M.Sc. Degree in Photonics and Biophotonics
(UGC – INNOVATIVE PROGRAMME)
An interdisciplinary programme.

Course No	Course Title
UFC C046	**PHOTONICS**

L	T	P	C
3	**1**	**0**	**4**

1. Introduction to photonics – Nature of Light – Wave and light terminology, Maxwell equation, light spectra and sources, absorption and emission, black body radiation. Geometric Optics – Light as a ray, law of reflection including plane mirrors, law of refraction including optical fiber applications, prisms and thin lenses including Lensmaker's equation, Lens problems and optical instruments using the thin lens equation.

2. Wave Optics – wave descriptive terminology, wave superposition (interference) including double – slit interference, diffraction and diffraction gratings, interference applications, eg. Michelson, Mach Zender and Fabry Perot interferometers, Thin film interference and Fiber Bragg Gratings. Diffraction Effects including: airy disk, near far field effects. Polarization principles including scattering, reflection and birefringence.

3. Introduction to Lasers – Basic terminology and theory of operation including specific requirements, principal types of lasers. Laser radiation hazards including effects on the eye and skin. Laser safety standards and hazard classifications. Laser safety precautions and protective measures.

4. Holography – Theory and basic principles, Requirement to record and reconstruct holograms – Experimental techniques- Recording Materials-Reflection holography and applications-Holographic interoferrometry-Nondestructive testing, optical memory.

5. Non-linear optics – Harmonic Generation, sum and difference frequency generation, wavemixing, OPO. Non-linear optic materials – inorganic and organic. Phase matching, efficiency of harmonic generation- powder and single crystal methods. Methods of determination of harmonic coefficients – Z-scan and EFISH. Phase conjugation.

References:

1. Photonics Essentials : An introduction with experiments, T.P. Pearsall, McGraw-Hill, 2002.
2. Optics and Photonics: An introduction, F.G. Smit and T.A. King, Jhon Wiley & Sons, 2000.
3. Lasers and Non-Linear Optics, B. Balkrishna Laud, Halsted press, 1992.
4. Fundamentals of Optics, F.A. Jenkins and H.E. White, McGraw Hill, 1981.
5. Optics, E. Hecht, 4th ed, Pearson Education 2002,.
6. Photonics, R. Menzel, Springer, 2001.
7. Basis of Halography, P.Hariharan, Cambridge Univ. Press, 2002.
8. Photonics and Lasers-An Introduction, R.S. Quimby, Wiley-Interscience, 2006.

Course No	Course Title
UFC C031	**CHEMICAL BIOLOGY**

L	T	P	C
3	1	0	4

1. Protein chemistry – Structure of amino acids, peptides and polypeptide, fibrous and globular proteins. Primary, secondary, tertiary and quaternary structure of proteins alpha helix, beta sheet, collagen structure; protein conformation angle, Ramachandran plot, bonds stabilizing protein structure, helix-coil transition. Metal ions in biology: Essential and trace elements. Enzymes and coenzymes, Metalloenzymes: properties of enzymes- catalytic power, specificity and regulation. Active site, inhibitors,enzyme kinetics – Michaelis-Menten equation. Enzyme action – mechanism. Enzyme catalysed reactions. Coenzyme: cofactors, prosthetic group. Oxygen transport: Heme proteins, oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanin and hemerythrin and cooperative effect.

2. Nucleic acids – Chemistry and properties of bases, nucleoside, nucleotide and nucleic acids; Watson and Crick model of DNA, sugar puckering, base stacking A, B, C and left handed Z form of DNA, denaturation of DNA. Lipids-classification, phosphoglycerides, prostaglandin, lipoprotein. Carbohydrates – mono,di and polysaccharides - storage, structure and function of carbohydrates.

3. Vitamins: Fat soluble vitamins: Occurrence, properties, structure and functions of vitamin A, D, E and K. Water soluble vitamins: Occurrence, properties, structure and functions of Thiamine, Riboflavin, pyridoxine, niacin, Biotin, Folic acid, B12, ascorbic acid.

