UNIVERSITY OF HYDERABAD
School of Physics

Ph.D (Physics)

Course Structure and Course details

February 2019

Ph. D. Course structure

Semester I **Total No. of Credits : 16**				
Course No.	Name of the course	Contact hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
PY801	Research methodology	4	---	4
PY8xx	Optional I	4	---	4
PY8xx	Optional II	4	---	4
PY8xx	Optional III	4	---	4

Research Scholars admitted to Ph.D. program of Physics are required to take a set of courses for a **minimum of 12 credits**, as recommended by the respective Doctoral committees. Among these "Research Methodology" course is mandatory for all the Research scholars. Optional courses I, II and III can be chosen from the following up to a maximum of 16 credits.

The Ph. D. students are required to acquire 55% marks to qualify in any of the courses.

If some of the courses below, which are offered as optional to M.Sc. students in the final semester, are chosen by a Ph. D student he/she is required to give an additional Seminar or submit a project report as instructed by the teacher.

Optional courses I, II and III to be chosen from the following list:
(In a given semester set of courses to be offered will be decided by the Dean depending on the number of takers and availability of a teacher for the course.)

PY 802 Advanced Quantum Mechanics
PY803. Advanced Experimental techniques
PY804. Advanced condensed matter Physics
PY805. Advanced Theoretical Methods
PY806 General Relativity and Cosmology
PY807 Advanced Computational techniques
PY808 Advanced Statistical Mechanics
PY809. Advances in Optics and Photonics
PY810 Probes of Condensed Matter
PY811. Quantum optics & Laser physics
PY812. Quantum Theory of Solids
PY813. Quantum Field theory
PY814 Soft Condensed Matter
PY 815 Advanced Particle physics

PY816 Nanoscience and Nanotechnology
PY817 Many body physics
PY818 Advanced electromagnetic theory

PY 801 Research Methodology

Research Methodology

Each of the following modules may be taught and evaluated by a different expert. Teaching may not necessarily be confined to classroom. Visits to laboratories, workshop, library etc. should be components of the course. Hands on exposure to instruments can also be included.
Each module may be evaluated independently by the concerned instructor.

Module I: Definition of problem and presentation of results

1. Overview of research methods involved – literature survey: journals, books, making hypothesis and model building, testing a hypothesis for acceptance or rejection
2. Introduction to presentation – poster, journals article, seminar

Module II: Data acquisition/analysis

1. Automation and computer interface – introduction to basic concepts of computer interface
   (a) DAQ cards (b) RS232, GPIB, TCP/IP protocols for instruments control. Introduction to Lab View
2. Data Analysis – Plotting, systematic errors, plotting of error bars, curve fitting etc.
3. Design Elements – Basics of machine drawing, visit to workshop, practice etc.

Module III: Computational tools

1. Introduction and scope of various programming techniques like FORTRAN, C, Mathematica, Matlab – packages like LaTeX, Word, Power Point, Excel
2. Application of above for real physics problems. (for extra assignments)

Module IV: Exposure to advanced research techniques

1. Laboratory experience on systems like Vacuum techniques, XRD, Thin film deposition system, SEM, AFM, Raman, NMR, Fluorescence spectrometer etc.
2. Computer simulation of Physics problems – molecular dynamics, Monte Carlo Techniques, Density functional theory etc.

PY 802 Advanced Quantum Mechanics

A brief review of exactly solvable potential problems (with emphasis on hydrogen atom and harmonic oscillator), approximate methods for many electron systems. Transformations and symmetries, angular momentum, symmetric & antisymmetric wave functions.
Scattering theory, time independent potential scattering. Time dependent scattering. Transition Probability. Low energy scattering and bound states, Born Approximation in potential scattering, Form factor and structure factors.

Second Quantization, SHO (in creation & annihilation operator). Linear chain of vibrating atoms–phonons, Field quantization (Fermions and Bosons), perturbative treatment of an electron gas. Quantum Theory of radiation. Spontaneous & Stimulated emissions. Relativistic QM (Klein Gordon and Dirac Equations and solutions without and with EM field)

PY 803. Advanced Experimental techniques

I. Study of Binary Phase diagrams, Phase rule, Lever rule, Compound and phase formation, Formation of Single and multiple phases, Eutectic, Peritectic, Eutectoid, Peritectoid temperatures, Estimation of content of phases coexisting in an alloy (3 hours)
Crystal Structures, Atom positions, Compounds of a Structure type (2 hours)
X-ray diffraction, Structure factor and missing reflections, Indexing of XRD pattern, determination of lattice parameters, JCPDS data files, identification of phases present, density and porosity (3 hours)

