiber (Understand level)
2. analyze the formation of modes in a planar optical wave guide (Analyze level)
3. examine single mode and multimode optical fibers and classify optical fibers based on their refractive index profiles (Analyze level)
4. compare the loss mechanisms in optical fibers and to compute various losses (Analyze level)
5. distinguish between different techniques to provide optical connections in fibers (Analyze level)
6. summarize the functioning of optical fiber sensors that use amplitude, phase, frequency and polarization type modulation schemes (Evaluate level)

MODULE I

Optical wave guides: Ray theory of propagation. Electromagnetic theory of wave propagation. Characteristics of planar wave guides, TE and TM modes in planar wave guide. Number of guided modes. Optical fibre, Types of fibers, Step index and graded index fibers. Characteristics of optical fibre.
Mode analysis: Weakly guiding fibre approximation, LP modes, Single mode fibre, cut- off wave lengths, spot size. Mode coupling, Elements of coupled mode analysis.

MODULE II

Transmission characteristics of optical fibers: Attenuation, absorption losses, Fiber bend losses, linear scattering losses, nonlinear scattering losses, Stimulated Raman and stimulated Brillouin scattering.
Dispersion: Phase and group velocities. Material dispersion, intra-modal dispersion and wave guide dispersion. Overall fibre dispersion. Dispersion modified fibers. Photonic crystal fibers, polarization maintaining fibers, solitons

MODULE III

Optical fiber measurements: Attenuation measurements, Dispersion measurements (time domain and frequency domain), Measurements of NA, Diameter and refractive index profile. OTDR. Testing of optical fiber systems

MODULE IV

Optical fibers and cables: Fabrication of optical fiber. Fiber drawing. Vapour phase deposition techniques. Cable design Optical fiber connection: joints and couplers Fiber splices, fusion splices, mechanical splices. Fiber connectors, Expanded beam connectors. Fiber couplers, Source to fibre and fibre to fibre coupling, Coupling losses, i/p, o/p couplers.

MODULE V

Periodic interaction in wave guides, Coupled mode equations, Power coupling between modes, directional couplers. Contra-directional coupling.
Fibre Bragg Grating, Long- period fiber Bragg Grating. Fabrication of Fibre Gratings.
Optical Fibre sensors: Intensity modulation sensors. Phase modulation sensors, Temperature, pressure, chemical and rotation sensors. Fibre optic gyroscopes. Evanescent wave sensors.
Integrated optical devices: couplers, OSA, Lenses

REFERENCES

1. Optical fiber communication-G Keiser ,McGraw Hill Education; Fifth edition (2017)
2. Understanding fiber optics, J Hecht, Laser Light Press, 5 edition (2016)
3. Introduction to fiber optics , Ajoy Ghatak and K. Thyagarajan, Cambridge Univ Press (2017)
4. Optical Fiber Communications: Principles and Practice, John M Senior, Pearson Education India, 3rd edition (2010)
5. Fundamentals Of Fibre Optics In Telecommunication And Sensor Systems, B P Pal, new age publishers (1992)

20-441-0204 LASER APPPLICATIONS

After completing this course, the students will be able to;

1. analyze the different nonlinear processes associated with light-matter interaction. (*Analyze level)*
2. apply a particular laser for surface modification applications. (*Apply level*)
3. apply appropriate optics along with laser for surface modifications. (*Apply level*)
4. explain the importance of lasers in chemical reactions. (*Understand level*).
5. apply interferometry basics to solve complex holographic and speckle images. (*Apply level*)
6. Identify lasers with appropriate wavelength for medical applications (*Understand level*)

MODULE I

Nonlinear optics, nonlinear optical coefficient, second order Non linear effects, electromagnetic formulation of 2nd order -nonlinear interaction, optical parametric oscillator. Basic ideas of third order optical nonlinear processes.

MODULE II

Industrial applications: Absorption of laser radiation by metals, semi conductors and insulators, laser drilling, welding, cutting and surface cleaning, optical fibre splicing, laser deposition of thin films.

MODULE III

Lasers in chemistry: schemes of laser isotope separation, laser induced chemical reactions, infrared photo chemistry, monitoring fast chemical reactions, study of photochemical processes, stimulation of photo chemical reaction and ultra fast processes.