4. Cell structure, cell cycle and stages of growth, continuous and synchronous culture, cell fractionation. Information flow, archae and eubacteria, eukaryotes. Single cell to multicellular organisms. Molecular organization of cell: plasma membrane, membrane structure, lipid bilayer, membrane proteins, carbohydrates, transport of small and macro molecules-ecocytosis, endocytosis, cytosol, ribosomes rough and smooth endoplasmic reticulum. Mitochondria-origin, evolution, structure, chemosmotic theory. Bioenergetics:respiratory chain, production of ATP in mitochondria. Chloroplast; origin and evolution, structure, light absorption, production of ATP and conversion of CO_2 to carbohydrate Glucose storage, Golgi apparatus-metal complexes in transmission of energy, chlorophylls, photosystem I and photosystem II.

References:

1. Bio-Chemistry, L. Stryer, 5th edition, Freeman, Newyork, 2003.
2. A.L. Lehninger, Principles of biochemistry, Worth Publishers, 4th edition, 2005
3. Cell and Molecular Biology, Edn. 8, E. D. P. Robertis and E.M.F.D. Robertis Jr International Ed. Inst. Med. Ltd. 1988.
4. Molecular biology of the Cell – Edn. 3., Bruce Alberts, Dennis Bray, Julian Lewis, Martin Raff, James D. Watson, 1994.
5. The cell: A molecular approach. G. M. Cooper, 2nd Edn. ASM press, Washington, 2000.
6. F. Wold, Macromolecules: Structure and Function, Prentice – Hall, 1971.
7. S.J. Lippard, and J.M. Berg, Principles of Bioinorganic Chemistry, University Science Books, 1994.

Course No	Course Title
UFC C032	**QUANTUM CHEMISTRY**

L	T	P	C
3	1	0	4

1. Fundamental concepts of Quantum Mechanics: Black body radiation, photoelectric effect, wave-particle duality, quantum theory of atomic spectra, Bohr model, Uncertainty Principle, Schrödinger equation, operator concepts, Basic postulates of quantum mechanics.

2. Application of quantum mechanics to simple systems: particle in a box, quantum numbers and degeneracy, quantum mechanical tunneling, simple harmonic oscillator, comparison of classical and quantum mechanical results, spherical harmonics, angular momentum, rigid rotor, hydrogen atom and hydrogen-like atoms, significance of quantum numbers n, l, m.

3. Approximation methods: variation method, perturbation method, Application of variation and perturbation methods to helium atom, wave functions for many electron atoms – antisymmetric wavefunctions, Slater type orbitals – Slater's rule, self-consistent- field approximation – Hartree's theory, Hartree-Fock SCF theory.

4. Application of quantum mechanics to diatomic and polyatomic molecules: Molecular orbital treatment of H_2^+ and H_2, singlet and triplet excited state of H_2, valence bond treatment of H_2, comparison of MO and VB treatments of hydrogen molecule. MO treatment of homo- and heteronuclear diatomic molecules, Walsh diagram for AY2 system, Hartree-Fock SCF-MO theory of molecules, Roothaan's equation.

5. Empirical, semi-empirical and non-empirical MO methods: Hückel MO theory for pi -electron systems (ethylene, butadiene and benzene) Extended Huckel MO theory, ZDO approximation, Brief account of semiempirical and ab initio methods (CNDO, INDO, MINDO, AM1 and PM3).

References:

1. R.McWeeny, Coulson's Valence, Oxford – ELBS, 3rd edition, 1979.
2. R.K. Prasad "Quantum Chemistry", New Age International Publishers, Rev. 3rd edition, 2006.
3. A.K. Chandra "Introductory quantum Chemistry" Tata McGraw Hill, 4th edn, 2000.
4. J.A.Pople and D.L.Beveridge, Approximate molecular orbital theory, McGraw Hill,1970.

