Department of Physics

Syllabus of M. Phil Physics Programme

With effect from 2016 admissions

I SEMESTER

Course Code	Subject	Core/ Elective	Credit	In semester Evaluation	End Semester Evaluation	Total Marks
PHY 4101	Physics of Materials and Theoretical Physics	C	5	60	40	100
PHY 4102	Literature Review & Seminar	C	3	100	-	100
PHY 4103	Research Methodology and Quantitative Techniques	C	5	60	40	100
PHY 4104	Advanced Electronics & Computer Programming	E	5	60	40	100
PHY 4105	Photonics	E	5	60	40	100
PHY 4106	Thin Film Technology	E	5	60	40	100
PHY 4107	Advanced Vibrational Spectroscopy	E	5	60	40	100
PHY 4108	Advanced Characterisation Techniques	E	5	60	40	100
PHY 4109	Emerging Electronic and Optoelectronic Materials and Devices	E	5	60	40	100
PHY 4110	General Relativity and Astrophysics	E	5	60	40	100
PHY 4111	Astrophysics	E	5	60	40	100
PHY 4112	Quantum Field Theory	E	5	60	40	100
PHY 4113	Advanced Quantum Mechanics	E	5	60	40	100
	Total for I Semester		18			

II SEMESTER

Course Code	Subject	Core/ Elective	Credit	In semester Evaluation	End Semester Evaluation	Total Marks
PHY 4201	Project Evaluation and Viva Voce	C	18	100	300*	400
	Total for the Programme		36			

* Out of 300 marks, 200 shall be for the evaluation of dissertation and 100 shall be for Viva -Voce examination. Both evaluation shall be done by the internal and external examiners.

PHYSICS OF MATERIALS AND THEORETICAL PHYSICS
PHY 4101 (Core Course)

Module 1: Semiconducting materials: Carrier concentration in intrinsic and doped materials - Fermi level variation - carrier generation and recombination - photoconductivity - carrier lifetime - effect of traps and defects - carrier transport - mobility - diffusion and drift currents - variation of mobility with temperature and impurities. Contact problems - semiconductor semiconductor contact - junction capacitance - depletion layer formation - metal semiconductor contact - junction currents with and without illumination - junction biasing - PIN photodiode - light detector - LED - pn junction laser. semiconductor quantum dots - superlattice structure - variations in electrical and optical properties.

References: :

1. Smith, Introduction to Semiconductors, John Wiley (1962)
2. Warner & Grung, Semiconductor Device Electronics, Holt, Rinehart, and Winston, (1991)
3. S. M. Sze, Semiconductor Devices: Physics and Technology, 3rd Ed. Wiley, (2013)
4. Neamen, Semiconductor Physics And Devices, McGraw-Hill (2011)

Module 2: Superconducting and Magnetic materials: Superconductivity - effect of magnetic field and electric current - type I and type II superconductors - vortex state - Josephson effect. Ginzburg - Landau theory - order parameter - Ginzburg-Landau equation - zero field case - fluxoid quantisation - field penetration - quantum vortex. BCS Theory - Cooper pairs - BCS order parameter - High Tc superconductors - YBCO compounds. Ferromagnetism – antiferromagnetism - ferrimagnetism - categories of magnetic ferrites – applications of ferrites.

References:

1. C. Kittel, Introduction to solid state Physics, 8th Edition. John Wiley (2004)
2. C. P. Poole, H. A. Farach and R. J.Creswick, Superconductivity, Elsevier (2014)
3. Michael Tinkham, Introduction To Superconductivity, Dover (2008)
4. J. W. Lynn, High temperature superconductivity, Springer Verlag (1990)
5. B. D. Cullity, C. D. Graham, Introduction to Magnetic Materials 2nd Ed., Wiley (2009)

Module 3: Group Theory: Groups - Definition and examples - Finite groups - nonabelian groups - permutation groups - mapping between groups. Subgroups - classes - cosets - conjugate and classes.

Representation theory - dipole moments - equivalent representation - reducible and irreducible representation - orthogonality theorem - characters - number of irreducible representations - character table - group nomenclature - product representations - physical applications. The symmetry group D2 and D3 - Basic ideas on U(1), SO(2) and SO(3).

