DEPARTMENT OF PHYSICS

(DST-FIST and UGC-SAP Sponsored)

SCHOOL OF PHYSICAL, CHEMICAL AND APPLIED SCIENCES

SYLLABUS - 2012

Ph.D -PHYSICS

PONDICHERRY UNIVERSITY
PUDUCHERRY – 605 014

PONDICHERRY UNIVERSITY
Department of Physics
Ph.D- Program in Physics

SL. NO	CODE	COURSE NAME	TYPE	CREDITS	PAGE
1	*PHYS-601	RESEARCH METHODOLOGY-I (THEORY)	HC	4	
2	*PHYS-602	RESEARCH METHODOLOGY – II (EXPT TECH)	HC	4	

Suggested Optional Soft Courses

SL. NO	CODE	COURSE NAME	TYPE	CREDITS	PAGE
3	PHYS603	LASER SPECTROSCOPY AND ITS APPLICATIONS	SC	4	
4	PHYS-604	MAGNETISM AND MAGNETIC MATERIALS	SC	4	
5	PHYS-605	FIBER OPTICS COMMUNICATION	SC	4	
6	PHYS-606	ADVANCED COMPUTATIONAL PHYSICS	SC	4	
7	PHYS-607	MAGNETIC NANO-PARTICLE	SC	4	
8	PHYS-608	QUANTUM OPTICS AND QUANTUM INFORMATION PROCESSING	SC	4	
9	PHYS-609	SOLID STATE SPECTROSCOPY	SC	4	
10	PHYS-610	ION BEAMS IN NANOTECHNOLOGY	SC	4	
11	PHYS-611	NONLINEAR SCIENCE: SOLITONS AND CHAOS	SC	4	
12	PHYS-612	SEMICONDUCTOR :LASER PHYSICS	SC	4	
13	PHYS-613	ACOUSTIC, DIELECTRIC TECHNIQUES AND ITS APPLICATIONS TO SOLUTIONS	SC	4	
14	PHYS-614	BIOPHYSICS	SC	4	
15	PHYS-615	SOLID STATE IONICS	SC	4	
16	PHYS-616	ADVANCED SOLID STATE PHYSICS	SC	4	
17	PHYS - 617	PALEOMAGNETISM - PALEOMAGNETIC RECONSTRUCTION OF CONTINENTS			
18	PHYS-618	BASIC PLASMA PHYSICS AND APPLICATIONS	SC	4	
19	PHYS-619	QUANTUM MECHANICS IN NON COMMUTATIVE PHASE SPACE	SC	4	
20	PHYS-620	QUANTUM COMPUTATION	SC	4	
21	PHYS-621	SCIENCE AND TECHNOLOGY OF SOLID STATE IONICS	SC	4	
22	PHYS-622	ADVANCES IN NONLINEAR OPTICS	SC	4	
23	PHYS-623	ATOMIC MANY BODY PHYSICS	SC	4	

*** Compulsory Subjects**

PHYS – 601: Research Methodology- I

Unit I: Continuum Simulations
Finite Difference, Finite Volume and Finite Element methods, FDTD method to Computational Eelectrodynamics, Computational Fluid Dynamics, Simulation of Reaction Diffusion Equations: Pattern formation, Solution of Nonlinear Partial Differential Equations: Spatio temporal chaos and Solitons.

Unit II: Monte Carlo Simulations
Random number generators, Monte Carlo Simulation, Markov Chain, Metropolis Algorithm, Configuration Bias Monte Carlo method, Wang Landau algorithm to compute density of states, Kinetic Monte Carlo Simulations: Coarse grained atomic simulations

Unit III: Molecular Dynamics Simulations
Euler, Verlet and Velocity-Verlet integrators for Newtons equations for MD, Interaction potential including long range interactions, Energy minimization techniques, Constant energy and constant temperature simulations, Free energy calculations, Statistical mechanics and treatment of simulation data, Visualisation of structure and data, Electronic degrees of freedom: Car - Parinello method.

Unit IV: Electronic Structure Simulations
Hartree and Hartree Fock methods. Beyond Hartree Fock: Wavefunction expansion and perturbation methods. Hohenberg-Kohn theorems, Degenerate ground state, Kohn-Sham equations - Spin polarised systems, definition of exact exchange within DFT, Local density approximation, Nonlocal correlations to LDA, Generalized Gradient approximation, Self interaction correction, Pseudopotential theory,

Unit V: Simulation Exercises
1. Solve heat diffusion equation using explicit and implicit finite difference method.
2. Solve Poisson equation using finite element method
3. FDTD method to simulate propagation of electromagnetic wave in dielectric media.
4. Simulation of 2D Ising model on a triangular lattice
5. Simulation of Q state Potts model on a 2D square lattice and compute density of states using Wang Landau algorithm
6. Simulate Langmuir adsorption desorption phenomena using Kinetic Monte Carlo method
7. Molecular dynamics simulation of a Lennard Jones liquid
8. Electronic Structure of simple elements using Abinit.

Text books:

1. R.M. Dreizler and E.K.U. Gross, Density Functional Theory, (Springer, Berlin, 1990)
2. R.G. Parr and Q. Yang, Density Functional Theory of Atoms and Molecules, (Oxford Science Publications 1989)
3. R.M. Martin, Electronic Structure: Basic Theory and Practical Methods, (Cambridge University Press 2004)
4. D. Raabe, Computational Materials Science: The Simualtion of Materials Microstructure and Properties, (Wiley-VCH, 1998)
5. J.D. Hill, L. Subramaiah and A.Maiti, Molecular Modeling Techniques in Material Science, (Taylor and Francis, 2005)
6. M. Meyer and B. Pontikis, Computer Simulation in Material Science: Inter-atomic Potentials, Simulation, Techniques and Applications, (Kluwer Academic,1991)
7. K. Ohno, K. Esfarjani and Y.Kawazoe, Introduction to Computational Material Science: from *ab initio* to Monte Carlo methods, (Springer-Verlag, 1999)
8. D.W. Heerman, Computer Simulation Methods, (Springer-Verlag, 1986)
9. M.P. Allen and D.J. Tildesley, Computer simulation of Liquids, (Oxford U. Press, New York, 1989)
10. Zoe H. Barber, Introduction to Materials Modeling, (Maney Publishing, 2005)

Phys - 602 RESEARCH METHODOLOGY – II **Credits 4**

Unit I: 5 Hours

Error Analysis and Hypothesis testing – Propagation of errors – Plotting of Graph – Distributions – Least squares fitting – Criteria for goodness of fits – Chi square test.

