M.Sc. Physics (2 YDC)

Scheme of Study (July 2021)

FIRST SEMESTER:

COURSE CODE	Title of the Course	L	T	P	Credit
PHY-511	Mathematical Physics	3	0	-	3
PHY-512	Classical Mechanics	3	0	-	3
PHY-513	Quantum Mechanics	3	0	-	3
PHY-514	Solid State Physics	3	0	-	3
PHY-531-545	Elective I	3	0	-	3
HUM-511	Communication Skills	2	0	-	2
PHY-515	Physics Laboratory-1	-	-	2	1
PHY-516	Seminar-1	-	-	2	1
				Total No. of Credits:	**19**

HUM-511, To be opted from the Humanities Department

SECOND SEMESTER:

COURSE CODE	Title of the Course	L	T	P	Credit
PHY-521	Advanced Quantum Mechanics	3	-	-	3
PHY-522	Electrodynamics	3	-	-	3
PHY-523	Statistical Mechanics	3	-	-	3
PHY-524	Fundamentals of Electronics	2	-	-	2
PHY-525	Thin Film Technology	3	-	-	3
PHY-546-550	Elective II	3	-	-	3
PHY-526	Research Methodology	-	2	-	2
PHY-527	Physics Laboratory-2	-	-	2	1
PHY-528	Seminar-2	-	-	2	1
				Total No. of Credits:	**21**

THIRD SEMESTER:

COURSE CODE	Title of the Course	L	T	P	Credit
PHY-611	Digital Electronics	3	-	-	3
PHY-612	Atomic & Molecular Spectroscopy	3	-	-	3
PHY-613	Nuclear & Particle Physics	3	-	-	3
PHY-614	Materials Science	3	-	-	3
PHY-615	Characterization Techniques	3	-	-	3
PHY-631-635	Elective III	3	-	-	3
PHY-616	Physics Laboratory-3	-	-	2	1
PHY-617	Seminar-3	-	-	2	1
				Total No. of Credits:	**20**

FOURTH SEMESTER:

COURSE CODE	Title of the Course	L	T	P	Credit
PHY-621	Major Project Dissertation	-	-	40	20
				Total No. of Credits:	**20**

Grand Total of Course Credits = 19 + 21 + 20 + 20 = 80

List of Elective (I)	
PHY-531 Nanoelectronics	PHY-532 Optoelectronics
PHY-533 Photonic Materials	PHY-534 Advanced Topics in Physics
PHY-535 Molecular Structures	PHY-536 Computational Methods
PHY-537 Semiconductor devices	PHY-538 Amorphous Materials
PHY-539 Low Temperature Behavior of Materials	PHY-540 Nano Fluids and Surfaces
PHY-541 Quantum Optics	PHY-542 Experimental Nuclear and Particle Physics
PHY-543 Renewable Energy Technologies	PHY-544 Soft Matter Physics
PHY-545 Computational Physics	
Elective (II)	
PHY-546 Laser Technology	PHY-547 Molecular Electronics and Biomolecules
PHY-548 Solar Photovoltaic Technology	PHY-549 Optical Sensors
PHY-550 Advanced Electromagnetic Theory	PHY-550 Astronomy and Astrophysics
Elective (III)	
PHY-631 Advanced Magnetic Materials	PHY-632 General Theory of Relativity
PHY-633 Nonlinear Dynamics	PHY-634 Physics of Quantum Devices
PHY-635 Quantum Field Theory	

FIRST SEMESTER

PHY-511 - MATHEMATICAL PHYSICS

Linear vector spaces, eigen values and eigen vectors of matrices, linear ordinary differential equations of second order, special functions. Fourier series and transforms, functions of a complex variable and residue calculus. Partial differential equations (Laplace equation in two and three dimensions in rectangular and polar co- ordinates, wave equation). Introduction to tensors and index notation, Introduction to group theory.

Recommended Books:

1. Mathematical Physics, H.K. Dass
2. Mathematical methods for Physicists, Arfken, Weber and Harris, Academic press.
3. Mathematical Methods in the Physical Sciences' Mary L. Boas , Wiley.
4. Advance Engineering Mathematics, Kreyzig Wiley

PHY-512 - CLASSICAL MECHANICS

Revision of Newtonian mechanics, constraints, Generalized coordinates Lagrange's equations of motion, Noethers theorem. Hamilton's function and Hamilton's equation of motion, Legendre transform, Phase space, Phase trajectories, Principle of least action, Hamiltonian principle.

Two body central force problem, Kepler problem, Scattering, Virial theorem. Non-inertial frames of reference and pseudo forces, Elements of rigid body dynamics. Small oscillations, Normal mode analysis, Normal modes of a harmonic chain. Principle and postulate of relativity, Lorentz transformation , Length contraction, Time dilation and the Doppler Effect, Relativistic invariance of physical laws.

Recommended Books:

1. Classical Mechanics, H. Goldstein, 2nd Edition, Narosa Pub.
2. Classical Mechanics, N.C. Rana and P.S. Joag ,Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
3. Mechanics ,L.D Landau and E.M.Lifshitz, Pergamon press, 1960
4. Classical mechanics, K.R.Srinivasa Rao, Univesities Press, Delhi
5. Introduction to mechanics, D. Kleppner, R.J. Kolenkow, McGraw Hill

PHY-513 - QUANTUM MECHANICS

Basic principles of Quantum mechanics, probabilities and probability amplitudes, wave functions, probability density and probability current. Schrödinger equation, application to linear harmonic oscillator, rigid rotor, hydrogen atom.

WKB approximation, WKB wave function criterion for validity of approximation, application to bound state. Identical Particles and Spin Angular momentum, Integral and Half integral angular momentum spin

Eigen functions, Conservation rules, Identical particles, Physical meaning of identity, Distinguishability of identical particles, Symmetric and Antisymmetric wave function, Construction from unsymmetrised function, Slater's Determinant, Connection of spin and statistics, Pauli spin matrices, scattering between identical particles, Stern-Gerlach Experiment

Recommended books:

1. Quantum Mechanics, E.Merzbacher, John Wiley (Asia) 1999
2. Quantum mechanics, G. Aruldhas ,
3. A Textbook of Quantum Mechanics, P.M.Mathews and K.Venkatesan, TMH
4. Principles of Quantum Mechanics, R.Shankar, Springer (Indian edition)
5 Quantum Mechanics, B.H.Bransden, C.J.Jaochim, Longman Publication.