Course No	Course Title
UFC C047	**PRACTICAL – I Optics and Computational Methods**

L	T	P	C
0	**0**	**4**	**4**

1. Polarization of light and verification of Malus Law.
2. Refraction of Light- Determination of refractive index of liquids
3. Diffraction grating-calculation of ruling, groove spacing of CD
4. Total Internal reflection in solids and to calculate its refractive index
5. Single slit and Double slit diffraction
6. Diffraction at circular aperture
7. Transmission grating
8. Michelson Interferrometer
9. Particle size determination
10. Holography
11. Preparation of input data for MO calculation
12. Construction of Molecular Orbitals using semi-empirical MO methods
13. Calculation of electron densities and net charges on atomic centres
14. Comparison of molecular geometries by CNDO, MNDO, AM1 and PM3 methods –Small molecules
15. Analysis of vibrational spectra of some simple molecules

Course No	Course Title
UFC C034	**GROUP THEORY AND SPECTROSCOPY**

L	T	P	C
3	1	0	4

1. **Group Theory**: Elements of symmetry, Point Groups, space symmetry, laws, group multiplication tables. Matrix representation, irreducible representation, character table. Application to spectroscopy.
2. **Vibrational Spectroscopy**: *Infrared spectroscopy*- harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant, bond strengths, anharmonicity, Morse Potential energy diagram, Hookes Law, Selection rules, normal modes of vibration, group frequencies, overtones and hot bands, factors affecting the band positions and intensities. Basics of IR instrumentation.
   Raman Spectroscopy: Classical and quantum theories of Raman effect, Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Resonance Raman Spectroscopy and coherent anti-Stokes Raman Spectroscopy (CARS). Basics of Raman instrumentation.

3. **Electronic Spectroscopy**: *Atomic spectroscopy*: Energies of atomic orbitals, vector representation of moment and vector coupling, spectra of hydrogen atom and alkali metal atoms.*Molecular Spectroscopy:* Energy level, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules. Natural line width and natural line broadening, transition probability, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation. Absorption laws- Beer-Lambert law, analysis of spectra – chromophore, auxochrome, blue and red shift, solvent effect and charge-transfer spectra. Inorganic electronic transitions-transition metal ions and lanthanides. UV-vis spectrophotometer instrumentation.

4. **Nuclear Magnetic Resonance Spectroscopy**: Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant "J". C-13, F-19 and P-31 NMR and advantages of FT NMR. NMR Instrumentation.

5. **X-ray diffraction**: Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electronic density. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules.

References:

1. Fundamentals of spectroscopy, C.N. Banwell and E.M. McCash, TMH, 2004.
2. Physical Chemistry, P.W.Atkins, 8th edn, 2006.
3. Physical Methods in Chemistry, R.S. Drago, 2nd edition, 1977.
4. Organic Spectroscopy, P.S. Kalsi, 2004.
5. Electronic absorption Spectroscopy and Related Techniques, D.N. Sathyanarayana,UP, 2001
6. Vibrational Spectroscopy, D.N. Sathyanarayana,UP, 2nd edn, 2004.
7. Solid State Chemistry, L. Smart and E. Moore, Nelson Thornes Ltd, 1995.
8. Chemical Applications of Group Theory, F.A. Cotton, John Wiley,1963

9. Group Theory in Chemistry, V.Ramakrishnan & M.S. Gopinathan, VP, 1988.

Course No	Course Title
UFC-C035	**PHOTOPHYSICS AND PHOTOCHEMISTRY**

L	T	P	C
3	1	0	4

1. **Basics:** Basic laws, Einstein Laws – absorption, Jablonski diagram, fluorescence, intersystem crossing, phosphorescence, lifetime and quantum yield. Rate Laws, Energy gap law. Kasha's principle. Stokes's shift**,** Fluorescence anisotropy.

2. **Techniques:** ***Absorpti*on** CW photolysis, photoreactors, light Sources, filters, photochemical quauntum yield and intensity measurements, detectors-PMT, Diode-array, CCD, ICCD.Study using time resolved techniques – pump-probe methods and instrumentation: Lasers-nanosecond, picosecond and femtosecond.Measurement of – Triplet quantum yield and Time resolved absorption spectrum. **Fluorescence techniques:** Steady-state fluorimeter- Time-resolved fluorimeter-TCSPC and Frequency domain, ultrafast fluorescence, femto-upconversion. – confocal and multiphoton. Fluorescence standards – lifetime and quantum yield.