12 Hour

Unit II

UV-VIS-NIR- Absorption Spectroscopy-Emission Spectroscopy- FTIR Spectroscopy NMR, NQR Mossbaure Spectroscopy -EPR Spectroscopy Radiometry and Photometry –Intensity, Power, Energy measurement of radiation, Photodiode, Avalanche photodiode, Photomultiplier Tubes, CCD, Thermopile Detectors, Optical modulation techniques. Heterodyne and Homodyne detection, Photon counting Boxcar averaging technique, Lock- in detection Technique, Temporal measurement of Pulse duration – nanosecond, picosecond and femtosecond pulses

Unit III 10 Hours

Scanning Probe Microscopy (AFM-STM) - Scanning Electron Microscopy – Transmission Electron Microscopy-Thermal Analysis (TG-DTA-DSC)

UNIT – IV: 10 Hours

Measurement of Magnetic field – Hall effect – Magneto- resistance – X-ray and neutron Diffraction. – Detection of X-rays, Gamma rays, charged particles, neutrons – Ionization chamber – Proportional counter – GM counter – Scintillation detectors – Solid State detectors –

UNIT – V: 12 Hours

Vacuum Techniques – Basic idea of conductance, pumping speed – Pumps: Mechanical Pump – Diffusion pump – Gauges – Thermocouple gauge – Penning gauge – Pirani gauge – Hot Cathode gauge – Low temperature systems – Cooling a sample over a range up to 4 K – Measurement of low temperatures-Deposition Techniques-Thermal Evaporation-Sputtering-Pulsed Laser Deposition

UNIT – VI: 12 Hours

Measurement of energy and time using electronic signals from the detectors and associated instrumentation – Signal processing – A/D conversion – multichannel analyzers – Time-of-flight technique – Coincidence Measurements – true to chance ratio – Correlation studies.

Textbooks

1. J.P. Holman (2000). *Experimental Methods for Engineers*. 7th Edition. McGraw Hill.
2. J. M. Lafferty (Editor) (1998). *Foundations of Vacuum Science and Technology.* Wiley Interscience.
3. Anthony Kent (1993). *Experimental Low-Temperature Physics* (Macmillan Physical Science).
4. Douglas C. Montgomery (2004). *Design and Analysis of Experiments*. John Wiley.
5. Laser Spectroscopy: Basic Concepts and Instrumentation (Springer Series in Chemical Physics Vol 5) by W. Demtr" Oder Springer-Verlag, Berlin, 3rd Edition.

Supplementary reading

1. T. G. Beckwith, R. D. Marangoni, J. H. Lienhard (2006). *Mechanical Measurements* (6th Edition). Prentice Hall.
2. Ernest O Doebelin. *Measurement Systems: Application and Design*. 5th edition. Tata McGraw Hill.
3. Albert D Helfrick and William D Cooper (1992). *Modern Electronic Instrumentation and Measurement Techniques*. Prentice Hall.
4. Hermann K P Neubert (2003). *Instrument Transducers: An introduction to their performance and design*. Oxford University Press.
5. J. A. Blackburn (2001). *Modern Instrumentation for Scientists and Engineers*. Springer

PHYS-603 LASER SPECTROSCOPY AND ITS APPLICATIONS

Unit I

Absorption and emission of light, Einstein's Coefficients, Discrete and continuous spectra. Transition Probabilities; Semi classical description of light and matter interaction; Line widths and profiles of spectral lines. Various broadening mechanisms

Unit II

Spectroscopic instrumentation: Spectrographs, mono-chromators Interferometers –Light detectors (Thermal detectors, Photo-emissive detectors, Photocells, Photomultipliers, Photodiodes and optical multichannel analyzer). Measurement of fast transient events- Lasers-(Basic elements and its characteristics). Lasers as spectroscopic light sources, fixed frequency and tunable lasers- Single mode and multimode lasers

Unit III

Nonlinear Optical Mixing Techniques (Second and third harmonic generation, Sum and difference frequency generation) Nonlinear absorption, Doppler limited absorption and fluorescence spectroscopy with lasers. Laser Raman Spectroscopy

Unit IV

Time Resolved Spectroscopy: Generation of Short laser pulses: Measurement techniques for optical transients- Lifetime measurements with lasers (Phase shift method, Pulse excitation, delayed coincidence technique) Quantum Beat Spectroscopy. Pulse Fourier Transform Spectroscopy. High resolution Spectroscopy- Spectroscopy of collimated atomic and molecular beams. Saturation spectroscopy Doppler free multi photon spectroscopy– spectroscopy of trapped ions

Unit V Applications:

Laser Photochemistry, Laser Isotope separation, Laser monitoring of the atmosphere, Laser Spectroscopy in biology, optical heterodyne detector, and Medical applications o f laser spectroscopy

Books:

1. Wolgang Demtroder UO, Laser Sepctroscopy, Springer Verlag)
2. S Svanberg, Atomic and Molecular Spectroscopy- Basic Aspects and practical applications (Springer Verlag).

PHYS-604 MAGNETISM AND MAGNETIC MATERIALS

Unit I Theoretical Background

(i)Fundamentals: Concept of magnetic moments- magnetic orderings- phase transitions magnetic susceptibility- magnetization- co-ercive field and remanance.

(ii) Disordered magnetics: Basic relations characterizing the behavior of a substance in magnetic field tensors of diamagnetic and paramagnetic susceptibility- classification of magnetic substances- diamagnetism- paramagnetism.- paramagnetism.

(iii) Ordered magnetics: Different types of magnetic structures in crystals- ferromagnetism, antiferro magnetism and ferromagnetism- magnetic symmetry- basic type of interaction in ordered magnetics- molecular field theory- the Curie and Neel points. Domain structure of ferromagnetic crystals and magnetization processes.

(iv) Anisotropy of ferromagnetic crystals: Peculiarities of the description of ferromagnetic crystals- magnetostriction anisotropy in ferromagnetic of different symmetry - magnetic anisotropy energy corresponding to zero strains zero stresses -equilibrium directions of spontaneous magnetization- magnetic anisotropy measurement.

(v) Magneto-elastic effect

Unit II Materials of interest

Soft magnetic materials- hard magnetic materials- thin films- ferrites- weakly ferrimagnetic crystals (canted anti ferromagnetics)- reorientation transition layered magnetic thin films- multilayer- DMS,GMR,CMR (Nano particle)

Unit III Synthesis mechanisms

Preparation of materials for magnetic study- composition- chemical reaction-Kinetics of reaction- Hume Rothery rule- phase transformation – Solid solutions-n Vegards law- magnetic phase transition- laboratory techniques- chemical identification to conduct chemical reaction- sample preparation for different studies- ceramic method- furnace operation- temperature control- pellet preparation – Sol-Gel , Co-precipitation- ball milling.