MODULE IV

Holography and speckle interferometry: Theory of hologram recording and reconstruction, thin and thick holograms, application of holography to character recognition and NDT, theory and applications of speckle interferometry.

MODULE V

Lasers in medicine: Photodynamic therapy, laser angioplasty, Lasers in surgery.
Other applications of lasers: Laser pollution monitoring, LIDAR laser gyros, laser induced fusion, laser energy requirements, laser induced fusion reactor, CD and CD ROM, laser cooling trapping. Lasers in computing and optical logic gates.

REFERENCES

Fundamentals of Photonics - B EA Salch and M Teich Wiley Int Sc, 2007
Lasers-Fundamentals and applications- Thyagarajan and Ghatak, Springer, 2010
Optical electronics -AYariv(4th Ed. Saunders College Pub. 1991)
Lasers and nonlinear optics - B B Laud(2nd Ed. Wiley Eastern 1993)
Textbook of modern optics - R S Sirohi, Orient Longmann, 1993
Laser cooling and Trapping - H J Metcalf. P. Vander, Springer Verlag, 1999
Industrial applications of lasers —John F Ready, Academic Press, 2nd edition (1997

20-441-0205 OPTICAL COMMUNICATION TECHNOLOGY

Course Outcomes:

On successful completion of this course students should be able to

1. describe the properties and advantages of optical guided communication (knowledge level)
2. identify the various components of optical fiber communication system (understand level)
3. describe the operation of optical receivers including the types of preamplifiers (understand level)
4. classify various multiplexing schemes and operation principles of wavelength division multiplexing (understand level)
5. distinguish semiconductor optical amplifier and erbium doped fiber amplifier and calculate its gain and power conversion efficiency (understand level)
6. describe various optical network topologies and its performance (understand level)
7. design and prepare optical power loss/gain budget with various line coding(application level)

Course Syllabus

Module I

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

Module II

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

Module III

Digital transmission systems, Point to point link, System considerations, Link power budget, Rise time budget, First window transmission distance, Transmission distance for single mode, Link line coding, NRZ codes, RZ codes, Block codes, Coherent Systems, Homodyne and Hetrodyne detection.

Multiplexing schemes, TDM, WDM concepts and components, Operational principles of WDM, Passive components, 2 x 2 fiber coupler, Fiber grating filters, Tunable filters, System consideration and tunable filter types.

Module IV

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

Module V

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

REFERENCES

1 Optical Fibre Communication - G Keiser, McGraw Hill(4th Ed), 2006

2 OpticalFibre Communications - JM Senior(Prentice Hall India 1994)

3 Fibre Optic Communication - CAgarwa1(Wheeler, 1993)

4 OpticalFibre Communication Systems- J Gowar(Prentice Hall, 1995).

5. Fibre Optic Communication -J Palais (Prentice Hall International 1988).

6 Optical networks: A practical perspective Kumar N Sivarajan and Rajeev Ramaswami, MarcourtAsia, 2010

20-441- 0206 NON LINEAR OPTICS, OPTICAL SIGNAL PROCESSING AND OPTICAL COMPUTING

Course Outcomes:

After taking this course, the student will be able to :

1. Discuss the basic theory of nonlinear optics including sum and difference frequency generation (understand level)
2. Analyze the origin of optical bistability and its implications (analyze level)
3. Examine different mathematical transforms used in optical signal processing and compute the transforms of given functions (Analyze level)
4. Construct spatial filtering geometries based on the Fourier transform property of lens (Apply level)
5. Analyze the role of various light modulators in signal processing (Analyze level)
6. Describe the basic concepts of optical computing and optical neural networks and their practical implementation (Understand level)

MODULE I

Nonlinear optical coefficients, second order and third order susceptibility tensors. Third order optical nonlinear phenomena -FWM OPC, intensity dependent refractive index, self focusing, SIT, nonlinear F-P etalon, Optical bistability, Optical transistor, SEED, optical logic gates, implementation and their application in optical computers

MODULE II

Mathematical transforms in signal processing, Fresnel transform, Hilbert transform, Radon transform, Mellin transform, two dimensional Fourier transforms and their properties, convolution and correlation, Effect of lens on wavefront, FT properties of single lens, optical transform function.