3. **Fluorescence spectroscopy:** Quenching of fluorescence, fluorescence lifetime, fluorescence quantum yield-method of determination, Rotation diffusion, Time resolved anisotropy, environmental influence on fluorescence properties and photo-bleaching. Solvent effect-Lippert equation, excited state acidity constants, Fluorescence analysis of excited state reactions. Ultrafast solvation dynamics. Two photon fluorescence.

4. **Fluorescence Applications:** Fluorophores-intrinsic, extrinsic- DNA, membrane and protein. Bimolecular quenching and Stern-Volmer analysis- application to proteins and membranes. FRET-. Photoindced electron transfer, Fluorescence signaling of metal ions, anions. Luminescence - Metal complexes.

5. **Photochemical reactions and applications** – electron transfer, proton transfer, addition reactions, elimination reactions, photoisomerisation, photosensitisation, Norrish type reactions. Photochromism, singlet oxygen. Photoionization – Single photon and Multiphoton. Triplet Energy Transfer. Reactions of Transition metal complexes- Ruthenium and Iron complexes. Solar Energy Conversion-Photoelectrochemical cells- Honda's cell, Dye sensitized solar cells.

References:

1. Rohatgi-Mukherjee Fundamentals of Photochemistry, Wiley-Interscence, 1992.
2. N.J. Turro Modern Molecular Photochemistry, University Science Books, 1991
3. J.R. Lakowicz Principles of Fluorescence Spectroscopy,3rd edn Kluwer, 2006..
4. B. Valeur.Molecular Fluorescence: Principles and applications, Wiley-VCH, 2001.
5. A. Sharma and S.G. Schulman, Introduction to Fluorescence Spectroscopy, Wiley-interscience, 1999.

Course No	Course Title
UFC C036	**LASERS THEORY AND PRINCIPLES**

L	T	P	C
3	1	0	4

1. Radiation in a cavity: Black body radiation – Modes of oscillation – Einstein coefficients – relation between the absorption coefficients and Einstein coefficients – Life time of excited state – Line broadening mechanisms.

2. Population inversion – Threshold condition-Gain profile – superradiance laser – rate equation for 2 level, 3 level and 4 level systems – conditions for CW and pulsed laser action.

3. Optical resonators: 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 – Guassian beam propogation – multimode oscillation – generacy.

4. Gain and saturation effects: 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.

5. Theory of Q-switching and experimental methods – Theory of mode locking and experimental methods – cavity dumping - active and passive mode locking, chirp. Measurement of Pulse width-autocorrelation. Pulse stretching. Gas Laser-Ar,Kr,CO2, N2, He-Ne, He-Cd, Excimer lasers. Solid state lasers-Nd-YAG Laser, Ti-saphhire, Ruby, Alexandrite lasers, Metal Vapour laser.

References:

1. W.T. Silvafast, Laser Fundamentals, Cambridge, 2003.
2. Lasers, Theory and Applications, K. Thyagarajan, A.K. Ghatak, Macmillan,1981.
3. Fundamentals of Light Sources and Lasers, Mark Csele Wiley-Interscience, 2004.
4. Laser Spectroscopy, W. Demtroder, 3rd ed, Springer, 2004.

Course No	Course Title
UFC C037	**PRACTICAL – II Spectroscopy**

L	T	P	C
0	**0**	**3**	**3**

1. Estimation of protein
2. Estimation of DNA
3. Cell counting using microscope
4. Recording of absorption and emission spectrum – Calculation of Stokes shift.
5. Fluorescence quantum yield measurement.
6. Determination of excited state dipole moment using solvent effect.
7. Stern-Volmer Analysis – Fluorescence quenching constant – Steady State experiments.
8. Fluorescence lifetime measurement – simple dyes and mixture of dyes
9. Stern-Volmer Analysis – Fluorescence quenching constant – Life time analysis.
10. Study of Protein fluorescence.
11. Binding of fluorophore with micelle.
12. Binding of fluorophore with DNA.
13. Fluorescence Anisotropy-Steady state
14. Raman lines – water and other solvents.