Unit IV Characterization

Particle size density- porosity- lattice constant using X-ray-Mossbauer spectroscopy, NMR, FMR, MOKE, MCD, - Hall Effect field measurement -VSM (Low and high field magnetic field and temperature)

Unit V Latest developments and applications

Essentials of crystal field theory- exposure to Ligand field theory- Magnetic sensors- Magnetic multi layer- Magnetic recording media- Stoners model-Andersons model explaining electrical conduction of ferrites (Localized bands) -Neutron scattering –Magnetite

Text Books

1. Magnetism: Principles And Applications- Derek craik, John Wiley & Sons LTD- 1995
2. Ferrite Materials: Science and Technology, B.Viswanathan, Narosa Publishing, VRK Murthy house 1990
3. Modern Crystallography, L.A.Shuvalov Berlin Helidelberg Springer Verlag New York 1981
4. Fundamentals of Solid State Physics - B.S.Saxena, P.N.Saxena, Pragati Pragasam R.C.Gupta Meerut 18th edition 2000.

Refernces

1. Ruderman M.A, and Kittel C, Phys. Rev, 96(1954)99
2. Blasses G, J.Phys. Chem. Solids, 27(1966)383
3. Becker J. J, J.Appl. Phys, 41(1970)1055
4. Traves D, J.Appl. Phys, 36(1965)1035

PHYS-605 FIBRE OPTICS COMMUNICATIONS

Unit I Linear And Nonlinear Waves (9)

Simple pendulum-Small and large oscillations-Duffing oscillator-Dissipative effects-Physical applications-Solitons-Methods to solve solitons -Soliton equations (K-dV,mK-dV, Sine-Gordon and nonlinear Schrodinger equation).

Unit II Maxwell Equations And Waveguides (9)

Maxwell equations-Refractive index-Frequency and intensity dependence of polarisation-Dielectric susceptibility-First order and higher order susceptibilities –Wave equation – Wave propagation in a conducting and anisotropic media.

Unit III Optical Fibres (9)

Fiber materials-Glass fibres-Plastic clad glass fibre-Plastic fibres-Fibre fabrication-Outside vapour phase oxidation-Vapour phase axial deposition-Modified chemical vapour deposition -Optical losses-Dispersion –Model birefringence.

Unit IV Nonlinear Effects In Fibre (9)

Self phase modulation(SPM) – Cross phase modulation(XPM) – Self steepening and focusing effects – Nonlinear retarded effects (SRS & SBS) – optical and spatial Solitons – Mathematical modeling – Wave length and time division multiplexing-Femto second solitons- SIT solitons (basic ideas).

Unit V Solitons In Optical Communications (9)

Generation and transmission of optical Solitons – Soliton Switching – Soliton reshaping – Pulse amplification and compression– Modulation instability – Dark Solitons. photonic crystal fibers- super continuum generation.

TOTAL :45hrs

Books For Study And Reference

1. G.Keiser, Optical fibre communication, McGraw-Hill Series, 2nd Edition,1983
2. P.G.Drazin and R.S.Johnson, Solitons: An Introduction, Cambridge University Press 1989.
3. G.P.Agrawal, Nonlinear Fibre Optics, Academic Press, 1995
4. A.Hasegawa and Y.Kodama, Solitons in Optical Communications, Oxford Press,1995.
5. M. Remoisenet , Waves called Solitons: Concepts and Experiments, Springer Verlag, 1992.

PHYS-606 ADVANCED COMPUTATIONAL PHYSICS

Unit I: Monte Carlo Simulations (10 Lectures)
Random number generators – Metropolis rejection technique – Markov Chain – Application of Monte Carlo simulation of 2D Ising model – Limitations of Metropolis algorithm – Wang-Landau algorithm.

Unit II: Simulating Chaotic Systems (10 Lectures)
Discrete dynamical systems – Oribits – Lyapunov exponents – Application to logistic map – Continuous dynamical systems – Rossler attractor – Lorenz attractor – Fractal dimension of strange attractors.

Unit III: Solving Partial Differential Equation (10 Lectures)
Finite difference method – Explicit and Implicit methods – Stability analysis – Application to diffusion equation – Solving Poisson equation – Introduction to finite volume and finite element methods.

Unit IV: Fast Fourier Transform (5 Lectures)
Discrete Fourier transform – Fast Fourier transform – Aliasing – Sampling theorem – Signal processing – Signal to Noise ratio.

Unit V: Computer Lab (15 Lectures)

1. Simulating paramagnetic to ferromagnetic phase transition in 2d Ising model on a square lattice.
2. Chaos in logistic map – Bifurcation diagram, Cobweb diagram, Lyapunov exponent as a function of parameter.
3. FFT of periodic, multi-periodic, quasi-periodic, chaotic and stochastic signals.
4. Fractal dimension of Lorenz attractor
5. Solution of diffusion equation

Text Books & References:

1. E. Isacson, H.B.Keller, Analysis of Numerical Methods, Numerical methods analysis, John Wiley & sons, New York 1972.
2. J.M. Thijssen, Computational Physics, Cambridge 1999.
3. Tao Pang, An Introduction to computational phsyics, Cambridge 1997.
   F.S. Acton, Numerical methods that work, Mathematical Association of America,
4. Rubin H. Landau and Manuel J P Mejia, Computational Physics: problem solving with computers, John Wiley 1997.
5. Numerical Recipes in Fortran, Press et al.

PHYS-607 MAGNETIC NANOPARTICLE

Unit I

Classification of magnetic materials (Diamagnet, Paramagnet, Ferromagnet, Antiferromagnet and Ferrimagnet). Basic concepts of spontaneous magnetization, Curie Temperature, Saturation magnetization and Neel Temperature. Origin of various kinds of magnetic anisotropies. Domain theory and its application in magnetic hysteresis. Single domain particle, multi-domain particle, and nanoparticle.

Unit II.

Various techniques for nanomaterials synthesis (specially, chemical route and mechanical milling/alloying route) and their aspects. Understanding of nanomaterials of various dimensions. Possible applications of magnetic nanoparticles.

Unit III.

Proposed models for magnetic nanoparticles and applications. Variation of magnetic parameters (e.g. Particle Magnetization, particle anisotropy, magnetic ordering temperature) with particle size. Inter-particle interactions and surface magnetism.

Unit IV.

Special topics (preliminary idea): Super paramagnetism, Collective magnetic Oscillation, Exchange bias effect, Magnetic Quantum Tunneling effect, Magneto- resistance and magnetic nanoparticle.

Books for reference:

1. K H Buschow, Hand book of magnetic materials, vol-8 North Holand, Amsterdam, 1995.
2. J L Dorman and D Fiorani, Magnetic properties of fine particles, North Holland, Amsterdam, 1991.
3. J A Mydosh, Taylor and Francis, Spin Glass an Introduction, London, 1993.
4. R C Handley, Modern Magnetic Materials: Principle and applications, Wiley Newyork, 2000.
5. C Kittal, An introduction to Solid state Physics, 8th Edition, Wiley, Newyork, 2004.

