University of Madras, Department of Theoretical Physics
M. Sc. (Physics) Course (2011 – 2013 Batch) (CBCS)

TPPHY C101 Mathematical Physics – I
No. of Credits: 4

UNIT 1: Vector Calculus
Generalized Coordinates – Spherical and Cylindrical Coordinates – Transformation of Coordinates – Laplacian Operators – Metrics – Examples from Physics – Simple Applications of Dimensional Analysis in Vector Calculus.

UNIT 2: Matrix Theory
Normal Matrices – Cayley–Hamilton Theorem – Matrix Expansion of Polynomials (Chebyshev Expansion, Hermite Expansion, Laguerre Expansion, and Legendre Expansion) – Minimum Polynomial of a Diagonalizable Matrix – Diagonalization of a (Real, Symmetric) Matrix – Reduction of a Quadratic Form to the Principal Axes Form – Orientation of the Positive Major Axis of an Ellipse – Its Position in the Quadrant w.r.t. the bisector – Simple Applications of Dimensional Analysis in Matrices.

UNIT 3: Sturm – Liouville Theory, Real Orthogonal Polynomials, and Fourier Series
Sturm-Liouville Theory and Real Orthogonal Polynomials: Second Order Linear Differential Equations – Sturm-Liouville Theory – Orthogonality of Eigenfunctions – Illustration with Simple Harmonic Oscillator Equation, Legendre, Chebyshev, Hermite, and Laguerre Differential Equations – Consequences of the Orthogonal Property – Applications to Fourier Series – Simple Applications of Dimensional Analysis in Sturm-Liouville Theory.

Fourier Series: Relishing Fourier with Feynman and Fourier – Fourier Series Expansion of Positive Integral Powers of x, in the Interval $[-\pi, \pi]$, using Feynman's Favourite Technique of Differentiating Under the Integral Sign – Sum Rules for Riemann Zeta Functions, Dirichlet Eta Functions, and Dirichlet Beta Functions – Dimensional Analysis of Fourier Series.

UNIT 4: Theory of Complex Variables
Analytic Functions – Cauchy-Riemann Conditions – Expression for e^z – Complex Contour Integration – Circular and Semi-Circular Contours (Poles as Singularities) – Recurrence Relations for the Riemann Zeta Functions, Dirichlet Eta Functions using a Rectangular Contour – Simple Applications of Dimensional Analysis in Complex Variables.

UNIT 5: Integral Transforms
Fourier Transforms
Fourier Integral Theorem – Fourier Transform – Inverse Fourier Transform – Fourier Transform of a Symmetric Rectangular Pulse – Properties of the sinc x Function – Fourier Transform of a Gaussian – Fourier Cosine Transform (FCT) – Fourier Sine Transform (FST) – Self-Reciprocal Problem in FCT and FST – Fresnel Integrals – Evaluation of Integrals using Operational Methods – Simple Applications of Dimensional Analysis in Fourier Transforms, FCT, and FST.

Laplace Transforms

Generation of a Table of Laplace Transforms – Inverse Laplace Transforms – Solution of Linear Differential Equations with Constant Coefficients – Simple Pole, Double Pole, and Triple Pole Problems - Simple Applications of Dimensional Analysis in Laplace Transforms.

Books for Study:

[1] M D Greenberg, Advanced Engineering Mathematics, 2nd Edition, International Edition (Prentice-Hall International, NJ, 1998; Pearson Education Asia, New Delhi, 2002).

[2] E Kreyszig, Advanced Engineering Mathematics, 8th Edition (Wiley, NY, 1999).

[3] G B Arfken and H J Weber, Mathematical Methods for Physicists, 5th Edition (Harcourt (India), New Delhi, 2001).

[4] E. Butkov, Mathematical Physics (Addison-Wesley, Reading, MA, 1968).

[5] S Lipschutz, Linear Algebra (Schaum's Series, McGraw-Hill, Singapore, 1981).

Books for Reference:

[1] H J Weber and G B Arfken, Essential Mathematical Methods for Physicists (Academic, An Imprint of Elsevier, California, 2004); First Indian Reprint (Reed Elsevier, New Delhi, 2005).

[2] L A Pipes and L R Harvill, Applied Mathematics for Engineers and Physicists, 3rd Edition. (McGraw-Hill, NY, 1971).

[3] C R Wylie and L C Barrett, Advanced Engineering Mathematics, 6th Edition, International Edition (McGraw-Hill, NY, 1995).

[4] J B Marion, Principles of Vector Analysis (Academic, New York, 1965).

[5] J R Tyldesley, An Introduction to Tensor Analysis for Engineers and Applied Physicists (Longman, London, 1975).

[6] D J Griffiths, Introduction to Electrodynamics, 2nd Edition (Prentice–Hall of India, New Delhi, 1994).

[7] D J Griffiths, Introduction to Electrodynamics, 3rd Edition (Prentice–Hall of India, New Delhi, 1999).

[8] M R Spiegel, Vector Analysis (Schaum's Series, McGraw–Hill, Singapore, 1981).

[9] S Barnett, Matrix Methods for Engineers and Scientists (McGraw–Hill, New York, 1979).

[10] A W Joshi, Matrices and Tensors in Physics, 3rd Edition (Wiley–Eastern, Madras, 1995).

[11] D W Lewis, Matrix Theory (Allied, New Delhi, 1995).

[12] F Ayres, Matrices, Asian Student Edition (Schaum's Series, McGraw–Hill, Singapore, 1983).

[13] G P Tolstov, Fourier Series (Prentice-Hall, NJ, 1962).

[14] M R Spiegel, Fourier Analysis (Schaum's Series, McGraw-Hill, NY, 1974).

[15] M R Spiegel, Laplace Transforms (Schaum's Series, McGraw-Hill, NY, 1986; Tata McGraw- Hill,New Delhi, 1995).

[16] M E Van Valkenburg, Network Analysis, 3rd Edition (Prentice-Hall of India, New Delhi, 1997).