Course No	Course Title
UFC C038	**BIOPHOTONICS**

L	T	P	C
3	1	0	4

1. **Photobiology:** Interaction of light with biological matter - absorption spectroscopy of biopolymers – study of conformational dynamics– optical activity and circular dichroism - non-linear optical processes with intense laser beams, photo-induced effects in biological systems – fluorescence detection and quantification of nucleic acids, proteins and cells.

2. **Bio-Imaging:** Principles of microscopy – illumination methods – resolution – numerical aperture –specification and design of optical elements and light sources. Optical aberrations – design and selection of lens systems for minimal aberration. Contrast techniques: Bright field – dark field - phase contrast – DIC. Imaging of vesicles, organelles and cells. Fluorescence microscopy – selection of fluorphores and filters - fluorescence lifetime imaging – FRET - Frequency-Domain lifetime imaging – FRAP – FLIP – imaging of cellular processes. Confocal imaging and detection - laser scanning confocal microscopy – optical sectioning – spatio-temporal processes. High sensitive and high-resolution imaging – single fluorophore imaging and detection - ratiometric imaging in biology – single photon counting principles and applications. Fluorescence Correlation Spectroscopy – multiphoton excitation – multiphoton imaging - imaging of soft and hard tissues.

3. **Optical biosensors:** Fluorophores and labeling procedures for biosensing - fluorescence immunoassay – total internal reflection microscopy – detection of biomolecules and their interactions by surface plasmon resonance and evanescent illumination - flow cytometry – application in medical diagnostics.

4. **Optical Force Spectroscopy:** Theory of optical trapping – single beam and dual beam trap - optical stretcher - holographic tweezers - calibration of optical forces – dynamics of particle in optical confinement - microrheology of complex systems by optical manipulations – DNA-protein interactions – mechanistic characterization of biomolecules and cells. Laser dissection and catapulting. Recent advances in optical tweezers application in biology.

5. **Light activated therapy & Medical applications:** - Low level light therapy and photodynamic therapy-sensitisers, singlet oxygen generation, light sources, mechanism, light delivery **tissue engineering**:use of ultrashort pulse lasers for tissue welding, tissue contouring; tissue regeneration-opthalmalogy and dermatology. Surgical applications of lasers- cancer, gynecological and endoscopy.

References:

1. P.N. Prasad, Introduction to Biophotonics, John-Wiley, 2003.
2. G. Marriot & I. Parker in Methods in Enzymology, Vol.360,2003.
3. G. Marriot & I. Parker in Methods in Enzymology, Vol.361,2003.

Course No	Course Title
UFC C039	**SEMICONDUCTORS AND DEVICES**

L	T	P	C
3	1	0	4

1. Introduction: Elementary properties of semiconductors - Types of semiconductors - intrinsic and extrinsic semiconductors - p,n type semiconductors - Doping of semiconductors (High level and Low level) –Electronic band Structure.

2. Electron transport phenomena: Theory of electron transport in crystalline semiconductors - Boltzmann's transport equation for Bloch states - relaxation time - relaxation time approximation to the low field transport coefficients - scattering mechanism - electron scattering by static defects - phonons - high fields effects - hot electron transport theory.

3. Thermal effects in Semiconductors: Thermal conductivity - Thermo-electric power - Thermomagnetic effects - condition of degeneracy - strong magnetic fields - relative magnitudes of the magnetic effects. Methods of determining of characteristic properties of Semiconductors: The minimum energy gap - mobility of electrons and holes - carrier concentration - effective mass - energy levels in the forbidden band due to impurities - thermal methods - optical methods - minority carrier lifetime - injection ratio.