PHYS-608 QUANTUM OPTICS & QUANTUM INFORMATION PROCESSING

UNIT I

Quantum theory of radiation; Quantization of free electromagnetic field; Fock states, Lamb shifts, Quantum beats, coherent & squeezed states of the field, Quantum distribution theory & partially coherent radiation (Q-representation and Wigner- Weyle distribution)

UNIT II

Field- Field and Photon – Photon interferometry, First & second order Coherence; photon detection & quantum coherence functions. Photon counting &Photon statistics; Classical & Quantum description of TWO source interference, Atom-field interaction- Semiclassical & Quantum theory.

UNIT III

Laser without inversion & other effects of atomic coherence & interference Resonance flurescence Quantum theory of laser- density operator approach and Heisenberg- Langevein approach Theory of micro Masers. Atom optics.

UNIT IV

EPR paradox; hidden variable & Bell's theorem; Quantum calculation of the correlation in Bell's theorem; Bell's theorem without inequalities (GHZ equality).Quantum Cryptography (Bennett- Brossard protocol) Quantum Non demolition measurement.

UNIT V

Quantum circuits; Quantum search algorithm, Quantum Computers-Physical realization, Condition for quantum computation, Different implementation schemes for quantum computation; Quantum information theory (Distinguishing Quantum states, Data compression, Classical& Quantum information & noisy Quantum channels), Entanglement as physical resonance, Quantum key distribution and security of quantum key distribution.

Text Books

1. M.O.Scully & M.Suhail Zubairy, Quantum optics.
2. M A Nielsen & I L Chuang, Quantum Computation & Quantum Information.
3. Rodney Loudon, The Quantum theory of light.

PHYS-609 SOLID STATE SPECTROSCOPY

Unit 1 Atomic Spectroscopy - Free Ion
The Free-ion; free ion terms for d2 and f2 configuration; Spin-orbit Coupling; Energy level states for d2 and f2 configuration; Ground states for fN configuration; Rare earth free-ions; Coulomb and Spin-orbit energies - Intermediate coupling. [Chapter III of Figgis and Chapter II of Hufner]

Unit II Ligand Field - Introduction
The concept of ligand field; The scope of ligand field theory; The Physical properties affected by ligand fields; Ligand fields and f electron systems; The magnetic properties of actinide element compounds. [Chapter I and Chapter XIII of Figgis]

Unit III Group Theory
Sketch of Group theory; Kramer's degeneracy; Crystal field splitting - D3hsymmetry; Product of two representations - Selection rules; Examples of selection rules -D3h symmetry; Applications of theoretical results to the analysis of experimental data.[Chapter III of Hufner].

Unit IV Optical Spectra of Rare Earth Ions
Judd-Ofelt theory for the parametrization of intensities; Radiative properties; Upconversions in rare earths; Luminescent properties of Eu3+ and Tb3+ ions. [Chapter III of Hufner].

Unit V Trivalent Rare Earth Ions in Crystal Field
Introduction; Parametrization of crystal field splittings; The spin Hamiltonian; Examples of crystal field parametrization; Model description of the crystal field. [Chapter III of Hufner]

Unit VI Rare Earth Lasers
Introduction; Principles of laser action; Typical rare earth lasers; Nd:YAG and Nd:glass lasers; Energy level scheme of the Nd in YAG [Chapter XI of Hufner]

Unit VII Optical Instruments and Spectral Analyses
Spectrographs and Spectrophotometers for UV, VIS and IR regions; Absorptionand Emission spectra; Temperature dependent spectra; Axial, Sigma and Pi polarizationspectral measurements.

Text Books for References
1. B.N.Figgis, Introduction to Ligand Fields , Wiley Eastern Limited, New Delhi (1976).
2. S.Hufner, Optical Spectra of Transparent Rare Earth Compounds, Academic Press, London (1978).

PHYS- 610 ION BEAMS IN NANOTECHNOLOGY

Unit – I
Introduction: Effect of size on material properties, Quantum size effect and density of states, low dimensional systems and their applications. Introduction to microscopy: SEM, STM,AFM, TEM and their application in nanotechnology.(12 hours)

Unit – II
Ion – Solid interactions: Stopping and range of ions in solids, elastic collisions and kinematics, swift heavy ions, Coulomb explosion and thermal spike models, Nano track formation and its applications in nano technology.(10 hours)

Unit – III
Ion beam techniques: RBS, ERDA, NRA and PIXE, Ion channeling, defect analysis, lattice location and lattice strain measurements, Quantum well intermixing and band-gap tuning. (12 hours)

Unit – IV
Ion beams in nano-technology: Ion irradiation of surfaces, surface roughness, formation of nanopores, hillocks and self assembled nanodots, embedded nanoparticles and their applications in optoelectronics, Focused ion beams, nano-scale fabrication, ion beam milling and nanolithography.(14 hours)

Books:
1. T. L. Alford, L.C. Feldman and J. W.Mayer, Fundamentals of nanoscale film analysis Springer USA, 2007.
2. Ed. H.S. Nalwa, Handbook of nano-structured materials and nanotechnology", Acad. Press, CA, 2000.

PHYS-611 NONLINEAR SCIENCE: SOLITONS AND CHAOS

Unit I General
Linear waves-ordinary differential equations (ODEs)-Partial differential equations(PDEs)- Methods to solve ODEs and PDEs.- Numerical methods –applications-Nonlinear oscillators-Nonlinear waves-Nonlinear ODEs-Nonlinear PDEs.

Unit II Coherent Structures
Solitons - Generation soliton equations – AKNS Method, Backlund transformation, Hirota bilinearization method, Painleve analysis.

Unit III Solitons In Physical Systems
Derivation of Korteweg-de-Vries(KdV) equation, Modified K-dv equation, Nonlinear Schrodinger equation and Burger's equation – Physical significance.

Unit IV Chaos In Physical Systems
Classical chaos - phase space - fixed point analysis - Hamiltonian theory - period doubling phenomena-Fractals – Pattern formation - Duffing oscillator- Nonlinear oscillator – Standard map – integrable mapping- Non integrable mappings Kepler's problem - order and chaos – Simple applications of chaos in physical systems - Quantum chaos-Applications.

Unit V Applications
Nonlinear optics-Fluid dynamics-Magnetic systems-Liquid crystals-Biomolecules- Medical physics-Plasma and Astro physics-Electronic circuits-Optical communications.

