SIR PADAMPAT SINGHANIA UNIVERSITY

Udaipur

SCHOOL OF ENGINEERING

Course Curriculum of 2-Year M.Sc. Degree Programme in Physics (Specialization in Non-linear dynamics & Theoretical Atomic & Molecular Physics) (Batch- 2018-2020)

Credit Structure

<table>
<tr><th colspan="2">M. Sc. Core</th><th colspan="2">M. Sc. Elective</th></tr>
<tr><th>Category</th><th>Credits</th><th>Category</th><th>Credits</th></tr>
<tr><td>Departmental Core Subjects</td><td>56</td><td rowspan="2">Departmental Electives</td><td rowspan="2">25</td></tr>
<tr><td>Minor Subjects</td><td>06</td></tr>
<tr><td>Total</td><td>62</td><td>Total</td><td>25</td></tr>
<tr><td colspan="3">Grand Total</td><td>87</td></tr>
</table>

Distribution of Total Credits & Contact Hours in all Semesters

S. No.	Semester Number	Credits/Semester	Contact Hours/week
1	I	20	25
2	II	24	30
3	III	22	28
4	IV	21	32
	Total	87	--

Course Structure: M. Sc. 2018-20

Semester - I

S. No.	Course Code	Course Title	L	T	P	Credit(s)
1	PH-551	Mathematical Physics	4	0	0	4
2	PH-552	Classical Mechanics	4	0	0	4
3	PH-553	Elementary Quantum Mechanics	4	0	0	4
4	PH-554	Physics Laboratory - I	0	0	5	5
5	EC-570	Electronics	3	0	0	3
					Total Credits	20
					Total Contact Hours/week	25

Semester - II

S. No.	Course Code	Course Title	L	T	P	Credit(s)
1	PH-555	Statistical Physics	4	0	0	4
2	PH-556	Electrodynamics	4	0	0	4
3	PH-557	Physics of semiconductor devices	4	0	0	4
4	PH-558	Solid state Physics	4	0	0	4
5	PH-559	Physics Laboratory – II	0	0	5	5
6	MA-558	Computational Techniques for Physicists	2	0	1	3
					Total Credits	24
					Total Contact Hours/week	30

Semester - III

S. No.	Course Code	Course Title	L	T	P	Credit(s)
1	PH-561	Advanced Quantum Mechanics	4	0	0	4
2	PH-562	Nuclear & Particle Physics	4	0	0	4
3	PH-563	Physics of Nanomaterials & Nanodevices	4	0	0	4
4	PH-566	Physics Laboratory – III	0	0	5	5
5	PH-5XX	Departmental Elective – I	4	0	0	4
6	PH-560	Seminar	0	0	1	1
					Total Credits	22
					Total Contact Hours/week	28

Semester - IV

S. No.	Course Code	Course Title	L	T	P	Credit(s)
1	PH-5XX	Departmental Elective – II	5	0	0	5
2	PH-580A	Dissertation Seminar	0	0	1	1
3	PH-580B	Dissertation	0	0	13	13
4	PH-580C	Dissertation (Viva)	-	-	-	3
					Total Credits	21
					Total Contact Hours/week	32

List of Departmental Elective(s) - I

S. No.	Course Code	Course Title	L	T	P	Credit(s)
1	PH-564	Nonlinear Dynamics - I	4	0	0	4
2	PH-565	Theoretical Atomic & Molecular Physics - I	4	0	0	4

List of Departmental Elective(s) - II

S. No.	Course Code	Course Title	L	T	P	Credit(s)
1	PH-567	Nonlinear Dynamics - II	4	0	0	4
2	PH-568	Theoretical Atomic & Molecular Physics - II	4	0	0	4

* A student will choose departmental electives from the same stream (Nonlinear Dynamics or Theoretical Atomic & Molecular Physics) in both III & IV semesters

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Semester - I

(Departmental Core Subject)

PH-551	L-T- P-C
Mathematical Physics	4-0-0-4

Objective: *The objectives of this course is to introduce students to the use of mathematical methods to solve physics problems; & provide students with basic skills necessary for the application of mathematical methods in physics.*

Course Content

Tensor: Introduction, rank & number of components of a tensor, contravariant & covariant tensors, transformation of covariant, contravariant & mixed tensors, addition, multiplication & contraction of tensors.

Complex Analysis: Function of complex variable, derivative & the Cauchy-Riemann differential equations, analytic function, line integral of complex function, Cauchy's integral theorem, Cauchy's integral formula, Taylor's & Laurent series, Cauchy's residues theorem, singular points of an analytic function, evaluation of residues, Liouville's theorem, evaluation of definite integrals.

Ordinary Differential Equations**:** Second-order homogeneous & nonhomogeneous differential equations with constant & variable coefficients.

Special Functions**:** Series solution method, solutions & basic properties like orthogonality, recurrence relations, graphical representation & generating functions of Bessel's, Hermite's, Legendre's & Laguerre's & associated Legendre functions.

Second-order partial differential equations**:** Laplace, Poisson, Helmholtz, Wave & Diffusion equations.

Integral transforms**:** Laplace transforms - first & second shifting theorems, inverse Laplace transform-first & second shifting theorems, Laplace transform & inverse Laplace transform of derivative & integral of function, Convolution theorem.

Fourier series - Fourier series of arbitrary period, Summation of the Fourier series.

Fourier Transform - Fourier sine & cosine transform, inversion formula for Fourier sine & cosine transforms, change of scale property, shifting theorem, multiple Fourier transform, Convolution theorem, Fourier transform of the derivatives of a function.

Text/Reference Books

1. Introduction to Mathematical Physics by Charlie H. PHI. 1972.
2. Applied Mathematics for Engineers and Physicists by Louis A. Pipes & Lawrence R. Harvill, 3rd Ed. McGraw-Hill Book Company. 1970.
3. Advanced Engineering Mathematics by Kreyszig E. John-Wiley. 1983.
4. Mathematical Physics by Gupta B.D. Vikas Publishing House Pvt. Ltd. 1978.
5. Mathematical Physics by Butkov E. Addison-Wesley Publishing Company. 1968.
6. Mathematical Methods in Physics By Arfken & Weber. 5th Ed. Academic Press. 2001.

