CRYSTALLOGRAPHY AND MOLECULAR BIOPHYSICS

Unit-I **Cell: Its organelles and molecules**

Basic structure of prokaryotic and eukaryotic cells–mitochondiria and the generation of ATP–Chemical composition of living systems – molecular components of cell – chemical structure of carbohydrate–Lipids-proteins–Nucleic acids–hetromacromolecules.

Molecular interactions

Molecular forces–forces hold macrmolecules together–intermolecular weak forces-van der waals-inductive force-dispersion force-Lenard-Jones potential-hydrogen bond – hydrophobic forces-acid, bases and pH, pK, pl and buffering.

Unit-II **Macromolecular Structure**

Nucleic acid structure–conformation of monomers and polymers–double helical structure of DNA–polymorphism of DNA–DNA super coiling – structure of transfer RNA.

Protein structure–amino acids–primary structure–peptide bond–secondary structure – α-helix and β-sheet-tertiary and quaternary structure – Virus.structure.

Unit-III **X-ray Protein Crystallography**

Crystals and symmetries–crystal system–Pont groups–space groups–Preparing Protein samples – protein crystal growth–X-ray sources–diffraction–data collection and data reduction–computational techniques–Phase problem–Patterson function–Fourier technique–Isomorpous replacement –molecular replacement–Anomalous scattering – refinement–fitting maps.

Unit-IV **Physics of Bio-membranes and Enzymes**

Cell membrane –structure of cell membrane – membrane asymmetry – transport through membrane – active transport–Passive transport–transport of charged particles.

Enzymes : Chemical Kinetics and catalysis – Enzymatic reactions–Chemical aspect of enzymatic action–conformation of enzyme–Physics of enzyme-substrate interactions.

Unit-V

Molecular thermodynamics

Equilibrium thermodynamics – near equilibrium thermodynamics- Gibbs free energy – chemical potential – thermodynamic analysis of membrane transport – phase equilibrium – irreversible thermodynamics.

Molecular mechanism of genetic information transfer

Genetic code – transmission of genetic information – molecular mechanism of Protein synthesis-transcription – translation – recognition of Amino acids – Protein Biosynthesis-principle of molecular recognition – intercellular interaction..

Books for study

1. Molecular Biophysics –Structure in motion- M. Duane; Oxford University Press.
2. Introduction to Molecular Biophysics – J. A. Tuszynski and M. Kurzynski; CRC Press Publications
3. Principles of Physical Biochemistry- K.E. Van Holde, N.C. John and P.S. Ho Prentice Hall Publications
4. Biophysics – M. V. Volkenshtein ; Mir Publications , Moscow.
5. Biophysical Chemistry
   - Part I. The conformation of Biological macromolecules.
   - Part II. Techniques for the study of biological structure and fuction.

Part III. The behavior of biological macromolecules ; C. R. Cantor and P. R. Schimmel; Publications W. H. Freeman

6. Practical Protein Crystallography- Duncan E. McRee- Academic Press Publications.

Books for Reference

1. Biophysics An Introduction – Rodney M. J. Cotterill; John Wiley Publication
2. Biophysics – Vasantha Pattabhi and N.Gautham; Narosa Publishing House
3. Biophysics – Roland Glacer; Pringer Publications
4. Elementary Biophysics An Introduction – P. K. Srivastava ; Narosa Publishing House.

Molecular Modelling and Dynamics

Unit-I Cell: Its organelles and molecules

Basic structure of prokaryotic and eukaryotic cells–mitochondiria and the generation of ATP–Chemical composition of living systems – molecular components of cell – chemical structure of carbohydrate–Lipids-proteins–Nucleic acids–hetromacromolecules.

Molecular interactions

Molecular forces–forces hold macrmolecules together–intermolecular weak forces-van der waals-inductive force-dispersion force-Lenard-Jones potential-hydrogen bond – hydrophobic forces-acid, bases and pH, pK, pl and buffering.

Unit-II Macromolecular Structure

Nucleic acid structure–conformation of monomers and polymers–double helical structure of DNA–polymorphism of DNA–DNA super coiling – structure of transfer RNA. Protein structure–amino acids–primary structure–peptide bond–secondary structure – α-helix and β-sheet-tertiary and quaternary structure – Virus structure. Enzymes:Chemical Kinetics and catalysis – Enzymatic reactions–Chemical aspect of enzymatic action–conformation of enzyme–Physics of enzyme-substrate interactions.