4. Optical properties of semiconductors - Optical constants - Light absorption spectrum - Light absorption edge - Effect of free charge carriers on the absorption edge - Fundamentals of absorption and reflection - Absorption of light by lattice - Light absorption by free charge carriers - Intrinsic light absorber - Photo resistive effect - Demper effect - Photovoltaic effect - Faraday effect.

5. Application of semiconductors: Use of Semiconductors in electrical technology - Rectifiers - Transistors - Photodiode - Photo-electric power generator - Photo cells - Infra-red detectors - Infra-Red and Microwave modulators - Thermopiles - Thermo-electric refrigerators - Thermistors,Varistors and Other non-linear resistor.

References:

1. S.M. Sze, Semiconductor Devices, Physics and technology, Wiley Publishers, New York,1985
2. S.P.Keller, Handbook on Semiconductors, Vol. 1-4, T.S. Moss, Ed., North-Holland, Amsterdam, 1980.
3. R.K.Willardson andA.C.Beer, Semiconductors & Semimetals Vol.2, 24, 27 - Raymond
   Dingle, Academic Press Inc., New York, 1987
4. Charles M. Wolfe, Nick Holonyak, JR, Gregory E. Stillman, Physical Properties of Semiconductors - Prentice Hall International Inc., London, 1989.
5. Adir Bar. Lev, Semiconductors & Electronic Devices Prentice Hall of India, New Delhi, 1987.
6. Paul.N.Butcher, Norman.H.March and Mario.P.Tosi, Crystalline Semiconducting materials and devices Plenum Press New York and London, 1986.
7. L. Aleksandarov, Growth of Crystalline Semiconductor Materials on Crystal Surfaces, Elsevier, Amsterdam, 1984.

Course No	Course Title
UFC C040	**NANOPHOTONICS**

L	T	P	C
3	1	0	4

1. Fundamentals: Photons and electrons-confinement of photons and electrons, tunneling, badgap, cooperative effects. Nanoscale optical interactions, nanoscale confinement of electronic interactions.

2. Quatum confinement and Plasmonics: Quatum wells, quantum wires, quantum dots, quatum rings, quantum confined Stark-effect, Superlattices,Core-shell structures-Optical properties and lasers. Plamonics-metal nano particles, nano rods, nano shells, local field enhancement, applications.

3. Characterisation of Nanomaterials: X-ray, XPES, TEM, SEM, SPM, NSOM, Surface enhanced Raman and IR.

4. Photonic Crystals: Basics, Theory, Fabrication, Optical circuitry, non-linear optic crystals, Photonic Crystal Fibres, Applications-communication and sensors. Lquid Crystals-nematic, semectic and cholosteric phases: director and order parameter-display devices.

5. Nanocomposites and nanolithography: Waveguides, random lasers, nanocomposite optoelectronics, polymer dispersed liquid crystals. Nanolithography: Photoresists-positve and negative, polymeric materials, Two photon lithography, near-field lithography, plasmon priting, nanosphere lithography, Dip-pen and nanoimprint lithography.

Reference:

1. Nanophotonics, P.N. Prasad, Jhon Wiley, 2004.
2. Photonic Crystals, K. Bush etal, Wiley-VCH, 2004.
3. Nanoparticles, G.Schmid, Wiley-VCH, 2004.

Course No	Course Title
UFC C041	**PRACTICAL - III Lasers and Optoelectronics**

L	T	P	C
0	**0**	**4**	**4**

1. NLO efficiency measurement
2. Measurement of Pulsewidth of a pulsed laser- autocorrelation
3. Detector characterization-LDR, photodiode and phototransistor.
4. Characteristics LED
5. Characteristics of solar cell
6. Laser divergence and beam profile measurement
7. Bending loss and attenuation in optical fibres.
8. Optical Modulation – Fiber Optics communication.
9. Pulsed Laser alignment, optics cleaning
10. Brewster Angle Determination
11. Measurement of Numerical Aperture of Optical Fibre
12. Determination of splice losses in optical fibres.
13. PC-PC communication through optical fibres.
14. Upconversion and Pump-probe technique
15. Metal Nanoparticle – Chemical synthesis and spectral characterization.
16. Flash photolysis – Transient spectrum & Kinetics

Course No	Course Title
UFC C043	**LASER MATERIAL PROCESSING**

L	**T**	**P**	**C**
3	**1**	**0**	**4**

1. Industrial Laser Systems: Laser beam characteristics – beam focusing effects-focused spot size-power density-high power laser systes – focusing optics – steering optics – mechanisms – overview of industrial lasers – CW, pulsed – Q-switched and mode locked.