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Semester - I

(Departmental Core Subject)

PH-552	L-T-P-C
Classical Mechanics	4-0-0- 4

Objective: *To develop familiarity with the physical concepts & facility with the mathematical methods of classical mechanics.*

Course Content

System of particles: Conservation laws, constrained motion, Constraints, Degree of freedom, generalized co-ordinates.

Variational principle & Lagrangian Formulation: Calculus of variations, Euler-Lagrange differential equation, Hamilton's principle, Deduction of Lagrange's equations of motion by different method, D'Alembert's principle, Rayleigh's dissipation function, Lagrangian for a charged particle in an electromagnetic field. Applications of Lagrange's equations of motion, Non-holonomic system: Lagrange's method of undetermined multipliers, Conservation theorems (first integrals of equations of motion), Routhian function.

Hamiltonian Formulation of Mechanics: Phase space & the motion of the system, Hamiltonian, Hamilton's canonical equations of motion, Physical significance of H, Hamilton's canonical equations of motion in different co-ordinate system, Applications of Hamiltonian's equation of motion, Hamiltonian for a charged particle in an electromagnetic field, Principle of least action, Canonical transformations, Infinitesimal contact transformation, Hamilton-Jacobi method, H-J equation for Hamilton's characteristic function, Application of H-J method, Action & angle variables, Poisson brackets, Jacobi's identity, Infinitesimal contact transformations, interpretation in terms of Poisson brackets, The angular momentum & Poisson brackets, Poisson bracket in Quantum Mechanics, Lagrange's brackets, Liouville's theorem.

Motion under Central Force: Equivalent one body problem, General features of central force motion, Equivalent one dimensional problem-features of orbits, Inverse square law-Kepler problem, Virial theorem, Rutherford scattering, Center of mass & Laboratory co-ordinates, Transformation of scattering problem to laboratory co-ordinates.

Relativistic Mechanics: Basic postulates of Relativity, Lorentz transformations, Relativistic generalization of Newton's law, Lagrangian & Hamiltonian formulation of relativistic mechanics, covariant Lagrangian & Hamiltonian formulation.

Text/Reference Books

1. Classical Mechanics by Goldstein H. Addison Wesley. 1980.
2. Mechanics by Somerfield A. Academic Press. 1952.
3. Classical Mechanics by Gupta S.L., Kumar V. & Sharma R.C. Pragati Prakashan. 1988.
4. Classical Mechanics by Upadhyay J.C. Himalaya Publishing House. 2003.
5. Classical Mechanics by Rana &Joag, Tata McGraw Hill.

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Semester - I

(Departmental Core Subject)

PH-553	L-T-P-C
Elementary Quantum Mechanics	4-0-0-4

Objective: *The objective of this course is to introduce the fundamentals of quantum mechanics & its applications.*

Course Content

Why Quantum Mechanics? The quantum concept, Postulates of quantum mechanics Schrodinger equation: Derivation & Solution, Physical interpretation of wave function, Expectation values, Probability current density, Ehrenefest's theorem, Uncertainty principle, Complementarity principle.

One-dimensional problems: Wells & barriers, Harmonic oscillator by Schrodinger's equation, Applications of Schrodinger equation in Spherical Symmetric System: Rigid Rotator & Hydrogen Atom, Degeneracy.

Operators in QM: Orthogonal sets, Completeness, Different type of operators, Eigen values & Eigen functions, Operator formalism in QM, Commutation Algebra, Commutatively & simultaneous Eigen functions. Hilbert space, Operators as matrix, Matrix form of wave function, Schrodinger, Heisenberg & Interaction matrix representation, Dirac's Bra & Ket vectors, Direct sum & product of Hilbert space, Co-ordinate & momentum representation.

Identical particles, Symmetric & anti-symmetric wave functions, Particle exchange operator, Pauli exclusion principle, Spin angular momentum, Stern-Gerlach experiment, Spin matrices for electron, Commutation relations.

Angular momentum operator, Spin angular momentum, Total angular momentum operators, Commutation relations of total angular momentum, Eigen values of J^2 & J_z, J_+ & J_-, J_x & J_y, Addition of angular momentum, CG coefficients, Wigner-Eckart theorem.

Approximate method- Time independent perturbation theory, Non-degenerate & degenerate cases, Applications: – normal He atom, perturbed harmonic oscillator, Zeeman Effect & Stark effect.

Text/Reference Books

1. Quantum Mechanics by Schiff L I. 3rd Ed. McGraw-Hill.1968.
2. Quantum Mechanics Theory and Applications by Ghatak A. K. & Lokanathan S. 3rd Ed. McMillan India Limited. 1997.
3. Quantum Mechanics: A modern approach by Das A. & Milissionos A.C. Gordan and Breach Science Publishers.
4. Quantum Mechanics An Introduction by Grenier W. 3rd Ed. Springer. 1994.
5. Modern Quantum Mechanics by Sakurai J.J. Addison-Wesley. 1999.

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Semester - I

(Minor Subject)

EC-570	L-T-P-C
Electronics	3-0-0-3

Objective: *An understanding of basic electronic abstractions on which analysis & design of electrical & electronic circuits & systems are based, including lumped circuit, digital & operational amplifier abstractions.*

Course Content

Operational Amplifier: Frequency Response of an Op-Amp-Parameters of an Op-Amp-Sign Changer-Scale Changer-Adder-Subtractor-Phase Shifter-Differential Amplifier-Integrator-Differentiator-Analog Computer Setup to Solve Linear Simultaneous Equation-Differential Equations in Physics- Logarithmic & Exponential Amplifiers-Active Filters.

Digital Circuits & Devices: Logic Families-Combinational Logic-Function of Combinational Logic-Flip Flops & other Multivibrators-Counters Shift Registers-Memories RAM, ROM, PROM, EPROM-Charge Coupled Devices (CCD)

Signal Processing & Data Acquisition: Wave Form Generators & Wave Shaping Circuits-Sinusoidal Oscillators-Phase Shift Oscillator-Wein Bridge Oscillator-Crystal Oscillator Multivibrators Comparators-Schmitt Trigger-Square Wave & Triangular Wave Generators-Pulse Generators-IC 555 Timer & its Application-Signal & Signal Processing-Analog Multiplexer & Demultiplexer-Sample & Hold System-D/A Converters-A/D Converters.