PHY-514 - SOLID STATE PHYSICS

Crystal structure, Bravais lattice, crystal diffraction, concept of reciprocal lattice, bonding of solids, Defects in Solids, Phonons, lattice specific heat. Free electron theory, Drude model of electrical and thermal conductivity, Electrons in periodic lattice, Bloch theorem, Band theory, Kronig-Penney model, Classification of solids. Hall Effect, Effective mass, mobility, Einstein's relation, Generation – Recombination, continuity equation. Superconductivity, Critical Magnetic field and critical current density, Meissner Effect, type-I and type-II superconductors, London's equations, Thermodynamics of the superconducting state, Entropy and Specific heat in the superconducting state, Ginzburg Landau Theory of superconductivity, BCS theory of superconductivity, Josephson junction.
Recommended Books:

1. Introduction to solid state physics, Charles Kittel, John Wiley and Sons.
2. Solid state physics, A. J. Dekkar, Prentice Hall of India.
3. Solid state physics, C.M. Srivastava.
4. Elementary Solid State Physics Principles and Applications: M. Ali Omar
5. Solid State Physics: S.O. Pillai.

FIRST SEMESER PHY-515 :PHYSICS LABORATORY-1

List of Experiments:

1. Determination of the Hall voltage developed across the sample material and also the Hall coefficient, mobility of charge carriers and carrier concentration of that material.
2. Determination of the resistivity and energy band gap of a semiconducting material using 4-Probe Method.
3. Determination of the excitation potential of Argon using Franck-Hertz apparatus.
4. Magnetic Susceptibility of Liquids – Quincke's Method, Powder-Faraday Method
5. Hysteresis (B – H Curve)
6. Solar-Cell Characteristics
7. Determination of Planck's Constant
8. Characteristics of Photo Diode, Photo Transistor, LDR, LED
9. To determine the wavelength of He- Ne LASER using Michelson interferometer
10. I-V characteristics of photoresistor.

PHY-516 SEMINAR-1

SECOND SEMESTER

PHY-521 – ADVANCED QUANTUM MECHANICS

Time dependent and independent perturbation theory, quantum theory of radiation- Einstein's A & B coefficients, Sudden approximation, sudden reversal of a magnetic field, Adiabatic approximation. Schrödinger, Heisenberg and Interaction picture, representation of operators and equations of motion
Many Electron Systems-Atoms and Molecules, Thomas-Fermi Statistical Model, Hartree's self-consistent field method, Hartree-Fock method, molecular orbital theory for Hydrogen Ion- LCAO approximation, Heitler-London theory of hydrogen molecule
Scattering Theory Scattering amplitude, Born approximation- Integral equation of scattered waves. Relativistic Wave equations The Klein-Gorden equation for free particle and electromagnetic Potential, The Dirac equation, Properties of Dirac matrices, Free particle solutions, existence of electron spin
Recommended books:

1. Quantum Mechanics: LI Schiff, McGraw Hill
2. Quantum Mechanics: Mathews and Venkatesan
3. Quantum Mechanics: Ghatak and Loknathan, MacMillan Publishers
4. Quantum Mechanics: Eugen Merzbacker, John Wiley & Sons
5. Quantum Mechanics: DJ Griffith, Pearson Education 8. Quantum Mechanics VolI & II: Cohen Tannoudji, John Wiley

PHY-522 – ELECTRODYNAMICS

Gauss law, Laplace and Poisson's equation, induced charges, Green's theorem, Laplace equation, Boundary conditions and uniqueness theorem, method of images, multipole expansion.
Biot-Savart law, magnetic vector potential, magnetic field in matter.

Faraday's law, Maxwell's equations, conservation laws, electromagnetic wave in free space, wave equation, reflection, refraction and propogation of waves. Dipole radiation, electric and magnetic dipole radiation.

Fields at the surface of and within conductor, cylindrical cavity and wave guide, Modes in rectangular waveguide, Modes in dielectric waveguides.

Recommended Books:

1. Classical Electrodynamics, J.D. Jackson, 3rd edition., Wiley, 1999.
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd edition, PHI, 2011
3. Classical Electricity and Magnetism, W.K.H. Panofsky and M. Phillips, 2nd ed.,Addison- Wesley, 1962.
4. Electricity and magnetism, A.S.Mahajan,A.A.Rangwala, Tata McGraw Hill publishing company limited

PHY-523 –STATISTICAL MECHANICS

First law, second law, entropy, Thermodynamic potential, Maxwell relations, chemical potential , Phase equilibria.
Macro & micro state, phase space, density distribution in phase space, micro canonical, canonical and grand canonical ensembles, partition function, free energy, calculation of thermodynamic quantities.
Classical statistical mechanics, Postulates, derivation of thermodynamic laws, equipartition theorem, classical ideal gas, Gibbs paradox, statistics of paramagnetism. Quantum Statistics, Postulates, density matrix, ensemble, Third Law of Thermodynamics, Ideal gases, Liovillie's theorem. Equilibrium condition, classification of phase transitions, phase diagram, Claussius- Clapeyron equation, Van-der-Walls equation, second order phase transition, Ginzberg– Landau theory, Ising model, ferromagnetism, law of mass action, diffusion , Brownian motion. Maxwell – Boltzmann, Bose –

Einstein, Fermi – Dirac distributions, Bose condensation, and introduction to non-equilibrium processes.

Recommended Books:

1. Statistical mechanics , Kerson Huang , Wiley India
2. Fundamentals of Statistical mechanics, B.B. Laud, New Age International
3. Statistical Physics, F Reif, Berkley Physics Course, Vol 5
4. Statistical Thermodynamics, M.C.Gupta, New Age International
5. Statistical Mechanics, J.K.Bhattacharya, Narosa publishing house

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PHY-524 – FUNDAMENTALS OF ELECTRONICS

P-N Junction: Built in potential, width and capacitance of depletion region; Current flow in biased p-n junction, Varactor diode, Zener diode and its characteristics, Photo diode and Solar cell. Transistors: n-p-n and p-n-p transistors, current flow in transistors, h-parameters, FET and MOSFET: Principle of operation, characteristics and parameters. Operational amplifiers: Differential amplifier using transistors, operational amplifier characteristics, negative feedback configuration, application circuits (inverter, non-inverter, adder, integrator, differentiator, waveform generator, comparator and Schmidt trigger). Transistor as a switch, feedback in amplifier. Digital logic gates, combinational circuits, Digital techniques and applications, registers, counters and comparators. A/D and D/A convertors, applications. Transducers (temperature, pressure, magnetic field, vibration, optical and particle detectors), Impedance matching, amplification (op amp based, instrumentation amplifier, feedback) filtering and noise reduction, shielding and grounding.