References:

1. M.Lakshmanan (Ed.,) Introduction to Solitons, Springer-Verlag, 1988.
2. M.J.Ablowitz and H.Segur, Solitons and Inverse Scattering Trasform,Philadelphia(1981).
3. P.G.Drazin and R.S.Johnson, Solitons : An Introduction, Cambridge University Press,1989.
4. A.J. Licthenberg and M.A. Lieberman Regular and Stochastic Motion, Spinger Verlag, Berlin (1983)
5. J.M.T Thompson and H.B. Stewart, Nonlinear Dynamics and Chaos, John Wiley and Sons,1989.
6. A.S. Davydov, Solitons in Molecular Systems, 2ed.,Kluwer Academic Publishers.
7. A.Hasegawa and Y.Kodama, Solitons in Optical Communications, Oxford Press, 1995.

PHYS-612 SEMICONDUCTOR LASER PHYSICS

Unit I
Essential Semiconductor Physics Band theory, doping, heavy doping, recombination and generation of photons, non equilibrium carrier statistics. Refractive index of a semiconductor laser cavity.

Unit II
Laser Fundamentals: Population inversion in semiconductors, p-n homo junction laser and its output characteristics, active region and threshold current, optical properties of the junction, gain in semiconductors.

Unit III
Double Hetero Structure: Materials and growth techniques – brief outlook, electronic properties of hetero junctions, optical properties of hetero-junctions, lateral mode control.
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Unit IV
Quantum Wells: Semiconductor quantum wells, density of states in 2-D systems, optical transitions, gain, strained quantum wells, optical and electrical confinement.

Unit V
Diode Laser Modeling: Rate equations of idealized diode laser, gain compression, small signal rate equations, real laser diodes: InGaAsP/InP quantum well lasers, three level rate equation models for quantum well SCH lasers.

Books :

1. D. Sands, Diode Lasers, Institute of Physics, UK (2005).
2. L. A. Coldren and S. W. Corzine, Diode lasers and photonic integrated circuits, John Wiley & Sons, Inc., 1995.
3. Eli Kapon, Semiconductor lasers – Part – I., (Fundamentals), Ed., Academic Press, 1999.

PHYS-613 AQUSTIC, DIELECTRIC TECHNIQUE AND ITS APPLICATION TO LIQUID SOLUTIONS

Unit 1
Sound propagation, velocity of plane wave in medium, absorption of plane longitudinal waves in low velocity liquids, general considerations and relaxations, propagations of ultrasonic longitudinal waves in a relaxing medium.

Unit 11
Generation and detection of ultrasonic waves, optical diffraction method, ultrasonic interferometer, pulse technique, pulse propagation, pulse overlap, sing around technique, velocity measurements, systems of velocity measurements, applications to liquids. , mixtures , polymers and solid substances.

Unit 111
Thermo elastic effect, physical description, phenomological analysis, attenuation and velocity change due to thermo elastic effect, dislocation damping, description, attenuation and velocity, anomalous ultrasonic velocity effects associated with dislocation behavior, the generations of harmonics in crystalline solids due to dislocations, some selected experimental result, interactions of spin wave and ultrasonic weaves, in ferromagnetic crystals, experimental observations concerning spin waves and ultrasonic waves

Unit 1V
The electrical properties of water molecules, dielectric theory, static dielectric constant, dielectric constant in strong electric field, dielectric loss, and dispersion , dispersion conductivity, experimental technique, microwave dielectric properties of water.

Unit V
Classification of liquid, potential functions, structural determinations, motion in liquids, equations for pair distribution function, Kirkwood super approximation, critical properties of van der Waals fluid, one dimensional ising model, Onsager's solution.

Books for study and reference:

1. A J Mathewson, Molecular acoustics, wily-inter science 1971
2. Jack Blits, Fundamentals of ultrasonic, Butter words, London 1967.
3. R Truell, Ultrasonic methods in solids state physics, Academic London 1967.
4. J B Hasted, Acoustic Dielectrics, Champion and hall London, 1967.
5. J S Roulingson, Liquid and liquid mixture, Butter wroth Londen1959.
6. C A Ctronton, Introduction to Liquid state Physics, John Willy and Sons.
7. N Pierre Hauson and Ian R Mc Donald, Theory of simple Liquids, Academic Press, 1986.

PHYS-614 BIOPHYSICS

Unit I Life and Its Physical Basis (10 Lectures)
What is life? – Life and energy – Forces and energies at nanometer scales – Intermolecular interactions and electrostatic screening – Chemical bonding and stability of molecules –Chemical composition of living systems.

Unit II Thermodynamic basis of life (10 Lectures)
Heat, temperature, chemical equilibrium, Boltzmann distribution – Energy type and thesecond law of thermodynamics – Brownian motion – Chemical kinetics and catalysis –Metabolism in animals and photosynthesis in plants.

Unit III The Cell (15 Lectures)
The cell as a basic unit of life's organization – The components: membranes, cytoskeleton, organelles – The central role of macromolecules: proteins, nucleic acid, carbohydrates –Surface tension and mechanical properties of cell membranes – The cell interior as a tough neighborhood: Brownian motion and viscosity and their influence on particle motion in the cell – Basic structure of prokaryotic and eukaryotic cells, mitochondria and the generation of ATP – Energy and information flow in the cell.

Unit IV Proteins: Structure and Function (10 Lectures)
From linear polymer to functioning molecular machine: the role of weak interactions – Thestructural organization within proteins: primary, secondary, tertiary, and quaternary levels oforganization – Varieties of proteins: globular and fibrous – The stability of proteins as measured by free energy and denaturation – Motions within proteins – how enzymes work –Proteins as binding machines: measurement of binding and thermodynamic analysis.

Unit V Nucleic Acid and Genetic Information (10 Lectures)
Deciphering the genetic code – Why a double helix – How structure stores information – TheReplication process – From DNA to RNA to protein – How DNA is packed in the cell nucleus.

Text Books & References:

1. Rodney M. J. Cotterill John, Biophysics: An Introduction, Wiley & Sons Canada, Ltd., 2002
2. Rolland Glaser, Biophysics, Springer Verlag, Heidelberg, 2001
3. J. Pennycuick , Newton rules biology : a physical approach to biological problems .
4. Edward K. Yeargers Basic biophysics for biology, 1992
5 . Harold J. Morowitz, Energy flow in biology; biological organization as a problem in thermal physics.
6. Gaylon S. Campbell, John M. Norman Introduction to environmental Biophysics, 1998.

PHYS-615 SOLID STATE IONICS

Unit I

Types of Ionic solids- Fast Ionics Solids-Point Defect type-Sub Lattice type – Fast Ionic materials – alkali metal ion conductors - β aluminas- Silver ion conductors- Cation conductors- Oxygen ion conductors – Halide ion conductors – Proton conductors –Electronic conductors with ionic transport.