Antennas & Wave Propagation: Terms & Definition-Effect of Ground on Antennas-Grounded $\lambda/4$ Antenna-Ungrounded $\lambda/2$ Antenna-Antenna Arrays-Broadside & End Side

Arrays-Antenna Gain-Directional High Frequency Antennas-Wideband & Special Purpose Antennas-Sky Wave Propagation- Ionosphere-Ecles & Larmor Theory-Magneto Ionic Theory-Ground Wave Propagation.

Microwaves: Microwave Generation-Multicavity Klystron-Reflex Klystron-Magnetron-Travelling Wave Tubes (TWT) & other Microwave Tubes-Microwave Transistors-MASER-Tunnel Diode-Gunn Diode.

Communication Electronics: Analog & Digital Signals – Modulation – Types of Modulation- Amplitude modulation theory – Frequency spectrum of the AM wave – Representation of AM – Power relations in the AM wave – Generation of AM – Basic requirements- Description of frequency & phase modulation – Mathematical representation of FM – Frequency spectrum of the FM wave- Effects of noise on carrier – pre emphasis & de emphasis -other forms of interference- intersystem comparisons-comparison of wide band & narrow band FM – Generation of FM– Pulse Modulation Techniques

Text/Reference Books

1. Physics of Semiconductor Devices.Wiley Eastern
2. Integrated Electronics-Millman & Halkias.Tata McGraw Hill.
3. Microelectronics-Millman & Grabel.McGraw Hill
4. Digital Fundamentals.Floyd.UBS
5. Digital Principles and Applications.Malvino. McGraw Hill.
6. Electronic Communication Systems. Kennedy G. & Davis.Tata McGraw Hill.
7. Principles of Communication Systems.Taub S.Tata McGraw Hill.
8. Electronics & Radio Engineering.Terman F.E. McGraw Hill.
9. Communication Systems.Carlson. McGraw Hill.
10. Communication Systems. Haykin S.John Wiley & Sons.

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Semester - I

(Departmental Core Subject)

PH-554	L-T-P-C
Physics Laboratory - I	0-0-5-5

Objective: *The purpose of this course is to empower the student with practical skills in fundamental experiments of Physics.*

List of Experiments

PART-I

1. Michelson Interferometer
   (a) To determine the wavelength of a laser using the Michelson interferometer.
   (b) To determine the wavelength and difference of two wavelengths of a Sodium Light source using the Michelson interferometer.
2. Hall effect experiment
   (a)To determine the Hall voltage developed across the sample material.
   (b)To calculate the Hall coefficient and the carrier concentration of the sample material.
3. Diffraction using LASER
   (a)To determine the wavelength of laser light from single and double slit diffraction patterns
   (b)To determine the size of circular aperture using a known wavelength laser light source.
   (c)To develop and understand the multiple slit diffraction patterns
4. Milliken’s Oil drop method

(a)To experimentally demonstrate the concept of Millikan's oil drop experiment.

(b)To find the terminal velocity of the drop.

(c)To find the charge on a drop.

5. Four Probe method

   To study the variation of resistivity of semiconductors (p and n type) as a function of temperature by using Four probe Method and determine the band gap of semiconductor

6. Parallel plate capacitor and dielectric constant

   (a) To study the variation of capacitance of a parallel plate capacitor as a function of distance between the plates and area of the plates.

   (b) To study the variation of capacitance of a parallel plate capacitor with various dielectric materials

7. Rydberg constant

   (a) To study the emission of light from a hydrogen discharge source

   (b) To learn the empirical formulas to characterize the pattern of visible spectral lines from hydrogen and determine the Rydberg constant

8. Coupled pendulum

   To study normal modes of oscillations of two coupled pendulums and to measure the frequncies of these normal modes, as well as the spring constant k.

9. Quinke's method

   To determine the volume magnetic susceptibility of Manganese sulphate/$FeCl_3$ solution of different concentrations

PART-II

1. To get familiar with working knowledge of the following Instruments

   (a) Cathode Ray Oscilloscope

   (b) The Multimeter

   (c) Function generator

   (d) Regulated power supply.

2. To study the operation of an op-amp as inverting, non-inverting and differential amplifiers in open loop configuration.

3. To study the operation of an op-amp as inverting, non-inverting and differential amplifiers in closed loop configuration.

4. To study the application of op-amp as Summing, Scaling, and Averaging Amplifiers in Inverting, Non-Inverting and Differential Configurations.
5. To study the operation of op-amp as an integrator and differentiator.
6. To study the operation of first order and second order Low pass Butterworth filter.
7. To study the operation of first order and second order high pass Butterworth filter.
8. To study the operation of Phase shift oscillator and Wien's Bridge oscillator.
9. To study the operation of op-amp as Square Wave Generator, Triangular wave Generator and Sawtooth Wave Generator.
10. To study the operation of op-amp as Basic Comparator and Voltage Limiters.
11. To study the operation of op-amp as Clippers and Clampers.
12. To study the operation of op-amp as Schmitt Trigger.
13. To study the operation of Digital to Analog converter using
    (a) R-2R Ladder circuit and
    (b) Binary weighted resistors.

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Semester - II

(Departmental Core Subject)

PH-555	L-T-P-C
Statistical Physics	4-0-0-4

Objective: *The main goal of this course is to acquire fundamental knowledge of classical & quantum statistical mechanics; construct a bridge between macroscopic thermodynamics & microscopic statistical mechanics by using mathematical methods & fundamental physics for individual particles.*

Course Content

Foundations of Statistical Mechanics, Specification of states of system, Contact between statistics & thermodynamics, Classical ideal gas, Entropy of mixing & Gibb's paradox. Micro canonical ensemble, Phase space, Trajectories & density of states, Liouville's theorem, Canonical & grand canonical ensembles, partition function, calculation of statistical quantities, Energy & Density fluctuations.