Recommended Books:

1. Solid state electronic devices, B.G. Streetman, Prentice Hall of India, New Delhi, 1995
2. Microelectronics, J.Millman, Mc Graw Hill International, 1987.
3. Process control and instrumentation, C. D. Johnson, Prentice Hall of India, New Delhi, 2000

PHY-525 – THIN FILM TECHNOLOGY

Brief introduction regarding different methods for thin film formation (Physical and chemical), nucleation and growth mechanism. Electrochemical deposition: Introduction, principle, Faradays laws of electrolysis, electrode, electrolyte, additives, power supply, substrate, Classification of elctrodeposition: potentiostatic, galvanostatic and cyclic voltametry, Steps involved in electrodeposition process, Over potential term, nucleation and growth mechanism, advantages and disadvantages, a case study. Spray Pyrolysis: Principle, preparative parameters: influence of temperature, precursor's solution, Model for films deposition: Atomization of precursor's solution, Aerosol transport, decomposition of precursor, advantages and disadvantages, a case study of SnO_2 deposition. Spin Coating: Modeling spin coating, advantages and disadvantages, a case study. Physical methods: Introduction physical vapor deposition (PVD) and Chemical Vapor deposition (CVD) Evaporation Methods: Thermal Evaporation (vacuum evaporation), Flash evaporation, Laser evaporation, Molecular Beam Epitaxy. Types of CVD: atmospheric pressure, low pressure, plasma enhanced CVD. Sputtering: Basic principle of sputtering process, brief regarding triode sputtering, ion beam sputtering

Recommended books:

1. Thin Film Phenomenon, K. L. Chopra, Mc Graw Hill, 1969.
2. Hand Book of Thin Film Technology, L. I. Maissel and R. Glang Mc Graw Hill, 1969
3. Thin Film Processes. J. L. Vossen and W. Kem, (Academic Press, 1978)
4. The Material Science of Thin Films, M. Ohring (Academic Press, 1972)
5. Chemical Solution Deposition of semiconductor Films, Gary Hodes, Marcel Dekker Inc
6. Thin Film Deposition Using Spray Pyrolysis, J. Electroceramics, 14 (2005) 103-111
7. Handbook of semiconductor electrodeposition, R.K.Pandey, S.N.Sahu, S.Chandra
8. Spin Coating for rectangular substrates, A Thesis written by G. A. Luurtesema, University of California, Berkeley, 1997

PHY-526 RESEARCH METHODOLOGY

Foundation research, problem identification and formulation, concept and importance of research, Qualitative and quantitative research, data generation and interpretation, technical report and paper writing, Ethical issues related to publishing and plagiarism, Bibliography management. Managerial skills, Industry institution visits and interaction.

PHY-527: PHYSICS LABORATORY-2

List of Experiments:

1. To calculate the frequency of oscillations of RC phase shift oscillator
2. Study of RC Coupled CE amplifier – Two stages with feedback – Frequency response and voltage gain
3. Study of Push-pull amplifier using complementary – symmetry transistors power gain and frequency response.
4. Study of Active filters – low pass and high pass-first and second order frequency response and roll off rate.
5. Study of gain of Inverting/ Non-inverting amplifier and also study the frequency response characteristics and find out the bandwidth..
6. Study of frequency response characteristics of differentiator/ integrator.
7. Study of frequency response characteristics of Clipper Clamper circuit.
8. Verification of truth table of OR, AND and NOT gates.
9. To determine the frequency and wavelength in a rectangular waveguide working in TE10 mode
10. To study the drain, transfer; drain resistance, amplification factor, and Trans conductance characteristics of an FET.

PHY-528 SEMINAR-2

THIRD SEMESTER

PHY-611 – DIGITAL ELECTRONICS

Number Systems, Codes (Grey code, ASCII code and BCD code), Logic gates, Half& full adder and subtractor, RTL,DTL, TTL and ECL Logic circuit, Karnaugh (K-) Map, Pairs, Quads and Octets, RS, JK, D, T, JK M/S Flip flops, Race problem, Preset and Clear inputs. Pin out Diagrams, Truth Tables and Working of Decoders: 1-of-4(IC 74AS139) and 1-of-16 (IC 74154), BCD to Decimal Decoder(IC 7445), BCD to Seven Segment Decoder Driver(IC 7446A, 7448), Encoders: Decimal to BCD Encoder (IC 74147), Regulated Power Supply (IC-555, IC-723), Multiplexers: 16-to-1(IC 74150) and Implementation of Boolean Functions, Demultiplexer: 1-of-16 Demultiplexer/ Decoder(IC 74154). Weighted Resistor D/A Converter, Ladder Network D/A Converter, D/A Converter Specifications-Resolution, Accuracy, Linearity, Settling Time, Temperature Sensitivity A/D Conversion, Quantization and Encoding, Parallel-comparator A/D Convertor, Successive. Approximation A/D Converter, Counter method, Single and Dual Slope A/D Converter, Specifications of A/D converters

Recommended Books:

1. Integrated Electronics, Millman and Halkias
2. Digital Principle and Applications, A P Malvino and D P Leach
3. Digital Circuit and Design, S. Salivahanan and S. Arivazhagan

PHY-612 - ATOMIC & MOLECULAR SPECTROSCOPY

Vector model of atoms, term for equivalent and non-equivalent electron atoms, Hyperfine structure and width of spectral line, Spectra of alkali metals, Helium Atom Normal and anomalous Zeeman Effect, Paschen –Back effect, Stark effect, line broadening mechanism, rotation and vibrational spectra of molecules. Electronic spectra of molecules, Frank-Condon Principle, dissociation energy, rotational fine structure of electronic vibration transitions, Raman spectra Characterization techniques: NMR spectroscopy, ESR spectroscopy.

Lasers, Theory of optical resonant cavity, Q- switching and mode locking in Lasers, different types of Lasers.

Recommended Books:

1. Atomic Spectra,H.D.White , Tata McGraw Hill Publication.
2. Molecular structure & spectroscopy, G.Aruldhas;
3. Fundamentals of molecular spectroscopy, Colin N.Banwell & Elaine M.McCash,
4. Quantum Physics of atoms, molecules, solids nuclei & particles, Robert Eisberg, Robert Resnick, Second edition, John Wiely & sons(Asia) Ltd.(1985)
5. Physics of atoms and molecules, Bransden, Joachim, Longman publishing group

PHY-613 - NUCLEAR & PARTICLE PHYSICS

Basic nuclear properties: size, shape and charge distribution, spin and parity, binding energy, semi empirical formula, liquid drop model. Nature of nuclear force, form of nucleon-nucleon potential, Deuteron problem. Evidence of Shell structure, single particle shell model, its validity and limitations, Rotational spectra, elementary ideas of alpha, beta and gamma decays and their selection rules, fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Classification of fundamental forces , Elementary Particles and their Quantum numbers, Gellmann-Nishijima formula, Quark model, baryons and mesons, C, P, T invariance, Application of symmetry arguments to particle reactions, Parity non-conservation in weak interaction, Relativistic kinematics.