Molecular thermodynamics

Equilibrium thermodynamics – near equilibrium thermodynamics- Gibbs free energy – chemical potential – thermodynamic analysis of membrane transport – phase equilibrium – irreversible thermodynamics.

Unit-III Molecular quantum mechanics

Concepts of computational chemistry- Born Oppenheimer approximations- Application of Hartree-Fock equations to molecular systems- approximate Molecular orbital theories- Correlation methods- DFT –MP2-semi-empirical methods.

Unit-IV Molecular mechanics

General features-bond stretching -angle bending-improper torsions- out of plane bending-cross terms- non-bonded interactions- point charges- calculation of atomic charges-polarization- van der Waals interactions- hydrogen bond interactions- Water models- Force fields- all atoms force field and united atom force field.

Energy minimization

Statement of the problem- Derivatives; Non-derivative minimization methods: The simplex method- Sequential univariative method. Derivative methods: First-order Derivative-Steepest decent methods- Conjugate gradients. Second-order Derivative: Newton-Raphson method- Minima, Maxima, saddle points, convergence criteria.

Unit-V Simulation methods

Time averages- ensemble averages- Molecular dynamics methods- Monte Carlo methods-Differences between MD and MC- Energy- Pressure- Temperature- Temperature dynamics: Simulated Annealing procedure. Initial configuration-Periodic boundary conditions-Solvent access-Equilibration- cutoffs- Problems and overcoming it- Time step- Constraint dynamics-Systematic methods- Random search methods- Distance geometry- Use of distance constraints in NMR.

Biomaterials

Unit I

Introduction to biomaterials

Biomaterials- historical development- impact of biomaterials-metals (stainless steels – cobaltchromium alloys -titanium based alloys) – ceramics-surface reactive ceramic- resorbable ceramics (Calcium phosphate based ceramic materials)-synthetic polymers and its biomedical use-biodegradable synthetic polymers-Hydrogel - Polyurethanes - Polyamides –biopolymers-collagens-Gelatin - Chitin and chitosan- Alginate- Cellulose– composites.

Unit II

Calcium phosphate ceramics

Chemistry of calcium phosphate bio ceramics – preparation, mechanical properties and biological performance of tri-calcium phosphate, tetra-calcium phosphate, biphasic calcium phosphate, hydroxyapatite and other phosphates -calcium phosphate bone cements – preparation, properties - setting behavior and bio compatibility.

Unit III

Synthesis methodology of nanomaterials

Introduction –top down approach (physical methods) - laser evaporation method – RFPlasma – pulsed laser deposition method – lithography - mechanical milling – bottom upapproach(chemical methods) – hydrothermal – co-precipitation method - sol-gel method - micelles technique/microemulsion- microwave synthesis – electrodeposition

Unit-IV

Characterizations of nanomaterials

Characterization of biomaterials- X-ray diffraction- Fourier transform infrared spectroscopy-scanning electron microscopy- transmission electron microscopy- thermal analysis: TGA, DSC and DTA- Elemental analysis: XRF, EDX, XPS and ICP- density and porosity measurements-microhardness- scratch test–nanoindentation - size and surface measurement:particle size analyzer – zeta potential and contact angle measurement - biological evaluation: bioactivity, dissolution and biocompatibility studies.

Unit-V

Applications of biomaterials

Tissue grafts-tissue engineering– biosensors-drug delivery systems-orthopedic implants- knee joint repair-dental implants-oral implants, bioprobes.

References:

1. Sujata V. Bhat, Biomaterials, 2nd Edition, Narosa Publishing House, 2005.
2. T. Kokubo, Bioceramics and their clinical applications, Woodhead Publishing Limited, Cambridge, 2008.
3. S. Ramakrishna, M. Ramalingam, T.S. Sampath Kumar,W.O. Soboyejo, Biomaterials: A Nano Approach, CRC press, 2010.
4. Duong D. Do. Adsorption analysis: equilibria and kinetics, Vol. 2, Imprical college press, 1998.
5. Yang Leng, Materials Characterization:Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons, 2009.
6. Park J. B and Bronzino J. D., Biomaterials - Principles and Applications, CRC press, 2002.
7. Ratner. B, Hoffman. A, Schoen. F, Lemons. J, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press , 2004.
8. Michael Lvsaght and Thomas J.Webster, Biomaterials for artificial organs, Woodhead publishing Limited, 2011.