2. Thermal process in interaction zone: Depth of penetration with respect to laser energy density – reflectivity of metals with respect to wavelength – Rate of heating and cooling. Maximum temperature and depth of hardended layer. Different gases used during laser material processing – optical regimes in laser material processing – key hole effect.

3. Surface Treatment: Necessity for surface modification – surface cladding –surface alloying – hard facing – shock hardening – Typical laser variables in surface allying – processes variables – beam profiles used in surface alloying – different methods to obtain desired penetration depths – Laser cladding – experimentation.

4. Different modes of laser beam welding – comparison between laser beam and electron beam welding – influence on different parameters – Absorptivity – Welding speed – Focussing conditions – Advantages and limitations of laser welding – Laser welding of industrial materials – Recent developments in laser welding techniques.

5. Laser Cutting and Drilling: Laser energy density for cutting and drilling – Melt fleshing mechanism- different 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, 1996.
2. Reddy, J.F. High power Laser Applications, AP, 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, NY, 1983.
5. UV Lasers: Effects and Applications in Materials Science, Cambridge University Press, 1996.
6. William M. Steen, Laser Material Processing, Springer-Verlag. 2003.

Course No	Course Title
UFC C044	**OPTOELECTRONICS AND FIBRE OPTICS**

L	T	P	C
3	1	0	4

1. Solar energy and solar cells - carrier transport across p-n junction solar cells - Heterojunction solar cells - Schottky barrier and MIS solar cells - Contacts and surface properties: Contact structures - Antireflection coatings - Surface texturing - Grid design - Etching - Solar cell arrays - Radiation damage on solar cells. The calculation of solar efficiency. Some common and emerging solar cells - Fabrication process and photovoltaic performance of some standard solar cells like Silicon, Gallium arsenide (GaAs), Indium phosphide(InP), Copper indium selenide($CuInSe_2$), Cadmium Telluride (CdTe), Cu_2S based solar cells and polycrystalline thin film silicon solar cells and amorphous silicon solar cells.

2. Photonic devices: Light Emitting diodes- radiative recombination process, LED materials, LED construction ,LED performance, LED for fiber optics, Semiconductor lasers- Edge emitting, vertical cavity surface emitting (VCSEL) and distributed feed back laser– Quantum well Devices Lasers for optical communication system.

3. Display Devices-Plasma Displays, OLED-display devices. Photodetectors – Thermal detectors – Photodiode- avalanche photodiode, phototransistors, photomultiplier tube- image intensifier- photoconductor.

4. Fiber Optics – Basis, Structure of optical fibers- light propagation – Critical angle, Modes, Numerical Aperture. Types of optical fibers- step index, Graded index, single mode and multimode fiber, V-Number. Fiber Materials and Fiber Manufacture. Attenuation and dispersion in optical fibers. Dispersion management-bit rate and optical bandwidth- Measurement of fibre characteristics- Fibre Attenuation, dispersion, refractive index profile - Optical time domain reflectometry.

5. Fiber optic communication -Optical transmitters. Optical receivers. Modulation and Demodulation – Analog, Digital. Multiplexing –WDM, TDM. Fibre amplifiers: Semiconductor optical amplifires, EDFA, PDFA & Raman. Public communication network.: Nonlinear effects in fibers- SPM, GVD. Fibre optic sensors.

