Department of Physics

Savitribai Phule Pune University

Two-year M.Sc. (Physics) full-time course

(Credit and Semester based Syllabus to be implemented from Academic Year 2016-17)

Revision of Structure and Syllabi

Preamble

This syllabus has been proposed as per the guidelines of UGC and the Handbook for **CREDIT SYSTEM (CS) For SEMESTER PATTERN of Post Graduate Programs**, prepared by **Professor Vilas Kharat Dr. V. B. Gaikwad**.

All the theory courses have been modified to be of less than or equal to 4 credits. Laboratory courses are of 5 credits. As per the directives of the Handbook,
"Except the credits for practical courses, wherever applicable, a student can register for less number of courses in a semester subject to the condition that such a student will have to complete the degree in a maximum of four years or as per the prevailing rules of the University. This facility will be available subject to the availability of concerned courses in a given semester and with a maximum variation of 25 % credits (in case of fresh credits) per semester."

It was also found that the students have to learn at a slower pace initially. Hence in the first semester, the number of credits has been kept as 23 instead of 25 for all the students.

The project work will start in the third semester and will carry two credits; however, there will be only continuous assessment with no term-end examination at the end of the third semester. Project will continue in the fourth semester and there will be continuous assessment for 8 credits and term-end evaluation for the total of 10 credits of project will be held at the end of the fourth semester.

One of the highlight of our post-graduate program is that a large number of elective courses are available for students which are directly linked to the state-of-the-art research being carried out in the Department. Students can choose two such elective courses in Semester III and IV. There is associated laboratory of 2.5 credits with each of these courses. In the revised syllabus, two more optional courses are made available which can be broadly classified as supplementary to theoretical/computational and experimental streams.

One credit of a theory course will be equivalent to 15 clock hours of teacher-student classroom contact in a semester. For the courses in the first year, the syllabi are designed as per number of lectures and number of tutorials while for the second year courses, apart from lectures, seminars, discussions and tutorials together will make up for the contact hours.

For laboratory courses, although the credits are 5, the total contact hours are 120.

As per the handbook, "among the minimum number of credits to be earned by a student to complete a Post Graduate Degree program (100 credits), the student will have to earn minimum 75% credits from the Department of Physics and the remaining up to 25 % credits could be earned from any subject(s) of any faculty conducted at other PG Department/ PG Center. In any case, a student will have to earn compulsory credits from the Department of Physics over and above.

Other rules related to attendance and evaluation are as per the prevailing rules of the University. Important among them are cited here.

- A student who wishes to register for the third semester should have obtained at least pass or higher grades in at least 50% credits out of the total number of credits offered at the first and second semester of the first year.
- The evaluation of a course means the evaluation of total number of credits of that course. As such, all the credits taken together of a particular course will be evaluated in two parts continuous assessment (CA) and end semester examination (ESE) or term-end examination (TEE). Weightage for CA would be 50% and for ESE (TEE) would be 50%.
- A student will get a pass or higher grade in all the credits of a course after having obtained minimum 40 marks from CA (minimum 15 out of 50) and ESE (TEE) (minimum 15 out of 50) taken together and will get a grade and grade points in the respective course. Otherwise, a student will get grade F (Fail) in that respective course and will not gain any credits or grade points towards that course.
- If a student fails to gain the credits of any course (declared F grade in that course) then the student can reattempt the course with CA (if the course is conducted in that semester) and ESE (TEE) both or with ESE (TEE) only (if one has scored 15 in CA) in the subsequent ESEs (TEEs) within a period of 4 years (or till his/her registration is valid as per the prevailing rules) from the date of admission for the first semester.

M. Sc. (Physics) Semester-wise course structure

- Credits for all theory courses are either 2 or 4 (contact hours per credit = 15)
- Credits for laboratory courses are 5 (contact hours per credit = 24)
- Total number of credits for each semester may be different but sum of all credits of Semesters I to IV = 100