CRYSTAL GROWTH AND CHARACTERIZATION

UNIT-I :Basics of Crystal Growth

The crystalline state –concept of crystal growth –Importance of crystal growth –Crystal Growth theory: Classical theory –Gibbs-Thomson equation –Kinetic Theory of nucleation –Energy of formation of a nucleus –Adsorption at Growth surface –Statistical theory of nucleation –Free energy of formation of nucleus considering translation, vibration and rotation energies. Nucleation concept: Homogeneous and heterogeneous nucleation.

UNIT-II :Solution Growth

Solution -Choice of solvents -Preparation of solution –Solubility and super solubility -Saturation and Super Saturation –Measurement and expression of super saturation -Meir's Solubility diagram -Constant temperature bath and crystallizer –Seed preparation and mounting- Low temperature solution growth -Slow cooling and solvent evaporation methods –Temperature gradient method -Gel growth –Structure of gel –Importance of gel technique –single and double diffusion method.

UNIT-III:Growth from Melt and flux

Fundamentals of melt growth –Phase diagram and phase rules –Bridgman method –Vertical Bridgman technique experimental arrangement -Czochralski technique experimental arrangement–Verneuil method –Kyropolous Method –Zone melting method. Flux growth – Choice of flux –Growth kinetics –Growth techniques –Slow cooling method –Temperature gradient method –High pressure method –Accelerated crucible rotation technique.

UNIT-IV :Vapour Growth and Epitaxy

Basic principle–Physical vapour deposition –Evaporation and sublimation process –sputtering – Chemical vapour deposition –Advantages and disadvantages –Physical vapour transport – Transported materials and transporting agents –simultaneous use of several transporting agents – Rules for transport of materials –Thermodynamics of chemical vapour deposition process . Epitaxy –Vapour phase epitaxy –Liquid phase epitaxy –Molecular beam epitaxy – ChemicalBeam Epitaxy.

UNIT-V:Characterization Methods

X-ray powder diffraction method-Single crystal X-ray diffraction method–Optical methods-UV-Vis-NIR spectroscopy studies-Band gap calculation-Fluorescence and Photoluminescence studies-SHG and Z- scan technique –Thermal studies-TGA, DTA and DSC –Vibrational studies-Infrared spectroscopy -Fourier Transforms Interferometer-Raman spectroscopy- Electrical properties-DC conduction mechanism-Low field and high field conduction-AC conduction mechanism.-SEM and EDAX techniques.

Books for Study:

1. P.SanthanaRagavan, P.Ramasamy, Crystal Growth And Processes, KRU Publications, Kumbakonam (2000)
2. J.C.Brice, Crysatl Growth Process, John Wiley Publications, New York (1996)

Books for References:

1 K.Sangawal, Elementary Crystal Growth –Sahan Publisher, UK, 1994.

2 M.M.Flaktor, I.Garret, Growth of Crystals from Vapor, Chapmann and Hall (1988)
3 H. H. Williard, L. L. Merritt, J. Dean, and F. A. Settle, Instrumental Methods of Analysis – Sixth Edition, CBS Publishers & Distributors, Delhi (1986).
4 P.Ramasamy, ISTE Summer school Lecture Notes, Crysatl Growth Centre, Anna University, Chennai(1991)
5 M. William and D. Steve, Instrumental Methods of Analysis (CBS Publishers, New Delhi, (1986).
6 A.A.Chernov, Modern crystallography:III,-Crysatal Growth in Solid State, Springer Series, NewYork (1984)
7 B.R.Pamplin, Progress in Crystal Growth Characterization, Pergamon Press Ltd. (UK)
8 X.F.Zong, Y.Y.Wang, J.Chen, Material and Process characterization for VLSI, World Scientific, New Jersey (1998).

Semiconductor Electronics

Unit 1: Properties of semiconductors

Electrons and Holes in Semiconductors- The Fermi–Dirac Distribution Function and the Density of States - Intrinsic and Extrinsic Semiconductors- Donors and Acceptors in Semiconductors. Inter-band Electronic Transitions in Semiconductor- Optical Absorption-recombination Processes- Radiative Transitions- Non-radiative transition Mechanisms- Spontaneous and Stimulated Emission- Effects of External Perturbations on Semiconductor Properties.