Density matrix, Statistics of ensembles, Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac & Bose-Einstein statistics, Properties of ideal Bose & Fermi gases, Bose-Einstein condensation.

Expansion of classical gas, Virial equation of state, Ising model, mean-field theories of Ising model in three, two & one dimensions, exact solutions in one-dimension.

Landau theory of phase transition, Critical indices, Scale transformation & dimensional analysis. Correlation of space-time dependent fluctuations, Fluctuations & transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem, The Fokker-Planck equation.

Text/Reference Books

1. Fundamentals of Statistical and Thermal Physics by Reif F. McGraw-Hill Kogakusha. 1985.
2. Statistical Physics by Landau and Lifshitz. Butterworth-Heinemann, Oxford, UK. 2005.
3. Statistical Physics by Huang K. John Wiley. 2004.
4. Statistical Mechanics by Gupta &Kumar. Pragati Prakashan, Meerut. 2005.
5. Statistical mechanics by Pathria R. K. Elsevier India. 2005.

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Semester - II

(Departmental Core Subject)

PH-556	L-T-P-C
Electrodynamics	4-0-0-4

Objective: *The main objective is to introduce the fundamental theory & methods of electrodynamics based on the Maxwell's theory of electromagnetic fields.*

Course Content

Electrostatics: Electric field, Gauss law, Differential form of Gauss law, Another equation of electrostatics & the scalar potential, surface distribution of charges & dipoles & discontinuities in the electric field & potential, Poisson & Laplace equations, Green's Theorem, Uniqueness of the solution with Dirichlet or Neumanm Boundary conditions, Formal solution of electrostatic Boundary value problem with Green's Function, Electrostatic potential energy & energy density, capacitance.

Boundary-Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere, Point charge in the presence of a charged insulated conducting sphere, Point charge near a conducting sphere at fixed potential, conducting sphere in a uniform electric field by method of images.

Multipoles, Electrostatics of Macroscopic Media Dielectrics: Multipole expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media, Boundary value problems with dielectrics; Molar polarizability & electric susceptibility, Models of molecular polarizability, Electro-static energy in dielectric media.

Magnetostatics: Introduction & definition, Biot-Savart law, the differential equations of Magnetostatics & Ampere's law, Vector potential & Magnetic induction for a circular current loop, Magnetic fields of a localized current distribution, Magnetic moment, Force & torque on & energy of a localized current distribution in an external magnetic induction, Macroscopic equations, Boundary conditions on B & H.

Time varying fields Conservation Laws & Relativistic Electrodynamics: Energy in a magnetic field, Vector & Scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Poynting's theorem & conservation of energy & momentum for a system of charged particles & EM fields, Conservation laws for macroscopic media.

Mathematical properties of the space-time, special relativity, Invariance of electric charge covariance of electrodynamics, Transformation of electromagnetic fields, Electromagnetic field tensor, Transformation of four potentials & four currents, Tensor description of Maxwell's equation.

Text/Reference Books

1. Classical electrodynamics. Jackson J.D. 2nd Ed. John Wiley & Sons. 1975.
2. Classical Electricity and Magnetism. Panofsky & Philips. New Delhi, Indian Book. 1962.
3. Introduction to Electrodynamics, Griffiths. Pearson Education. 2005.
4. Classical theory of Electrodynamics. Landau &Lifshitz. New York, Pergaman Press. 1960.
5. Electrodynamics of Continuous Media, Landau & Lifshitz. New York, Pergaman Press. 1960.
6. Elements of Electromagnetics Mathew N.O. & Sadiku, 2nd Ed. Oxford Univ. Press. 1999.

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Semester - II

(Departmental Core Subject)

PH-557	L-T-P-C
Physics of Semiconductor Devices	4-0-0-4

Objective: *The objective of this course is to introduce fundamentals physics of semiconductors. This course also help, to know about fundamental aspects of various semiconducting devices.*

Course Content

Intrinsic & Extrinsic Semiconductors, mobility of carriers, mobility & conductivity, Hall effect, Effective mass, Direct & Indirect semiconductors, Conductivity modulation, generation & recombination of charges, diffusion, the continuity equation, Injected minority carrier charge, the potential variation within a graded semiconductor four probe method of resistivity measurement.

P-N Junction relation, types of junctions, P-N junction diode, voltage current relationship, width of depletion region, junction capacitance, junction breakdown, switching of the diode, types of diode.

Bipolar junction transistor; Types, Current Components, CB,CC,CE configuration, DC & AC analysis, Hybrid model, current gain, voltage gain, input & output resistances, approximation model, High frequency model (Just reference),switching of transistors, load line concept, Basic concept of thermal stability of transistor.

Junction field effect transistor & MOSFET; Types, V-I characteristics, operation methods, low & High frequency model (Just Reference)

Four layer diode (P-N-P-N), SCR, Principle of operation, transistor analogy, methods of Turning On & Turning Off (Just reference), Gate characteristics, DIAC, TRIAC, light activated thyristor, Applications of SCR in the following areas: Over voltage protection, Zero voltage switch, Logic & Digital Circuits, Pulse circuits.

Text/Reference Books

1. Integrated Electronics by Millman J. and Halkias C. McGraw Hill, New York. 1972.
2. Electronic Devices and circuits by Malvino.
3. Solid State Electronic Devices and Integrated Circuits (PHI) by Sterectman B. G. Prentice Hall Inc.1995.
4. Physics of Semiconductors Devices by Sze S.M. John Wiley & Sons.1999.

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Semester - II

(Minor Subject)

MA-558 L-T-P-C
Computational Techniques for Physicist 2-0-1-3

Objective: *The purpose of this course is to empower the student with practical skills in physics and engineering problems. Beginning with an analysis of the relevant principles at play, the dimensions and scale of the problem, and concluding with the design and implementation of the numerical and graphical analysis that leads to an understanding of the system.*

Course Content

Programming Fundamentals: Introduction- Functions, Characters, Operators and Commands. Basic Arithmetic -Basic Operations with Scalars, Vectors and Arrays-Matrices and Matrix Operations-Complex Numbers- Built-In Functions-Illustrative Examples.