Semester	Course Code	Course Title	No. of Credits	Remarks
Semester I	PHY-T103	Quantum Mechanics-I	4	Compulsory
	PHY-T104	Electronics	4	Compulsory
	PHY-T105	Classical Mechanics	4	Compulsory
	PHY-T106	Mathematical Methods in Physics-I	4	Compulsory
	PHY-T107	Solid State Physics-I	2	Compulsory
	PHY-P101/102	Basic Physics Laboratory-I / Fortran and Numerical Analysis (5)	5	Compulsory
Total			**23**	
Semester II	PHY-T203	Quantum Mechanics-II	4	Compulsory
	PHY-T204	Electrodynamics-I	4	Compulsory
	PHY-T205	Statistical Mechanics	4	Compulsory
	PHY-T206	Mathematical Methods in Physics-II	4	Compulsory
	PHY-T207	Atoms and Molecules	4	Compulsory
	PHY-P201/202	Basic Physics Laboratory-I / Fortran and Numerical Analysis (5)	5	Compulsory
Total			**25**	
Semester III	PHY-T307	Solid State Physics-II	4	Compulsory
	PHY-T303/302	Methods of Computational Physics / Methods of Experimental Physics-I	4	Optional
	PHY-T310 to 327	Special paper-I	4	Compulsory
	PHY-T308	Semiconductor Physics and Devices	2	Compulsory
	PHY-T304	Electrodynamics -II	4	Compulsory
	PHY-T309	Special Relativity	2	Optional
	PHY-P300	Project	2#	Optional
	PHY-P301	Basic Physics Laboratory –II (A)	2.5	Compulsory
	PHY-P310 to 327	Special Laboratory	2.5	Optional
Total			25/27	
Semester IV	PHY-T401	Nuclear Physics	4	Compulsory
	PHY-T403/402	Special Topics in Theoretical Physics / Methods of Experimental Physics-II	4	Optional
	PHY-T410 to 427	Special paper-II	4	Compulsory
	PHY-P400	Project	8#	Optional
	PHY-P401	Basic Physics Laboratory –II (B)	2.5	Compulsory
	PHY-P410 to 427	Special Laboratory	2.5	Optional
Total			27/25	

Project in Semester III is of 2 credits. Evaluation of those credits will consist of continuous assessment only in Semester III. The remaining part of the project is in Semester IV and is for 8 credits. Evaluation for the 8 credits will have continuous assessment. Term-end examination for the project of total 10 credits will be at the end of Semester IV.

QUANTUM MECHANICS – I

Module 1 : 2 credits (20L + 10T)

1-D problems in quantum mechanics: Wells and barriers, Harmonic oscillator, Hermite polynomials and their properties, Qualitative plots of wave functions and their interpretation
Formalism of Quantum Mechanics: State Vectors, Observables and operators, Ket space, Bra space and Inner product, Hermitian operators, Eigenvalues and Eigenfunctions, Completeness, Matrix representation of states and operators, Commutability and compatibility, Uncertainty relation for x and p from their commutator, Change of basis, Unitary transformations, Representations in different bases
Time-evolution of a quantum system: Schrödinger, Heisenberg and Interaction pictures, Constants of the motion.
Simple harmonic oscillator by operator method, States with minimum uncertainty product, Coherent States, Landau level problem.

Module 2 : 2 credits (20L + 10 T)

Theory of angular momentum : Orbital angular momentum operators, Commutation relations, Raising and lowering operators, Representation of operators and states in spherical coordinates, Spherical harmonics, Plots for spherical harmonics.
Spherically symmetric potentials, Solution of hydrogen atom problem, Plots for wave functions.
Intrinsic Spin angular momentum: Pauli matrices and spin 1/2 eigenstates.
Addition of angular momenta, Clebsch -Gordan coefficients, Wigner-Eckart theorem(statement).
Identical particles, Spin and Statistics. Symmetric and antisymmetric wave functions, Slater determinants and Permanents.
Symmetry in quantum mechanics : Space and time translations, discrete lattice translations, Discrete Parity and time reversal symmetries.
Quantum measurements: Wave function collapse, Spin correlation measurements and Bell's inequality, entanglement.

Text Books :

1. Quantum Mechanics, L. I. Schiff (McGraw-Hill).
2. Quantum Physics, S. Gasiorowicz (Wiley International).
3. Modern Quantum Mechanics, J. J. Sakurai (Addison Wesley).
4. Quantum Mechanics, D. J. Griffiths (Pearson Education).

