Department of Physics
Savitribai Phule Pune University, Pune 411007
Course: M. Sc. (Physics with Astrophysics)

SEMESTER-I

SEMESTER-II

Semester I : Total No. of Credits: 22, [Major core 14+Major Elective 4 + RM (4) + OJT (0)+RP(0)]		
MAJOR CORE		
Subject Code	**Subject Title**	**Credits**
PHY-CT101	APPLIED ELECTRONICS	2
PHY-CT102	CLASSICAL MECHANICS	2
PHY-CT103	QUANTUM MECHANICS-I	2
PHY-CT104	MATHEMATICAL METHODS IN PHYSICS	4
PHY-CP105	BASIC PHYSICS LABORATORY	4
PHY-CP106	COMPUTER PROGRAMMING AND NUMERICAL METHODS	
	MAJOR CORE TOTAL	**14**
MAJOR ELECTIVE (ANY TWO)		
Subject Code	**Subject Title**	**Credits**
PHY-ET101	FUNDAMENTALS OF ELECTRONICS	2
PHY-ET102	FUNDAMENTALS OF CLASSICAL MECHANICS	2
PHY-ET103	ELEMENTARY FLUID MECHANICS	2
PHY-ET104	BASICS OF ELECTRONIC CIRCUIT DESIGN	2
	MAJOR ELECTIVE TOTAL	**4**
PHY-RM100	RESEARCH METHODOLOGY	4
	SEMESTER-I TOTAL	**22**

Semester II : Total No. of Credits: 22, [Major core 14 + Major Elective 4 + RM (0) + OJT (4)+RP(0)]		
MAJOR CORE		
Subject Code	**Subject Title**	**Credits**
PHY-CT201	STATISTICAL MECHANICS	2
PHY-CT202	ELECTRODYNAMICS -I	4
PHY-CT203	QUANTUM MECHANICS-II	4
PHY-CP204	BASIC PHYSICS LABORATORY	4
PHY-CT205	COMPUTER PROGRAMMING AND NUMERICAL METHODS	
	MAJOR CORE TOTAL	**14**
MAJOR ELECTIVE (ANY TWO)		
Subject Code	**Subject Title**	**Credits**
PHY-ET201	ESSENTIALS OF STATISTICAL PHYSICS	2
PHY-ET202	ATOMIC AND MOLECULAR PHYSICS	2
PHY-ET203	THERMAL PHYSICS	2
PHY-ET204	BASICS OF ATOMS AND MOLECULES	2
	MAJOR ELECTIVE TOTAL	**4**
PHY-OJ200	ON-JOB TRAINING	4
	SEMESTER-II TOTAL	**22**

Semester-I and Semester-II of M.Sc. Physics with Astrophysics course is same as M.Sc. Physics course.

T: Theory, P: practical

SEMESTER-III

Semester III : Total No. of Credits: 22, [Major core 14+Major Elective 4 + RM (0) + OJT (0)+RP(4)]		
MAJOR CORE		
Subject Code	**Subject Title**	**Credits**
PHY-ICT301	RELATIVISTIC ELECTRODYNAMICS AND RADIATION PROCESSES	4
PHY-ICT302	INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS	4
PHY-ICT303	ASTRONOMY TECHNIQUES	4
PHY-ICP304	ASTROPHYSICS LAB-I	2
	MAJOR CORE TOTAL	**14**
MAJOR ELECTIVE		
Subject Code	**Subject Title**	**Credits**
PHY-ET301-322	ELECTIVE (Any two Electives from Annexure-I)	2+2
	MAJOR ELECTIVE TOTAL	**4**
PHY-IRP300	RESEARCH PROJECT-I	**4**
SEMESTER-III TOTAL		**22**

Please see the Annexure-I for the list of Elective subjects, offered in semester-III.

SEMESTER-IV

Semester IV : Total No. of Credits: 22, [Major core 12+Major Elective 4 + RM (0) + OJT (0)+RP(6)]		
MAJOR CORE		
Subject Code	**Subject Title**	**Credits**
PHY-CT401	NUCLEAR PHYSICS	4
PHY-ICT402	ASTROPHYSICAL DYNAMICS	4
PHY-ICT 403	GENERAL RELATIVITY	2
PHY-ICP404	ASTROPHYSICS LAB-II	2
	MAJOR CORE TOTAL	**12**
MAJOR ELECTIVE		
Subject Code	**Subject Title**	**Credits**
PHY-IET401-404	ELECTIVE (Any two Electives from Annexure-II)	2+2
	MAJOR ELECTIVE TOTAL	4
PHY-IRP400	RESEARCH PROJECT-II	6
SEMESTER-IV TOTAL		**22**

Please see the Annexure-II for the list of Elective subjects, offered in semester-IV.