MODULE III

Time and space integrating architecture, spectrum analysis, Vanderlugt filter, image spatial filtering, SLMS - AO, MO, EO, LC based SLMs

MODULE IV

Optical numerical processing - Simple arithmetic, evaluation of polynomials, optical implementation of Matrix vector multiplication, Matrix-matrix multipliers, differentiation, integration and solutions of partial differential equations

MODULE V

Optical neural network - characteristics of ANN, use of optics in ANN, neuron as nonlinear element, Associative memory using pattern matching by vector-matrix multiplication, double and multilayer NN structure, training a NN, Hopfield net, optical implementation of NN.

REFERENCES:

1. Signal Processing Using Optics : Fundamentals, Devices, Architectures, and Applications, B G Boone , Oxford Univ Press , 1st edition (1998)
2. Optical Computing : A Survey for Computer Scientists,D G Feitelson, MIT Press (2001)

3. Optical Signal Processing, Anthony VanderLugt, John Wiley & Sons (2005)
4. The Principles of Nonlinear Optics, Shen, John Wiley & Sons, 1st edition (2002)
5. Introduction to Fourier Optics, Joseph Goodman, Roberts and Company Publishers, 3rd edition (2016)

20-441-0207 BIO PHOTONICS

Course Outcomes:

After taking this course, the student will be able to:

1. Understand the basic theory and science of interaction of light with cells and tissues, optical imaging techniques, to analyze different optical biosensors and its implications.
2. Understand material properties of photo sensitizers used for photodynamic therapy.
3. Examine different tissue engineering strategies using light
4. Understand the concept of flow cytometry and design flow cytometer
5. Analyze the role of various optical geometries in biosensing.
6. Understand the basic concepts of optical tweezers and practical implementation

MODULE I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers human eve and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.

Optical coherence Tomogaphy, Spectral and time-resolved imaging. Fluorescence, resonance energy transfer imaging, nonlinear optical imaging.

MODULE II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, dark-field and differential interference contrast microscopy, Florescence, confocal andmultiphoton microscopy.

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

MODULE III

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

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

MODULE IV

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

MODULE V

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

REFERENCES

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

20-441-0208 LASER SPECTROSCPY

Outcomes:

On completion of the course, the student should be able to:

1. list the fundamental concepts of spectroscopic techniques(Remember level)
2. summarize the most common methods in laser spectroscopy (Understand level)
3. analyse the interactions of electromagnetic radiation and matter and their applications in spectroscopy(Analysis level)
4. relate advanced spectrometers within the field of laser induced fluorescence, laser Raman spectroscopy, and to analyze fluorescence spectra (Apply level)
5. identify main components of modern optical spectroscopic instruments (Remember level)
6. interpret spectroscopic data collected by the methods discussed in the course (Evaluation level)
7. develop an in-depth knowledge of these topics so that spectroscopic methods can be successfully applied to the student's research projects (Create level)

MODULE I

Spectroscopic technique, General ideas of spectroscopic studies and their importance — conventional spectroscopic recording in UV-Vis-IR region using dispersing spectrographs, Fluorescence spectroscopy, spectra of rare earth ions and atoms, spectra of RE ions in sulphide and fluoride crystals, Phosphorescence, colour centres, fluorescence of dyes, evaluation of quantum efficiency.

MODULE II

Thermal Lens Spectroscopy, Focal Length of TL, single and double beam configurations. Applications of TLS, overtone spectroscopy, evaluation of thermal and optical parameters. Photoacoustic spectroscopy: PA effect in gases, liquids and solids, RG theory, design of PA spectrometer, applications of PAS, evaluation of optical and thermal parameters, imaging and microscopy.

MODULE III

High resolution spectroscopy; saturation spectroscopy, Doppler free spectroscopy, single atom spectroscopy, Rydberg atoms and their spectra. Special Techniques of Nonlinear Spectroscopy, Multiphoton Spectroscopy, Transient absorption spectroscopy.