Reference Books:

5. Quantum Mechanics (Non-Relativistic Theory), L.D. Landau and E.M. Lifshitz (Elsevier).
6. Quantum Mechanics : Vols. I & II , C. Cohen-Tannaudji, B. Diu, F. Laloe (John Wiley).
7. Quantum Mechanics: Fundamentals, K. Gottfried and T-Mow Yan (Springer).
8. Introduction to Quantum Mechanics, L. Pauling and E. B. Wilson (McGraw Hill).
9. Quantum Mechanics, B. Crasemann and J.D. Powel (Addison-Wesley).
10. Quantum Mechanics : Vol. I & II, A.P Messiah (Dover)
11. The Principles of Quantum Mechanics, P. A. M. Dirac (Clarendon Press, Oxford).
12. Quantum Mechanics, I. Levine (Allyn and Bacon).
13. A Modern Approach to Quantum Mechanics, J. Townsend (University Science Books).
14. Essential Quantum Mechanics, G.E. Bowman (Oxford University Press).
15. Quantum Physics, M. Le Bellac (Cambridge University Press).

Electronics

Module 1 : 1 credit (10L + 5T)

Basic working principles of A.C. and D.C. circuits.

Network theorem: Kirchhoff's law, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Bi-junction Transistor (BJT): Transistor fundamentals, Transistor biasing circuits.

Module 2 : 1 credit (10L + 5T)

Transistor: AC models, Voltage amplifiers, CC and CB amplifiers, Class A and B Power Amplifiers, push pull for PA system, Differential Amplifier, its parameters, Common Mode Rejection Ration (CMRR).

Module 3 : 1 credit (10L + 5T)

OPAMP : Op Amp Theory, Linear Op Amp Circuits, Non Linear Op Amp Circuits, applications (Adder, subtractor, active filters, AC voltmeter). Positive and negative feedback and their effects on the performance of amplifier, Barkhausen criteria, Oscillators-LC and RC : Wien bridge, phase shift Hartley and Colpitt. IC based oscillators and timer circuits. Regulated power supplies-series, shunt and line filters, Wave shaping circuits.

Module 4 : 1 credit (10L + 5T)

Digital Electronics-Logic gates, Arithmetic circuits, Flip Flops, Digital integrated circuits-NAND & NOR gates as building blocks, X-OR Gate, simple combinational circuits, K-Map, Half & Full adder, Flip-flop, shift register, counters, Basic principles of A/D & D/A converters; Simple applications of A/D & D/A converters. Introduction to Microprocessors. Elements of Microprocessors.

Text Books :

1. Electronics Principles, A. P. Malvino (Tata McGraw Hill).

Reference Books :

2. Electronics Fundamentals and Applications, J. D. Ryder (John Wiley-Eastern).
3. Integrated Circuits, J. Milman and C.C. Halkias (Prentice-Hall).
4. Digital Principles and Applications, A. P. Malvino, D.P. Leach (McGraw Hill).

CLASSICAL MECHANICS

Module 1 : 1.5 credits (16L + 7T)

Generalized coordinates and momenta, Phase space, Variational Calculus, Hamilton's principle of least action, Derivation of Lagrangian and Hamilton's equations of motion from principle of least action, Phase portraits of some simple systems, Symmetries and conservation laws, Noether's theorem, Canonical Transformations. Poisson brackets, Hamilton-Jacobi equation. Action-angle variables.

Module 2 : 1.5 credits (16L + 6T)

Central forces. Two body problem. Stability of orbits. Classification of orbits.
Application to planetary motion: Kepler's laws.

Scattering in central force fields: centre of mass and laboratory frames of reference, scattering kinematics. Rutherford scattering.

Rigid body dynamics: Euler-Chasle theorems, Moment of inertia tensor. Euler's equation of motion, Euler angles. Symmetric top.
Non-inertial reference frames, Pseudo forces – centrifugal, Coriolis and Euler forces. Applications

Module 3 : 1 credit (10L + 5T)

Small oscillations. Systems of coupled oscillators. Normal modes and normal coordinates. Generalization to continuum limit.

Text Books:

1. Classical Mechanics, H. Goldstein, C. P. Poole and J. Safko (Pearson).
2. Classical Mechanics, N. Rana and P. S. Joag (McGraw Hill).

Reference Books:

3. Classical Mechanics, J. R. Taylor (University Science Books).
4. Mechanics, L. D. Landau and E. M. Lifshitz (Butterworth-Heinemann).
5. Classical Mechanics, R. D. Gregory (Cambridge University Press).
6. Classical Dynamics of Particles and Systems, S. T. Thornton and J. B. Marion (Cambridge University Press).
7. Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, W. Greiner (Springer).
8. Classical Dynamics: A Contemporary Approach, J. V. Jose and E. J. Saletan (Cambridge University Press).
9. Classical Mechanics, D. Strauch (Springer).