Unit II

Various methods of preparation of amorphous/glassy, poly and single crystalline materials – thermal evaporation – sputtering – glow – discharge decomposition –chemical vapour deposition – melt quenching – gel dissociation – crystal growth technique – x-ray diffraction and differential thermal analysis-Glass transition – factors determining glass transition temperatures – structure – microscopic structure – modeling– microscopic structure – examples.

Unit III

Point Defect Type: Point defect type super ionic conductors – transport mechanism through defects – jump frequency – ionic conductivity and diffusion co-efficient – defect concentration – pure and doped crystals – impurity vacancy association – coulomb interactions-Application of transport theory to fluoride and Oxygen ion conductors: Molten Sub-lattice type: Molten Sub-lattice type solid state ionic conductors – Hyper mann's theory – Rices Strassler & Toouch's theory – Welch Dieme's theory – Lattice gas theory – Path Probability and Moute Carlo Methods – Ionic Percolation theory – Jahn Teller Model-Dynamics- ion transport – free ion model – domain model – jump diffusion model and frequency dependent conductivity.

Unit IV

Macroscopic properties – electrical conductivity – diffusion thermo electric power-Microscopic properties – x- ray diffraction studies – a.c. conductivity – dielectric relaxation – NMR – ESR – far IR – Mossbauer Spectroscopy – Raman Scattering – Photo Electron Spectroscopy – Ultrasonic attenuation – velocity.

Unit V

Thermodynamic studies – general aspects of solid state batteries – electrolyte – compatibility between electrode substance and solid electrolytes – electrode structure –interface between electrode and solid electrolyte – High temperature fuel cells – solid state potentiometer gauges for gaseous species – coulometer – electro-chemical capacitor eletrochromic display system.

Text Book:

1. A.R. West, Solid State Chemistry.
2. S. Chandra, Superionic Solids.
3. Principles of Electronic Ceramics, L. L. Hench and J. K. West, (JohnWiley & Sons, New York, 1990).

PHYS-616 ADVANCED SOLID STATE PHYSICS

Unit I Thermal Properties Of Materials
Introduction- specific of solids-classical model-Einstein's model-Density of state-Debye's model-Thermal conductivity of solids- thermal conductivity due to electrons-thermal conductivity due to phonons-thermal resistance of solids

Unit II Free Electron In Crystals
Introduction-electron in one dimensional potential well-electron in three dimensional potential well- quantum state and degeneracy-the density of state-Fermi Dirac distribution function-effect of temperature on Fermi distribution function-the electronic specific heat.

Unit III Super Conductivity
Introduction-discovery-historical aspects - sources of super conductivity-response of magnetic field-the Messnor effect-types of super conductivity-thermodynamics of super conducting transitions-isotope effect – London equation-Coherence length-BCS theory – Josffson's effect.

Unit Iv High Temparature Super Conductivity
Introduction – High temperature cuprate super conductors-Crystallography of cuprate-thermal and transport properties-Normal state properties of high Tc – oxides specific heat capacity-the role of phonons-RVB theory-super conducting devices applications.

Text Books :
1. Philip Philip, Advanced solid state physics, overseas press
2. Haug, rouf Advances in solid state physics, Springer.
3. Ashroft / Mermin,Solid state physics, Thomson books.

Reference Books:
1. Henry Ehren Reich and David Turenbul,Solid state physics, Academic press.
2. Jeffry W. Lynn, High temperature Super conductivity, Spinger.
3. Gerald burns, High Temparature Super conductivity: An Introduction.
4. C G Cuper, Introduction to theory of Super Conductivity, Clarden press.

PHYS – 617 PALEOMAGNETISM:
PALEOMAGNETIC RECONSTRUCTION OF CONTINENTS

Unit I Basics Of Paleomagnetism
Various types of remanent magnetism Natural remanent magnetism, Thermo remanent magnetism Chemical remanent magnetism, Viscous remanent magnetism Isothermal remanent magnetism Piezo remanent magnetism.Oriented samples and their collection – Measurement of magnetic directions. 12Hr

Unit II Instruments And Laboratory Techniques
Astatic Magnetometer Spinner Magnetometer Cryogenic Magnetometer Magnetic susceptibility meter.Techniques of Alternating field Demagnetisation, Thermal Demagnetisation, Chemical Demagnetisation. 12 Hr

Unit III Statistical Methods And Presentation Of Paleomagnetic Data
Fisher statistics, Computation of Mean remanent magnetic directions Characteristic magnetic directions-Virtual geomagnetic pole positions- Apparent polar wander path (APWP)– using stereonet- Molleweids projection-Comparison of APWPs for different purposes– Assigning age to unknown geologic formation- Correlation of movement of different continents. 15 Hr

Unit II Reversal Earth' S Magnetic Field
Normal and reversal of magnetic poles – polarity of time scales, frequency of reversals Superchrons-Permian–Kiaman magnetic reversal, Cretaceous normal superchron.Sea floor spreading, plate tectonics-Marine magnetic anomalies. 10 Hr

Unit V Paleomagnetic Reconstruction
Paleomagnetic signatures in rocks-Geodynamics of different tectonic regions.Reconstruction of continents-Columbia super continent-Phanerozoic super continent Rodinia supercontinent, Eumarica-Gondwanaland-Pangea-their breaking and movement indifferent direction to the present positions. 11 Hr

Books:

1. D.H.Tarling, Paleomagnetism, Chapman and Hall, London (1983).
2. E.Irwing, Paleomagnetism and its Applications to Geological and Geophysical Problems, Wiley, New York (1964)
3. R.Thompson and F.Oldfield, Environmental Magnetism, Allen and Unwin, London (1986)
4. O'Reilly, Rock and Mineral Magnetism, Chapman & Hall, New York (1984)
5. Michael W Mc Elhinny and Philip L.Mc Fadden Academic Press USA (2000).
6. Paleomagnetism Robert F Butler, Electronic Version, University of Portland, Portland Oregon (2000).

PHYS 618 BASIC PLASMA PHYSICS AND APPLICATIONS

Unit 1 Basics of Vacuum Technology (10)

Basic physics, what is "Vacuum"? Terms and Units, Absorption, Desorption, Vacuum Applications, Vacuum pumps, Design and function, Operation and maintenance, Rotary Vane Pumps, Roots Pumps, Dry Compressing Pumps, Turbo-molecular Pumps. Gas flow, types of gas flow, pumping speed and throughput, measurement of gas flow rate, residence time, flow velocity, conductance.