Unit 2: Carrier Transport Phenomenon

Carrier concentration in intrinsic and doped materials – Carrier life time – Effect of traps and defect states – Carrier Drift: Drift Current Density - Mobility Effects -Conductivity -Velocity Saturation. Carrier Diffusion: Diffusion Current Density - Total Current Density – Variation of mobility with temperature and impurities – metal semiconductor contact problem – Depletion layer formation – Electron photon scattering – current in one dimension – current in two and three dimensions – basis of coherent transport.

Unit 3: States of Semiconductors

Charge Carriers in Semiconductors: Equilibrium Distribution of Electrons and Holes - The n_o and p_o Equations -The Intrinsic Carrier Concentration -The Intrinsic Fermi-Level Position. Dopant Atoms and Energy Levels: Qualitative Description -Ionization Energy. **The Extrinsic Semiconductor**: Equilibrium Distribution of Electrons and Holes -The n_op_o Product -The Fermi-Dirac integral. **Non-equilibrium Excess Carriers in Semiconductors:** Carrier Generation and Recombination- Excess Carrier Generation and Recombination- Characteristics of Excess Carriers

Unit 4: Nanoscience

Introduction to nanotechnology, physics of low-dimensional materials, quantum effects, 1D, 2D and 3D confinement, Density of states, Excitons, Zero-, One-, Two- and Three- dimensional structure, Size controlled nanoparticles and their properties: optical, electronic, magnetic properties; surface plasmon resonance; Mechanical Properties – Thermodynamic Properties.

Unit 5: Energy Application

Hydrogen energy storage, Electrochemical energy storage: Battery and super capacitor – fundamentals and technologies, characteristics and performance comparison: Lead-acid, Nickel-Metal hydride, Lithium Ion based hybrid system. Principles of photovoltaic conversion; Losses in Solar Cells: Recombination loss- Contact Losses. Solar cell basics and materials

BOOKS FOR STUDY

1. Semiconductor Physics and Devices - Basic Principles, Donald A. Neamen, Third Edition.
2. Semiconductor devices: Physics and technology by S. M. Sze.
3. Introduction to Nanoscience and Nanotechnology by Chattopadhyay K.K– 2009
4. Supercapacitor: Instrumentation, Measurement and Performance Evaluation Techniques by Satyajit Ratha, Aneeya Kumar Samantara,

BOOKS FOR REFERENCE

1. Electronic principles - Malvino, TMH, eighth edition, 2015.
2. Nanomaterials for Electrochemical Energy Storage Devices by Poulomi Roy, S. K. Srivastava, wiley.

NANOSCIENCE AND TECHNOLOGY

Unit I: Introduction to Nanomaterials

Introduction to nano technology - Importance of nanomaterials - classifications of nanostructures (0D,1D,2D,3D), Band theory of metals and semiconductors - Carrier concentration in intrinsic and doped materials- composites, porous materials - Size dependent variation in Mechanical, Physical- Chemical- electronics- reaction- catalytic properties.

Unit II: Synthesis techniques

Physical and Chemical Routes for Synthesis of Nanomaterials: Dip coating, Spin coating - Sputtering techniques- Ball Milling – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis and Molecular Beam Epitaxy (MBE)-Chemical precipitation and co-precipitation- Sol-gel synthesis- Microemulsion or reverse micelles- Solvothermal and hydrothermal synthesis - Thermolysis routes, Microwave heating synthesis- Sonochemical synthesis- Electrochemical synthesis - Photochemical synthesis, Synthesis in supercritical fluids, Chemical bath deposition.

Unit III: Layered materials

Types of layered materials and their crystal structure:Graphene, structure, synthesis and functionalization of Graphene- Graphene composites-Applications of Graphene, Graphene Oxide- Structural characteristics layered double hydroxides (LDHs) –Preparation and Properties ofLDHs nanosheets- Memory effect, Characterization aspects- Applications of LDHs-Two dimensional transition metal dichalcogenides (TMDs): synthesis, structure, properties and Application.

Unit IV:Nanocatalyst

Nano catalyst- basic Principle – Classification of catalysts - Adsorption-Thermodynamics and statistical mechanics of adsorption-Mode of Action of Catalysts, (Activity, Selectivity, and Stability) – Contact time- Catalyst Deactivation - Introduction to photocatalysis: Principle- Band energy engineering- Degradation of dye.