Programming: Control Flow Statements: *if, else, else if, switch* Statements-*for, while* Loop Structures-*break,* Statement-Input/output Commands-Controlling Output. Graphics: 2D Plots- Graph of a Function- Titles, Labels, Text in a Graph- Line Types, Marker types, Colors-3D Graphics- Curve Plots-Mesh and Surface Plots-Illustrative Examples.

Numerical Methods I: Finding Roots of a Polynomial-Bisection Method-Newton Raphson Method-Solution of Simultaneous Linear Equation by Gauss Elimination Method-Solution of Ordinary Differential Equation by Euler, Runge-Kutta Fourth Order

Methods-Evaluation of Integrals by means of Simpson's One Third Rule-Girafe's Root Squaring Method for solving Algebraic Equation.

Numerical Methods II: Solving Partial Differential Equations- Finite difference method – Explicit and Implicit Methods – Stability analysis – Application to diffusion equation – Solving Poisson equation – Introduction to finite volume and finite element methods- Random number generator – Importance sampling – Metropolis algorithm – Monte Carlo simulation.

List of Experiments

1. Introduction to programming language, Fundamentals: Functions, Characters, Operators and Commands.
2. To practice Basic Arithmetic in programming language - Basic Operations with Scalars, Vectors and Arrays-Matrices and Matrix Operations, Complex Numbers.
3. To practice Programming with Control Flow Statements: *if, else, else if, switch* Statements-*for, while* Loop Structures-*break,* Statement-Input/output Commands.
4. To practice Graphics: 2D Plots, Graph of a Function- Titles, Labels, Text in a Graph- Line Types, Marker types, Colors-3D Graphics- Curve Plots-Mesh and Surface Plots-Illustrative Examples.
5. To write algorithm and program to implement the Bisection Method to find roots of Non-linear equations.
6. To write algorithm and program to implement the Newton-Raphson method to find roots of Non-linear equations.
7. To write algorithm and program to implement the Girafe's Root Squaring Method for solving Algebraic Equation.
8. To write algorithm and program to implement the Numerical Integration method : Simpson's 1/3 rule.
9. To write algorithm and program to implement the Direct Method to solve Linear simultaneous equations: Gauss-Elimination Method.

10. To write algorithm and program to implement the Euler and Runge-Kutta Methods of IV order to solve Differential equations.
11. To write algorithm and program to implement the Explicit Finite difference methods of solving Partial differential equations.
12. To write algorithm and program to implement the Implicit Finite difference methods of solving Partial differential equations.

Text/Reference Books

1. Applied Numerical Analysis. Gerald G. E. & Wheatley P. O. Addison Wesley. 1988.
2. Numerical Methods for Mathematics, Science & Engineering. Mathews J. H. PHI. 1994.
3. Elementary Numerical Analysis. Atkinson K. John Wiley & Sons. 1978.
4. Numerical Methods for Scientific & Engineering Computation. Jain M. K., Iyengar S. R. K. & Jain R.K. Wiley Eastern. 2003.
5. Numerical Analysis. Burden R. L. & Faires J. D. 7^{th} Ed. Thomson Brooks Cole. 2001.
6. Numerical Methods for Scientists & Engineers. Rao K. S. PHI. 2001.
7. Numerical methods in Science and Engineering**.** Venkataraman M.K. National Publishing Co. Madras.
8. Introductory Methods of Numerical Analysis. Sastry S.S. Prentice Hall.

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Semester - II

(Departmental Core Subject)

PH-558	L-T-P-C
Solid State Physics	4-0-0-4

Objective: *The aim of this course is to provide students with a background & understanding of the fundamentals of the solid state physics & to expose them to some exciting current research in this field.*

Course Content

Lattice dynamics & optical properties of solids: Interatomic forced & lattice dynamics of ionic & covalent crystals, metals. Analysis of strain, elastic compliance & stiffness constants, elastic energy density, elastic stiffness constants of cubic crystals & elastic waves in cubic crystals.

Vibration of crystals with monatomic basis, two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons, phonon heat capacity, Plank distribution, density of states in one & three dimensions, Debye model for density of states, Debye T^3 law, Einstein model, thermal conductivity, phonon-phonon interaction-umklapp process, thermal expansion.

Band theory & Semiconductors: Nearly free electron model, origin & magnitude of energy gap, Bloch function, Kronig-penney model, wave equation of electron in periodic potential, number of orbital's in a band, band gap in semiconductors, equation of motion, effective mass in semiconductors, intrinsic carrier concentration, impurity conductivity, Fermi surfaces, tight bonding method for energy gap, De Hass-van Alfen affect.

Superconductivity: Meissner effect, type I & type II superconductors, heat capacity, microwave & infrared properties, isotope effect, London equation, coherence length, Cooper pairs, BCS theory (no derivation), field quantization in a superconducting ring, duration of persistent current, high temperature superconductors

Diamagnetism & Paramagnetism: Langevin Diamagnetism equation, quantum theory of diamagnetism of mononuclear systems, Paramagnetism, quantum theory of Paramagnetism, s-rules, cooling by isotropic demagnetization, paramagnetic susceptibility of conduction electrons.

Ferromagnetism & Antiferromagnetism: Ferromagnetic order, magnons, Neutron magnetic scattering, ferromagnetic order, Antiferromagnetic order, Ferromagnetic domains, single domain particle, magnetic bubble domains

Magnetic resonance: Nuclear magnetic resonance, Line width, hyperfine splitting, nuclear quadrupole resonance, ferromagnetic resonance, Antiferromagnetic resonance, Electron paramagnetic resonance, Principle of maser action.

Text/Reference Books

1. Introduction to Solid state Physics by Kittel C. 7th Ed. John Wiley. 1995.
2. Solid State Physics by Dekker A. J. MacMillan. London. 1965.
3. Solid state physics by Pillai S. O. New Age International Publishers. 2005.
4. Solid State Physics by Singhal R. L. Kedar Nath Ram Nath Publishers. 2001.