Unit II Collision processes in gases discharge mechanism (10)

Collision cross-section, Elastic and Inelastic Collisions, ionization, excitation, relaxation, recombination, three body recombination, dissociation, ion-neutral collision, Charge transfer, Meta-stable-collisions, total collision cross-section, breakdown mechanism of gases, Gaseous discharge, Characteristic of dc Glow discharge, positive column, cathode sheath, negative glow, negative glow and Faraday dark space, Analysis of positive column, Analysis of cathode region.

Unit III Plasma and Plasma Parameters (10)

Definition of plasma, electron and ion temperature, plasma potential, sheath formation and floating substrate, Debye shielding, The Contact Potential, sheath formation and Bohm criterion, cathode sheath, Plasma oscillations, electron & ion oscillation, Ambipolar diffusion.

Unit IV Plasma sources and Applications (10)

Limitations of dc glow discharges, RF discharges, Inductive discharges, power transfer efficiency, matching network, electron-cyclotron resonance discharges, helicon-discharges, surface wave discharges, DBD discharges, characteristics and application of respective discharges, hollow cathode discharge, planer magnetron discharge, plasma etching, dc sputtering, rf sputtering, thin film formation, plasma nitriding, PECVD for nano-material fabrication, Tokomaks & ITER and challenges of controlled fusion

Unit V Experimental Demonstration (20)

- Dependence of breakdown voltage on pressure and electrode gap (Paschen Curve).
- Measurement of Plasma parameters by electrostatic probe (Langmuir Prob).
- To measure the plasma parameters by double Langmuir prob
- To launch an ion-acoustic wave and demonstrate collective behavior of the plasma
- Measurement of plasma parameters of pulsed dc discharges
- Characterization of dc magnetron discharges and estimation of sputtering yield
- Studying the conditions for atmospheric pressure plasmas (Dielectric Barrier Discharges)

Text Books

1. Chapman, Brian N. "Glow discharge processes" A Wiley-Interscience Publications
2. M. A. Lieberman and A. J. Lichtenberg, Principles of Plasma Discharges and Material Processing, John Wiley & Sons, New Jersey, 2005.
3. Y. P. Raizer, "Gas Discharge Physics", Springer 1991.

Reference Books

1. P. I. John, Plasma Science and the Creation of Wealth, Tata McGrow-Hills, New Delhi, 2005.
2. F.F. Chen, "Plasma Physics and Controlled Fusion", Plenum Press, New York, 1984

PHY-619 QUANTUM MECHANICS IN NONCOMMUTATIVE PHASE SPACES

Unit I

Weyl-Wigner correspondence: Operator ordering in Hilbert space – Introduction to Weyl correspondence – Wigner distribution function as an Inverse Weyl correspondence – Properties of Wigner distribution functions – The phase space analogue of operator product in Hilbert space – Properties of Moyal Star product or deformed product – Generalized Liouville equation in phase space.

Unit II

Postulational formulation of Quantum Mechanics in Phase space: Classical particle as localized Dirac delta distributions – Postulates about quantum domain – Integral form of Quantum condition – a generic form of quantum distribution function in phase space – Properties of Wigner distribution functions – Phase space analogues of eigenvalue equations.

Unit III

Noncommutative Quantum Mechanics in Hilbert Space: Introduction to noncommutative spacetimes – Deformed product approach to noncommutative spaces - Noncommutative quantum mechanics through Bopp-shifted operators.

Unit IV

Noncommutative Quantum Mechanics in Phase Space: Generalized deformed products in phase space – postulational formulation of noncommutative quantum mechanics in phase space – derivations of Schrödinger and other dynamical equations

References:

1. H. Weyl, The Theory of Groups and Quantum Mechanics.
2. R. Courant and D. Hilbert, Methods of Mathematical Physics.
3. E.P. Wigner, On the Quantum Correction for Thermodynamic Equilibrium, Phys. Rev. 40 (1932) 749.
4. J.E.Moyal, Quantum Mechanics as a Statistical Theory, Proc.Cambridge Phil.Soc.45(1949)99.
5. G. Baker, Formulation Of Quantum Mechanics Based On The Quasi-Probability Distribution Induced On Phase Space, Phys. Rev. 109(1958)2198.
6. M.Hillery, R.F. O'Connell, M.O.Scully, E.P.Wigner, Distribution Functions in Physics: Fundamentals, Phys.Rept.106(1984)121.
7. S. Bellucci, A. Nersessian and C. Sochichiu, Two phases of the noncommutative quantum mechanics, Phys. Lett, B 522, 345 (2001).
8. B. Muthukumar, Remarks on the formulation of quantum mechanics on noncommutative phase spaces, JHEP 0701, 073 (2007).

PHYS-620 QUANTUM COMPUTATION

Unit-I Classical & Quantum Information Theory

Shannon entropy - mathematical properties - von Neumann entropy - mathematical properties - information coding and data compression - channel noise capacity - the Holevo bound - error corrections.

Unit-II Foundations Of Quantum Mechanics

physics of information – quantum information - quantum bits and quantum gates - states and ensembles - axioms of quantum mechanics - qubit & qubit measurements - density matrix - bipartite composite systems - history & applications of q-correlations.

Unit-III Quantum Entanglement

entanglement - the resource of q-communication - measure of entanglement - non-separability of epr pairs - hidden quantum information - Einstein locality - bell inequalities - the aspect experiment and the uses of entanglement.

Unit-IV Quantum Computation

classical & quantum circuits - efficient quantum algorithms - quantum data base search - Fourier algorithm - Grover algorithm - generalized search and structured search – periodicity – factoring -phase estimation - simulations of quantum systems.

Books

1. Desurvire Emmanuel, Classical & Quantum Information Theory, Cambridge University Press, Isbn No.978-0--88171-5 (2009)
2. Stenholm & Anti Souminen, Quantum Approach to Informaticsstin, John Wiley & Sons, Isbn No. 0-471-73610-3 (2005).
3. L.Diosi, A Short Course In Quantum Information Theory, Springer-Verlag Berlin Heidelberg, Isbn No.3-540-38994-6 (2007).
4. Mikio Nakahara & Testuo Ohmi, Quantum Computing (From Linear Algebra to Physical Realizations),
5. Taylor & Francis Group, Llc, Crc Press, Isbn No.0-7503-0983-0 (2008).
6. A.Nielsen & I.C.Chuang, Quantum Computation & Quantum Informationm, Cambridgre University Press, Isbn No. 81-7596-092-2 (2006).

PHYS-621 SCIENCE AND TECHNOLOGY OF SOLID STATE IONICS

Unit-I Point Defects In Ionic Crystal
Vacancies and Interstitials atoms-Frenkel and Schottky type defects-Point defects generated by dopant ions-Conductive electrons and holes in ionic crystals
Types of Ionic solids:Fast Ionic materials; alkali metal ion conductors - β aluminas- Silver ion conductors- Cation conductors- Oxygen ion conductors – Halide ion conductors – Proton conductors

Unit-II Diffusion Process In Ionic Crystals
Phenomenological aspects of diffusion-Microscopic aspects of diffusion-Measurement of diffusion coefficients.
Electrical conduction in solids:Measurement of conductivity-Determination of transference numbers-Interrelation among diffusion coefficient, mobility and ionic conductivity.