Recommended Books :

1. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988
2. Atomic and Nuclear Physics, S.N.Ghoshal , S.Chand publication
3. Introduction to high Energy Physics, P.H. Perkins, Addison-Wesley, London, 1982.

4. Introduction to Elementary Particles, D. Griffiths, Harper and Row, New York, 1987.
5. Introductory nuclear physics, Y.R. Waghmare, Oxford – IBH, Bombay, 1981.
6. Nuclear Physics, Kapaln, 2nd addition, Narosa, Madras, 1989.
7. Introduction to Nuclear Physics, F.A. Enge, Addison-Wesley, 1975

PHY-614 - MATERIALS SCIENCE

Introduction to materials. The phase rule, single component system, Binary Phase diagrams Microstructural changes during cooling, Lever Rule, Some typical phase diagrams, Time scale for phase changes, nucleation and growth, nucleation kinetics, growth kinetics and overall kinetics, Applications, Solidification and crystallization, the glass transition.

Fick's laws and their solutions, the Kirkendall effect, mechanisms of diffusion. Types of polarization, complex dielectric constant, polar and non-polar materials, Dielectric breakdown, piezoelectricity, ferroelectricity, electroceramics, multilayer capacitors.

Magnetic parameters, classification of magnetic materials, Ferromagnetic materials, ferrites, Applications of magnetic materials, Multiferroics

Recommended Books:

1. Materials Science and engineering: a first course, V. Raghavan fifth Edition (Prentice-Hall of India) 2004.
2. Materials Science and Engineering – An Introduction, W.D. Callister Jr. (John Wiley & Sons,) 1991.
3. Materials Science, J. C. Anderson, K. D. Leaver, R.D. Rawlings and J.M. Alexander, 4th Edition, Chapman & Hall (1994).
4. Electrical Properties of Materials , seventh Edition l.Solymar and D. Walsh (Oxford Univ.Press Indian Edition) 2006
5. Essentials of Materials Science and Engineering, Askeland, Pradeep Phule, Thomson learning (India Edition)
6. Principles of Materials Science and Engineering, William Smith, McGraw-Hill Publication

PHY-615 - CHARACTERIZATION TECHNIQUES

Generation of X-rays, Moseley's law, Absorption of X-rays, Absorption edge, structure factor, Powder method, Rotation method, Filter, detectors and counters. X-ray characterization of single crystal, polycrystalline, thin films, super-lattices and nanomaterials. Determination of crystal structure, lattice parameter and strain (Tensile and compressive), XRF Basics electron diffraction. Working principles and construction of Scanning electron microscope, electron gun, field emission, resolution, types of scans: line scan and area scan. Basics of EDS, Sample preparation, Factors influencing image. Working principles and construction of transmission electron microscope, analysis of image. Principles and working of DTA, DSC, TGA and Dialtometry. Basics UV- Visible Spectroscopy, Photoluminiscence, FTIR and Raman Spectroscopy. Resistivity/Sheet Resistance of Semiconductors, Basics of linear four probe and Van der Pauw methods, I- V characteristics of metal – semiconductor, Thermoelectric measurements.

Recommended Books:

1. Elements of X- ray diffraction, B.D. Cullity, Addison- Wesely Publishing company, 1956.
2. Transmission electron microscopy: A text book of Materials Science, David Williams and C.B.Carter, 2009.
3. Scanning Electron Microscopy: Physics of Image Formation and Microanalysis: Ludwig Reimer, 1998.
4. Introduction to Thermal Analysis Techniques and Applications, Brown and M Ewert, 2001.
5. Electrical characterization of semiconductor materials and devices, M. Deen and F. Pascal, 2007.
6. Electrical Properties of Materials, D. Walsh and L. Solymar, 7th Edition, 2007.

PHY-616 PHYSICS LABORATORY-3

List of Experiments:

1. X-Ray Diffraction – Determination of lattice parameters of a crystalline solid
2. UV-Vis Spectrophotometer – Determination of absorption coefficient and bandgap
3. Measurement of ac and dc Electrical Conductivity of bulk and thin film
4. Measurement of e/m using Geiger Muller Counter
5. Dielectric Constant and Curie Temperature of Ferroelectric Ceramics
6. Study of Electron Spin Resonance spectrum of paramagnetic substance
7. Study of Nuclear Magnetic Resonance spectrum of magnetic substance
8. Study the Magnetoresistance behaviour of deposited sample
9. Regulated Power Supply using IC-555, IC-723
10. Filp flops a. SR flip-flop b. Clocked SR flip-flop c. JK flip-flop d. Master-slave flip- flop e. D- flip-flop f. T- flip-flop
11. Design of full adder/ full substracter.

PHY-617 SEMINAR-3

List of Electives

List of Elective (I)

PHY-531 Nanoelectronics	PHY-532 Optoelectronics
PHY-533 Photonic Materials	PHY-534 Advanced Topics in Physics
PHY-535 Molecular Structures	PHY-536 Computational Methods
PHY-537 Semiconductor devices	PHY-538 Amorphous Materials
PHY-539 Low Temperature Behavior of Materials	PHY-540 Nano Fluids and Surfaces
PHY-541 Quantum Optics	PHY-542 Experimental Nuclear and Particle Physics
PHY-543 Renewable Energy Technologies	PHY-544 Soft Matter Physics
PHY-545 Computational Physics	
Elective (II)	
PHY-546 Laser Technology	PHY-547 Molecular Electronics and Biomolecules
PHY-548 Solar Photovoltaic Technology	PHY-549 Optical Sensors
PHY-550 Advanced Electromagnetic Theory	PHY-551 Astronomy and Astrophysics
Elective (III)	
PHY-631 Advanced Magnetic Materials	PHY-632 General Theory of Relativity
PHY-633 Nonlinear Dynamics	PHY-634 Physics of Quantum Devices
PHY-635 Quantum Field Theory	