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Semester - II

(Departmental Core Subject)

PH-559	L-T-P-C
Physics Laboratory - II	0-0-5-5

Objective: *The purpose of this course is to empower the student with practical skills in fundamental experiments of electronics.*

List of Experiments

PN diode

1. (a) Study the volt – ampere (V – I) characteristics of silicon P – N junction diode
   (b) Study the volt – ampere (V – I) characteristics of zener diode
2. (a) Study the characteristics of half wave rectifier without filter
   (b) Study the characteristics of half wave rectifier with filter
3. (a) Study the characteristics of full wave rectifier without filter
   (b) Study the characteristics of full wave rectifier with filter

Characteristics of BJT in CB, CE modes

4. (a) Study the input and output characteristics of a transistor in common base configuration
   (b) Study the input and output characteristics of a transistor in common emitter configuration

Amplifier

5. (a) Study the common emitter amplifier to find
   (i) cut – off frequencies
   (ii) bandwidth and phase angle
   (iii) mid band voltage and current gain and

(iv) input and output characteristics

(b) Study the common collector amplifier to find

(i) cut – off frequencies

(ii) bandwidth and phase angle

(iii) mid band voltage and current gain and

(iv) input and output characteristics

<u>Characteristics of various transistors</u>

6. (a) Study and plot the emitter characteristics (V_E vs. I_E) of a UJT and its use as a relaxation oscillator

(b) Study the drain characteristics and transfer characteristics of a FET

<u>MOSFET Characteristics</u>

7. Study the characteristics of enhancement type and depletion type MOSFETs

<u>S.C.R. Characteristics</u>

8. (a) Study the V - I characteristics of S.C.R. in forward bias and reverse bias

(b) Study the V – I characteristics of Gate turn – off thyristor (i.e, GTO)

<u>DIAC Characteristics</u>

9. Study the V – I characteristics of DIAC in forward bias and reverse bias

<u>TRIAC Characteristics</u>

10. Study the V – I characteristics of TRIAC in forward and reverse bias

<u>RF and Microwave</u>

11. (a) Study the characteristics of Klystron tube

(b) Study the characteristics of Magnetron tube

<u>Antenna and waves</u>

12. (a) Study the characteristics of simple λ/2 dipole antenna by antenna trainer kit, transmitting and receiving mast and RF detector

(b) Study the characteristics of folded λ/2 dipole antenna by antenna trainer kit, transmitting and receiving mast and RF detector

13. (a) Study the characteristics of 3 – element simple Yagi – Uda antenna by antenna trainer kit, transmitting and receiving mast and RF detector

(b) Study the characteristics of 5 – element folded Yagi – Uda antenna by antenna trainer kit, transmitting and receiving mast and RF detector

Timers

14. Study the characteristics of monostable multivibrator
15. Study the characteristics of astable multivibrator
16. Study the characteristics of bistable multivibrator
17. Study the characteristics of voltage controlled oscillator (i.e, VCO) and phase locked loop (i.e, PLL)
18. Study the characteristics of switched mode power supply (i.e, SMPS)

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Semester - III

(Departmental Core Subject)

PH-561	L-T-P-C
Advanced Quantum Mechanics	4-0-0-4

Objective: *The objective of this course is to introduce various approximate methods, scattering theory & fundamentals of relativistic quantum mechanics & its applications to study the various properties of atoms, molecules & solids.*

Course Content

Approximate methods: Variational method, WKB approximation, Applications of Variational & WKB method, Time dependent perturbation theory, Harmonic perturbation, Fermi's golden rule, Transition probabilities, Adiabatic & Sudden approximation, Semi classical treatment of radiation.

Quantum Theory of Scattering: Collision in 3-D & scattering, Laboratory & CM reference frames, Scattering amplitude, Differential scattering cross section & total scattering cross section, General formulation of scattering theory, Born approximation, Applications of Born approximation, Partial Wave Analysis & Phase Shift, Applications of PWA, The Lippmam-Schwinger equation.

Relativistic wave equations: Klein-Gordan equation, Solution of Klein-Gordan equation, Dirac's relativistic equation, Solution of Dirac's equation.

Quantization of Fields: Classical approach to field theory, Second quantization, Quantum equation of field, Quantization of non-relativistic Schrödinger equation, Creation, Annihilation & Number Operators, Quantization of Klein-Gordan equation.

Text/Reference Books

1. Quantum Mechanics by Schiff L I. 3rd Ed. McGraw-Hill. 1968.
2. Quantum Mechanics Theory and Applications by Ghatak A. K. and Lokanathan S. 3rd Ed. McMillan India Limited 1997.
3. Quantum Mechanics: A modern approach by Das A. and Milissionos A.C. Gordan and Breach Science Publishers.
4. Quantum Mechanics An Introduction by Grenier W. 3rd Ed. . Springer. 1994.
5. Modern Quantum Mechanics by Sakurai J.J. Addison-Wesley. 1999.
6. Quantum Physics (atoms, molecules…) Eisberg R. and Resnick R. J. Wiley.
7. Quantum Field Theory by Mandal F. & Shaw G. John–Willey.

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Semester - III

(Departmental Core Subject)

PH-562 L-T-P-C
Nuclear & Particle Physics 4-0-0-4

Objective: *The objectives of this course are to introduce students to the fundamental principles & concepts governing nuclear & particle physics & have a working knowledge of their application to real –life problems.*

Course Content

Nuclear Properties: The Nuclear Radius, Mass & Abundance of Nuclides, Nuclear Binding Energy, Nuclear Angular Momentum & Parity, Nuclear Magnetic Moments, Nuclear Excited States; The Force Between Nucleons: Deuteron, Nucleon-Nucleon Scattering, Proton-Proton & Neutron-Neutron Interactions, Properties of Nuclear Force, The Exchange Force Model; Nuclear Models: The Shell Model, Even-Z, Even-N Nuclei & Collective Structure, More Realistic Models; Radioactivity.

Radioactive Decay Law, Quantum Theory of Radioactive Decays, Alpha Decay, Beta Decay, Gamma decay; Nuclear Reactions: Conservation Laws, Energetic, Isospin, Reaction Cross-sections, Coulomb scattering, Nuclear Scattering, The Optical Model, Compound-Nucleus Reactions, Direct Reactions, Resonance reactions, Heavy-Ion Reactions; Neutrons, Nuclear Fission, Nuclear Fusion; Nuclear Spin & Moments, Hyperfine Structure.