Mathematical Methods in Physics – I

Module 1 : 1.5 credits (15L + 8T)
Finite dimensional vector spaces: Vector space, Linear independence, Bases, Dimensionality, Isomorphism. Linear transformations and operators in vector spaces, Matrices, Change of basis, Similarity transformations, Diagonalization, Simultaneous diagonalization of commuting operators, Eigenvalue and Eigen vectors. Inner product, orthogonality and completeness, complete orthogonal set, Gram-Schmidt orthogonalization procedure, self-adjoint and unitary transformations.

Module 2 : 1.5 credits (15L + 7T)
Complex Analysis: Functions of complex variables, Analytic functions, Cauchy-Riemann conditions, Multivalued functions, Cauchy's theorem and Cauchy integral formula, Derivatives of analytic functions, Liouville theorem, Power series, Taylor's theorem and Laurent's theorem, Calculus of residues, Evaluation of real definite integrals, Integrals involving branch cuts, Summation of series using complex integration, Principal value integrals and Dispersion relations.

Module 3: 1 credit (10L + 5T)
Fourier series, Fourier integrals, Fourier transform, Inverse Fourier transform, Parseval relations, Convolutions.

Special functions and their properties: Classification of singularities of Legendre, Bessel, Hermite, Laguerre and their associated equations. Power series and contour integral solution of Legendre and Associated Lagendre equation near regular singular points.

Text Books

1. Finite dimensional vector spaces, P. R. Halmos (Springer Verlag).
2. Mathematics of Classical and Quantum Physics, F.W. Byron and R.W. Fuller (Dover).
3. Complex variables and Applications, R. V. Churchill (McGraw Hill).
4. Complex variables : Introduction and Applications, M.J. Ablowitz and A.S. Fokas (Cambridge University Press).
5. Functions of Mathematical Physics, B. Spain and M.G. Smith (Van Nostrand Reinhold).
6. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris (Academic Press).

References Books:

7. Linear Algebra, K. Hoffman and R. Kunze (Pearson).
8. Algebra, M. Artin (Pearson).
9. Matrix Analysis, R.A. Horn and C.R. Johnson (Cambridge University Press).
10. Complex analysis, L. Ahlfors (Tata McGraw Hill).
11. Fourier series and Boundary value problems, R. V. Churchill (McGraw Hill).
12. Differential Equations with Applications, G. Simmons (Pearson).
13. Green's Functions and Boundary value problems, I. Stakgold and M.J. Holst (Wiley).
14. Mathematics for Physicists, P. Dennery and A. Krzywicki (Dover)
15. Mathematical Physics, S. Hassani (Springer)

16. Mathematical Methods in Classical and Quantum Physics, Tulsi Dass and S.K. Sharma (Orient Blackswan).
17. Advanced Engineering Mathematics, E. Kreyszig (John Wiley & Sons).
18. Mathematical Methods of Physics, J. Mathews and R.L. Walker (Addison Wesley).

Solid State Physics - I

Module 1 : 1 Credit (10L + 5T)

Revision of crystal structures : Real lattices, packing fraction, reciprocal lattices, Brillouin zones, Ewald sphere construction.
Geometric structure factor and atomic form factor, concept of electron and neutron scattering.
Point defects, line defects and dislocations.

Module 2: 1 Credit (10L + 5T)

Free electron theory : Free electrons, density of states, Fermi momentum, Fermi energy and Fermi temperature, Thermal properties of free electron gas, Fermi-Dirac distribution, calculation of electronic contribution to specific heat of metal.

Text Books :

1. Solid State Physics, N. W. Ashcroft and N. D. Mermin, (CBS Publishing Asia Ltd.)
2. Introduction to Solid State Physics, C. Kittel, (John Wiley and Sons.)

Reference Books :

3. Introductory Solid State Physics, H. P. Myers, (Viva Books Pvt. Ltd.)
4. Solid State Physics, H. Ibach and H. Luth, (Springer-Verlag).
5. Fundamentals of Solid State Physics, J. R. Christman, (John Wiley and Sons.)
6. Solid State Physics, A. J. Dekkar, (Prentice Hall).
7. Solid State Physics, J.J. Quinn and K-Soo Yi (Springer).

PHY-P101/P201 : Basic Physics Laboratory -I

Group A (Electronics)

1. Temperature to frequency conversion using a thermister and astable multivibrator circuit.
2. Transfer characteristics of UJT & FET.
3. Operational Amplifier characteristics using IC 741.
4. Capacitance measurement using IC 555.
5. Characteristics of a solar cell.