PHY-531 NANO ELECTRONICS

Spintronic: Spin Injection, GMR & TMR, Spin valve effect, spin valves and MRAM devices
Solid state devices: quantum dots, quantum wires, , Photonic bandgap materials, nanoscale photonic devices, Special phenomena in 2D and 3D nano structures.
The basic properties of liquid crystals and their display and non-display applications at the Nanoscale.
REFERENCES
1. Nano Electronics and Information Technology: Rainer Waser

PHY-532 OPTO ELECTRONICS

Principle of light guidance in optical wave guides. Fabrication and types of Optical fibres, rays and modes, losses in optical fibres and applications.Optical fibre interconnectors, concept of optical waveguides.Nonlinear optics.Second harmonic generation.Birefringence.Electrooptics (Kerr effect, Pockels effect, Faraday effect), Magneto-optics. Optical Integrated Circuits, Light Emitting Diode, Solar Cells.
REFRENCES :

1. Optical Electronics : A. Ghatak & K. Thyagarajan
2. Quantum Electronics : A. Yariv
3. An Introduction to Optical Fibers :A.H. Cherin

PHY-533 PHOTONIC MATERIALS

Atomic scale structure of materials. Magnetism: moments, environments and interactions, order and magnetic structure. Scattering theory: Excitations of crystalline materials, magnetic excitations, sources of X-rays and neutrons. Interaction of matter with photon: L.A.S.E.R. Chaotic light and coherence. Laser spectroscopy.Multiphoton processes. Light scattering by atoms.Electron scattering by atoms.Coherence and cavity effects in atoms. Trapping and cooling.
REFRENCES :

1. Light &Matter : Yehuda Band
2. NanoPhotonics :Paras N. Prasad
3. Nanostructured Films &Coatings : Gang Moog Chow

PHY-534 ADVANCED TOPICS IN PHYSICS

Electrets physics: various types of electrets, methods of preparation, various studies on electrets, uses of electrets. Luminescence: various kinds of luminescence, theory of luminescence, paramagnetic behavior, activators and co-activators, Clustering, colorcenters. Preparation techniques and application, Amorphous semiconductor materials, Preparation techniques in bulk form & in thin form. Rocking and quenching of materials. Characterization of amorphous materials.

REFRENCES :

1. Amorphous Materials : S.R. Elliot
2. Physics of Amorphous Solids : Richard Xylen

PHY-535 MOLECULAR STRUCTURES

Molecular structure: Born-Oppenheimer approximation; Electronic structure ionic and covalent bonding, H2, H2+; Vibrational and rotational structure.

Molecular spectra: Microwave, infrared and optical spectra of molecules; selection rules, experimental set-ups and examples; Raman spectroscopy. ortho-para states.

Molecular processes: Collisions with electrons and heavy particles; Experimental techniques.

REFERENCES

1. Physics of Molecules : Wolf Gang Demtroder
2. Hand Book of Molecular Physics & Quantum Chemistry :Stephen Wilson

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PHY-536 COMPUTAIONAL METHODS

Differential equation, special functions Bessel's, Hermite's.Laguerre polynomials. Eigen value, Eigen functions. Perturbation theory.Numerical analysis.Idea of visual basic, c++ and c-sharp.

REFERENCES

1. MatehmaticalPhysics : S.S. Rajput
2. Visual Basic & C ++ :Shyaum Series

PHY-537 SEMICONDUCTOR DEVICES

Semi conducting materials, p-n junction, space charge and electric field distribution at junctions, forward & reversed biased condition, minority & majority carrier currents, Zener and avalanche break downs, Schottky barrier, Shockley diode & silicon control rectifier, Zener diodes, tunnel diodes, photo diodes. Two port network analysis, H,Y & Z parameters, BJT in CE configuration, Constants of CB & CE amplifier, FET, MOSFET, Equivalent circuit of FET. Source amplifier.Idea of transistor biasing and amplifiers.

REFRENCES :

1. Electronic Devices &Circuits :Millman&Halkins
2. Solid State Electronic Devices : Ben G Streetman
3. Microwave Principle : W.J. Reich
4. Electronics : S. Bhadran

PHY-538 AMORPHOUS MATERIALS

Physics of Amorphous Material: preparation of amorphous materials, metallic glass, thermal evaporation techniques such as sputtering, CVD Techniques, quenching. Glasses, theory for glass transition, glass transition temperature. Chalcogenide glasses. Structure of disordered materials. Experimental techniques, electronic density of states. Localization phenomenon, transport , optical and dielectric properties.

REFRENCES :

1. Amorphous Materials : S.R. Elliot
2. Physics of Amorphous Solids : Richard Xylen
3. Electronic process in Non- Crystalline Materials : Davis & Mott.
4. Disordered Material an Introduction : Paolo M. Ossi

PHY-539 LOW TEMPERATURE BEHAVIOR OF MATERIALS

Thermodynamics & liquefaction of gases, Cryostat design , Transport Phenomenon, Fermi surface, Magnetism. Conductivity of solids, Technique of measurement, Paramagnetic & Nuclear adiabatic demagnetization.Superconductivity.fundamental phenomena of super conductivity, Meissner effect, London equation, Type I and Type II superconductors, qualitative idea of Cooper pairing and BCS theory. Ginsburg-Landau theory, coherence length, Green's functions of electrons and phonons, isotope effect, The BCS Hamiltonian, the gap parameter, Superconductor in a field, flux quantization effect, SQUIDS, High-Tc materials.

REFRENCES

1. Superconductivity :WernerBuckel& Reinhold
2. Thermodynamics :M.S.Yadav
3. Treatise on Heat :V.K. Shrivastava

PHY-540 NANO FLUIDS AND SURFACES

Nanofluidics and surfaces: liquid structure near solid-liquid interfaces (simple liquids; layering electrolytes: Poisson-Boltzmann equation; Debye Hückel approx.) Hydrodynamic boundary condition: slip vs. non-slip, electro kinetic effects (electrophoresis, electro osmotic effect, electro viscous effect), surface reconstruction, dangling bonds and surface states

REFRENCES :

1. Nano- The Next Revolution : Mohan Sunder Rajan (NBTI)
2. Introduction To Nano Technology : Charles P. Pode (Springer)
3. Quantum Dot Heterostructures :D.Bimberg, M.Grundman

PHY-541 QUANTUM OPTICS

Quntum theory of light: field quantization, lamb shift, quantum beats Quantum theory of coherence: photon detection and quantum coherence functions, first order coherence and Young's double source experiment, second order coherence, physics behind Hanburry-Brown and Twiss experiment, interference of two photons, photon antibunching, Poissonian and sub-Poissonian light, photon counting and photon statistics. Classical and non classical light: Coherent, Fock and squeezed states of light, coherent state as an eigen state of annihilation operator and as a displaced harmonic oscillator state, properties of coherent state, physics of squeezed states, squeezed state and uncertainty relation, squeezed coherent state, quadrature variance, multimode squeezing, squeezing via nonlinear optical processes, applications of squeezed states for quantum noise reduction beyond standard short noise limit. EPR paradox, hidden variable, Bell's theorem and quantum cryptography, Quantum nondemolition (QND) measurement: conditions for QND, QND measurement of photon number by optical Kerr effect and by dispersive atom-field coupling, QND measurement in optical parametric processes Quantum optical tests of complimentarity: a micro maser with path detector, quantum eraser and quantum optical Ramsey fringes.