[17] R T Stefani, C J Savant, Jr, B Shahian, and G H Hostler, Design of Feedback Control Systems, 3rd Edition (Saunders College, NY, 1994).

[18] A V Oppenheim, A S Willsky, and S H Nawab, Signals and Systems, 2nd Edition (Prentice-Hall of India, New Delhi, 1995).

[19] R M Rao and A S Bopardikar, Wavelet Transforms – Introduction to Theory and Applications (Addison-Wesley, Reading, MA, 1998; Pearson Education Asia, New Delhi, 2000).
[20] R C Gonzalez and R E Woods, Digital Image Processing, 3rd Edition (Prentice-Hall, Upper Saddle River, NJ, 2008; Pearson Education in South Asia, New Delhi, 2008).
[21] A W Goodman, Analytic Geometry and the Calculus, 4th Edition (Macmillan, NY and Collier Macmillan, London, 1980).
[22] R P Feynman, R B Leighton, and M Sands, The Feynman Lectures on Physics (Narosa, New Delhi, 1997), Vol. 1, Chapters 22 – 25, pp. 22 – 1 – 25 – ??.
[23] P S Deepa, Mathematical Analysis of Phase Measurement and Dimensional Analysis of Phase (M. Phil. Dissertation, University of Madras, October 2004, unpublished).
[24] P R Subramanian, Mathematical Methods, in Condensed Matter Theory (Refresher Course Materials),
edited by Rita John (University of Madras, October 2010, unpublished,), Chapter 19, pp. 303 – 332.
[25] P R Subramanian and A Jestin Lenus, Dialogue on Dimensional Analysis (Book), to be published.

TPPHYC 102 Electronics

No. of Credits: 4

Unit 1: ***Semiconductor Devices:*** Semiconductors – Elemental, binary and ternary semiconductor oxides – Layered semiconductors –Energy bands – transition between bands – carrier concentration.

FET, MOSFET, UJT, SCR, TRIAC – structure, working and characteristics – FET amplifier – UJT relaxation oscillator – SCR/ TRIAC for power control

Unit 2: ***Microwave Devices:*** Tunnel diode – Transfer electron, Gunn Diode (transfer electron device – Avalanche transit time devices and impatt diodes.

Photonic Devices: Photoconductive sensors – Junction type photoconductors: (a) PN photodiodes (b) PIN photodiodes (c) Avalanche photodiode (a) NPN photoduo diode (c) phototransistors and applications.

Recent Advances in Technology: Introduction to nano – electronics and spintronics.

Unit 3: ***Digital Electronics:*** Counters and Registers, Synchronous counters, Design of counters of different modulus – Shift Registers and their applications.

Semiconductors memories: ROM, EPROM, EEPROM – Static and Dynamic RAM.

Unit 4 ***Applications of OP AMPS:*** Binary weighted ladders – Digital to analog converter - Accuracy and resolution of DAC – A to D converters – Counter method conversion, Continuous Conversion, Dual slope conversion methods – Successive approximation – Accuracy and resolution of ADC.

Differential DC Amplifier – Instrumentation amplifier – Phase Locked Loop – Peak detector, Zero crossing detector – Stable AC coupled amplifier – Analog integration and differentiation – solution to Simultaneous and Differential equations using Op Amps – Active filters – Comparator – Sample and hold circuit – Logarithmic amplifiers – Waveform generators – Regenerative comparator – Rectifier circuits – phase shift circuit – 555 Timer – Applications.

Books for Study and Reference:

1. Peter Y. Yu, Manuel Cardona, *Fundamentals of Semiconductors Physics and Materials Properties*, Springer, (14th Edn.)
2. S.M. Sze, *Semiconductor Devices – Physics and Technology*, John Wiley, New York (2nd Edn.)
3. Allen Mottershead, *Electronic Devices and Circuits - An Introduction.*
4. Malvino and Leach, *Digital Principles and Applications*, Tata McGraw Hill, (4th Edn.)
5. Herbert Taut and Donald Schilling, *Digital Integrated Electronics*, McGraw Hill International Edn.
6. Janet Millman and Christos C. Halkias, *Integrated Electronics - Analog and Digital Circuits and Systems*, McGraw Hill.
7. R.A Gayakwad, *Op Amps and Linear Integrated Circuits*, Prentice Hall of India Pvt. Ltd (4th edn.)
8. Richard A. Honeycutt, *Op Amps and linear integrated circuits*, Delmar publishers.

CLASSICAL MECHANICS AND RELATIVITY

TPPHYC 103

No. of credits: 4

Unit 1: LAGRANGIAN AND HAMILTONIAN FORMULATIONS: Newton's equations and conservation laws for systems of particles, D'Alembert's principle and Lagrange's equations of motion, Hamiltonian and Hamilton's equations of motion.

Unit 2: SIMPLE APPLICATIONS: Tow-body central force problem, scattering by central potential, two – particle scattering, cross section in lab system. Small oscillations, transformation to normal coordinates and frequencies of normal modes, simple examples.

Unit 3: MECHANICS OF RIGID BODIES*:* Angular momentum and kinetic energy, moment of inertia tensor, Euler angles, Euler's equations of motion, torque-free motion, symmetrical top.

Unit 4: CANONICAL TRANSFORMATIONS: Hamilton's principle of least action, Lagrangian and Hamiltonian equations of motion, Poisson brackets, canonical transformations and their generators, simple examples. Hamilton Jacobi theory, action angle variables, application to harmonic oscillator problem.

Unit 5: RELATIVITY**:** Lorentz transformations, relativistic mechanics, relativistic Lagrangian and Hamiltonian for a particle; Space-time and energy-momentum four vectors, centre of mass system for two relativistic particles.