Group B (Basic Processes)

1. Study of thermionic emission & measurement of work function.
2. Critical potential measurement using Franck-Hertz tube.
3. Measurement of de Broglie wavelength (λ) and interplanar distance (d) using electron-diffraction method.
4. Counting statistics for radioactive decay
5. Determination of mass absorption coefficient for beta rays.

Group C (Measurement of Physical Constants)

1. e/m ratio of electron using Thomson method.
2. Magnetic susceptibility measurement using Gouy's Method.
3. Milikan's oil drop experiment.

Group D (Optics)

1. Wavelength measurement of Na-source using Michelson interferometer.
2. Study of Fabry Perot interferometer & measurement of d.
3. Rydberg's constant using constant deviation prism.
4. Zeeman effect-study and use of L G Plate.
5. Coherence & width of spectral lines using Michelson interferometer.

Recommended Reference Books :

1. Practical Physics, Worsnop and Flint.
2. Measurement, Instrumentation and Experiment.
3. Design in Physics, Michael Sayer, Abhai Mansingh.
4. Fundamentals of Optics, Jenkins and White, McGraw-Hill, International Edition.
5. Solid State Physics, A. J. Dekker, Macmillan India Ltd., (1998).
6. Electronics Principles, Malvino.
7. Physics Lab. Experiments, Jerry D. Wilson, D. C. Heath and Company.

PHY-P102/202 : COMPUTER LABORATORY 5 Credits (120 Lab. Hours)

A. Exercises for acquaintance (only some experiments are listed here) : (Using FORTRAN90)

1. To find the largest or smallest of a given set of numbers.
2. To arrange a given set of numbers in ascending/descending order using Bubble sort algorithm.
3. Division of two complex numbers (treating a complex number as an ordered pair of real numbers).
4. To generate and print first hundred prime numbers.
5. To generate and print an odd ordered magic square.
6. Transpose of a square matrix using only one array.
7. Matrix multiplication.

B. Numerical Analysis :

1. Lagrange Interpolation.
2. Divided difference interpolation.
3. Root finding methods

(i) Binary search, (ii) Regula falsi, (iii) Newton-Raphson Method (iv) Method of successive approximations (v) secant method.

4. To locate the extrema of a function.
5. Evaluation of Bessel Functions.
6. Solution of simultaneous equations : (i) Gaussian Elimination (ii)Gauss-Seidel method.
7. Least Squares Approximation : (i) Linear fit, (ii) Fitting an exponential.
8. Numerical Integration : (i) Simpson's rule, (ii) Gaussian Quadrature.

and experiments similar to the above.

(Note : The course is expected to comprise of 20 exercises).

Books :

1. Computer Programming in FORTRAN 77, V. Rajaram, Prentice Hall of India, 3rd Edition.
2. Computer Oriented Numerical Methods, V. Rajaraman, Prentice Hall of India.
3. Numerical Methods for Scientist and Engineers, H. M. Antia, Tata McGraw Hill.
4. Numerical Methods with Fortran IV case studies, Dorn & McCracken, John Wiley and Sons.
5. Numerical Recipes in FORTRAN (2nd Edn.), W. H. Press, S. A. Teakalsky, W. T. Vellerling, B. P. Flannery, Cambridge University Press.
6. Programming in Fortran 90/95 – Rajaram, Prentice-Hall of India

Quantum Mechanics – II

Module 1 : 1 credit (10 L + 5 T)
Time-independent perturbation theory: Non-degenerate and degenerate cases; Applications such as the Stark effect, Fine Structure of the Hydrogen atom.
Variational method and applications such as the Helium Atom
WKB approximation: Connection formulas, Bohr-Sommerfeld quantization condition and Gamow formula.

Module 2 : 1.5 credits (15 L + 8 T)
Time- dependent perturbation theory: Interaction picture, Dyson series, Transition probability, Constant perturbation, Fermi's golden rule, Harmonic perturbation, transition probability and interpretation as absorption and emission, principle of detailed balance. Application to ionization of hydrogen atom.
Application to interaction of classical radiation field with matter: Absorption and induced emission, Electric dipole transitions, Selection rules, Decays and lifetime, natural line-width. Transition probability for spontaneous emission, Detailed balance and Planck distribution formula, Einstein A and B coefficients. The Photoelectric effect for H-atom.
Adiabatic and sudden approximations.