REFRENCES

1. Quantum Optics, M.O. Scully and M.S. Zubairy, Cambridge University Press.
2. Elements of quantum optics, P. Meyster and M. Sargent, Springer VerlaG.
3. Quantum Optics, D. F. Walls and G. J. Miburn, Springer Verlag
4. Quantum Optics: An Introduction, Mark Fox, Oxford Master Series in Physics.
5. Introductory Quantum Optics, C.C. Gerry and P.L. Knight, Cambridge University Press.

PHY-542 EXPERIMENTAL NUCLEAR AND PARTICLE PHYSICS

Passage of radiation through matter : Interaction of heavy charged particles, neutrons, gamma rays and relativistic particles. Radiation Detection : Detection mechanism, characteristics of detectors. Detectors in Nuclear Physics : gas detectors, scintillation counters, solid state detectors. Detectors in Particle Physics : Drift Chambers, spark chambers, bubble chambers, time projection chambers.

Accelerators : Van de Graff, LINAC, Cyclotrons, Synchrotons, Colliders. Pulse Processing : Timing and Energy measurements, data acquisition and analysis. CAMAC and NIM Standards.

REFRENCES

1. W. R. Leo, Techniques for Nuclear and Particle Physics Experiments, Springer Verlag, 1994.
2. M. S. Livingston and J.P. Blewett, Particle Accelerators, McGraw-Hill, New York, 1990.
3. Glenn F. Knoll, Radiation Detection and Measurements, John Wiley and Sons, 1989.

PHY-543 RENEWABLE ENERGY TECHNOLOGIES

Introduction to world energy scenario, Renewable energy resources, Radiation, Solar Geometry, radiation models; Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures, introduction to thermal systems (flat plate collector), solar architecture, solar still, air heater, panel systems; Photovoltaic; Introduction to semiconductor physics, doping, p-n junction, Solar cell and its I-V characteristics, PV systems components, design of a solar PV systems. Biomass, Biomass resources, wood composition, pyrolysis, gasifiers, biogas, biodiesel, ethanol; Wind, Introduction, types of wind machines, Cpl curve &betz limits, wind recourse analysis; Systems, stand alone, grid connected, hybrid, system design; Hydro systems, Hydro resources, types of hydro turbine, small hydro systems; Other systems, Geothermal, wave energy, ocean energy.

REFRENCES

1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, IIEd
2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, IIEd, John Wiley
3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering
4. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York.
5. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London.

PHY-544 SOFT MATTER PHYSICS

Basic phenomenology, Liquid crystals, polymers, membranes, surfactants, colloids, gels. Phase transitions, Landau theory, order parameter (conserved and non-conserved), nucleation and spinodal decomposition. Nematic liquid crystals, Mean field theory for isotropicnematic transition, Landau-deGennes theory, Effect of spatial gradients, Onsager's theory for isotropicnematic transition. Polymers, random walk, gaussian chain, excluded volume, Flory theory, Deforming polymer chains, Temperature effects, Field theories and RG approach, solutions, melts, dynamics – Rouse and Zimm. Membranes and interfaces – Free energy and shape transitions. Flow and deformation of soft matter, mechanical properties and molecular models, colloids – rheology and dimensional analysis, viscoelasticity and response functions. Optional: Elastic soft matter, Fundamentals, Kuhn theory of rubber elasticity, polymer gels. Physics of jamming, Supercooled liquids, and search for a transition, Jamming phase diagram for glasses, foams, and granular matter.

REFRENCES

1. M. Doi, Soft Matter Physics, Oxford University Press,
2. P.M. Chaikin& T.C. Lubensky, Principles of Condensed Matter Physics
3. The Physics of Liquid Crystals, Oxford University Press,
4. M. Doi& S.F. Edwards, The Theory of Polymer Dynamics, Oxford University Press,
5. P.G. de Gennes, Scaling Concepts in Polymer Physics, Cornell University Press,
6. W.B. Russel, D.A. Saville, W.R. Schowalter, Colloidal Dispersions, Cambridge University Press, 1989

PHY- 545 COMPUTATIONAL PHYSICS

Introduction and Python Tools, Software Basics and Errors/Uncertainties, Monte Carlo Techniques, Numerical Differentiation and Integration, Matrix Computation, Searching and Fitting, Differential Equations, ODE Applications, High performance Computing, Fourier Transforms, Nonlinear Dynamics, Embedded computing: Arduino, Low-level computing: FPGA.

Introduction to LABVIEW Introduction to LABVIEW tools palette, controls & functions palette, data types, conversion – front panel, block diagram construction, parallel data flow, create indicators/controls/constants math operations, booleans, arrays, case structures, sequences – for loops, while loops – I/O reading and writing to files, paths, graphing, timed loops, signal generation/processing, waveform types, connecting to hardware, DAQ.

REFRENCES :

1. Computational Physics , Koonin Steven E., Taylor & Francis Inc, 1998
2. Computational Methods for Physics, Debasish Lohar

Elective (II)

PHY-546 LASER TECHNOLOGY

Interaction of radiation with matter, absorption and stimulated emission, absorption and gain coefficient, spontaneous emission, homogeneous and inhomogeneous broadening, Doppler width. basic principles of lasers , properties of laser beams, population inversion in three and four level lasers, resonance frequencies, modifications of the laser output, single mode operation, Q- switching.

laser materials and types of lasers, solid state lasers, characteristics of dye lasers, semiconductor lasers. Laser applications. Material processing metrology and Remote sensing. Laser induced controlled thermonuclear fusion. Laser applications in spectroscopy.