UnitV: Applications of Nanocatalyst

Applications of Nanocatalysts: Energy processing - Gasoline production – Fuel cell – Energy Conversion & Storage; Synthesis of fine chemicals- Hydrogenation / dehydrogenation-Environmental protection.

References:

1. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, GuozhongGao, Imperial College Press, 2004.
2. Fundamentals of Nanotechnology, Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009.
3. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009.

4. Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag, 2004.
5. Catalysis: Principles and Applications, Edited by B. Viswanathan, S. Sivasanker, A.V. Ramaswamy, Narosa Publishing House, 2011.
6. Photocatalysis, Edited by Masao Kaneko, Ichiro Okura, Springer, 2003.
7. Handbook of Heterogeneous Catalysis,G. Ertl, H. Knozinger and J. Weitkamp, Vol 1-5, Wiley - VCH.
8. Principles and Practice of Heterogeneous Catalysis,J. M. Thomas and W. J. Thomas Wiley- VCH.
9. Structural Aspects of Layered Double Hydroxides, David G. Evas and Robert C. T. Slade Struct Bond, (119)1-87, 2006.
10. Graphene-based materials and their composites: A review on production, applications and product limitations,Velram Balaji Mohanet.al, Composites Part B, (142) 200–220,2018.
11. Recent development of two-dimensional transition metal dichalcogenides and their applications,Wonbong Choiet.al,Materials Today, 20 (3), 116-130, 2017.

MATERIALS SCIENCE

UNIT I : CRYSTAL STRUCTURE

Bonding in solids- Crystalline state of solids- Unit cells and Space lattices – Crystal structures- Crystal planes and directions- Miller Indices - Diffraction of X-rays by crystal - Bragg's equation – Single crystal- Poly crystal- Crystal Defects- point, line and surface defects.

UNIT II : THERMAL BEHAVIOUR OF MATERIALS

Various theories of lattice specific heat - classical theory, Einstein's theory and Debye's theory - Lattice vibration - one dimensional lattice of identical atoms - specific heat of one dimensional lattice - diatomic linear lattice - thermal conductivity of insulators.

UNIT III : DIFFUSION IN METALS AND PHASE CHANGE

Fick's 1^{st} and 2^{nd} law of diffusion- Solution to Fick's second law-Kirkendall effect - diffusion along dislocation, surface and grain boundary - Phase transformation – Phase diagram –Phase rule .

Unit IV: Materials

Conductor: Resistivity- Free electron Theory- conductor- superconductor- intrinsic and extrinsic semi conductor; **Magnetism:** Magnetic materials- classification- ferromagnetism – domain theory–soft and hard magnetic materials. **Dielectrics:** Dielectric materials - polarization- temperature effect – capacitors- frequency effect – ferroelectric material- electric break down

Unit V : Advanced Materials and Tools

Smart materials - ferroelectric, piezoelectric, optoelectric materials - photoconductive nanomaterials – biomaterials – superalloys - shape memory alloys. Materials characterization techniques: Scanning electron microscopy- transmission electron microscop - atomic force microscopy- atomic absorption spectroscopy- differential scanning calorimetry.

Text Books:

1. Raghavan V, "Materials Science and Engineering: A First Course", 5^{th} Edition, Prentice Hall of India Pvt. Ltd., 2004.
2. James F Shackelford, " Introduction to Materials Science for Engineers", 7^{th} Edition,Pearson Prentice Hall, 2009

Reference Books:

1. Callister W D, "Materials Science and Engineering : An Introduction", 7^{th} Edition, John Wiley & Sons, Inc., 2007.

2. Vernon John, "Introduction to Engineering Materials", 3rd Edition, Palgrane Publication, 2003.
3. Dekker A J, "Solid State Physics", Macmillan and Co., 2000.
4. Van Vlack L H, "Elements of Materials Science and Engineering", 5th Edition, Addison Wesley, New York, 1989.

Renewable Energy Sources

Unit-I

Introduction: Energy - forms of energy - measurement - Fossil fuels and Nuclear Energy - their limitation-need of renewable energy - non-conventional energy sources. An overview of developments in Offshore Wind Energy - Tidal Energy-Wave energy systems - Ocean Thermal Energy Conversion- solar energy- biomass - biochemical conversion - biogas generation - geothermal energy tidal energy - Hydroelectricity.