Module 3: 1.5 credits (15 L + 7 T)
Scattering theory: Scattering amplitude, differential scattering cross section and total scattering cross section , Lippman-Schwinger equation, Born approximation, Applications and validity of the Born approximation, Optical theorem
Method of partial waves: Partial wave expansion, Unitarity and Phase shifts; Scattering by a perfectly rigid sphere and square well potential, Ramsauer-Townsend effect; Complex potential and absorption, Collision of identical particles, Levinson's theorem

Aharanov-Bohm effect and Berry's phase.

Text Books:
1. Modern Quantum Mechanics, J. J. Sakurai (Addison Wesley).
2. Quantum Mechanics, L. I. Schiff (McGraw-Hill).
3. Quantum Physics, S. Gasiorowicz (Wiley International).
4. Quantum Mechanics, D. J. Griffiths (Pearson Education).

Reference Books:
5. Quantum Mechanics(Non-Relativistic Theory), L.D. Landau and E.M. Lifshitz (Elsevier).
5. Quantum Mechanics : Vols. I & II , C. Cohen-Tannaudji, B. Diuand F. Laloe (John Wiley).
7. Quantum Mechanics: Fundamentals, K. Gottfried and T-Mow Yan (Springer).
8. Introduction to Quantum Mechanics, L. Pauling and E. B. Wilson (McGraw Hill).
9. Quantum Mechanics, B. Crasemann and J.D. Powel (Addison-Wesley).
10. Quantum Mechanics -Vol. I & II, A.P Messiah (Dover)
11. The Principles of Quantum Mechanics, P. A. M. Dirac (Clarendon Press, Oxford).
12. Quantum Mechanics, I. Levine (Allyn and Bacon). .
13. A Modern Approach to Quantum Mechanics, J. Townsend (University Science Books).
14. Essential Quantum Mechanics, G.E. Bowman (Oxford University Press).
15. Quantum Physics, M. Le Bellac (Cambridge University Press).

ELECTRODYNAMICS-I

Module 1 : 1 credit (10L + 5T)
Coloumb's law, Gauss's law, Scalar electric potential, Poisson's equation and Laplace's equation, Electrostatic potential energy, Simple applications, Simple boundary value problems illustrating various techniques such as method of images, separation of variables, Green's functions, Multipole expansion.

Module 2 : 1 credit (10L + 5T)
Dielectric materials, Polarization, Electric field of a polarized material, Bound charges, Gauss's law in dielectric materials, Linear dielectric materials, Boundary conditions at the interface of two dielectrics.

Module 3 : 1 credit (10L + 5T)
Steady currents, Biot-Savart law and Ampere's law, Simple applications, Magnetic vector potential, Multipole expansion, Magnetic materials, Magnetization, Magnetic field of magnetized material, Bound currents, Linear magnetic materials, Boundary conditions.

Module 4 : 1 credit (10L + 5T)
Electromotive force, Electromagnetic induction: Faraday's law, Inductance, Energy in magnetic fields, Maxwell correction to Ampere's law, Maxwell equations, Wave equations for electric and magnetic fields and their solutions.
Electromagnetic units and equations, Connection between Gaussian and SI system of units

Text Books:

1. Classical Electrodynamics, J. D. Jackson, (John Wiley).
2. Introduction to electrodynamics, D. J. Griffiths,

Reference Books :

3. Classical theory of fields, L. D. Landau and E. M. Lifshitz, (Addison-Wesley).
4. Electrodynamics of continuous media, L. D. Landau and E. M. Lifshitz, (Addison-Wesley).
5. Electrodynamics, A. Somerfield, (Academic Press, Freeman and Co.).
6. Classical Electricity and Magnetism, W.K.H. Panofsky and M. Phillips: (Addison-Wesley).
7. Feynman Lectures Vol. II.
8. Berkeley Series Volume II.
9. Electricity and Magnetism, Reitz, Milford, Christy
10. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa).

STATISTICAL MECHANICS

Module1: 1 credit (10L + 5T)
A brief revision of the laws of thermodynamics. Thermodynamical work for magnetic, dielectric, elastic systems. Legendre transformation, Thermodynamic potentials.
Statistical basis of thermodynamics. Elements of ensemble theory. Microcanonical ensemble. Macroscopic and microscopic states. Classical phase space, phase space density, Liouville's theorem, Statistical origin of entropy. Application to the ideal gas. Gibbs paradox and Gibbs correction term. Quantum states and the phase space.