II. Origin of complex dielectric permittivity in materials, Debye theory of dielectric
relaxations, Analysis of dielectric data based on Debye theory
Jones matrix formalism for measuring the birefringence of optically anisotropic Materials
A basic introduction to Rheology and Rheometers

III. Interferometry : Basics, applications & current status
Polarimetry : Basics, applications & current status

IV. Theory & Applications of X-ray & Neutron Reflectivity
Investigation of micro-structure & composition using Field Emission Scanning Electron Microscope (FESEM)
Introduction to Low temperature Magnetic, Transport and Magneto-Transport measurement Techniques using Physical Property Measurement System (PPMS)

V. Impedance Spectroscopy: Basics, measurements and applications
Thin films: Overview of preparation techniques. Physical Vapour Deposition techniques with PLD as an example.
Necessity for Thin films, Effect of substrate and role of dimensionality,

Characterization of films- various techniques

PY 804. Advanced condensed matter Physics

Elastic properties.
Dielectric and Ferroelectric materials.
Optical properties of solids.

Magnetism: Langevin Diamagnetism and Paramagnetism; Van Vleck Paramagnetism, Crystal-field effects; John-Teller effects; Adiabatic demagnetization; Landau diamagnetism, Pauli paramagnetism, The De Haas-Van Alphen effect, Molecular field theory of ferromagnetism; Heisenberg-exchange interaction; Spin Waves; Slater-Puling Curve; Shape, magnetocrystalline and other types of anisotropy; Origin and observation of ferromagnetic domains; Brief introduction to antiferromagnetism & Ferrimagnetism, Different types of magnetic interactions.

Superconductivity: Basic properties of superconductors. Phenomenological thermodynamic treatment.Two fluid model; Magnetic behaviour of superconductors, intermediate state, London's equations and penetration depth, quantized flux. Pippard's non-local relation and coherence length. Ginzburg-Landau theory, variation of the order parameter and the energy gap with magnetic field, isotope effect; electron-phonon interaction and cooper pairs, brief discussion of the B.C.S. theory, its results and experimental verification; (p- and d-wave pairs). Dc and ac Josephson effects, SQUID; Brief introduction to High temperature superconductors.

PY 805. Advanced Theoretical Methods

1. **Matrices and Tensors**:

a. Introduction to Matrices. Special Matrices, Eigenvalue Problem, Bilinear and Quadratic Forms, Kronecker Sum And Product Of Matrices. The Rotation Matrix, Pauli Spin Matrices and Dirac matrices. Determinants and Singular value Decomposition.

b. Cartesian and General Tensors. Higher Rank Tensors, Moment Of Inertia Tensor, Stress, Strain. The Concept of Parallel Displacement of Vectors in Riemannian Space and Covariant Derivative Of Tensors, The Curvature Tensors And Its Properties.

2. **Fourier transforms**: Fourier series - Fast Fourier Transform, Short time Fourier transform- The Dirichlet conditions - Convolutions and the convolution theorem - Aliasing - Worked examples.

3. **Wavelet Transform**: Introduction - Discrete wavelet transform - Discrete time and continuous wavelet transforms - Multiresolution Analysis - Applications of

wavelet transform in 1D (signal/time series) and 2D (image analysis) worked examples.

4. **Fractals:** Fractal Dimension, Self-Similarity, Power-law behaviour, Scaling exponent- monofractal - multifractal - singularity spectrum-worked examples.

5. Differnetial equations, Greens functions, perturbative methods, Introduction to some well-known differential equations of Physics: Heat equation, wave equation, Strum Liouville problem.

6. Interacting Bose and Fermi gases, Hartree-Fock Approximation, Introduction to density Functional theory

References.