MODULE IV

Laser Raman spectroscopy, SRS, CARS, PARS.
Time Resolved Spectroscopy, Lifetime Measurements with Ultrafast Laser pulses, Pump-and –Probe Techniques, Frequency Comb Spectroscopy

MODULE V

Plasma spectroscopy, evaluation of plasma parameters from plasma spectra.

Laser ablation inductively coupled plasma optical emission spectroscopy (LA-ICP-OES), Laser-induced breakdown spectroscopy (LIBS), Laser induced fluorescence spectroscopy,

REFERENCES

1. Laser spectroscopy,W Demtroder,Springer Verlag ,2014
2. Photoacoustic spectroscopy—Rosenewaig (Wiley,NY),1981
3. Thermo optics spectroscopy—JSell(AcademicPress),1992
4. Principles of Plasma spectroscopy—H R Greim, Cambridgemonographs,2005
5. Ultrafast Spectroscopy-Quantum information and wavepackets-Joel Yuen-Zhou, Jacob J Krich, Ivan Kassal, Allan S Johnson and AlánAspuru-Guzik, IOP Publishing Ltd 2014.
6. Femtosecond Optical Frequency Comb: Principle, Operation, and Applications- Jun Ye, Steven T. Cundiff, Springer 2005
7. Time-Resolved Stimulated-Emission and Transient-Absorption Microscopy and Spectroscopy-P. T. C. So, C. Y. Dong, K. M. Berland, T. French, E. Gratton, vol 5. Springer, Boston, MA.

20-441-0209 SCIENCE AND TECHNOLOGY OF PLASMA

Course objectives

After completing the course the students should be able to

1 discuss the theoretical formulation of plasma phenomena (Understand level)
2 analyse the dynamics of charged particle in Electric and magnetic field (Analyse level)
3 explain the concept of plasma instabilities (Apply level)
4 Illustrate the kinetic and fluid description of plasma (Analyse level)
5 differentiate the weak and strong nonlinear process in plasma (Analyse level)
6 discuss the technical application of plasma, explain the laser produced plasma and its diagnostics (Understand level)

Module I

Plasma State: Definition of Plasma, Concept of Plasma temperature, Debye shielding, Quasi-neutrality, Plasma parameters, Plasma approximation, Natural existence of Plasma, application of plasma.Dynamics of charged particles in electro-magnetic fields

Module II

Drift of charge particle under different combination of electric and magnetic field, crossed electric and magnetic field, homogenous electric and magnetic field spatial and time varying electric and magnetic field

Module III

Kinetic theory of Plasma,Vlasov equations, Solution of linearized Vlasov equation, Langmuir waves, Ion-sound waves, Wave-particle interaction and Landau damping. Boltzmann equation, Saha equation, Boltzmann's H Theorem.Maxwell velocity distribution conducting fluids, fundamental equation of magneto hydrodynamics (MHD), magnetic confinement.

Module IV

Plasma instabilities and classification, Two-stream and gravitational instabilities. Nonlinear Debye shielding , Nonlinear process in plasma, Shock &soliton formation

Module V

Thermonuclear fusion, Requirements for fusion plasmas- confinement, Tokamakfusion reactors. Dusty plasma in laboratory and space, Dust charging processes, Waves in dusty plasma. Laser plasma interaction, Inertial confinement, High-harmonic generation, Laser wakefield electron accelerator, X-ray laser.

References

1. Fundamentals of plasma physics, 3rd ed. (Springer, New York 2004) – J A Bittencourt
2. Introduction to plasma physics and controlled fusion, 2nd ed. (Plenum, New York 1984) – Francis F Chen
3. Introduction to plasma theory (John Wily & Sons, New York 1983) – D R Nicholson
4. Introduction to plasma physics, R J Goldston, P H Rutherford
5. The physics of laser plasma interaction (Cambridge university press Cambridge 1988) – W L Kruer
6. Fundamentals of plasma physics – Paul M Bellan

SEMESTER III

20-441-03XX Open Elective*

*Management for Scientists and Engineers offered by School of Management Studies OR Any interdisciplinary Electives offered in the MOOC platform