BOOKS FOR STUDY

1. H.Goldstein :*Classical Mechanics*
2. T.W.B.Kibble :*Classical Mechanics*
3. R.Resnick :*Introduction to Special Theory of Relativity*

BOOKS FOR REFERENCE

1. L.D. Landau and E.M.Lifshitz :*Mechanics*
2. K.R.Symon *:Mechanics*
3. J.L.Synge and B.A.Griffith *:Principles of Classical Mechanics*
4. S.N.Biswas :*Classical Mechanics*

General Practical I

TPPHYC 104

No. of credits: 4

*ANY **FIFTEEN** EXPERIMENTS TO BE DONE*

1 . OPAMP – Inverting and non – inverting amplifier, voltage follower, Summing, difference and average amplifiers.
2 . OPAMP — Integrator and Differentiator.
3 . OPAMP – solving simultaneous equations.
4 . OPAMP – Design of Schmitt Trigger.
5 . OPAMP – Construction of Monostable multivibrators.
6 . OPAMP – Construction of Astable multivibrators.
7 . Up/Down counters using 7476/7473.
8 . Shift register, Ring counter, Johnson counter using J – K flip flops 7476/7473.
9 . Phase locked loop.
10 . Characteristics of SCR and TRIAC.
11 . OPAMP – Design of the phase shift oscillator and the Wien bridge oscillator.
12 . UJT characteristics.
13 . UJT relaxation oscillator.
14 . JFET characteristics.
15 . Cornu's method – Young's modulus by Elliptic fringes.
16 . Stefan's constant.
17 . Band gap energy – Thermistor.
18 . Hydrogen spectrum – Rydberg's constant.
19 . Thickness of the enamel coating on a wire – By diffraction.
20 . Coefficient of linear expansion – Air wedge method.
21 . Permittivity of a liquid using an RFO.
22 . Lasers: Study of Laser Beam Parameters.
23 . F.P.Elaton using spectrometer.
24 . Solar constant.
25 Solar spectrum – Hartmann's formula.

BOOK FOR REFERENCE:

D.Chattopadhyay, P.C.Rakshit, and B.Saha, *An advanced Course in Practical Physics*, 6th Edn. (Books and Allied, Kolkata, 2002).

Applications of Theory of Probability and Statistics

TPPHYE 101
No of Credits: 3

1. Introduction to probability:
   Sample space and events, probability defined on events, conditional probability, Bayes' theorem, independent events.

2. Random variables:
   Discrete random variables: Bernoulli random variables, binomial random variables, Poisson random variables.
   Continuous random variables: Uniform random variables, gamma random variables, normal random variables.

3. The moment-generating function:
   Examples of moment generating function, properties of moment generating function, recurrence properties, sequences of random variables.

4. Sums of random variables:
   Law of large numbers, normal approximation to binomial distribution, central limit theorem, distribution of a sum of finite number of random variables.

5. Markov chains
   Chapman-Kolmogorov equations, classification of states, limiting probabilities, some applications.

References:

1. Introduction to probability models, S.M. Ross (Elsevier Publishers)

2. Introduction to probability and statistical applications, P.L. Meyer (Oxford and IBH Publishing company).

Introduction To Scientific Computing

TPPHYE 102
No. of Credits: 3

Introduction and Solution of Equations
Approximations : Round of Errors Truncation Error - Introduction and Fundamental Concepts – Newton's Method - Fixed Point Iteration Method – Discussion On Solution of Linear System.

Interpolation and Approximation
Lagrangian Polynomials – Divided Differences – Newton's Forward and Backward Difference Formulas – Least Square - Discussion On Interpolating With A Cubic Spline.

Numerical Differentiation and Integration
Derivatives From Difference Tables – Numerical Integration By Trapezoidal and Simpson's Rules – Gaussian Quadrature Formulas

Ordinary Differential Equations

Single Step Methods: Taylor Series Method – Euler and Modified Euler Methods – Fourth Order Runge – Kutta Method For Solving First and Second Order Equations – Discussion On Multistep Methods

BOOKS

1. Scarborough, James Blaine. Numerical Mathematical Analysis, 6th ed. Baltimore, MD: Johns Hopkins Press
2. Hildebrand, Francis Begnaud. Introduction to Numerical Analysis.
3. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, 7/E Pearson Education India
4. Hamming, R.W. Numerical Methods for Scientists and Engineers, 2nd ed. New York: Dover
5. Numerical Methods for Engineers by Steven Chapra and Raymond Canale

Numerical Methods and Computer Programming

TPPHYC 105

No. of credits: 5

Numerical Methods

Unit 1: The Solution of Numerical Algebraic and Transcendental Equations: Approximate values of the root – Bisection method - Regula falsi method – Repeated plotting – Newton Raphson method – Geometric significance of Newton-Raphson method – Inherent error in Newton-Raphson method – Method of iteration for algebric equations.

Simultaneous equations in several unknowns: Newton Raphson method for simultaneous equations - Method of iteration for for simultaneous equations.

Solutions of Linear Algebraic Equations: Gauss elimination method – Gauss Jordan method – Crout's method – Gauss-Seidel iterative method – Relaxation method – Gauss method (Inverse of a matrix) - Crout's method (Inverse of a matrix).

Unit 2: Interpolation: Differences – Effect of error in a tabular value – Differences of a Polynomial – Newton’s Forward interpolation formula – Newton’s backward interpolation formula - Interpolation with unequal intervals of arguments: Divided differences – Newton’s general interpolation formula – Lagrange interpolation formula

Central difference interpolation formulas: Gauss forward formula – Gauss backward formula- Stirling’s interpolation formula.