1. Matrices and Tensors in Physics,A. W. Joshi,New Age International, 1995
2. Mathematical Methods for Physicist- Arfken & weber - Elsevier (2005)
3. A student's guide to Fourier transforms - J. F. James, Cambridge University Press, 2010.
4. Introduction to Wavelet Theory and it's applications - R S Rao & AS Bopardikar, Addison and Wesley Longman (1998).
5. Non-linear dynamics and chaos - Steven Strogatz, SARAT publishers, CRC Press (2000).
6. Quantum theory of Many Particle systems - A.L. Fetter & J.D. Walecka

PY 806 General Relativity and Cosmology

Review of tensor. Differential geometry (basic). Fundamental metric tensor, 1-form 2-form etc, Parallel transport, Christoffel symbols, covariant derivative, geodesic equation, geodesic deviation equation. Riemannian curvature tensor, Ricci tensor, Ricci scalar, Weyl curvature tensor. Einstein field equations, Einstein-Hilbert action. Newtonian approximation of Einstein field equation. Schwarzschild solution, Black holes, Hawking radiation. Experimental tests of general relativity, Relativistic stellar stricture equation, white dwarf, Chandrasekhar limit. Lane-Emden equation.

Cosmology, Cosmological principle, Newtonian, Einstein model, De-sitter model. Friedmann solution., physics of the early universe, CMB, Cosmological perturbations and field equations, tensor, scalar, gravitational waves, CMB anisotropy, physics of CMB. Inflation and dark energy.

1. Classical Theory of Fields: L. D. Landu and E. M. Lifshitz
2. Introduction to Cosmology: J. V. Narlikar
3. Gravitation: C. W. Misner, K. S.T horne and J. A. Wheeler
4. Gravitation and Cosmology: S. Weinberg
5. Classical Fields: General relativity and Gauge Theory: Moshe Carmeli
6. General Relativity: Robert M Wald
7. Modern cosmology: Dodelson

PY 807 Advanced Computational techniques

This is a Lab/Theory course with an aim to meet the day to day requirements of research scholars for scientific computation, data visualization and data fitting. The goal is to acquaint the students with the routines/functions/toolboxes in softwares like MATLAB, Mathematica, Octave (linux clone of matlab), Maxima, etc. At the end of the course students should have enough skills to tackle most of the following.

Data input/output
Curve/surface plots
Simultaneous equations and matrix inversion

Root finding for both algebraic and transcendental equations
Eigenvalues and eigenvectors
Interpolation and integration
Special functions
Stiff and nonstiff differential equations
Fourier and other transforms
Initial and boundary value problems

The above are to be covered preferably via physics problems (from any branch of physics depending on the expertise of the instructor). The same problem may, in principle, cover many of the above modules.

Advanced students will be exposed to pseudo-spectral and FDTD methods for solving partial differential equations using recently acquired programs like BEAMPROP and FULLWAVE.

PY 808 Advanced Statistical Mechanics

The Ising model: Multicomponent order parameters: The N-vector model: Exactly soluble models: Ising chain and a few other examples.

The reromalization group (RG) approach, Real-space and momentum-space RG methods and application to simple models.

Quantum fluids: BCS theory of superconductivity, liquid helium

Langevin and Fokker-Planck equations, Fluctuation-dissipation theorem. Linear response theory, non-equilibrium phase transitions.

Recommended books :

1. Equilibrium statistical physics — M. Plischke and B. Bergesen
2. Modern theory of critical phenomena — S. K. Ma
3. A modern course in statistical physics — L. E. Reichl
4. Statistical Mechanics — J. K. Bhattacharya

PY 809. Advances in Optics and Photonics

Brief Recap of Optics, Lasers: Origin, measurements, importance & applications Lasers, Q-
switching, Gaussian Beams, ABCD matrices, Group Velocity, Role of pulsed em radiation and
propagation

Bridging basics to Advances: Optics to Nonlinear Optics to Ultrafast Optics:
Dispersion, Wave equation, Phase Matching conditions,
Nonlinear Optics: SHG, THG, SFG, DFG, OPO, DC Retification, Wave Mixing
Tools utilized in the evolution of Advances in Optics & Photonics
Quantum Optics, Classical and squeezed states

Generation & Characterization of ultrafast events:
Theory and Demonstration

Active, Passive & Kerr-Lens Mode-locking, Chirped Pulse Amplification
Dispersion of ultrashort pulses, Group Velocity Dispersion (GVD), Group Delay Dispersion
(GDD), Ultrafast sources, Focusing of ultrashort pulses
Spatio- Temporal Effects via Kostenbauder ABCD Matrices of Ultrashort pulses,
Characteristics and Measurement of ultrashort pulses, Pulse shaping, Amplification of ultrashort pulses

Nonlinear refractive index, Self-action effects, Fiber lasers, Ultrafast spectroscopy and interferometry, Material processing, Medical applications, Supercontinuum emission, Filamentation, Theoretical Formulation, Numerical simulation

New Frontiers:
Few cycle laser pulses, Terahertz generation, High Harmonic Generation, attosecond pulses, Strong
Field Science (SFS) / High Energy Density Science (REDS)

Tutorials and Demonstrations will be part of this course.