T: Theory, P: practical

Annexure-I:

(Semester-III Physics with Astrophysics)

ELECTIVE SUBJECTS FOR SEMESTER-III [ANY TWO]		
Subject Code	**Subject Title**	**Credits**
PHY-ET301	METHODS IN EXPERIMENTAL PHYSICS-I	2
PHY-ET302	METHODS IN EXPERIMENTAL PHYSICS-II	2
PHY-ET303	X-RAY CRYSTALLOGRAPHY	2
PHY-ET304	BIO-PHOTONICS	2
PHY-ET305	MEDICAL PHYSICS	2
PHY-ET306	OPTOELECTRONICS	2
PHY-ET307	RADIATION PHYSICS	2
PHY-ET308	BASICS OF SEMICONDUCTORS	2
PHY-ET309	PHOTODEVICES	2
PHY-ET310	RIETVELD ANALYSIS	2
PHY-ET311	RADIATION BIOLOGY	2
PHY-ET312	PHYSICS OF DIAGNOSTIC INSTRUMENTS	2
PHY-ET313	METHODS OF COMPUTATIONAL PHYSICS-I	2
PHY-ET314	METHODS OF COMPUTATIONAL PHYSICS-II	2
PHY-ET315	SPECIAL TOPICS IN QUANTUM MECHANICS	2
PHY-ET316	ADVANCED MATHEMATICAL PHYSICS	2
PHY-ET317	QUANTUM MANY BODY THEORY	2
PHY-ET318	CLASSICAL FIELD THEORY	2
PHY-ET319	RELATIVISTIC QUANTUM MECHANICS	2
PHY-ET320	GROUP THEORY IN PHYSICS	2
PHY-ET321	ADVANCED STATISTICAL MECHANICS	2
PHY-ET322	DENSITY FUNCTIONAL THEORY	2

Annexure-II:

(Semester-IV Physics with Astrophysics)

ELECTIVE SUBJECTS FOR SEMESTER-IV [ANY TWO]		
Subject Code	**Subject Title**	**Credits**
PHY-IET401	COSMOLOGY	2
PHY-IET402	HIGH ENERGY ASTROPHYSICS	2
PHY-IET403	STATISTICAL TECHNIQUES IN COSMOLOGY	2
PHY-IET404	RADIO GALAXIES AND QUASARS	2

Department of Physics
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Course: M. Sc. (Physics)

SEMESTER-I

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Core
Course Code: PHY-CT 101	Course Title: Applied Electronics
Credit: 02	

Course Objectives:

1. In this course emphasis will be given on basics concepts related to operational amplifier their applications.
2. Students will also be trained to understand basic requirements of Oscillator, Power Supply, Refulators and their
3. In Digital Electronics, basic understanding of building block and their applications will be given.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	OP-AMP : 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-2	Credits: 1	10 L , 5 T
	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.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. Understand characteristics features of operational amplifier and trained to design operational amplifier-based circuit.
2. Students will have basics understanding of oscillator, power supply and regulator and their functioning.
3. Students will get flavour of digital electronic circuits and their applications.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

1. *Electronics Principles, A. P. Malvino, Tata McGraw Hill, New Delhi.*
2. *Electronics Fundamentals and Applications, J. D. Ryder, John Wiley-Eastern Publications.*
3. *Integrated Circuits, Milman and Halkias, Prentice-Hall Publications.*
4. *Digital Principles and Applications, A. P. Malvino, D.P. Leach, McGraw Hill Book Co. 4thEdition (1986).*

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Core
Course Code: PHY-C T102	Course Title: Classical Mechanics
Credit: 02	

Course Objectives:

1. To strengthen the basic concepts of classical mechanics and provide a solid foundation for advanced studies in physics and engineering.

2. To introduce important techniques that are necessary to build core concepts in classical mechanics, enabling students to analyze complex physical systems with precision and clarity.

3. To develop problem-solving skills with appropriate rigor that helps the student to improve their analytical ability in tackling real-world challenges in classical mechanics and related fields.