Particles & Interactions, Gauge Theories: Internal Symmetries, Isospin, Unitary Symmetry, Representation of SU(3); The Quark Model, Color, Evidence for Color, Parton Model, Bjorken Scaling; Charm, the Charmed Quark, J/Psi & its Family, Correspondence between Quarks & Leptons; PCAC & Soft Pion Theorems; The Vector-

Current Ward Identity, Axial-Vector-Current Ward Identity, Anomaly; Phenomenology of Weak Interactions: The Weinberg-Salam Model, GIM Mechanism, W & Z Particles, The Higgs Particle, CP Violation, CKM Mixing.

Text/Reference Books

1. Structure of the Nucleus. Preston M.A. & Bhaduri R.K. Addison--Wesley, Reading. 1994.
2. Introductory Nuclear Physics. Krane K.S. John Wiley & Sons, New York. 2006.
3. High Energy Astrophysics Longair, M.S. Cambridge University Press. 2006.
4. Active Galactic Nuclei. Krolik J. Princeton University Press.1999.
5. Particle Astrophysics. Perkins D. Oxford University Press. 2003.
6. Quarks and Leptons by Halzen F. & Martin A. D. Wiley.

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Semester - III

(Departmental Core Subject)

PH-563 L-T-P- C
Physics of Nanomaterials & Nanodevices 4-0-0-4

Objective: *The objective of this course is to introduce nanostructured materials & their properties. This course also help, to know various synthesis techniques as well devices for characterization of Nanomaterials.*

Course Content

Definition & properties of Nanostructured materials, Methods of synthesis of Nanostructured materials, Special experimental techniques for characterization of Nanostructured materials, Transmission electron microscope, Scanning Tunneling Microscope, Atomic Force Microscope, Quantum size effect & its applications.

Electron confinement in infinitely deep square well, Confinement in two & one dimensional well, Idea of quantum well structure, Quantum dots, Quantum wires.

Determination of particle size, Increase in width of XRD peaks of Nanomaterials, Shift in photoluminescence peaks, variations in Raman spectra of Nanomaterials.

Different methods of preparation of Nanomaterials, Bottom top: Cluster beam evaporation, Ion beam deposition, chemical bath deposition with capping techniques & Top down: Ball Milling, Lithography.

Applications of quantum devices: quantum well & quantum dot lasers, ultra-fast switching devices, high density memories, dc & rf squids, multi-state logic circuits, long wavelength detectors, photonic integrated circuits.

Text/Reference Books

1. Handbook of Nanostructured Materials and Nanotechnology. Singh H. Nalwa.
2. Nanotechnology Molecular designed materials by Gan-Moog Chow & Kenneth E. American Chemical Society.
3. Quantum Dot heterostructures by Grundmann D. M. & Ledentsov N. N. John Willey & Sons. 1998.
4. Nano particles and nano structured films, Preparation characterization and applications. Fendler J. H. John Willey & Sons. 1996.
5. Physics of semiconductor nano structures by Jain K. P. Narosa. 1997.

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Semester - III

(Departmental Elective Subject)

PH-564 L-T-P-C
Nonlinear Dynamics - I 5-0-0-5

Objective: *The objective of this course is to introduce various fundamental principles, theoretical procedures, numerical techniques & technological applications of nonlinear dynamical systems. It also highlights the current advances in this emerging area of interdisciplinary research.*

Course Content

Dynamical systems: linear & nonlinear dynamical systems, working definition of nonlinearity & effects of nonlinearity.

Linear oscillators & predictability: free oscillations, damped oscillations, damped & force oscillations.

Nonlinear oscillators: free oscillations, damped oscillations, forced oscillations, primary resonances & jump phenomenon, secondary resonances - sub harmonic & super harmonic, nonlinear oscillations & bifurcations.

Qualitative features of dynamical systems: Autonomous & non-autonomous systems, equilibrium points, phase space & phase space trajectories, stability of equilibrium points, attractors & repellors, Criterion for stability of equilibrium points & classification of equilibrium points, periodic attractors, quasi periodic attractor, chaotic attractor, concept of dissipative & conservative dynamical systems.

Simple bifurcations: Saddle node bifurcation, pitchfork bifurcation, transcritical bifurcation, Hopf bifurcation.

Chaos in discrete dynamical systems: equilibrium points of logistic map & their stability, periodic solutions, chaotic solution & sensitivity on initial condition, bifurcation diagram, construction of Coweb diagram, strange attractor & self similarity in Henon-map, period doubling route to chaos in Henon map.

Route to chaos: Period-doubling route to chaos, quasiperiodic route to chaos, intermittence route to chaos, type-I intermittence & standard bifurcations in maps.

Chaos in dissipative nonlinear oscillators: Bifurcation & chaos in Duffing oscillator, intermittent transition, quasiperiodic route & strange non-chaotic attractors, period doubling & bifurcation in Lorenz equations, introduction to other chaotic oscillators-driven Van der Pol oscillator, damped & driven pendulum, Morse oscillator & Rossler oscillator, necessary conditions for the occurance of chaos in discrete & continuous dynamical systems.

Chaos in nonlinear electronic circuits: linear & nonlinear electronic circuit elements, linear circuit-resonant RLC circuit, nonlinear circuits-Chua's diode & bifurcation & chaos in circuit containing Chua's diode, chaos in simplest dissipative circuit-MLC circuit & its stability analysis, analytical & numerical studies, other useful nonlinear circuits: RL diode circuit, Hunt's nonlinear circuit, p-n junction diode oscillator & Colpitt's oscillator.

Characterization of periodic & chaotic motions: Lyapunov exponents, computation of Lyapunov exponents for maps & continuous dynamical systems, power spectrum, autocorrelation & dimension of attractor & criterion for chaotic motion.

Advances in chaotic dynamics: time-series analysis, chaotic scattering, controlling of chaos, synchronization of chaos (only brief introductions).