References:

1) Femtosecond Laser Pulses, Claude Rulliere
2} Ultrashort Laser Pulse Phenomena, Jean-Claude Diels and Wolfgang Rudolph
3) Ultrafast Optics, Andrew M. Weiner
4) Physics of Atoms and Molecules, Bransden and Joachain
5) Femtosecond Laser Spectroscopy, Peter Hannaford
6) Literature and Notes provided by teacher.

Pre-requisites: Geometrical and Wave Optics, Einstein's A and B coefficients, Fourier Transforms,
Solving PDE, Laser Physics, Overview of Bachelor level Physics.

PY 810 Probes of Condensed Matter

Investigation of structural and physical properties of solids using the following experimental techniques:

1. X-ray diffraction and Neutron scattering Techniques
2. Point groups, Character Tables and vibrational spectroscopy, Raman Scattering and other optical probes.
3. Other spectroscopic techniques: ESR/EPR/NMR/NQR, Mossbauer spectroscopy and Positron Annihilation.
4. Thermal properties: specific heat, thermal conductivity, thermal expansion, Differential Scanning Calorimetry
5. Other Physical props: ac and dc conductivity, Hall Effect, magnetoresistance, Magnetic susceptibility, Magnetization and Phase transitions.

Note: Some of the Topics under Items 4 and 5 are given for Seminars by the Students.

Recommended books:

1. "Definitions and Theorems of Group Theory" by F.Albert Cotton
2. ESR, EPR
   "Electron Spin Resonance" by J.E.Wertz and J.R.Bolton
   "Electron Paramagnetic Resonance" by J.W.Orton
   "Electron Spin Resonance of Paramagnetic Crystals" by L.A. Sorin and M.V. Vlasova
3. "X-ray Diffraction" by H.P Klug and L.E. Alexander
   "Neutron Diffraction" by G.E. Bacon
4. "Solid State: Nuclear Methods" Methods of Experimental Physics; Vol 21 edited by J.W. Mundy et.al. for NMR, MBE, PA
   "Applications of Mossbauer Spectroscopy" first edition by Richard L.

Cohen
"Positron Annihilation Spectroscopy" by Hans Kuzmany
5. Thermal Properties of Solids by Ventura G and Perfetti M
"Thermal Expansion "R E Taylor;
"Thermal conductivity" Ed. Terry Tritt;
6. "Magnetism and Magnetic Materials" by JMD Coey (2009) ;and by David Jiles (2015)
7. "Techniques of Materials Research" edited by R.F. Bunshah

PY 811. Quantum optics & Laser physics

Review of Quantized EM field and coherent state representations
Review of Nonclassical states of radiation field - squeezed states, generation using optical parametric down conversion, detection
Entanglement in two mode squeezed vacuum, application of entanglement to quantum teleportation, introduction to some non Gaussian Nonclassical states
Optical interferometry with single photons and Other forms of Nonclassical light
Transformation of different field states at the beam splitter
Quantum coherence, interference
Cavity QED
Absorption, emission and scattering of radiation, quantum interference and entanglement in radiating systems
Coherent control of optical properties, coherent population trapping, EIT, dispersion management and subliminal light
Quantum optical effects in nanomechanical systems

Books

1. Quantum Optics by Girish S Agarwal, Cambridge university press, 2013.
2. Essential Quantum Optics by Ulf Leonhardt, Cambridge university press, 2010

PY 812. Quantum Theory of Solids

Free electron theory; Band theory
Lattice dynamics in three dimensions
Electron phonon interaction, Boltzmann transport equation, Resistivity of metals
Interacting electron gas, Hartree-Fock approximation, RPA
Second quantization; Elementary excitations
Superconductivity, BCS theory

Books:

G. D. Mahan: Many particle physics
C. Kittel : Quantum theory of Solids

PY 813 Quantum Field Theory

Lagrangian and Hamiltonian formulations, variational principle, Euler-Lagnrange equation, invariance of action and conservation laws, review of field quantization, quantization of guage field, invariance of electromagnetic field under Lorentz transformations, electromagnetic field in the Lorentz guage. Proca field.

Interaction of an electron field with the radiation field, discussion of guage invariance and minimal coupling – CPT theorem.