Module 2: 1 credit (10L + 5T)
Canonical ensemble, Partition function and thermodynamic variables, Energy fluctuations. Boltzmann distribution. Applications to the thermodynamics of an ideal gas, Specific heat of solids (classical and Einstein models), and Paramagnetism (Langevin and Brillouin models). Equipartition and virial theorem.
Thermodynamics of interacting systems – Van der Waals gas and 1D Ising model.

Module 3: 1 credit (10L, 5T)
Grand canonical ensemble, Partition function and thermodynamical variables,
Density and energy fluctuations, Application to the problem of adsorption.
First order and second order phase transitions, Phase equilibria

Quantum statistics: Density matrix. Pure states and statistical mixtures. Density matrices for microcanonical, canonical and grand canonical ensembles. Representation of density matrices in energy, coordinate and momentum bases, with suitable examples.

Module 4: 1 credit (10L, 5T)
Ideal Bose gas: Bose-Einstein statistics, Partition function, Thermodynamic behaviour, Bose-Einstein condensation in ideal Bose gas.
Applications : Black body radiation. Planck's law and its limiting cases (Raleigh-Jeans law, Wien's displacement law), Stefan-Boltzmann law.
Phonon gas. Specific heat of solids (Einstein and Debye models).

Ideal Fermi gas.: Fermi-Dirac statistics, Partition function, Thermodynamic behaviour
Applications : Degenerate electron gas (free electrons in a metal), Fermi energy and mean energy, Fermi temperature, Fermi velocity and specific heat .
Estimation of the size of white dwarfs.

Text Books:

1. Statistical Mechanics, Pathria and Beale (Academic Press).
2. Statistical Mechanics, Huang (Wiley).

Reference Books :

3. Statistical Physics of Particles, Kardar (Cambridge University Press).
4. Statistical and Thermal Physics, Gould & Tobochnik (Princeton University Press).
5. An Introduction to Statistical Mechanics and Thermodynamics, Swendsen (Oxford University Press).
6. Thermodynamics and Statistical Mechanics, Greiner, Neise, Stocker, Springer, 2010.
7. Statistical Mechanics, Reif
8. Statistical Physics (Part 1), L.D. Landau and E. M. Lifhsitz (Elsevier)

Mathematical Methods in Physics – II

Module 1: 1 credit (10L + 3T)
Probability theory. Fundamental laws of probability. Random variables. Probability distributions. Moments of the distributions. Binomial, Poisson and Normal distributions. Conditional probability distribution, joint probability distribution. Characteristic functions. Central limit theorem. Random walks (1D, 2D and 3D) and their applications to physical processes (diffusion, paramagnetism)

Module 2: 1 . 5 credits (15L + 9T)
Ordinary inhomogeneous differential equations: Solution by Greens function method (2-3 lectures).
Special functions and their properties (continued from MMP-I): Power series and contour integral solutions of Bessel, Hermite and Laguerre equation, Laguerre polynomial and associated Laguerre polynomial, Hermite ploynomial, Spherical harmonics, Generating functions, Sturm-Liouville systems and orthogonal polynomials. Hypergeometric and confluent hypergeometric functions (1 lecture)
Laplace transform, Inverse Laplace transform (Bromwich integral)

Module 3: 1.5 credits (15L + 8T)
Infinite dimensional vector space: Function space, inner products, Hilbert space Complete orthogonal sets of functions, Weiserstrass's theorem. Operators on Hilbert space, Expansion in terms of eigenfunctions. Generalized functions (delta function).

Introduction to tensor analysis: Cartesian tensors, transformation properties and simple applications (elasticity, moment of inertia and special relativity). Spherical tensors.

Text Books:

1. P. R. Halmos, Finite dimensional vector spaces (Springer).
2. Functions of Mathematical Physics, B. Spain and M.G. Smith (Van Nostrand Reinhold).
3. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris (Academic Press).
4. Mathematics of Classical and Quantum Physics, F.W. Byron and R.W. Fuller (Dover).
5. Tensor Analysis for Physicists, J. A. Schouten (Dover).

