TPPHY C 002 --- Advanced Topics in Physics

1. **Relativistic Quantum Mechanics**: Dirac equation; Plane wave solutions and negative energy states; Spin of the electron; Covariant form the Dirac equation and proof; Bilinear covariants._
2. **Classical Fields** : Lagrangian & Hamiltonian Formulations; Variational Principle; Euler-Lagrange equations; Noether's theorem & Conservation Laws; Lorentz transformations and Conservation of Energy -- Momentum and angular momentum tensors; Internal symmetries and associated conservation laws.
3. **Quantisation of Relativistic Fields** : Quantisation of scalar and Dirac Fields fields; Number operator; States; Invariant Green's functions
4. **Quantisation of Relativistic Fields** : Quantisation of Electromagnetic field; Number operator; States; Invariant Green's functions.
5. **QED:** Interaction of electrons with electromagnetic field; Coulomb scattering of electron; Feynman diagrams and applications to some processes

Books :

(1) A Text Book of Quantum Mechanics
P M Mathews & K Venkatesan
(2) Relativistic Quantum Mechanics
J D Bjorken & S Drell
(3) Quantum Field Theory -- *David Lurie*
(4) Relativistic Quantum Fields
J D Bjorken & S Drell
(5) Particle Physics & Introduction to Field Theory
T D Lee

Department of Theoretical Physics

University of Madras

M.Phil. Theoretical Physics

Advanced Topics in Condensed Matter Physics

Code: Credits: 5

(1) **Energy bands** – Free electron theory – Free electron gas in 3D – Fermi sphere and surface – Density of States (DOS) – Nearly free electron model in periodic lattices – Bloch theorem – Kronig Penny one dimensional model – limitation of this model.

(2) **Band theoretical methods –** Hatree and Hatree-Fock methods – Exchange and correlation schemes – Density Functional Theory - APW – KKR – LMTO – TBLMTO – Pseudo potential methods – Total energy calculation.

(3) **Applications of Band structure methods** – Solids under high pressure – Structural stability and phase transformation – Calculation of bulk modulus and its derivatives.

Comparison between band structure methods and experimental methods – Limitations of band theory.

Basics of full potential methods – Introduction to VASP and WIEN 2k methods.

(4) **Quantum confinement in nano solids**:

Bulk to nano transition – quntum confinent – size effects - Idealized quantum wells, wires and dots - size and dimensionality effects - Delocalization and confinement- dimensionalities of quantum nano structures - conduction electrons and dimensionality – Electronic structure from bulk to quantum dots - Fermi gas and density of states (DOS) – DOS in quantum confined systems - Bloch oscillations - Potential wells - Partial confinement – disorder in quantum confined systems – Properties dependent on Density of states.

(5) **Recent developments**

Essentials of Spintronics, Photonics and Nano Electronics

Books for study:

1. C. Kittel, Introduction to Solid State Physics, Seventh Edition, Wiley, 1996.
2. R. Asokamani, Solid State Physics, Principles and Applications, Amaya Publishers, New Delhi, 2006.
3. Stanley Raimes, The Wave Mechanics of Electrons in Metals, North Holland, 1967.
4. J.M.Ziman, Principles of the Theory of Solids, II Edition, Vikas Publishing House Pvt. Ltd., New Delhi, 1979.
5. Nanostructures - Theory and modeling, C. Delerue and M.Lannoo
6. Solid State Physics – Essential Concepts, David W. Snoke
7. The Physics and Chemistry of Nanosolids, Frank J. Owens and Charles P.Poole Jr
8. Density Functional Theory, David S. Sholl and Janice A. Steckel
9. Condensed Matter Theory, Edited by Rita John, UGC Academic Staff College, University of Madras, 2010.

Books for reference:

1. Neil W. Ashcroft and N. David Mermin, Solid State Physics, Harcourt Brace College Publishers, 1976.
2. A. Mookerjee and D.D. Sarma, Electronic Structure of Alloys, Surfaces and Clusters, Eds., Taylor & Francis (2003)
3. H.L. Skriver, The LMTO Method, Springer – Verlag, 1984.
4. T.L. Loucks, Augmented Plane Wave Method, Benjamin, New Yark, 1967.
5. G.C. Fletcher, The Electron Band Theory of Solids, North Holland, Amsterdam, 1971.
6. W.A. Harrison, Solid State Theory, Tata McGraw-Hill, 1970.

Advanced Mathematical Methods for Physicists (TPPHYC 001)

1. Complex Analysis:

Complex Contour integrations with simple poles multiple poles and branch cuts. Series summation and conformal transformation - Saddle point – Integration method.

2. Integral Transforms:

Laplace, Fourier and mellin transforms. Bromwich Integral and inverse transformation-
Uses involving differential and integral equations.

3. Vector Spaces:

General coordinate transformation in vector spaces- contravariant and covariant vectors- Metric , covariant derivatives-Curvature tensor.

4. Elements of Group Theory:

Finite groups and their representations. Schur's lemma- Group characters and orthogonality relations -lie algebra – SU(n) algebras.