Covariant perturbation theory, S-matrix expansion in the interaction picture, Feynman diagrams and Feynman rules for Q.E.D. Thompson scattering, Compton scattering and Miller scattering. A brief introduction to charge and mass renormalization, Bethe's treatment of Lamb shift.

Recommended books:

1.	Advance Quantum Mechanics	J. Sakurai
2.	Relativistic Quantum Fields. Vols. I & II	Bjorken and Drell
3.	Quantum Field Theory	Mandl
4.	Particles and Fields	Lurie
5.	Quantum Theory of Fields. Vols. I & II	Weinberg

PY 814 Soft Condensed Matter

1. **Introduction to Soft matter:** Forces, energies, length and time scales and in soft matter. Soft mater systems (colloids, surfactant/micellar systems, gels, polymer solutions, polymers, Polyelectrolytes, microemulsions, membranes, biological macromolecules), Interactions (electrostatic, van der Walls, hydrophilic and hydrophobic interactions, depletion interaction). Soft matter in nature: DNA and RNA, Proteins, Polysaccharides, membranes, some aspects of Industrial and Technological applications. [5 lectures],

2. **Experimental techniques to investigate structure, dynamics, flow and deformation in soft matter:** Scattering techniques (Small-angle X-ray scattering (SAXS), Ultra-small-angle- X-ray scattering (USAXS), Small-angle (SANS) and inelastic neutron scattering, Static and Dynamic light scattering (SLS & DLS), Optical microscopy, digital video microscopy, confocal laser scanning microscopy, Atomic Force Microscopy (AFM), Electron microscopy (TEM; SEM; Cryo-TEM). Optical Tweezers; Dielectric Spectroscopy; Rheology [8 lectures]

3. **Colloids:** Sterically stabilized and Charge stabilized colloids, Colloidal interactions, Synthesis of monodisperse colloidal particles, characterization,

Structural ordering, Dynamics, Phase Transitions [Gas-liquid, Melting/Freezing, Glass Transition, Crystal-Amorphous], Magnetic colloids, Core-shell partciles, Colloids under confinement, Colloidal alloys, Colloidal epitaxy, Rheology of colloids, Bio-colloids; Applications of colloidal crystals [6 lectures]

4. **Liquid Crystals:** Nematic, Cholestric and Smectic (A, B, C and other exotic) phases of long rod like molecules, Nematic and columnar phases of discotic molecules, Elastic continuam theory of liquid crystals, Frustration and re-entrant phenomena, Glassy states, Ferroelectric liquid crystals, Liquid crystals in electric and magnetic fields; Kerr effect and Electro optic effects; Twisted nematics and smectics; Applications of liquid crystals in dispalys, communication devices and image and signal processing [8 lectures]

5. **Surfactants**: Types of surfactants, self-assembled phases in solutions, Micellization and critical micelle concentrations (CMC), Langmuir-Blodgett films, Monolayer, Bilayers and Vesicles, Lyotropic liquid crystalline phases, Complex phases in surfactant solutions and micro emulsions, lipids [5 lectures]

6. **Polymer Solutions, Polyelectrolytes & Polymer hydrogels:** a single ideal chain; mean-square end to-end distance, radius of gyration. Gaussian chain. Freely jointed chain. Worm-like chain, Stretching and confinement, structure factor, Excluded volume, solvent quality, theta-temperature. Polymer solutions: Flory-Huggins Theory, osmotic pressure, scaling laws for good solvents, Size of a polymer in semi-dilute solutions, poor solvents and phase separation, Measurements of polymer sizes in solution: osmotic pressure, light scattering, intrinsic viscosity, Polyelectrolytes: Debye-Huckle theory, Donnan equilibrium, Manning condensation; Physical gels, chemical gels and photo-polymerized gels, Sol-Gel transition, Swelling and shrinking of polymer hydrogels, Theory of gelation, formation of hydrogels, Rheology and Characterization of hydrogels, Rheological models: Maxwell model. [8 lectures]

Recommended books

1. Soft Condensed Matter, R. A. L. Jones, (2002) Oxford University Press, Oxford
2. Introduction to Soft Matter (2nd edition), I. Hamley, (2000) J. Wiley, Chicheste
3. Intermolecular and Surface Forces, J.N. Israelachvilli (Academic Press, London, 1992)
4. Colloidal Dispersions, W. B. Russel, D. A. Saville, W. R. Schowalter (Cambridge University Press 1992)
5. Ordering and Phase Transitions in Charged Colloids'', Eds. A.K.Arora and B.V.R. Tata (VCH-1996)
6. Soft Matter: Complex Materials on Mesoscopic Scales: J.K.G Dhont, G. Gompper and D. Richter (Eds.) (Forschungzentrum, Julich GmbH, Julich - 2002)