Unit 3: Numerical Differentiation: Newton’s forward and backward difference formulae to compute the derivatives – Derivatives using Stirling’s formula – Maxima and minima of a tabulated function . Solution of differntial equations: Euler's method – Improved Euler's method and Modified Euler's method -

Numerical Integration: Trapezoidal rule-truncation error in trapezoidal formula – Richardson’s deffered approach to the limit - Romberg’s method – Simpson’s rule – Extended Simpson’s rule – truncation error in Simpson’s formula

Computer Programming

Introduction to Fortran 77 in Linux – Flowcharts – data types – integer – real – double precision – constants and variables – arithmetic operations – heirarchy of operations – arithmetic expressions – relational operators – logical operators – intrinsic functions – flow of control – control structures – statement labels and explicit transfers of control – GOTO statement – conditional execution of statements – simple IF statement – block IF statement - iterative execution of statements – DO loop – nesting of DO loops – rules for using DO loop – while loop – arrays – DIMENSION

statement – subprograms – function and subroutines – COMMON statement – use of DATA, PARAMETER, and EXTERNAL statements in programs – using text editors in linux - compiling and running fortran programs in Linux – reading input from files and writing output to files in linux

Practicals

1. Finding the root of the equation by Bisection method
2. Finding the root of the equation by Regula Falsi method
3. Finding the root of the equation by Newton Raphson method
4. Developing the difference table.
5. Iteration using Newton's forward interpolation formula.
6. Iteration using Newton's backward interpolation formula.
7. Iteration using Newton's general interpolation formula.
8. Iteration using Stirling interpolation.
9. Finding out the polynomial of the set of tabular values using iteration techniques.
10. Finding out the derivative of the given function by iterative procedure.
11. Finding out the maxima and minima of a tabulated function.
12. Differentiation using Euler's method.
13. Differentiation using Runge Kutta method.
14. Integration by Trapezoidal rule.
15. Estimation of a physical quantity from the available data.
16. Determination of orbits of a rocket with a particular eccentricity.

Books for reference:

1) Solutions of Numerical equations by J.B. Scarborough.(VI edition)
2) Numerical methods and Fortran programming (with application in Engineering and Science) by Daniel D Mc Cracken.
3) Numerical methods for Mathematics, Science and Engineering by John H. Mathews
4) Numerical methods in Science and Engineering by M.K. Venkataraman (National publishing Company)
5) Numerical methods for Sciencntific and Engineering computation by M.K. Jain, S.R.K. Iyengar and R.K. Jain (II edition, WILEY Pub.)
6) Elementary Numerical Analysis – An Algorithmic Approach by Samuel D. Conte and Carl de Boor

ELECTROMAGNETIC THEORY

TPPHYC 106

No. of Credits: 4

Vector calculus, Coordinate Systems, Vector Fields, The scalar/vector product, Line integrals, Surface integrals, Volume integrals, Gradient, Divergence, The Laplacian, Curl, Divergence theorem, Stokes's theorem, the delta function, the Green function.

Electrostatics: Coulomb's law , Gauss’s law and applications, The electric scalar potential, Electrostatic energy, Conductors, Boundary conditions on the electric field, Capacitors, Poisson's equation, The uniqueness theorem, The method of images, Boundary value problems in Cartesian/Cylindrical/Spherical coordinates, Polarization, Dielectric media, Dielectric Materials and permittivity, Linear media, Clausius-Mossotti relation, Boundary conditions for ${\bf E}$ and ${\bf D}$, Boundary value problems with dielectrics, Energy density within a dielectric medium

Magnetic Force, The Lorentz force The Biot-Savart Law and its Applications, Ampere’s circuital Law, Steady Electric Currents; current density, Boundary condition for current density, Equation of continuity, The magnetic vector potential, Magnetic Dipole, Magnetization, Magnetic Field Intensity, Magnetic energy, Magnetic forces and torques, Magnetic susceptibility and permeability, Ferromagnetism, Boundary conditions for ${\bf B}$ and ${\bf H}$, Magnetic energy, Inductance, Self-inductance, Mutual inductance, Magnetic energy, Magnetic Fields In Material Media;

Maxwell's equations: Faraday’s Law, The displacement current, Maxwell's equations in matter, boundary conditions, Gauge transformations, Plane Wave Solutions to Maxwell’s Equations, polarisation, dispersion, inhomogeneous wave equation and its Solution, Electromagnetic waves, Green's functions, Retarded potentials, Retarded fields, Propagation in a dielectric medium, Propagation in a conductor, Wave-guides, Electromagnetic Power Flow; Reflection And Transmission Of Normally and Obliquely Incident Plane Waves

Electromagnetic radiation Radiation from a generalized localized source,The Hertzian dipole, electric dipole radiation, magnetic dipole radiation, radiation from an antenna.

Special relativity, four vectors, time dilation and the Lorentz-Fitzgerald contraction, The Lorentz transformation, Transformation of velocities the four-velocity, energy and momentum, covariant and contravariant vectors, tensors, The charge-current density four-vector, the Lorentz force, the energy-momentum tensor, Gauge invariance, The electromagnetic field tensor, Transformation of fields, Relativistic particle dynamics

BOOKS :

1. John David Jackson, Classical Electrodynamics Third Edition, Wiley
2. T. Tsang, Classical electrodynamics, World Scientific Pub Co
3. Walter Greiner, Classical Electrodynamics, Springer
4. D. J. Griffiths, Introduction to electrodynamics, Printice Hall India

TPPHY C 107 --- Quantum Mechanics - I

No. of Credits: 4

1. **Introduction** : Brief review of Old Quantum Theory; The Stern-Gerlach experiment, and discussion; Need for a new Quantum theory

2. **Schroedinger Equation** & **Basic Formalism** : Interpretation of and conditions on the wave function; Ehrenfest's theorem; Stationary States; Postulates of Quantum Mechanics; Hermitian operators for dynamicsl variables; eigenvalues and eigenfunctions; Uncertainty principle; Identical particles; Symmetry and antisymmetry of wavefunctions

3. **Exactly Solvable Problems in One Dimension** : Particle in a box; Square well potential; Rectangular Barrier Penetration (tunneling); Periodic potentials & energy bands; Simple harmonic Oscillator (differential equation method & Ladder operator methods)

4. **Three Dimensional Problems** : Particle in Central Potential; Angular momentum and Spherical Harmonics; Particle in a spherical well; Hydrogen atom; Charged particle in a uniform magnetic field

5. **Angular Momentum** : Commutation relations; Eigenvalue spectrum; Spin angular momentum states; Pauli matrices; Addition of angular momenta; C.G. Coefficients

Books :

1. A Text Book of Quantum Mechanics -- *P M Mathews & K Venkatesan*
2. Introduction to Quantum Mechanics -- *David J Griffiths*
3. Quantum Mechanics -- Aruldhas