Unit-III Lithium Ion Batteries
Basic concepts of rechargeable lithium batteries- Materials for lithium secondary batteries-Active materials for positive electrodes; Layered oxide cathodes, Spinel oxide cathodes and high voltage materials. Active materials for positive electrodes; Lithium metal, carbon based materials, Composites of Sn, Sb and Al and nitrides and phosphides. Inorganic ceramic electrolytes; Perovskite, Nasicon and Lisicon type and Lithium metal halides, nitrides and phosphides.

Unit-IV Synthesis And Characterization Techniques
Solid state and wet chemical methods for preparation of polycrystalline ceramic materials –thin film; thermal evaporation, RF sputtering, Pulsed laser deposition (PLD) Structure; Comparison of X-ray and Neutron diffraction, Raman- thermal analysis (TG, DTA and DSC), Microscopic; SEM and TEM, electrical conductivity; ac impedance.

Unit-V Battery Technology
Primary and secondary batteries-Sodium- Sulfur batteries-polymer lithium batteries- All Solid state thin film Lithium ion batteries.
Electrochemical devices: Electrochromical display, electric double-layer capacitors and electrochemical memory devices.
Sensing devices: Ion sensors -Oxygen sensors -Sensors for Combustible gases; CO, Alcohol and H_2 sensor.
Photo-Electrochemical devices: Photo-regenerative secondary batteries- Application of photo-intercalation.

References:

1. T.Kudo and K.Fueki, Solid State Ionics (VCH,Tokyo, Japan)1990.
2. S.O.Pillai, Solid State Physics Structure and Electron related properties(Wiley Eastern Limited, New Delhi) 1994.
3. Azaroff; Introduction to Solids (TMH, New Delhi)
4. H.P.Myers; Introductory Solid State Physics (Viva. New Delhi) 1998.
5. B. V. R. Chowdari, M. A. Careem, M A K L Dissanayake, R M G Rajapakse, V A Seneviratne, "Solid State Ionics: Advanced Materials for Emerging Technologies, (World Scientific Publishing Company) 2006.
6. S.Selvasekarapandian, N.Kalaiselvi, B. Nalini, V. Jozeph, Solid state ionics and its applications, Bharathiar university (TMH New Delhi) 2006.
7. T. Minami, M. Tatsumisago, M. Wakihara, C. Iwakura, "Solid State Ionics for Batteries" (Springer) 2005.
8. J. Ross Macdonald, Impedance Spectroscopy: emphasizing solid materials and systems, (John Wiley & Sons) 1987.
9. A.R. West, Solid State Chemistry, (John wiley & Sons)1984.
10. S. Chandra, Superionic Solids, North-Holland, Amsterdam, 1981.
11. Principles of Electronic Ceramics, L. L. Hench and J. K. West, (JohnWiley & Sons, New York), 1990.
12. Lithium Batteries – Science and Technology, Gholamabbas Nazri, Gianfranco Pistoia (Springer) 2004.
13. Advances in Lithium-ion Batteries, Walter A. van Schalkwijk, Bruno Scrosati, (Plenum Publishers) 2002
14. Solid State Batteries, C. A. C. Sequeira, A. Hooper, (North Atlantic Treaty Organization. Scientific Affairs Division) 2003.
15. Lithium-ion Batteries: Solid-Electrolyte Interphase, Perla B. Balbuena, Yixuan Wang (Imperial college press) 2004.

PHYS 622 ADVANCES IN NONLINEAR OPTICS

Unit – I 12hours

Origin Of Optical Nonlinearities

Classical theory of anharmonic oscillators. Wave equations description of nonlinear optical susceptibilities Quantum mechanical treatment of nonlinear optical susceptibilities, Frequency and intensity dependence of polarization and dielectric susceptibility First order and higher order susceptibilities

Unit II 12 hours

Second order optical nonlinearities:

Second harmonic generation –sum and difference frequency generation, parametric processes- Simple theory and calculation of nonlinear polarization –Various phase matching technique in SHG

Unit III 12 hours

Third order optical nonlinearities:

Third harmonic generation, Four wave mixing, Kerr Nonlinearity, Intensity dependent effect, Self Phase modulation, Cross phase modulation Stimulated Raman Scattering (SRS) Stimulated Brillioun Scattering, Parametric gain –Parametric amplification and oscillation

Unit IV 12 hours

Applications: Frequency mixing and upconversion Difference frequency generator, Optical Phase Conjugation-Theory and Applications, Photorefractive effect and applications, Solitons-Theory and applications – Optical bistability.

Unit V 12 hours

Nonlinear optical materials (Structure property relations and its applications):

Nonlinear Optics of Organics and Polymers, Liquid Crystal, Photorefractive materials, Organic doped glasses, Rare earth doped glasses and crystals, Semiconductors, Optical Fibers and Photonic Crystals Fibers, Ferroelectric Materials and other Novel optical materials

Text Books

1. Nonlinear Optics– Robert W Boyd
2. Nonlinear Photonics-Y Guo, C K Kao, E.H.Li, K. S.Chiang
3. Principles of Nonlinear Optics- Y R Shen
4. Nonlinear Optics – N. Bloembergen
5. Nonlinear Optics of Organic Molecules and Polymers- H S Nalwa and S Miyata
6. Optical Phase Conjugation-R A Fischer
7. Quantum Electronics–A Yariv
8. Growth and Characterization of Nonlinear Optical Materials – N B Singh

Supplementary Reading

1. Handbook of Nonlinear Optics-R Sutherland

PHY-623 ATOMIC MANY BODY PHYSICS

Unit I
Many body Hamiltonian –Hartree fock and Dirac Fock formalism - restricted HF equations- unrestricted HF equations.

Unit II
Many body perturbation theory applied to coulombs s interaction Second quantization-Wick's theorem – size extensively- size consistency-configuration interaction.

Unit III
Diagrammatic formalism-Coulombs interaction diagrams-JLV theorems-Correspondence between MBPT terms and diagrams.

Unit IV
Coupled cluster formalism-Closed shell coupled cluster –open shell coupled cluster formalisms.

Reference Books:

1. A. Lindgren and J. Morrisson, Atomic many body theory, Publisher Springer (Jun 1982).
2. Attila Szabo, Julie Azabo, Neil S. Ostlund, Modern Quantum Chemistry, Dover Publications, Inc.(02-Jul-96).