7. Polymer Solutions: An Introduction to Physical Properties", Iwao Toraoka (John Wiley & Sons, 2002)
8. The Physics of Liquid Crystals (2nd Edition), P.G. de Gennes and J. Prost,
9. Liquid Crystals (2nd Edition) S. Chandrasekhar
10. Physical properties of polymeric gels, J.P.C. Added (John Wiley & Sons, 1996)

PY 815 Advanced Particle physics

Introduction to Lie Algebra of SU(2) and SU(3) Multiplets
Gell-Mann-Okubo Mass formula
Quark and Quarkonium states
Justification of color

Relativistic kinematics
Scattering cross-section, Life-times
Introduction to S-matrix,
Feynman diagrams and Matrix elements

Electromagnetic form factors,
Basic idea on parton model and deep inelastic scattering

Weak Interactions, V-A theory,
Pion decay, Muon decay
Charged current Neutrino-electron scattering
Neutral current Neutrino-quark scattering
Cabibbo Theory, CKM mechanism,
Gauge Symmetries
Ideas about spontaneous Symmetry breaking
Salam-Weinberg model and its simple tests

Recommended Books:

1. Quarks and Leptons: Halzen and Martin
2. Gauge Theory of Weak Interactions: Walter Greiner and Berndt Muller
3. An Introduction to standard model of particle physics: W. Cottingham, D. Greenwood

PY 816 Nanoscience and Nanotechnology

Introduction

Historical Perspective; Finite size effects on physical properties (Optical, Magnetic, Mechanical and Transport properties) of materials; Properties of quantum structures such as quantum dots, quantum wells, nanowires, layered materials.

Fabrication of nanostructured materials and devices
Top-down and bottom-up approaches of nanomaterial synthesis; Physical and Chemical Vapor deposition, Vapour-liquid-solid synthesis, Chemical synthetic protocols; Sol-gel; Hydrothermal synthesis; Mechanical milling; Nanocluster deposition; Other novel methods of nanomaterial synthesis.
Lithographic techniques: electron beam lithography, x-ray lithography, nanoimprint lithography, dip pen lithography.

Characterisation
Scanning probe and tunneling Microscopy; X-ray diffraction; Electron Microscopy; scanning near field optical microscopy; X-ray photoelectron spectroscopy; photoluminescence and Raman spectroscopy with emphasis on information that can be extracted about nanomaterials such as size and shape of particles, crystal structure, nanoscale optical, transport and magnetic behavior.

Special materials
Graphene and other layered materials, carbon nanotubes etc.

Applications
Single electron devices; sensors; resistive memories; nano-electro mechanical systems; plasmonics; drug delivery; therapy and diagnostics; energy harvesting, storage and generation; superhydrophobic surfaces.

Recommended textbooks

Introduction to Nanotechnology, by Charles Poole andFrank Owens (Wiley publishers)

Nanotechnology: Principles and Practices by Sulabha K. Kulkarni, (Springer)
Fabrication Engineering at the Micro- and Nanoscale (The Oxford Series in Electrical and Computer Engineering)4th Edition by **Stephen A. Campbell**

PY 817 Many body physics

Systems of identical particles, Symmetric and anti-symmetric wave functions;

Interacting electron gas, Hartree and Hartree-Fock Approximations:

Second quantization for bosons and fermions, Perturbative treatment of interacting electron gas problem, Random phase approximation.

Green function, Self energy, Dyson equation, Equation of motion method.

Diagrammatic perturbation theory, Wick's theorem, Feynman diagrams, applications to: electron gas, and many boson systems with condensed phase.

Electron-phonon interaction and resistivity.

BCS theory of superconductivity.

Recommended books:

1.	Many Electron Theory	S. Raimes
2.	Quantum Many-Particle Systems	J. H. Negele & H. Orland
3.	Quantum Theory of Solids	C. Kittel
4.	Many Particle Physics	G. D. Mahan
5.	The Many-Body Problem	W. E. Perry
6.	The Many-Body Problem	D. Pines
7.	Green Functions in Solids	E. N. Economou
8.	Interacting Fermi Systems	Nozieres and Pines