References:

1. K. F. Riley M. P. Hobson and S. J. Bence, Mathematical Methods for Physics and Engineering, Cambridge University Press (2006)
2. Tai L. Chow, Mathematical Methods for Physicists, Cambridge University Press (2000)

Module 4: Second Quantization: Many body Schrödinger equation - symmetry postulate - solutions - symmetric and antisymmetric wavefunctions - Fock space. Second quantization of bosons - commutation relations - Fock space - field operators - representation of operators -Hamiltonian - Heisenberg operators. Second quantization of fermions - creation and annihilation operators - field operators.

Reference:

1. Y. V. Nazarov, J. Danon, Advanced Quantum Mechanics a Practical Guide, Cambridge University Press (2013).

RESEARCH METHODOLOGY AND QUANTITATIVE TECHNIQUES
PHY 4103 (Core Course)

Module : 1

Meaning of research – Objective of research – Motivation in research – Types of research – Research approaches – Research and Scientific method – Research process – Criteria of research – Important sources of informations – Information on organisation involved in physics related research-writing research proposal – writing scientific papers – searching for scientific information – quality of research parameters – citation, h-index, impact factor – information on physics related scientific journals- ethical issues- laboratory safety precautions

Module : 2

Open source software – Linux. Basic Information about open source software – the user interface challenge. Installations of Red Hat, Fedora, Ubuntu.

MATLAB – Arithmetic operations – elementary MATH Built-in functions. Defining scalar variables. Creating arrays – array addressing – mathematical operations with arrays – script files – two dimensional plots. Programming in MATLAB - plotting of graph with MATLAB, Polynomials, curve fitting and interpolation, plotting of data with origin, Igor

Module : 3

Errors classification and propagation – systematic errors – Random errors – error propagation. Combination of independent terms – Monte Carlo Methods – Probability distribution – properties of probability distributions – Binomial distribution – examples – Poisson distribution – Normal distribution – central limit theorem – Lognormal distribution – Lorentz distribution – Hazard function – exponential distribution – Population Statistics - chi-square distribution - student's distribution –F-distribution – Linear regression analysis- Method of least square-linear fitting.

Module : 4

Material analytical techniques : Structural analysis – XRD, electron diffraction – Imaging techniques – SEM, TEM, AFM & - Principal Compositional analysis – XPS, EDAX, ICP, SIMS –Optical Studies – Principle of Optical absorption – Band gap and defect level analysis – Photoluminescence – applications.

Reference books :

1. M. P. Marder, Research Methods for Science, Cambridge University Press, (2011).
2. C.R. Kothari, Research Methodology Methods and Techniques, Second Revised Edition, New Age International Limited Publishers, (2004).
3. H. J. C. Berendsen, A student guide to Data and Error Analysis, Cambridge University Press, (2011).

ADVANCED ELECTRONICS AND COMPUTER PROGRAMMING
PHY 4104 (Elective)

Module 1: Computer Programming: Computer fundamentals, Programming in FORTRAN, Constants and Variables, Logical and Arithmetic IF, Computed GO TO, DO Loops, Implied DO Loops, Subscripted variables, One Dimensional Arrays, Two Dimensional and multidimensional arrays, Matrix Algebra, Subprograms, Subroutine and Functions. Programming techniques – Merging and Sorting.

Text Book:
1. Seymour Lipschutz and Arthur Poe, Programming With Fortran- Schaum Series, Mc. Graw Hill (1978)

Module 2: Microprocessor and Microcontrollers: - Assembly language programming, Intel 8086, Architecture Instructions set, Programming 8086, Examples, Microprocessors with advanced architecture,286, 386, 486 Pentium Series, RISC and CISC Processors. Microcontrollers and Microcontroller Based Systems - Intel MCS51 Architecture, Instructions set, Applications of Microcontrollers

Text Books:
1. P. K. Sridhar and P. R Ghosh, Microprocessor for Scientists and Engineers from 0000 to 8085, Prentice Hall, New Delhi (1991)
2. Gaonkar R. S., Microprocessor Architecture – Programming and Application with 8085, Penram Publishers, 3rd Edition (1997)
3. Uhlenbeck J., The 8086/8088 family – Design and Interfacing, Prentice Hall, New Delhi

Module 3: Application of op-amps: Analog computers, Solutions of differential equations, Analog computation and simulation, waveform generation, sample and hold circuits, Unity gain buffers, Filters, Delay equalisers, Feedback control system, Servo controllers, Application of Feedback control systems, Simulation of Transfer Function, Time, Amplitude and Combined Amplitude and Time Scaling.