General Practical II

TPPHYC 108
No. of credits: 4

*ANY **FIFTEEN** EXPERIMENTS TO BE DONE*

1 . Digital to Analog converter using IC 741 – R/2R ladder.
2 . D/A Converter – Binary weighted resistor.
3 . Active filters - Low pass, High pass and Band pass.
4 . Arithmetic operations using IC 7483.
5 . 7490 as scalar and display using 7447.
6 . Regulated power supply 12 – 0 – 12 for OPAMP experiments.
7 . Half-adder, Half-subtractor and Full-adder and Full – subtractor using NAND/NOR gates.
8 . Study of the attenuation characteristics of the phase shift and the Wien networks.
9 . Regulated power supply 5 volt for digital experiments.
10 . Clock generators using 7400 and 7413 ICs.
11 . Study of R-S, Clocked R – S and D flip-flops using NAND/NOR gates and J-K and D flip – flops using 7476/7473.
12 . 555 – Astable multivibrators – Voltage controlled oscillator.
13 . 555 – Monostable multivibrators
14 . 555 – Schmitt Trigger.
15 . TRIAC Power Control.
16 . Design of common source FET amplifier and its frequency response.
17 . Young's modulus – Hyperbolic fringes.
18 . Determination of strain hardening coefficients.
19 . Viscosity of liquid – Meyer's disc.
20 . Arc spectrum – Iron
21 . Arc spectrum – Copper.
22 . Edser and Butler fringes – Thickness of air film.
23 . B – H loop using anchor ring.
24 . Specific charge of an electron – Thomson's method.
25 . Experiments on optical fibre.

BOOK FOR REFERENCE:

D.Chattopadhyay, P.C.Rakshit, and B.Saha, *An advanced Course in Practical Physics*, 6th Edn. (Books and Allied, Kolkata, 2002).

TPPHY E 103 --- Elementary Quantum Mechanics

(For other Departments)

No. of Credits: 3

1. **Introduction** : Old Quantum Theory; Bohr – Sommerfeld conditions and applications; Review of experiments – the Stern – Gerlach experiment and discussion. Need for a new Quantum theory.
2. **The Schroedinger Equation** : Postulates of Quantum Mechanics; Concepts of Quantum States, Operators and their Significance; The Schroedinger equation, its significance and its applications to the free particle, the simple harmonic oscillator, particle in a central potential, the hydrogen atom;
3. **Angular Momentum & Approximation Methods** : Ideas of angular momentum and its addition; Time – independent Perturbation theory; Variational method; Applications of these methods.

Books : Quantum Mechanics -- *Aruldhas*

MATHEMATICAL TECHNIQUES

TPPHYE 104

No of Credits: 3

Complex Analysis

Power Series Expansions - Singularities and Laurent Series- Residue Theorem and Its Applications

Greens Function

Definition - Construction of Green's Functions - Gf For Sturm-Liouville Operator - Series Expansions - The Fourier Transform Method - Retarded Green's Functions

Partial Differential Equation

Boundary Value Problems - Laplace, Heat and Wave Equations - Separation of Variables - Eigenfunction Expansions - Rectangular Membrane Circular Membrane - Laplace Equation In Spherical Co Ordinates

Finite Group Theory

Group Theory - Definition - Groups As Symmetries - Homomorphisms -Subgroups and Quotient Groups - Cosets - Conjugacy Classes - - Isomorphism - Symmetric Group - Cayley's Theorem

BOOKS

1. Eugene Butkov, Mathematical Physics, Addison Wesley
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley
3. G. Arfken and H. Weber, Mathematical Methods for Physicists, 6th edition, Academic Press, 2005
4. K. F. Riley, M. P. Hobson, S. J. Bence, Mathematical methods for physics and engineering, Cambridge University Press

Quantum Mechanics II

TPPHYC 109

No. of Credits: 5

Approximation Methods

Stationary State Perturbation Theory : Non Degenerate and Degenerate Perturbation Theory - Hydrogen In An External Electric Field - The Helium Atom
Variational Method: Ground State - Excited States - The Helium Atom – Hydrogen Molecule
Wkb Approximation : Bohr Somersault Quantum Condition - Tunneling

Scattering Theory

The Born Approximation -Validity Of Born Approximation - Phase Shifts – Partial Wave Analysis – Center Of Mass To Laboratory Frame Of Reference – Identical Particles

Time-Dependent Perturbation Theory

Constant Perturbation - Oscillatory Perturbation - Fermi's Golden Rule - Emission and Absorption Of Radiation – Adiabatic and Sudden Approximation

Representation Transformation Symmetries

Schrodinger, Heisenberg, and Interaction Pictures - Symmetries Conservation Laws – Space Inversion – Time Reversal

Relativistic Wave Equation

Klein-Gordon Equation : Charge and Current Densities - Interaction With Electromagnetic Fields
Dirac Equation : Relativistic Hamiltonian – Plane Wave Solution Of Dirac Equation - Dirac Matrices – Relativistic Electron In Central Potential

BOOKS

1. PM Mathews and K Venkatesan, Atext book of Quantum Mechanics, second edition, Tata McGraw Hill

2. E. Merzbacher, Quantum Mechanics, third edition , McGraw-Hill.
3. Nouredine zettili, Quantum Mechanics Concepts and Applications John Wiley & Sons

TPPHYC 110 --- Statistical Physics
No of Credits: 4

1. **Thermodynamics** : Equation of state for various thermodynamic systems; Laws of Thermodynamics; Consequences of equations of state and Thermodynamics laws; thermodynamics potentials; Maxwell's relations, Thermodynamic equilibrium conditions; Phase equilibrium; Gibbs' phase rule, phase transitions; Ehrenfest's classification.
2. **Classical Statistical Mechanics** : Postulates; Liouville's theorem, microcanonical, canonical & grand canonical ensembles; Virial theorem & Equipartition of Energy theorem in these ensembles; equivalence of these ensembles; expressions for entropy in terms of probabilitity in these ensembles; applications of these ensembles to classical ideal gas, N harmonic oscillators; Langevin's theory of paramagnetism, problem solving.
3. **Quantum Statistical Mechanics** : Postulates of Quantum Statistical Mechanics; Density operator and matrix; applications to electron in a magnetic field, free particle, harmonic oscillator, and to multiparticle systems; Ideal Bose and Fermi gases in micro-canonical and Grand canonical ensembles; Bose-Einstein and Fermi-Dirac distributions; equations of state.
4. **Ideal Bose and Fermi gases** : Thermodynamic behavior; Expressions for equation of state, thermodynamic quantities in terms of Bose-Einstein & Fermi-Dirac functions and virial expansions;
5. **Applications** : Bose-Einstein condensation; Fermi energy and Momentum; Black body radiation; Einstein & Debye theory for heat capacity (possibly Ising model)