REFRENCES :

1. Introduction to Laser Physics : K. Shimoda
2. Laser Spectroscopy A Basic Concepts and Instrumentation : W. Demtr der
3. Atomic and Laser Spectroscopy : A. Corney

PHY-547 MOLECULAR ELECTRONICS AND BIOMOLECULES

Organic semiconductors, Organic molecules as switches, motor-molecules and biomimetic components .conducting polymers, light emitting polymers, The self-assembly of complex organic molecules, Molecular connections and the integration of molecular components into functional devices**,** Contact issues, Structure of biomolecules; Biotechnology, recombinant DNA technology, molecular biology. Structural and functional principles of bionanomachines, Interfacing bio with non-bio materials, Porous silicon

REFRENCES

1. Molecular Electronics : T. Helgakar
2. Semiconductor Quantum Dots :MasumotaTakaga

PHY-548 SOLAR PHOTOVOLTAIC TECHNOLOGY

The Sun Light: World Energy scenario – Advantages and challenges of solar energy harnessing - Source of radiation – solar constant– solar intensity at earth's surface – direct and diffuse radiation – apparent motion of sun-solar insolation data –solar charts – measurement of diffuse, global and direct solar radiation: pyrheliometer, pyranometer, pyregeometer, net pyradiometer-sunshine recorder.

Semiconductors for Solar Cell: *Silicon:* preparation of metallurgical, electronic and solar grade silicon -*Production of single crystal silicon:* Czokralski (CZ) and Float Zone (FZ) method– imperfections – carrier doping and lifetime – Germanium –compound semiconductors – growth & characterization– amorphous materials – transparent conducting oxides – anti-reflection principles and coatings – organic materials.

Characterization and Analysis: Device isolation & analysis – ideal cell under illumination – solar cell parametersshort circuit current, open circuit voltage, fill factor, efficiency; optical losses, electrical losses, surface recombination velocity, quantum efficiency – measurements of solar cell parameters; I-V curve& L-I-V characteristics, internal quantum yield measurements – effects of series and parallel resistance and temperature.

REFRENCES :

1. Larry D. Partain (ed.), Solar Cells and their Applications, John Wiley and Sons, New York .
2. J. Nelson, The Physics of Solar Cells, Imperial College Press.
3. R. H. Bube, Photovoltaic Materials, , Imperial College Press.

PHY-549 OPTICAL SENSORS

Characteristics of Light**:** Introduction – plane polarized wave – propagation of a light through a quarter wave plate – reflections at a plane interface – Brewster angle – total internal reflection-interference-refraction – concept of coherence – diffraction of Gaussian beam.

Fiber optic fundamentals: Numerical aperture – attenuation in optical fibers – pulsed dispersion in step index optical fiber – loss mechanisms – absorptive loss – radiative loss- principle of optical waveguides – characteristics of fibers – pulsed dispersion in planar optical waveguide – modes in planar waveguides – TE,TM modes – propagation characteristics of step index and graded index optical fibers. Fiber optic Sensors: Intensity-modulated sensors – transmission concept – reflective concept – microbending concept-intrinsic concepts – transmission and reflection with other optical effects – source of error and compensation schemes – phase modulation mechanisms in optical fibers-optical fiber interferometers – optical fiber phase sensors for mechanical variables – the optical fibersagnac interferometer – optical fiberinterferometric sensors.

Frequency modulation in optical fiber sensors: Introduction – optical fiber Doppler system – development of the basic concepts. polarization modulation in fiber sensors- introduction – optical activity – Faraday rotation – electro-gyration – electro-optic effect- kerr effect – photoelastic effect – polarization modulation sensors.

REFRENCES

1. D.A. Krohn, Fiber Optic Sensors: Fundamentals and Applications, 2nd edition, Instrument Society of America.
2. B. Culshaw, Optical Fiber Sensing and Signal Processing, Peter Peregrinus Ltd.
3. Djafar K. Mynbaev and Lowell L. Scheiner, Fiber-Optic Communications Technology, Pearson Education Asia.

PHY-550 ADVANCED ELECTROMAGNETIC THEORY

Physics of Plasmas: Electrical neutrality in plasma – particle motion in electric field – Larmor radius =particle in crossed electric and magnetic fields – hydromagnetic equation – plasma oscillations and waves. Optical Dispersion:Drude-Lorentz harmonic oscillator model – resonance absorption by bounded charges – normal and anomalous dispersion – Cauchy relation – plasma frequency – skin depth – dielectric relaxation. Potentials and Fields**:** Maxwell's equation – scalar and vector potentials – gauge invariance – Coulomb gauge and Lorentz gauge – solution of inhomogeneous wave equation– retarded potentials. Radiating System: Radiation from an arbitrary source – special cases: oscillating dipole, accelerated point charge – radiation damping – Thomson cross section.

Special Theory of Relativity: Lorentz transformation and Einstein's postulates – geometry of space-time – Lorentz transformation as orthogonal transformation – covariant form of electromagnetic equations – transformation laws for electromagnetic fields – field of a moving point charge.

REFRENCES

1. J. D. Jackson, Classical Electrodynamics, 2nd edition, John Wiley &Sons .
2. E. C. Jordon and K. G. Balmain, Electromagnetic Waves and Radiating Systems, 2nd edition, Prentice Hall of India.
3. L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields, 4th edition, Elsevier.

PHY-551 ASTRONOMY AND ASTROPHYSICS

The solar system: Celestial mechanics, Elliptical orbits, Kepler's laws, Virial theorem; Earth-moon system, Tidal forces, Precession of earth's axis, Interiors, Atmospheres; Planets, Terrestrial planets, Jovian planets; Observational tools: Blackbody radiation, Specific intensity and flux density; Stellar parallax, Magnitudes, Colour index; Basic optics and optical telescopes; Radio telescopes; Infrared, ultraviolet and X-ray telescopes; Coordinates and time. Star: Classification, Formation of spectral lines, Hertzsprung-Russell diagram, Atmosphere, Description of the radiation field, Opacities, Radiative transfer. Structure of spectral lines. Sun: Interior, Atmosphere, Solar activity, Helioseismology. Stellar interiors: Hydrostatic equilibrium, Energy transport and convection, Model building, Main sequence. Binary stars: Classification, Mass determination, Accretion disks in close binaries, White dwarfs, neutron stars, and black holes in binaries. Star formation: Interstellar dust and gas, Formation of protostars, Pre-main sequence evolution. Post main sequence evolution: Evolution on the main sequence, Late stages of evolution, Fate of massive stars, supernovae. Degenerate remnants of stars: White dwarfs, Chandrasekhar limit, Neutron stars, Pulsars

REFRENCES

1. Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
2. Introductory Astronomy & Astrophysics, M. Zeilik and S. A. Gregory, 4th Edition, Saunders College Publishing.
3. Theoretical Astrophysics, Vol II:Stars and Stellar Systems, T. Padmanabhan, Cambridge University Press.
4. The Physical Universe: An Introduction to Astronomy, F. Shu, Mill Valley : University Science Books.