Text Books:
1. Milman and Halkias, Integrated Electronics, Mc. Graw Hill, (1983)
2. Rajaram, V., Analog Computation and Simulation. Prentice-Hall of India Pvt. Ltd,(2006).

Module 4: Digital Communication: - Fundamentals of digital communication - A/D conversion - sampling & quantization - Low pass sampling – Aliasing - Signal Reconstruction - Quantization - Uniform & non - uniform quantization - quantization noise - Logarithmic Companding of speech signal - PCM - TDM - Different modulation techniques. General ideas on cell phone, optical fibre communications & satellite communications

Text Books:
1. S. Haykin, Digital Communications, John Wiley, (2005)
2. George Kennedy and Bernard Davis, Electronic Communication System, Tata Mc. Graw Hill, (1999)
3. Theodore S. Rappaport, Wireless Communication Principles and Practice, Prentice Hall, (1999)

References:
1. Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, 2nd Edition, California Tech. Publishing (1999)
2. Aditya Mathur, Introduction to Microprocessors, 3rd Edition (1998)
3. Barry B Brey, The Intel Microprocessors – 8086/8088, 80186, 80286, 80386, 80486 – Architecture, Programming and Interfacing, 8rd Ed., Prentice Hall, (2008)

PHOTONICS
PHY 4105 (Elective)

Module 1 : Ray Optics & Wave optics:
Matrix optics – Ray transfer matrix, Matrices of simple optical components, Matrices of cascaded optical components, Postulates of wave optics- Monochromatic waves – Plane wave, Spherical wave, paraxial waves, Beam Optics – Gaussian beam – properties, beam radius, divergence, depth of focus, Transmission through optical components- beam shaping

Module 2: Lasers:
Theory of laser oscillation, characteristics of the laser output- three and four level lasers- line broadening mechanisms – Optical resonators - Modes – Q factor – Q switching and Mode locking, Laser systems – Ar^+, CO2, Nd:YAG, Diode Pumped Solid-State Laser, Quantum well laser, Dye laser, Quantum Cascade Laser.

Module 3: Photon Sources, Detectors & Fiber Optics:
LED, Semiconductor injection lasers, Photo conductors, Photodiodes, Avalanche photodiodes, Noises in Photo detectors
Fiber optics – Step-index. Graded index fiber, Numerical aperture of fiber, Guiding of light – Fiber cutoff wavelength, Splicing & Joining of fiber, Illumination & Dispersion, single mode fibers – Fiber Optic Communication.

Module 4: Fourier Optics & Nonlinear Optics:
Optical Fourier transform – Image formation – Spatial filtering Holography – Holographic Code – Fourier Transform holography, Volume holography
Nonlinear Optics – Nonlinear wave equation – Nonlinear optical media, second order nonlinear optics, Second Harmonic Generation, Three wave mixing, Self focusing, Four wave mixing

References:

1. Bahaa E A Saleh and Malvin Carl Teich, Introduction to Photonics: Wiley Publications (1991)
2. Hecht, Optics: Wiley Publications (2002)
3. A. K. Ghatak & R. Thyagarajan Optical Electronics: Cambridge University Press(1993)
4. A.Yariv , Quantum Electronics: Wiley Publications (1989)
5. V V Rampal , Photonics: Elements and Devices: Wheeler Publications(1992)
6. A. K. Ghatak & R. Thyagarajan Lasers: Theory and Applications: Macmillan India Ltd,(1997)

THIN FILM TECHNOLOGY
PHY 4106 (Elective)

Module 1

High vacuum production - mechanical pumps - diffusion pumps - turbomolecular pumps - Getter and ion pumps - high vacuum system - bell jar vacuum system - leak detection - vacuum gauges - Pirani - Penning - cold cathode and ionisation gauges - residual gas analysis.