Books : 1. Thermodynamics, Kinetic Theory & Stat. Thermodynamics – *Sears & Salinger*
2. Statistical Mechanics -- *R K Pathria*
3. Introduction to Statistical Physics -- *Kerson Huang*

TPPHY C 111 --- Nuclear & Elementary Particle Physics

1. **Nuclear Forces** : Nucleon - nucleon interactions; Exchange forces and tensor forces;
Meson theory of nuclear forces; Nucleon-nucleon scattering; Singlet and triplet parameters; Charge independence; Isospin; Ground state of the deuteron; Magnetic moment; Quadrupole moment; S and D state admixtures.

2. **Nuclear Models** : Shell models; Spin-orbit coupling; Spins of nuclei; Magnetic moments; Schmidt lines; Liquid drop model; Bohr-Wheeler theory of fission; Collective model of Bohr and Mottelson

3. **Beta and gamma Decays** : Beta decay; Energy release in beta decay; Fermi theory of beta decay; Shape of the beta spectrum; Total decay rate; Angular momentum and parity selection rules; Comparitive half-lives and forbidden decays; Non-conservation of parity; Gamma decay and energetics; Multipole radiation; Angular momentum and parity selection rules; Internal conversion; Nuclear isomerism

4. **Elementary Particle Physics** : Interactions between elementary particles; Hadrons and Leptons; Symmetry and Conservation laws; CPT theorem; Classification of hadrons; Lie algebra, SU(2)-SU(3) multiplets; Quark model; Gellmann - Okubo mass formula for octed and decuplet hadrons; Phenomenology of weak interaction of hadrons and leptons; Universal Fermi interaction; Elementary concepts of V - A theory of weak interactions.

Books :
1. Theoretical Nuclear Physics – *J M Blatt & V F Weisskopf*
2. Nuclear Structure -- *A Bohr & B R Mottelson*
3. Nuclear Physics -- *R R Roy & B P Nigam*
4. Introduction to Elementary Particles -- *David Griffiths*

INTRODUCTION TO NANO SCIENCE
TPPHYE 105
No. of credits: 3

Unit 1: Physics of Bulk Solid: Atomic structure – Energy levels in atoms – Transition between energy levels – Bonding in solids – formation of bands - Crystal physics – Brillouin zones - types of crystals – Symmetry - Crystal planes and directions – Miller indices.

Free electrons in solid – Density of states – Fermi dirac distribution - Fermi surfaces – Effective masses.

Insulators , Semiconductors and Conductors – Direct and Indirect Band Gaps – Localized particles – Donars, Acceptors and Deep traps – Mobility- Excitons

Unit 2: Physics of nano solids: Definition of nanoscience and background – Importance of nano science size and Dimensionality effects – Conduction electrons and Dimensionality – Number of atoms on the surface – Effects of small size : Physical and chemical properties - Electronic - structural - mechanical - optical and magnetic properties – applications.

Potential Wells – Quantum Confinement - Partial Confinement – 3D,2D,1D and 0D confinements - Quantum Wells , Wires and Dots – Properties dependent on Density of States.

Unit 3: Experimental and Theoretical methods of verification of nano structures - Carbon Nanotubes – Synthesis, Properties and applications.

Reference Books:

1. CP Poole and FJ Owens, Introduction to Nanotechnology(2006) - A Wiley – Interscience publication.
2. Supriya Datta, Quantum Transport (2005) - Cambridge University Press.
3. Guozhong Cao, Nanostructures and Nanomaterials Synthesis, Properties and Applications(2006) - Imperial College Press.
4. Richard Booker and Earl Boysen, (2005), Nanotechnology, Wiley Publishing Inc. USA.
5. Pradeep T., (2007), Nano: The Essentials, Tata McGraw-Hill Publishing Co.
6. Mick Wilson, et al (2005), Nanotechnology, Overseas Press, New Delhi.
7. Rita John *(Edited)* ***Condensed Matter Theory,*** *Edited by*, UGC Academic Staff College, University of Madras, 2010.

TPPHYE 106 --- General Relativity & Cosmology

No. of Credits: 3

1. **Mathematical Basis of General Relativity** : Metric Connection, Geodesics as extremas, Covariant derivative, Curvature and its significance, Bianchi Identities, Four-dimensional space time, gravitational Red Shift, Equivalence Principle, Necessity to introduce non-flat spacetime, Principle of covariance.

2. **Field Equations and Exact Solutions** : Einstein's equations; The original approach and the Variational Approach; Symmetry and conservation laws; Schwarzschild solution; Classical Tests; Birkhoff's Theorem (Statement only); Concept of Horizon and of the Black Hole; Kruskal embedding; Kerr Metric and Kerr Solution

3. **Cosmology** : Basic Postulates; Observational Background, Isotropy and Homogeneity; Friedmann Metric; Open and Closed Models; Singularity; Raichoudhury Equations; Big Bang model and Steady State model, their comparisons and contrasts based on observational evidence; Microwave Background; Observation and Inference.