Unit-II

Solar Energy: Solar constant - spectral distribution of extraterrestrial radiation -Terrestrial Solar radiation geometry- empirical equation for estimating solar radiation- Instruments for measuring solar radiation-Pyrometer-sun shine recorder- solar thermal energy collectors- flat plate collectors- liquid heating flat plate collectors- concentrating type collectors. Thermodynamic limits to concentration- solar cookers-types of solar cookers- solar water heater- solar air heaters- solar distillation-Solar water pumping and solar thermal power plant. Solar photo-voltaic system, photovoltaic effect- efficiency of solar cells- semiconductor materials for solar cells-solar photovoltaic system- applications of solar photo-voltaic devices.

Unit-III

Biomass Energy: Biomass resources- biofuels- biogas- producer gas- biomass conversion technologies-biochemical conversion- biomass classification. Biogas technology- factors affecting biogas production-biogas plants – floating drum type plant- fixed dome type. Energy recovery from urban waste- power generation from landfill gas. Power generation from liquid waste- Ethanol from biomass.

Unit-IV

Wind Energy: Origin and classification of winds-Wind turbines- types of rotors- aerodynamics of wind turbines-wind energy extraction- wind characteristics- horizontal axis wind turbine generator. Modes of wind power generation. Advantages and disadvantages of a wind energy system.

Tidal Energy:tidal characteristics- tidal range-tidal energy estimation- energy and power in double cycle system- yearly power generation from tidal plants- types of tidal power plants-site selection for power plants- advantages and disadvantages of tidal power.

Unit-V

Hydrogen Energy: Environmental considerations- solar hydrogen through photo electrolysis and photocatalytic process- physics of material characteristics for production of solar hydrogen. Storage processes- solid state hydrogen storage materials- structural and electronic properties of storage materials-new storage modes- safety factors- use of hydrogen as fuel; use in vehicles and electric generation- fuel cells- hydride batteries.

Books for Study:

1. Non-Conventional Energy Sources, G.D.Rai, Khanna Publishers, New delhi, 1984

Books for Reference:

1. Solar Energies of thermal processe, A.Duffie and W.A. Beckmann, john – wiley, 1980.

2. Principle of Solar Engineering, F.Kreith and J.F.Kreider, McGraw-Hill,1978

3. Alternate Energy Sources, T.N. Veziroglu, Vol.5 and 6, Mc Graw - Hill, 1978.

4. Solar energy – principle of thermal collection and storage S P Sukhatme and j K Nayak, Tata Mc Graw Hill, Tata, 2008

LASER SPECTROSCOPY

Unit – I: Laser fundamentals

Laser action and quantum theory - Principle of Laser action - Amplification and population inversion - Designing a Laser - Increasing the Laser power - Inversion mechanisms - Laser beam properties - Types of lasers and characteristics - Solid State Lasers, Liquid Lasers, Gas Lasers, Semiconductor Lasers, Free Electron Lasers, X-ray Lasers and Chemical Lasers- Rare earth Lasers.

Unit – II: Spectroscopic Instrumentation

Spectrographs and spectrometers: Light sources - line light sources, continuum light sources, natural radiation sources - Spectral resolution instruments - prism spectrometers, grating spectrometers, Fourier Transform spectrometer - Detectors photomultiplier - photo cell - optical multichannel analyser - Charge Coupled Device (CCD) detector - Interference filters and mirrors - Absorption filters - Polarizers - optical methods of chemical analysis.

Unit – III: Non linear optical spectroscopy

Nonlinear response - nonlinear phenomenon and optical harmonic generation - second and third and harmonic generation - phase matching- nonlinear susceptibility - parametric amplification - stimulated Raman scattering - stimulated Raman scattering in gas mixtures - Resonance Raman Scattering - Electrical breakdown in gases - fluorescence spectroscopy with lasers.

Unit – IV: Time - Resolved Laser spectroscopy

Pulsed Lasers - Q - switched Lasers - Soliton Lasers - Generation of short optical pulses- Generation of high power ultra short pulses - measurement techniques for optical transients - lifetime measurements - Quantum - Beat spectroscopy - High resolution spectroscopy - spectroscopy of collimated atomic and molecular beams - saturation spectroscopy - Doppler free multi photon spectroscopy - Trapped ion spectroscopy.