Thin film preparation - vacuum evaporation - evaporation theory – rate of evaporation - Hertz-Knudsen equation - free evaporation and effusion - evaporating mechanisms - directionality of evaporation molecules - vapour sources – wire and metal foils - electron beam gun - flash evaporation - sputtering - DC sputtering - ion beam sputtering - chemical methods - electroplating - ion plating - vapour phase of growth – anodisation - thermal growth, MBE, CVD, ALD, MOCVD.

Module 2

Thickness measurements - optical methods - FECO - Fizeau's technique - ellipsometry - Vamfo - other techniques - electrical - mechanical - microbalance - quartz crystal monitor - film composition analysis - general ideas only. Nucleation theories - capillarity theory - atomistic theory - comparison - stages of film growth - incorporation of defects during growth.

Module 3

Reflection and transmission at an interface - Reflection and transmission by a single film - normal incidence case - reflectivity variation with thickness - anti reflection coatings - Electrical properties of metallic films - sources of resistivity - sheet resistance and TCR – Electrical conduction in discontinuous films - Electrical conduction in continuous films - theories of size effects - electrical conduction in thin insulating films - possible conduction mechanisms, general considerations - theory of one carrier space charge limited current flow without traps - metal insulator contact.

Module 4

Dielectric properties - Simple electrical theory - DC conduction mechanisms. high and low field conduction - temperature dependence - AC conduction mechanisms - relaxation peaks - frequency dependent phenomena - thin film devices - resistor - capacitors - active devices - thin film solar cells - thin film in integrated circuits.

References

1. Maissel and Glang, Handbook of thin film technology: McGraw Hill (1970)
2. K. L. Chopra , Thin film phenomena: Robert E. Krieger Publishing Co. NY(1929)
3. Dupy and Cachard, Physics of nonmetallic thin films: Plenum Press(1976)
4. Berry, Hall Harris, Thin film technology: Van Nostrand Reinhold Co. NY (1968)
5. D.R. Lamp, Electrical conduction mechanisms in thin insulating films: Mathew & Co. (1967)
6. A. Goswami, Thin Film Fundamentals: New Age International (P), Ltd. (1996)
7. Joy George , Preparation of Thin Films, Marcel Dekker, NY(1992)

ADVANCED VIBRATIONAL SPECTROSCOPY
PHY 4107 (Elective)

Module – 1

Fundamentals of Molecular Spectroscopy -Infrared Spectroscopy – Vibrating diatomic molecules – Simple harmonic oscillator model – anharmonic oscillator – Vibration of polyatomic molecules – Fundamental vibrations and their symmetries – Infrared techniques and instrumentation – Fourier Transform Infrared Spectroscopy sample handling techniques – Applications – Applications in Materials science, Biology and Medicine..

Module – 2

Origin of infrared and Raman Spectra – Vibration of diatomic molecules – Normal coordinates and normal vibrations – Classical and quantum theory of Raman scattering – Symmetry elements and point groups – Structure determination – Intensity of Raman Spectrum – Vibrational spectrum molecules. Effect of Isotope on Raman and IR spectrum.

Module – 3

Applications of Raman Spectroscopy – Instrumental techniques – Principles of Laser sources for excitation-Argon ion Laser, Nd:YAG Laser, Tunable dye Laser– Structure determination using Raman Spectroscopy,surface enhanced Raman scattering, Enhancement mechanism ,SERS substrates – Metal electrode – Metal sole – Nanomaterials – Biological and Medical applications of SERS.

Module – 4

Advanced Raman Techniques – Non linear optical effects – Hyper Raman effects – Classical treatment of hyper Raman Effect – Experimental techniques – Stimulated Raman Scattering – Inverse Raman Scattering – CARS – Experimental arrangement for CARS – Photoacoustic Raman Scattering – Multiphoton process - Phase transition studies of crystals using Raman spectroscopy.