Reference Books:

6. Linear Algebra, K. Hoffman and R. Kunze (Pearson).
7. Algebra, M. Artin (Pearson)
8. Matrix Analysis, R.A. Horn and C.R. Johnson (Cambridge University Press).
9. Fourier series and Boundary value problems, R. V. Churchill (McGraw Hill).
10. Differential Equations with Applications, G. Simmons (Pearson).
11. Green's Functions and Boundary value problems, I. Stakgold and M.J. Holst (Wiley).
12. Mathematics for Physicists, P. Dennery and A. Krzywicki (Dover)

13. Mathematical Physics, S. Hassani (Springer)
14. Mathematical Methods in Classical and Quantum Physics, Tulsi Dass and S.K. Sharma (Orient Blackswan).
15. Advanced Engineering Mathematics, E. Kreyszig (John Wiley & Sons).
16. Mathematical Methods of Physics, J. Mathews and R.L. Walker (Addison Wesley).
17. Tensor Calculus, J.L. Synge and A. Schild (Dover).
18. Tensors for Physics, S. Hess (Springer)
19. Tensor Calculus for Physics: A Concise Guide, D. Neuenschwander (Johns Hopkins University Press)

ATOMS and MOLECULES

Module 1: 1 credit (10L + 5T)

Atomic structure and Atomic spectra:

Revision of hydrogen atom (wave functions, orbital and spin angular momentum, magnetic dipole moment, spin-orbit interaction, fine structure, spectroscopic terms).

Multi-electron atoms: Central field approximation, Exchange symmetry of wave functions, electron configurations, Hartree-Fock theory, Self-consistent fields, L-S coupling, J-J coupling, Hund's rules.

Atoms in an electromagnetic field: Spectral lines, Selection rules, Some features of one-and two-electron spectra, fine structure spectra, hyperfine structure spectra, X-ray spectra, Stark effect , Zeeman effect and Paschen-Back effect

Module 2 : 1 credit (10L + 5T)

Molecular Structure and Molecular Spectra : Covalent, ionic and van der Waal bonding, Valence bond and molecular orbital approach for molecular bonding and electronic structure of homonuclear diatomic molecules, pairing and valency, heteronuclear diatomic molecules, hybridization, ionic bonding, electro-negativity, electron affinity.

Electronic structure of polyatomic molecules: hybrid orbitals, bonding in hydrocarbons.

Rotational levels in diatomic and polyatomic molecules: Rigid and non-rigid rotation

Vibrational levels in diatomic and polyatomic molecules. Morse oscillator model for vibrational levels

Module 3 : 1 credit (10L + 5T)

Group theory: Definition and properties of a group, Some examples of groups,

Molecules and symmetry groups: Symmetry elements and operations, General relations among symmetry elements and operations, Symmetry point groups, Classification of molecules,

Simple examples. Representations of groups, Shur's Lemma, The great orthogonality theorem,

Character tables.

Module 4: 1 credit (10L + 5T)

Masers and Lasers : Spontaneous and stimulated emission, Population inversion, optical pumping,coherence (temporal and spatial), Simple description of ammonia maser and carbon dioxide/helium-neon laser. Application of Lasers in cooling and trapping of atoms.

Atomic and molecular spectroscopic methods: Atomic and Molecular Polarizability, Molecular vibrations and group theoretical selection rules for infra red and Raman transitions,

Infra-red spectroscopy and Raman spectroscopy for vibrational level determination.

Microwave spectroscopy and Rotational Raman spectroscopy for rotational level determination,

Electronic spectroscopy for molecular structure determination (optical spectrophotometry, photoluminescence).

Nuclear Magnetic resonance and Electron spin resonance

Text Books :

1. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain, (Pearson).
2. Quantum Physics, Robert Eisberg and Robert Resnick, (John Wiley).
3. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, (Tata, McGraw Hill)
4. Molecular Spectra and Molecular Structure, Gerhard Herzberg, (D. Van Nostrand Company, Inc.)
5. Molecular Quantum Mechanics, P.W. Atkins and R. Freidman, (Oxford University Press)
6. Chemical Applications of Group Theory, F.A. Cotton (Wiley)
7. Quantum Chemistry, I. N. Levine (Wiley)

Reference Books :

8. Group Theory and Quantum Mechanics, M. Tinkham (Dover Publications Inc)
9. Group Theory and Quantum Mechanics by E. P. Wigner (Academic Press)
10. Group Theory and its Applications to Physical Problems, M. Hamersmesh (Pergamon Press)
11. Instrumental Methods of Analysis, H.H. Willard, L.L. Merritt, J.A. Dean, and F.A. Settle (CBS Publishers, Delhi)
12. Instrumental Analysis, D.A. Skoog, F.J. Holler and S.R. Crouch, (Cengage Learning, Delhi)
13. Modern Spectroscopy, J.M. Hollas, (John Wiley)
14. Introduction to Ligand Fields, B.N. Figgis (Wiley)
15. Lasers, B. B. Laud,