Unit – V : Laser - Spectroscopic Applications

Environmental research with Lasers - Absorption measurements – velocity measurements- Atmospheric measurements with LIDAR - Spectroscopic detection of water pollution - Lasers in

Photochemistry - Communications - Data processing - vegetation monitoring - Laser Isotope separation - Medicine: Photodynamic Tumour Therapy - Tissue Diagnostics with Laser Induced Fluorescence.

Books for Study and Reference:

1. Lasers and Nonlinear Optics by B.B. Laud, New Age International, New Delhi, 2007.
2. Lasers and Nonlinear Optics by G.D.Baruah, Pragati Prakashan, Meerut, 2009.
3. Atomic and Molecular Spectroscopy by S.Svanberg, Springer - Verlag, NewDelhi, 2007.
4. Laser Spectroscopy: Basic Concepts and Instrumentation by Wolfgang Demtroder, Springer Science, 2013.
5. Laser Spectroscopy: Techniques and Applications by E.Roland Menzel, CRC Press, 1994.
6. Laser Spectroscopy by Richard Brewer, Springer Science, 2012.
7. Optical Spectra of transparent rare earth compounds by S.Hufner, Academic Press, London, 1978.
8. Laser Theory and Applications by K. Thyagarajan and A.K.Ghatak, Mcmillan, 1981.
9. Industrial Applications of Lasers by K.Koebner, Wiley, 1984.
10. Introduction to Lasers and their applications by Donald C.O'Shea, W. Russel Callen and William T. Rhodes, Addison- Wesley, 1977.

ULTRASONICS

Unit – I : Ultrasonic waves

Characterization of ultrasonic waves - propagation through matter - different methods of ultrasonic waves - wave equation - absorption, reflection and transmission of ultrasonic waves - acoustic impedance, intensity and resonance.

Unit – II : Ultrasonic waves in materials

Propagation of ultrasonic waves in gases, liquids and solids- absorption and attenuation - nonlinear equations - nonlinear interactions within the acoustic mode - nonlinear interactions between the acoustic and non acoustic modes - cavitations, emulsification and cleaning.

Unit – III : Ultrasonic study of liquid mixtures and solutions

Molecular interactions - types - ultrasonic study - preparation of multi component mixtures - measurement techniques - coefficient of absorption- density and viscosity measurements - theories of ultrasonic velocity in mixtures and solutions - theories of liquid state - inadequacy - internal pressure, free volume - sound velocity - experimental determination.

Unit – IV : Ultrasonic Instrumentation

Detection of ultrasonic waves - measurement technique of ultrasound - pulse echo method - cross correlation method - scanning methods - A, B and C scan methods - ultrasonic surgical devices - therapy devices.

Unit – V : Ultrasonic advances

Ultrasonic transducers – Piezo composite transducers - measurement of flow rates and fill level - Non Destructive Testing of materials – Car's air bag sensors. Production of nanomaterials- synthesis of graphene, grapheme oxide and other nanomaterials – crystallization and freezing processes – solute crystallization

Books for Study and Reference:

1. Fundamentals of Ultrasonics by J. Blitz, Second Edition, Plenum Press, New York, 1967.

2. Physical Ultrasonics by Robert. T. Beyer and Stephen V. Letcher, Vol.32, Academic Press, New York, 1969.
3. Ultrasonic methods and applications by Blitz, James, Butter worths publishing, 1971.
4. Ultrasonics by Bemson Carlin, McGraw- Hill, 1960.
5. Ultrasonic methods of Non Destructive Testing by J. Blitz, G. Simpson, Chapman and Hall, London, UK,1971.
6. Ultrasonic methods in Solid State Physics by Rohn Truell, Academic Press, New York, 2013.
7. Ultrasonics: Data, Equations and their practical uses by Dale Ensminger, Foster B. Stulen, CRC Press, 2008.
8. Ultrasonics: Fundamentals, Technologies and Applications by Dale Ensminger, Third Edition, CRC Press, 2011.
9. Power Ultrasonics, Applications of High intensity Ultrasound by Juan Gallelo-juarez, Karl Graff, Woodhead Publishing, 2014.
10. Ultrasonic Transducers: Materials and design for sensors, actuators and medical applications by K.Nakamura, Woodhead Publishing, 2013.