Reference books:

1. G. Aruldas, Molecular structure and spectroscopy, PHI, (2007)
2. C. N. Banwell, E. M. McCash, Fundamentals of molecular spectroscopy, McGraw Hill (1972)
3. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A: Theory and Applications in Inorganic Chemistry, John Wiley, (1986)

ADVANCED CHARACTERISATION TECHNIQUES
PHY 4108 (Elective)

Module – 1

Diffraction techniques – XRD – Electron diffraction – Neutron diffraction – Structure determination techniques – Theory, Instrumentation and Sample handling Techniques of IR -Raman – NMR – ESR – Single Crystal XRD – Mossbauer Spectroscopy – GC MS – SIMS – EXAFS

Module – 2

Theory and Instrumentation of Elemental Identification techniques – ICP - AES – XPS – EDAX –Rutherford back scattering (RBS) – AES (Auger Electron Spectroscopy) – CHN Analysis – Theory and instrumentation of imaging techniques – AFM – FESEM – TEM - Stylus profiler – ellipsometry.

Module – 3

Electrical and Magnetic measurement techniques – VSM – SQUID- MOKE – conductivity measurements – Four probe method – Two probe method. Hall effect method – Analysis of Data. Cyclic voltammetric studies – Broadband spectroscopy of Dielectrics.

Module – 4

Principle of optical Microscopy – Dynamic light scattering – UV – Visible – NIR – DRS – Determination of Band gap – Photoluminescence – Fluorescence – Positron Annihilation Spectroscopy - Nonlinear studies - Z-scan - second harmonic generation.

Reference books:

1. G. Aruldas, Molecular structure and spectroscopy, PHI, (2007)
2. M. Sayer, A. Mansingh, Measurement Instrumentation and Experiment Design in Physics and Engineering, Prentice Hall of India Private Limited, (2000).
3. K. N. Tu, R. Rosenberg, Analytical Techniques for Thin Films, Academic Press, INC. 1988.

EMERGING ELECTRONIC AND OPTOELECTRONIC MATERIALS AND DEVICES
PHY 4109 (Elective)

Module 1 - Solid State Physics fundamentals
Crystal Structures, Reciprocal lattice- elastic scattering of waves-crystals and amorphous solids, Ewald constructions, Bragg condition, Direct and indirect bandgap semiconductors Low dimensional Systems –Electron confinement in two and one dimensional well, density of states of low dimensional systems. Excitons, QW lasers, One dimensional devices like LED and UV detectors, nanoparticle based sensors.

Module – 2 Thin Film Transistors
Metal-semiconductor ,ohmic contacts - Schottky barrier -Two terminal MOS structures - MOS capacitance voltage characteristics –Basic MOSFET operation -Gate Insulator considerations – Channel layer properties – Thin Film Transistors – types of TFT : amorphous and crystalline oxide TFTs - Basics of CMOS

Module – 3 Organic Electronics
Materials -Electronic Structures and Charge Carrier Generation in Organic Optoelectronic Materials-Charge Transport in conducting polymers-small organic Molecules for electronics and optoelectronics - Application: Flexible electronics- degree of flexibility, substrates, thin glass etc. Fabrication technologies - Batch processing , roll-roll processing, additive printing, Organic Field effect transistors- Organic Light Emitting Materials and Devices-Organic and polymer Photovoltaics

Module -4 Luminescence
Luminescence- Excitation and emission- Decay mechanism-Theoretical models and mechanisms of luminescence – Harmonic oscillators, two, three, N-level systems, Band to band absorption and luminescence, luminescence in impurity solids , Donor acceptor pair impurity, luminescence of free and bound excitons – Intrinsic luminescence- band to band luminescence, Exciton luminescence- Extrinsic luminescence - localized type - unlocalized type - Luminescence of nanomaterials