Books :
1. Lectures on General Relativity & Cosmology -- *J V Narlikar*
2. Introduction to General Relativity -- *R Adler, M Bazin & M Schiffer*
3. Theoretical Cosmology -- *A K Raichoudhury*
4. Lectures in General Relativity -- *A Papapetrou*

CONDENSED MATTER PHYSICS

TPPHYC112

No. of credits: 4

Unit 1: CRYSTAL PHYSICS: ***Crystal Structure*****:** Lattice representation - Simple symmetry operations - Bravais Lattices, Unit cell, Wigner -Seitz cell - Miller planes and spacing - Characteristics of cubic cells - Structural features of NaCl, CsCl, Diamond, ZnS – Close packing.

Diffraction: Bragg's law - Reciprocal representation - Diffraction conditions and Laue equations - Brillouin zones for cubic lattices - Rotation, Laue and Powder methods of X-ray diffraction (an overview only) - Concepts of Scattering , Structure and Temperature factors.

Crystal Binding: Interactions in inert gas crystals and cohesive energy - Interactions in ionic crystals and Madelung energy - Overview of Covalent, metal and hydrogen bonded interactions.

Unit 2: LATTICE DYNAMICS: Theory of elastic vibrations in mono and diatomic lattices - Phonons – Dispersion relations - Phonon momentum.

Heat Capacity**:** Vibrational modes - Einstein model - Density of modes in one and three dimensions - Debye Model of heat capacity.

Anharmonic effects: Explanation for Thermal expansion, Conductivity and resistivity – Umklapp process.

Unit 3: THEORY OF ELECTRONS IN SOLIDS: ***Free electron theory*****:** Energy levels and Fermi Dirac distribution (review) - Free electron gas in 3D - Density of States –Fermi sphere – Fermi surface - Heat capacity of the electron gas - Electrical and thermal Conductivity in metals - Lorentz number – Effect of magnetic field on Fermi sphere - *Hall effect.*

Energy bands and Fermi surfaces: *Energy Bands*: Nearly free electron model in periodic lattices - Energy gaps - Wave equation in periodic potential *(Bloch Theorem*) – Solution of central equation - Approximate solution near zone boundary.

Fermi Surfaces: Reduced zone and periodic zone schemes of construction - Construction of Fermi surfaces – Energy band calculation using 'tight binding', 'Wigner-Seitz' and 'pseudopotential' methods – Experimental studies of Fermi surfaces – *de Hass van Alphen* effect.

Unit 4: **MAGNETISM:** Diamagnetism - Quantum theory of paramagnetism - Rare earth ion – Hund's rule - Quenching of orbital angular momentum - Adiabatic demagnetization – Quantum theory of ferromagnetism - Curie point - Exchange integral - Heisenberg's interpretation of weiss field – Ferromagnetic domains - Bloch Wall - Spin Waves – Quantization - Magnons - Thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - Theory of antiferromagnetism – Neel temperature.

Unit 5: **SUPERCONDUCTIVITY:** Occurrence - Effect of magnetic fields - Meissner effect – Entropy and heat capacity – Energy gap - Microwave and infrared properties - Type I and II Superconductors.

Theoretical Explanation: Thermodynamics of superconducting transition – London equation – Coherence length – BCS Theory – Single particle tunneling – DC & AC Josephson effect – High temperature Superconductors – SQUIDS.

BOOKS FOR STUDY

1. Charles Kittel, ***Introduction to Solid State Physics,* 7th Edition**, Wiley India Pvt. Ltd. , New Delhi, 2004.
2. R. Asokamani, ***Solid State Physics,*** Anamaya Publishers, New Delhi, 2006.
3. M. Ali Omar, ***Elementary Solid State Physics – Principles and Applications,*** Pearson, 1999.

BOOKS FOR REFERENCE

1. J. Blakemore, ***Solid State Physics, 2nd Edition,*** W. B. Saunders Co, Philadelphia, 1974.
2. C. M. Kachhava, ***Solid State Physics,*** Tata Mcgraw Hill, New Delhi, 1990.
3. S. L. Altmann, ***Band Theory of Metals,*** Peragamon, Oxford.
4. N. W. Aschroft and N. D., Mermin, ***Solid State Physics,*** Rhinehart and Winton, New York.
5. M. Tinkham, ***Introduction to Superconductivity,*** Tata Mcgraw Hill, New Delhi, 1996.
6. A. J. Dekker, ***Electrical Engineering Materials***, Prentice Hall of India.
7. M. A. Wahab, ***Solid State Physics – Structure and Properties of Materials.*** Narosa, New Delhi, 1999.
8. S.O. Pillai, ***Problems and Solutions in Solid State Physics,*** New Age international Publishers, New Delhi, 1994.
9. Alexander O. E. Animalu, ***Intermediate Quantum Theory of Crystalline solids,*** Prentice Hall of India, New Delhi, 1978.
10. Eleftherios N. Economou, ***The Physics of Solids – Essentials and Beyond,*** Springer, 2010.
11. Rita John *(Edited)* ***Condensed Matter Theory,*** *Edited by*, UGC Academic Staff College, University of Madras, 2010.
12. L. Solymar and D. Walsh, Lectures ***on the Electrical properties of materials, Clarendon*** Press , Oxford, 1970.

SPECTROSCOPY

TPPHYC 113
No. of Credits: 4

Introduction - The Electromagnetic Spectrum - Absorption of Light - Emission of Light - Width and Shape of Spectroscopic Lines - Mathematical Methods - Atomic Spectroscopy : Observed Line Spectra - The Vector Model - Selection Rules and Energy Level Diagrams - Ls & Jj Coupling -Paschen–Back - Zeeman and Stark Effects - Hyperfine Structure

Microwave Spectroscopy: Interaction of Matter With Radiation – Einstein's Theory of Transition Probability – Rotation Spectroscopy – Rigid Rotor – Intensity of Spectral Lines – Molecular Parameters From Rotation Spectra

Infra-Red and Raman Spectroscopy: Characteristic Group Frequencies of Organic Molecule, Factors Influencing Vibrational Frequencies, Interpretation of Ir Spectra of Organic Molecules.

Raman Spectroscopy – Raman Effect – Rotational and Vibrational Raman Spectra - Applications of Raman Spectra.