Course Contents:

Module-1	Credits: 1	10 L , 5 T
	Central forces: Stability of orbits, classification of orbits. Scattering in central force fields: centre of mass and laboratory frames of reference, scattering kinematics. Rutherford scattering. Non-inertial reference frames, Pseudo forces: centrifugal, Coriolis and Euler forces. Applications	
Module-2	Credits: 1	10 L , 5 T
	Canonical Transformations, Hamilton-Jacobi equation. Action-angle variables. Rigid body dynamics: Euler-Chasle theorems, Moment of inertia tensor. Euler's equation of motion, Euler angles. Symmetric top. Small oscillations: normal modes and normal coordinates. Generalization to continuum limit.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. have understood the fundamental concepts of classical mechanics subject, enabling them to comprehend and analyze the behavior of particles, rigid bodies, and systems under various forces and constraints.

2. have acquired the problem-solving skills essential to classical mechanics subject, allowing them to confidently apply mathematical techniques and physical principles to solve complex and diverse mechanical problems.

3. be prepared to undertake advanced topics in classical mechanics subject, empowering them to explore specialized areas and contribute to cutting-edge research and technological advancements in the field.

Instructional design:

1. Lecture method
2. Tutorial method

3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

1. *Classical Mechanics, Goldstein, Poole, & Safko (Pearson).*
2. *Mechanics, Landau & Lifshitz (Butterworth-Heinemann).*
3. *Classical Mechanics, Taylor (University Science Books).*
4. *Classical Mechanics, Rana & Joag (McGraw Hill).*
5. *Classical Mechanics, Gregory (Cambridge University Press).*
6. *Classical Dynamics of Particles and Systems, Marion & Thornton (Cambridge University Press).*
7. *Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, Greiner (Springer).*
8. *Classical Dynamics: A Contemporary Approach, Jose & Saletan (Cambridge University Press).*
9. *Classical Mechanics, Strauch (Springer).*
10. *Classical Mechanics, A.K. Raychaudhuri (Oxford University Press)*

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Core
Course Code: PHY-CT103	Course Title: Quantum Mechanics-I
Credit: 02	

Course Objectives: The primary objective is to teach the students the physical and mathematical basis of Quantum Mechanics for non-relativistic systems

1. To introduce the students to formalism of Quantum Mechanics and elementary applications
2. To introduce important concepts to build core concepts in Quantum Mechanics
3. To develop problem solving skills with appropriate regior that helps the student to improve their analytical ability in Quantum Mechanics.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Revision of 1-D problems. Formalism of Quantum Mechanics: State Vectors, basis, Observables and operators, Inner product, Hermitian operators, Eigenvalues and Eigenfunctions, Unitary transformations, Simple harmonic oscillator by operator method, Time-evolution of a quantum system: Schrödinger, Heisenberg and Interaction pictures, Constants of the motion. Schrodinger equation in 3-D.	
Module-2	Credits: 1	10 L , 5 T
	Angular Momentum: Orbital angular momentum operators, Raising and lowering operators, Spherical harmonics. Spherically symmetric potentials, hydrogen atom. Spin angular momentum: Pauli matrices and spin 1/2 eigenstates.	

Learning Outcomes: Upon completion of the course, the student will learn

1. Solving the 1-D Schroedinger equation for standard potentials such as simple harmonic oscillators
2. The mathematical formalism of quantum theory.
3. Angular momentum and 3-D problems
4. The Spectrum of Hydrogen atom
5. Spin angular momentum

Instructional design:
1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:
1. Descriptive written examinations
2. Assignments

REFERENCES:

1. Quantum Mechanics, Cohen-Tannaudji, Din, Laloe Vols. I & II (John Wiley).
2. Modern Quantum Mechanics, J. J. Sakurai (Addison Wesley).
3. Quantum Mechanics, D. J. Griffiths (Pearson Education).
4. Quantum Mechanics, L. I. Schiff (McGraw-Hill).

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

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Core
Course Code: PHY-CT104	Course Title: Mathematical Methods In Physics
Credit: 04	

Course Objectives: Mathematical Methods in Physics is the integral part for thorough understanding and learning of any subject that come under Physics. The primary objectives of the study are,

1. To strengthen the basic logic behind the mathematical formulation of laws of Physics.
2. To introduce important mathematical techniques that are necessary to build core concepts in Physics.
3. To develop problem solving skills with appropriate regior that helps the student to improve their analytical ability.