Reference

1. A. J. Dekker- Solid State Physics, Macmillan, (1986)
2. Ali Omar – Elementary Solid State Physics: Principles and Applications, Addison-Wesley (1994)
3. John H. Davies, The physics of Low dimensional semiconductors, Cambridge University Press (1997)
4. G. Busch and H. Schade - lectures on solid state physics, Pergamon Press, (1976)
5. S.V. Gaponenko -Optical Properties of Semiconductor Nanocrystals, Cambridge University Press (1998)
6. D. R. Vij- Luminescence of Solids, Springer (2012)
7. Jin Zhong Zhang- Optical properties and spectroscopy of nanomaterials, World Scientific (2009)
8. Cousins K and Keith Cousins, "Polymers in Electronics", Smithers Rapra Technology Publishers, Akron, 2006.
9. Donald A. Neamen- Semiconductor physics and devices, McGraw Hill (2003)
10. Robert F Pierret – Semiconductor Device Fundamentals, Pearson (1996)

GENERAL RELATIVITY AND ASTROPHYSICS
PHY 4110 (Elective)

Module 1 Tensor analysis: Tensors - Contravariant and covariant tensors, direct product, contraction, inner product, quotient rule, tensor densities, dual tensors. Metric tensor, Parallel transport. Christoffel symbol, Covariant derivative, Riemannian geometry, Riemann curvature tensor, Ricci tensor, equation of geodesics.

Module 2 General theory of relativity (GTR): Drawbacks of Newtonian theory of gravity, Mach's principle, principle of equivalence - consequences - bending of light, redshift, time dilation. Gravity as curvature of spacetime, Einstein equation, reduction to Newtonian form.

Module 3 Stellar physics and applications of GTR: Stellar magnitude sequence - absolute magnitude and the distance modulus - the color index of a star - stellar parallax - stellar coordinates - stellar positions - spectral classification of stars - H-R diagram. - energy generation in stars - stellar evolution – white dwarfs - electron degeneracy pressure . Schwarzschild solution :Schwarzschild singularity, gravitational redshift, particle orbits - precision of the perihelion of planet Mercury. Introductory ideas on pulsars, neutron stars and black holes. Linearised gravitational waves(basic ideas).

Module 4 Cosmology: Cosmological Principle, Hubble's law. FRW model of the universe - FRW metric, cosmological redshift, open, closed and flat universes, matter dominated and radiation dominated universes. Particle horizon and event horizon, primordial nucleosynthesis, CMBR, flaws of the FRW model. Jean's mass in the expanding universe, evolution of the Jean's mass. Dark matter, recent acceleration of the universe, dark energy. (only introductory ideas.)

References:

1. Steven Weinberg: Gravitation and Cosmology, John Wiley and Sons (1972)
2. Hartle, J. B., Gravity: Introduction to Einstein's General Relativity, Pearson Education, (2003)
3. Peebles, P.J.E., Physical Cosmology, Princeton University Press, (1993).
4. Erika Bohm-Vitense, Introduction to Stellar Astrophysics, Vol. 3 : Stellar structure and evolution, Cambridge University Press (1992)

ASTROPHYSICS
PHY 4111 (Elective)

Module 1 Magnitudes: Apparent and absolute stellar magnitudes, distance modulus, bolometric and radiometric magnitudes, color-index, color temperature, effective temperature, brightness temperature, luminosity of stars. Equatorial, ecliptic and galactic system of coordinates. Apparent and mean solar time and their relations. Classification of stars, H-D classification, Hertzsprung-Russell (H-R) diagram.

Module 2 Fundamental Equations: Equation of mass distribution - equation of hydrostatic equilibrium - equation of energy transport by radiative and convective processes - equation of thermal equilibrium - equation of state. Stellar opacity - stellar energy sources.

Module 3 Stellar Models: The overall problem and boundary conditions. Russell Vogt theorem. Dimensional discussions of mass luminosity law. Polytropic configurations. Homology transformations.

Module 4 Stellar Evolution: Jean's criterion for gravitational contraction and its difficulties. Pre main sequence contraction under radiative and convective equilibrium. Evolution in the main sequence. Growth of isothermal core and subsequent development. Ages of galactic and globular clusters.