Nmr Spectroscopy : Theory, Principle - Chemical Shift - Spin-Spin Coupling - Nmr of Simple Organic Molecules - Electronic Spectroscopy of Molecules - Lasers : Spontaneous and Stimulated Emission - Optical Pumping - Population Inversion - Coherence - Co2 and He-Ne Lasers - Ammonia Maser

BOOKS

1. H. E. White, Introduction to atomic spectra, McGraw-Hill book company, inc.,
2. C.N.Banwell, Fundamentals of Molecular spectroscopy, Mc Graw Hill, Newyork, 1966.
3. Gerhard Herzberg, Molecular Spectra and Molecular Structure, Reitell Press
4. Mchale, Molecular Spectroscopy, Pearson Education India
5. J. M. Hollas, Basic Atomic and Molecular Spectroscopy, Royal Society of Chemistry.

THEORY OF NANO SOLIDS

TPPHYE 107

No. of credits: 3

Unit 1: Quantum Confined systems:

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.

Applications - Infrared detectors - Quantum dot lasers - confinement in disordered and amorphous systems.

Unit 2: Quasiparticles and excitons:

Introduction to excitons - Theory of bulk excitons - excitons in quantum wells - exciton binding energy - Excitons in Semi - empirical approaches - excitons in nano crystals of direct gap semiconductors - electron states in indirect gap semiconductors – Hole states – Screening of the electron – hole interaction and configuration interaction- Multi excitons – charging effects - single particle tunneling through semiconductor quantum dots.

Unit 3: Quantitative treatment of quasi-particles:

(i) Computational techniques: K.P Method and envelope function approximation – Tight Binding and empirical pseudopotential methods – Density Functional Theory - Comparison between different methods

(ii) Numerical Calculations: Interpretation of results – Comparison with experiments.

Books for Study:

1. **Nanostructures - Theory and modeling,** C. Delerue and M.Lannoo
2. **Solid State Physics – Essential Concepts**, David W. Snoke
3. **The Physics and Chemistry of Nanosolids,** Frank J. Owens and Charles P.Poole Jr
4. **Density Functional Theory,** David S. Sholl and Janice A. Steckel
5. **Condensed Matter Theory,** Edited by Rita John, UGC Academic Staff College, University of Madras, 2010.

TPPHYE 108 --- AstroPhysics & Advanced Nuclear Theory

No. of Credits: 3

1. **Stars** : Apparent and absolute magntitudes; stellar luminosity; Hertzprug – Russel (HR) diagrams; binary stars – visual binaries, eclipsing binaries spectroscopic binaries; mass-luminosity relation; spectral sequence; stellar atmospheres, photoabsorptio cross section, Saha equation.
2. **Stellar Structure** : Equations of stellar structure, early stages in life of a star, source of stellar energy, P-P chain and the CNO cycle, red giant stars, white dwarfs, neutron stars, supernovae and black holes, thermodynamics of black holes.
3. **Quark Model** : SU(3) Symmetry; Quark model for hadrons; Need for color quantum number; Color confinement; Solution of Dirac equation in a spherical cavity; MIT bag model
4. **Gauge Theories & Applications to Elementary Particle Physics** : Classical fields, Lagrangians and field equations; Symmetries & Conservation laws; Global and local gauge (phase) invariances; Abelian and non-Abelian gauge invariances; QCD Lagrangian; Dynamics of Color; Running coupling Constants in QED and QCD; Asymptotic freedom in QCD; Elements of Electroweak theory.

Books :

1. Astronomy : Structure of the Universe : *A E Roy & D Clarke*
2. Structure of the Universe : *J V Narlikar*
3. Introduction to High Energy Physics : *Donald H Perkins*
4. Models of the Nucleon : *R K Bhaduri*
5. Gauge Theory of Particle Physics : *IJR Aitchison & AJG Hey*
6. Gauge Theory Elementary Particles : *T P Cheng & L F Li*

TPPHYE 109 Advanced Topics in Mathematical Physics

No. of Credits: 3

1. Introductory concepts of group theory:

Properties of continuous gropus, linearization of a Lie group and properties of Lie algebra, structure constants, regular representation, inner product, inversion of the linearization map, isomorphism problem and the covering group.

2. Structure of simple and semisimple Lie algebras:

Example fo su(3), root space, properties of roots, simple roots and Cartan matrix, canonical commutation relation, Weyl group, Dynkin diagram.

3. Classification of simple Lie algebra:

The classical Lie algebras, the exceptional Lie algebras, highest weight representations, Dynkin indices, Casimir operators and Freudenthal's theorem.

4. Basic notions of differential geometry:

Manifolds, calculus on manifolds, differential forms, metrics with examples, definition of fundamental group, simplexes, triangulation of a space with examples.

References:

1. Semisimple Lie algebras and representations – Robert Cahn (Benjamin Cummings Publishing Co 1984).

2. Lie groups, Physics and geometry – Robert Gilmore (Cambridge 2008).

3. Topology and geometry for Physicists – C. Nash and S. Sen (Academic press 1983).

TPPHY E 110 --- Quantum Field Theory

No. of Credits: 3

1. **Classical Fields** : Lagrangian & Hamiltonian Formulations; Variational Principle; Euler-Lagrange equations; Noether's theorem & Conservation Laws; Lorentz transformations and Conservation of Energy-momentumand angular momentum tensor; Internal symmetries and associated conservation laws

2. **Quantisation of Relativistic Free Fields** : Quantisation of scalar, Dirac and electromagnetic fields; Number operator; States; Invariant Green's functions

3. **Interaction Quantum Fields & Perturbation Theory** : Interaction Picture; Time Evolution Operator; Covariant Pertubation theory; Normal product; Time ordered product & Wick's theorem; Invariant amplitude and Feynman rules; Scattering cross section; Spinor Electrodynamics and applications; Basic ideas on renormalization.

Books :
1. Quantum Field Theory : *David Lurie*
2. Relativistic Quantum Mechanics : *J D Bjorken & S Drell*
3. Relativistic Quantum Fields : *J D Bjorken & S Drell*
4. Particle Physics & Introduction to Field Theory : *T D Lee*