Elective (III)

PHY-631 ADVANCED MAGNETIC MATERIALS

Basics of magnetism: Para and diamagnetism,Metals and rd insulators, spin and orbital contributions, paramagnetism of 3 and 4 f ions. Various forms of interaction: direct exchange, super-exchange, double exchange, RKKY but also dipolar. Magnetic ordering: ferro, antiferro, Ferrimagnetism: mean field theory, excitations from the ground state, spin waves / magnons, Bloch law. Different form of magnetic energy: dipole/ demagnetizing/ magnetostatic, magneto-crystalline anisotropy, shape anisotropy, domains and domain wall, super paramagnetism. Magnetoresistance: AMR, GMR, CMR, TMR in multilayers/thin films, spin dependent scattering/conductions, basics of magnetic recording, spin valves, spin polarised transport/ spintronic.

REFRENCES

1. Michael Ziese, Martin J. Thornton (Ed), Spin Electronics, Springer.
2. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press.
3. Physics of Ferromagnetism, S. Chikazumi, Oxford University Press.
4. Introduction to Spintronics, S. Bandyopadhya and M. Cahy, CRC press.
5. Spin dependent transport in magnetic nanostructures, edited by S.Maekawa and T. Shinjo 620.168.3:669.018.5 spi
6. Magnetic hetereostructures, advances and perspectives in spin structuresand transport edited by H. Zabel, A.D. Bader 538.22 Mag

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PHY-632 GENERAL THEORY OF RELATIVITY

Covariance of Physical Laws, Special Relativity, The Equivalence Principle, Space and Space-time Curvature, Tensors in Curved Space-time, The Geodesic equation, geodesic Deviation Equation, Curvature and Einstein Field equations, Geometry Outside of a Spherical Star, Tests of General Relativity, Gravitational Radiation, Black Holes, Cosmology .

REFRENCES

1. Gravity- An introduction to Einstein's general relativity – James B. Hartle
2. Gravitation and Cosmology - S. Weinberg
3. Space-time and Geometry: An Introduction to General Relativity - Sean Carroll, Pearson.
1. Introduction to General Relativity - J. V. Narlikar, Cambridge.
2. Classical Theory of Fields - L. D. Landau and E. M. Lifshitz, Butterworth-Heinemann.

PHY-633 NONLINEAR DYNAMICS

Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincar`e section and iterative maps. One dimensional non--invertible maps, simple and strange attractors, period doubling and universality, intermittency, invariant measure, Lyapunov exponents. Higher dimensional systems, Henon map, Lorenz equations. Fractal geometry and examples of simple and fat fractals, concept of dimensions. Hamiltonian systems, integrability, Liouville`s theorem, action and angle variables, introduction to perturbation techniques, KAM theorem, area preserving maps, chaos and stochasticity.

REFRENCES

1. I. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press, 1982.
2. Steven H. Strogatz, Nonlinear Dynamics and Chaos, Addison Weseley,1994.
3. Edward Ott, Chaos in Dynamical Systems, Cambridge University Press,1993.
4. E. A. Jackson, Perspectives of Nonlinear Dynamics, Vol. 1&2, Cambridge University Press, 1989.

PHY-634 PHYSICS OF QUANTUM DEVICES

Introduction: Length and timescales, quantum and semi-classical regimes. Basics of Semiconductors: bandstructure, effective mass, carrier statistics Junctions: formation of p-njunctions, I-V characteristics, tunnel diodes, pi-n diodes, p-i-n-i-p.....superlattice structures, semiconductor

heterostructures, growth issues, bandalignment, interfacial 2DEG formation, self-consistent Schrodinger Eq. and PoissonEq. Solution. DOS in 2D, 1D and 0D Transport: Diffusion equations, Boltzmanntransport equations, scattering mechanisms, calculation of mobility, carrierdynamics under illumination condition, Generation and recombination of carriers rate equations, different recombination processes MOSFETs: MIS structures, C-Vcharacteristics, MOSFET Band diagram, operation regimes, surface charge density,surface potential, charge and field distribution, principle of operation of MOSFETs, Current-Voltage characteristics. Single Electron Transistors: SET structure, Equivalent circuit, coulomb blocked effect, coulombdiamond, Current-Voltage characteristics. Optoelectronic devices: Semiconductorunder EM field, absorption, reflection, refraction, transmission, basic operationprinciple of Solar cell, Quantum well LEDs and Laser diodes (LDs).

REFRENCES

1. Physics of semiconductor devices, Michael Shur (Prentice-Hall)
2. Quantum Heterostructures: Microelectronics and Optoelectronics, V. V. Mitin, V. A. Kochelap and M. A. Stroscio (Cambridge)
3. Physics of Low dimensional Semiconductors: An Introduction. J.H. Davies
4. Electron Transport in Mesoscopic Systems: SupriyoDutta.
5. Quantum Heterostructures, Vladimir Mitin, ViacheslavKochelap, Michael A. Stroscio
6. Nanotechnology (AIP Press: edited by Gregory Timp)

PHY-635 QUANTUM FIELD THEORY

Symmetries and conservation laws: Rotation, Translation, Lorentz and Poincare symmetries. Green's functions. Klein Gordon equation: canonical quantisation, time ordered product, Wick's theorem ,Fock space construction, complex scalar field. Dirac equation: plane wave solution, continuity equations, normalisation, gamma matrices, helicity, chirality. Free propogatorcalculations.Maxwell Field: its quantisation, Lorentz gauge, Coulomb Gauge, Gupta-Bleuler formalism, Massless and massive vector and spinor fields.

Parity, charge conjugation, time reversal symmetries, CPT theorem.Spontaneous breakdown of symmetries and Goldstone theorem, Higgs phenomenon; S-matrix calculation Electron-electron, electron-positron scattering, Renormalisation.

REFRENCES

1. C. Itzykson and J. B. Zuber, Quantum Field Theory, McGraw Hill.
2. P. Ramond, Field Theory: A Modern Primer, Addison-Wesley.
3. S. WeinBerg,The Quantum Theory of Fields: Volume 1, Foundations, Cambridge University Press. 4. M. E. Peskin, D. V. Schroeder, An Introduction to Quantum Field Theory, Westview Press.
4. A. Lahiri, P. B. Paul, A First Book of Quantum Field Theory, Narosa Publications.
5. L. H. Ryder, Quantum Field Theory, Cambridge University Press.
6. A. Das, Lectures on Quantum Field Theory, World Scientific.