Course Contents:

Module-1	Credits: 2	20 L , 10 T
	Linear Vector spaces and operators : Vector spaces, Linear independence, Bases, dimensionality isomorphisms. Linear transformations, inverses, matrices, similarity transformations, Eigenvalues and Eigenvectors. Inner product, orthogonality and completeness, complete orthogonal set, Gramm Schmidt orthogonalization procedure, Self-adjoint and unitary transformations. Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization. Hilbert spaces: Complete orthonormal sets of functions. Weierstrass's theorem (without proof) approximation by polynomial. Fourier series. Applications of Fourier series. Differential Equations and Special Functions: Power series solutions of second order differential equations (Legendre, Bessel, Hermite, Laguerre as special examples properties of these functions). Legendre polynomials, Spherical harmonics and associated Legendre polynomials. Hermite polynomials. Sturm-Liouville systems and orthogonal polynomials.	
Module-2	Credits: 2	20 L , 10 T
	Complex Analysis : Analytical functions, Cauchy-Riemann conditions, Rectifiable arcs, Line integrals, Cauchy's theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem. Calculus of residues, evaluation of real definite integrals, summation of series, elementary discussion of branch cuts, Applications : Principal value integrals and dispersion relations. Fourier integrals, Fourier transform, Parseval Relations, Convolution, Applications; Laplace transform, Bromwich contour, simple applications. Contour integral solutions of differential equations. Introduction to Green's functions and some applications to partial differential equations.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. Understand the concept of linear vector spaces and Eigenvalue problems that occur frequently in Physics
2. Thorough understanding of differential equations and their applications to Physics
3. Apply the powerful machinery of complex analytical function theory to physical problem.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

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. Mathematics for Physicists, Dennery & Krzywicki (Dover).
4. Linear Algebra, K. Hoffman and R. Kunze (Pearson).
5. M. Artin, Algebra, (Pearson).
6. Matrix Analysis, R.A. Horn and C.R. Johnson (Cambridge University Press).
7. Differential Equations with Applications, G. Simmons (Pearson).
8. Complex variables and Applications, R. V. Churchill (McGraw Hill).
9. Complex variables, Ablowitz and Fokas (Cambridge Univ. Press).
10. Complex analysis, Ahlfors (Springer).
11. Fourier series and Boundary value problems, R. V. Churchill (McGraw Hill).
12. Functions of Mathematical Physics, B. Spain and M.G. Smith (Van Nostrand Reinhold).
13. Green's Functions and Boundary value problems, I. Stakgold and M.J. Holst (Wiley).
14. Mathematical Physics, S. Hassani (Springer).
15. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, (Academic Press).
16. Mathematical Methods in Classical and Quantum Physics, Tulsi Dass and S.K. Sharma (Orient Blackswan).
17. V. Balakrishnan, Mathematical Physics with Applications, Problems and Solutions, ANE, Books 2019
18. Advanced Engineering Mathematics, E. Kreyszig (John Wiley & Sons).
19. Mathematical Methods of Physics, J. Mathews and R.L. Walker (Addison Wesley).
20. *Advanced Engineering Mathematics, E. Kreyszig (John Wiley & Sons).*

Course Information	
Year and Semester: M.Sc-I, Semester-I/II	Major Core
Course Code: PHY-CP105/204	Course Title: Basic Physics Laboratory
Credit: 04	

Course Objectives:

1. To get trained to perform experiments in Physics.
2. To introduce important experimental techniques.
3. To Collect data and revise an experimental procedure iteratively
4. To develop experimental skills.

Course Contents

	List of experiments	
	The proposed list of the experiments for Basic Physics Laboratory I (Any 12 experiments) 4. Characteristics of operational amplifier 5. UJT and FET characteristics 6. Magnetic Susceptibility 7. Temperature transducer (T to F converter) 8. Thermionic emission 9. Mass Absorption 10. Counting Statistics 11. Zeeman Effect 12. Fabry Perot Interferometer 13. Michelson interferometer 14. Absorption spectra of I2 molecule 15. Determination of Seebeck coefficient and understanding of Thermocouple working. 16. Recording and analysis of B-H curve 17. Millikan Oil drop method 18. Determination of e/m ratio 19. Frank-Hertz experiment	