Reference Books :

1. V. B. Bhatia, Textbook of astronomy and astrophysics with elements of cosmology, Narosa Publishing House (2001)
2. K. D. Abhyankar, Astrophysics - Stars and Galaxies, Sangam Books Ltd (2002)
3. S. Chandrasekhar, Stellar Structure, Dover (1967)
4. T. Padmanabhan, Theoretical Astrophysics (Vols.I,II,III) - Cambridge University Press, South asian edition (2010)
5. Menzel, Bhatnagar and Sen, Stellar Interiors, Chapman & Hall (1963)
6. S. L. Shapiro and S.A.Teukolsky, Black Holes, White Dwarfs and Neutron Stars - John Wiley (2008)
7. Cox and Giuli, Principles of Stellar Interiors - Vol.I and II.
8. R. Bowers and T .Deeming, Astrophysics, Jones & Bartlett Publishers (1984)

QUANTUM FIELD THEORY
PHY 4112 (Elective)

MODULE 1 Classical Field Theory. Canonical quantization - charged scalar field - Fock space. Quantization of spin (½) field. Quantization of electromagnetic field in Lorentz gauge - Gupta-Bleuler method. Feynman propagator for relativistic fields - Relation between propagators of spin (½) field and charged scalar field.

MODULE 2 Interaction picture - time-evolution operator. scattering matrix. Wick's Theorem - Feynman rules of quantum electrodynamics. Feynman diagrams. Scattering cross section for Bhabha scattering and Compton scattering.

MODULE 3 Path integral formulation: Harmonic oscillator - Feynman path integral in quantum field theory - path integral quantization of scalar fields - Wick Rotation. Perturbative evaluation of the path integral - Euclidean formulation - generating functional -Feynman propagator. Interacting fields

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MODULE 4 Gauge field theory: Degenerate vacua in quantum mechanics and quantum field theory. Spontaneous symmetry breaking of global symmetries and Goldstone bosons. Spontaneous symmetry breaking of local symmetries and Higgs mechanism. Abelian gauge theories- superconductivity. Standard model. Solitons and Instantons.

References

1. Walter Greiner, Field Quantization , Springer, (1996)
2. L.H. Ryder, Quantum Field Theory- Cambridge University Press; 2 edition (1996)
3. Ashok Das, Lectures in Quantum Field Theory-World Scientific (2008)
4. Michele Maggiore, A Modern Introduction to Quantum Field Theory- Oxford University Press (2005)
5. Tom Lancaster and Stephen J. Blundell, Quantum Field Theory for the Gifted Amateur- Oxford University Press; 1 edition (2014)
6. T. P. Cheng and Ling Fong Li, Gauge Theory of Elementary Particle Physics- Oxford University Press; 1 edition (2000)

ADVANCED QUANTUM MECHANICS
PHY 4113 (Elective)

MODULE 1 Many electron problem: Identical particles- spin and statistics-slater determinant. Many-Boson Schrödinger Equations - Self consistent field Theory - Hartree equation - Hartree-Fock approximation - Thomas Fermi approximation. Creation and annihilation operators for Bosons. Fock state. BCS theory. Quantum dots - Quantum Hall effects - Bose-Einstein Condensate.

MODULE 2 Classical-quantum Connection- WKB approximation- Bohr-Sommerfeld quantization condition. Geometric -phases - Berry phase-Aharonov Bohm effect.

MODULE 3 The Feynman path Integral probability amplitude. Time evolution kernel. Superposition of Trans-empirical paths- Dirac–Feynman formula. The Lagrangian- The Feynman path integral- quantization-action-harmonic oscillator.

MODULE 4 Quantum Information: EPR paradox - Bipartite states - Hilbert space of a Bipartite System- Observables. Density Operator-quantum entanglement- Von Neumann entropy. Quantum teleportation- No-Cloning theorem. Quantum cryptography- experimental implementations. Quantum gates and circuits-quantum algorithms- Deutsch-Jozsa algorithm-Shor's algorithms

References

1. Gennaro, Auletta, Mauro Fortunato, Quantum Mechanics - Cambridge University Press; 1 edition (2009)
2. Reinhold Blumel, Advanced Quantum Mechanics- Jones & Bartlett Learning (2010)
3. G. Benenti, G. Casati and G. Strini, Principles of quantum computation and information - World Scientific Publishing Company (2004)
4. Daniel R. Bes, Quantum Mechanics- Springer (2004)
5. Belal E. Baaquie, The Theoretical Foundations of Quantum Mechanics-Springer (2013)