References:

1. Fahrenbruch and Bube, Fundamentals of solar cells Academic press, UK, 1983
2. K.L.Chopra and Suhit Ranjan das, Thin film solar cells, Plenum press, UK,1983
3. S.O. Kasap, Optoelectronics and photonics: Principles and Practices, Prentice Hall, 2001
4. G.Gueskos et.al, Photonic Devices for Telecommunications: How to model and measure , Springer Verlag, 1998.
5. John A. Buck, Fundamentals of Optical Fibres, , Wiley, 2004
6. J. Wilson, J.F.B. Hawkes, Optoelesctonics-An Introduction, Prentice –Hall, 2004.

Course No	Course Title
UFC E001	**FLOURESCENCE SPECTROSCOPY FOR BIOLOGISTS**

L	T	P	C
3	**0**	**0**	**3**

1. Fundamentals of absorption- absorption coefficients, electronic transitions. Excited state energy relaxations – Radiative and non-radiative relaxations – Spectrum, Lifetime and quantum yield, Stokes Shift, Kasha's rule, Energy gap law . Fluorescence anisotropy,

2. Techniques: Spectrofluorimeter – exciation, emission. Quantum yield, Steady state anisotropy. Fluorescence lifetime measurement- Time domain and Frequency domain.

3. Fluorophores (Intrinsic, extrinsic, membrane and protein probes, DNA probes and biochemical sensing probes) Fluorescence quenching (protein accessibility, membrane quenching) Energy transfer- (FRET, protein folding, energy transfer in membranes, biopolymers, energy transfer and DNA hybridization)- protein fluorescence.

4. Fluorescence sensing- optical clinical chemistry-oxygen sensing-chloride sensors-glucose and ion sensing by energy transfer-optical detection of blood gases-Immunoassays. Flourescent labels. Photodynamic therapy-clinical applications of laser. Principles of flow Cytometer. Fluorescence imaging – confocal and multiphoton imaging.

References:

1. Joseph R. Lakowicz, Principles of fluorescence Spectoscopy, Kluwer, 3rd edn, 2006.
2. B. Valeur. Molecular Fluorescence: Principles and applications, Wiley-VCH, 2001.
3. A. Sharma and S.G. Schulman, Introduction to Fluorescence Spectroscopy, Wiley-interscience, 1999.

Course No	Course Title
UFC E003	**CRYSTAL GROWTH AND EXPERIMENTAL TECHNIQUES**

L	T	P	C
2	1	0	3

1. **Gel Method:** History & Nature of the gel method – Different gel medium - specific gravity - Silica gel - Agar gel - Gelatin gel - poly acrylamide gel - tetra methoxy Silane gel - Tetra Ethoxy Silane gel - Basic growth procedures - Doble Diffusion Technique - Single Diffusion Technique - Reaction Method - Chemical Reduction method - Decomplexing method - Solubility Reduction method - doping.

2. **Liquid Phase Epitaxy:** Introduction to Epitaxy - Phase equlibria - Basic concept of LPE growth process - Impurity segregation - Substrate surface preparation - Operational consideration - Physical principles of the LPE process - Equilibrium cooling - Step cooling - Super cooling - Two phase solution cooling - Electroepitaxy - Advantages and disadvantages of LPE as a growth technique for device materials.

3. **Methods of vapour phase growth** – Physical Vapor Transport (PVT) – Physical Vapor Deposition (PVD) – Chemical Vapor Deposition (CVD) – Chemical Vapour Transport (CVT) – reaction types - thermodynamics, kinetics - transport processes - Thermodynamics of Chemical vapor deposition process – physical, thermo – chemical factors affecting growth process.

4. **Semiconductor Device Fabrication**: Wafer Preparation: Bulk Crystal Growth - Cutting and Polishing - Surface Cleaning - Etching for oxide layer removal - Controlled dissolution of surfaces - Identification for batch processing.

5. **Deposition:** Deposition processes - Silicon dioxide - Silicon nitride - Other materials - Plasma assisted deposition - Plasma Enhanced Chemical Vapour Deposition (PECVD) - Oxidation: Growth mechanism and kinetics - Oxidation techniques and systems - Oxide properties - Redistribution at interface - Oxidation induced defects.

References:

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