Text/Reference Books

1. Nonlinear Dynamics: Integrability, chaos and patterns by Lakshmanan M. & Rajasekhar S. Springer Verlag. 2003.
2. Chaos and nonlinear Dynamics by Hillborn R. C. Oxford University Press. 2000.
3. Nonlinear oscillations, dynamical systems and bifurcation of vector fields by Guckenheimer J. and Holmes P. Springer Verlag, New York. 1990.
4. Chaotic and fractal dynamics by Moon F. C. John Wiley & Sons. 1992..
5. Chaos-An introduction to dynamical systems by Alligwood K., Sauer T. &Yorke J. A. Springer Verlag, New York. 1997.
6. Chaos in dynamical systems by Ott E. Cambridge University Press. 1993.

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Semester - III

(Departmental Elective Subject)

PH-565 L-T-P-C
Theoretical Atomic & Molecular Physics - I 5-0-0-5

Objective: *The objective of this course is to introduce the physical structure & behavior of atoms & molecules.*

Course Content

Interaction of One-Electron Atoms with Electromagnetic Radiation: Dipole approximation, Einstein Coefficients, Selection Rules, Line Intensities, Lifetimes, Line Shapes, & Line Widths, The Photoelectric effect, Fine structure, Hyperfine Structure.

The Stark Effect, the Zeeman Effect; Two- Electron Atoms: Ground State, Excited States, Auger Effect, Resonances;

Many-Electron Atoms: The Central Field Approximation, Thomas-Fermi Model, Atom Interferometry; Molecules: The Born-

Oppenheimer Approximation, the Hydrogen Molecule, Diatomic Molecules, Electronic Structure,

Rotational & Vibrational Structure, Polyatomic Molecules.

Text/Reference Books

1. Physics of Atoms and Molecules by Bransden B. H. & Joachain C. J., Pearson
2. Education.
3. Intermediate Quantum Mechanics by Bethe H. A. & Jackiw R. Levant Books, India
4. Atoms, Molecules and Photons by Demtroder W. Springer.

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Semester - III

(Departmental Core Subject)

PH-566 L-T-P-C
Physics laboratory - III 0-0-5-5

Objective: *The purpose of this course is to empower the student with practical skills in nuclear physics experiments.*

List of Experiments

1. To determine half-life of a radio Isotope using G.M. Counter.
2. To study absorption of particles & determine range using at least two Sources.
3. To study characteristics of G.M. Counter & to study statistical nature of radioactive decay.
4. To study spectrum of γ-particles Using Gamma ray spectrometer.
5. To calibrate a scintillation spectrometer & determine energy of gamma-rays from
6. an unknown Source.
7. To study Compton scattering of gamma-rays & verify the energy Shift formula.
8. To study the alpha particles using Spark chamber.
9. To study the Bremstrahlung effect Using Scintillation spectrometer.
10. To determine the end point energy of β-particles using β--ray Spectrometer.

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Semester - IV

(Departmental Elective Subject)

PH-567	L-T-P-C
Nonlinear Dynamics - II	5-0-0-5

Objective: *The objective of this course is to introduce various fundamental principles, theoretical procedures, numerical techniques & technological applications of nonlinear dynamical systems. It also highlights the current advances in this emerging area of interdisciplinary research.*

Course Content

Chaos in Hamiltonian systems: Hamilton's equation & Hamiltonian, phase space, Liouvelles theorem & phase space distribution, constants of motion & integrable systems, pendulum & simple harmonic oscillator, non-integrable systems, KAM theorem, possible orbits in conservative systems, period doubling & chaos in conservative systems, Henon-Heiles system, standard map, periodically driven undamped Duffing oscillator.

Integrability & notion of Integrability: complete Integrability, complex analytic Integrability, detection of Integrability: Painleve analysis, Painleve analysis & Integrability of two coupled nonlinear oscillators, symmetries & Integrability & its application to Henon Heiles system, a direct method for finding integral of motion, integrable systems with degrees of freedom more than two, integrable discrete systems & integrable dynamical systems on discrete lattice.

Linear & nonlinear dispersive waves: linear waves, linear nondispersive wave propagation, linear dispersive propagation, Fourier transform & solution of initial value problem, wave packet & dispersion, nonlinear dispersive systems, Cnoidal & solitary waves.

KDV equation & solitons: Scott Russel phenomenon & KdV equation, the Fermi-Pasta-Ulam numerical experiment on an harmonic lattices, asymptotic analysis & KdV equation, numerical experiments of Zabusky Kruskal, Hirota's bilinearization method.

Text/Reference Books

1. Nonlinear Dynamics: Integrability, chaos and patterns by Lakshmanan M. &. Rajasekhar S. Springer Verlag. 2003.
2. Chaos and nonlinear Dynamics by Hillborn R. C. Oxford University Press. 2000.
3. Nonlinear oscillations, dynamical systems and bifurcation of vector fields by.
4. Guckenheimer J & Holmes P. Springer Verlag, New York. 1990.
5. Chaos in classical and quantum mechanics. Gutzwiller M. C. Springer Verlag, New York. 1990.

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Semester - IV

(Departmental Elective Subject)

PH-568	L-T-P-C
Theoretical Atomic & Molecular Physics - II	5-0-0-5

Objective: *The objectives of this course to introduce various theoretical methods & approximations used to study the physical structure & behaviour of atoms & molecules.*

Course Content

The Hartree-Fock Method & the Self-Consistent Field Method; Theory of Multiplets: Electrostatic Interaction, Spin-Orbit Interaction, Interactions with External Fields; Atomic Collisions: Elastic Scattering At High Energies, At Low Energies, Corrections to Elastic Scattering, Elastic Scattering of Spin 1/2 Particles, Inelastic Scattering At High Energies, At Low Energies, Semi-classical Treatment of Inelastic Scattering, Classical Limit of Quantum Mechanical Scattering.

Text/Reference Books

1. Physics of Atoms and Molecules by Bransden B. H. & Joachain C. J., Pearson Education.
2. Intermediate Quantum Mechanics by Bethe H. A. & Jackiw R. Levant Books, India
3. Atoms, Molecules and Photons by Demtroder W., Springer.