Learning Outcomes: Upon completion of the course, the student would

1. learn to formulate hypotheses and devise and perform experiments to test a hypothesis. as individuals and in a team.
2. have gained training in conducting experiments in Physics
3. learn to apply scientific methodologies for problem solving.
4. have learned important techniques in Experimental Physics
5. have developed skills in designing and conducting experiments in Physics

Instructional design:
1) Lecture method
2) Laboratory sessions
3) Seminars

Evaluation Strategies:

1) Assesment of experimental skills and outcomes
2) Viva-Voce

REFERENCES:

1. Atomic Spectra and Atomic Structure by G. Herzberg, New York Dover Publication.
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, Tata, McGraw-Hill Publishing Company Limited.
3. Electronics Principles, A. P. Malvino, Tata McGraw Hill, New Delhi.
4. Fundamentals of Statistical and Thermal Physics, F. Reif (International Student Ed.) McGraw Hill..
5. Introduction to electrodynamics, D. J. Griffiths, Prentice Hall.
6. Solid State Physics, A. J. Dekkar, Prentice Hall.
7. Fundamentals of Optics, Jenkins and White, McGraw-Hill, International Edition.
8. Physics Lab. Experiments, Jerry D. Wilson, D. C. Heath and Company.
9. Elementary Solid State Physics, M. Ali Omar, (Addision-Wesely).
10. Foundations of Experimental Physics, Shailaja Mahamuni, Deepti Sidhaye, Sulabha Kulkarni, CRC Press.
11. Nuclear radiation detectors, S. S. Kappor and V. S. Rmanurthy. (Wiley Eastern Limited, New Delhi)
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Course Information	
Year and Semester: M.Sc-I, Semester-I/II	Major Core
Course Code: PHY-CP 106/205	Course Title: Computer Programming And Numerical Methods
Credit: 04	

Course Objectives:

1. To train the students to gain knowledge on numerical analysis and understand the basics of FORTRAN 90/95 programming language.
2. To introduce important numerical and programming techniques.
3. To develop numerical and algorithmic skills using FORTRAN 90/95 programming language.

Course Contents

	A. Basic Linux commands, text editors and gnuplot (in Lab); FORTAN Commands and Computer basics. B. Exercises for acquaintance (only some experiments are listed here): (Using FORTRAN 90/95): 1. To find the largest or smallest among a set of numbers. 2. To arrange a given set of numbers in ascending/descending order using Bubble sort algorithm. 3. To generate and print first hundred prime numbers. 4. Matrix addition and multiplication using subroutine. 5. Transpose of a square matrix using only one array. 6. Evaluate a polynomial using Horner's method. C. Numerical Methods: 1. Root finding methods (i) Bisection Method (ii) Newton-Raphson Method (iii) Secant method and applications. 2. Regression models: (i) Linear fit, (ii) Spline fit and applications. (a) Fit a given data set as well as find the standard deviation or error. 3. Lagrange Interpolation and Divided difference interpolation and its uses. 5. Numerical differentiation using forward, backward and mean difference method 6. Numerical Integration : (i) Simpson's rule, (ii) Gaussian Quadrature and applications. 7. Numerical solution of a first order differential equation. (Euler's methods) and applications. 8. Solution of simultaneous equations : (i) Gaussian Elimination method and applications. (Note: The course is expected to comprise 20 exercises).	

Learning Outcomes: Upon completion of the course, the student would

1. have gained training in numerical analysis and write their own FORTRAN programs.
2. have learned important techniques in numerical and programming techniques
3. have developed numerical and algorithmic skills
4. have developed enough skills to implement knowledge in quickly learning other programming languages.

Instructional design:

1) Lecture method
2) Laboratory sessions
3) Seminars

Evaluation Strategies

1) Assesment of numerical and programming skills and outcomes
2) Viva-Voce

REFERENCES:

1. Programming in Fortran 90/95 V. Rajaraman (Prentice-Hall of India).
2. A first course in Computational Physics, 2nd Ed., P. L. DeVries & J. E. Hasbun (Jones & Bartlett)
3. Computer Oriented Numerical Methods, V. Rajaraman (Prentice Hall of India).
4. Numerical Methods for Scientist and Engineers, H. M. Antia (Tata McGraw Hill).
5. Numerical Methods with Fortran IV case studies, Dorn & McCracken (John Wiley & Sons).
6. Numerical Recipes in FORTRAN (2nd Edn.), W. H. Press, S. A. Teakalsky, W. T. Vellerling, B. P.Flannery (Cambridge University Press).

Course Information	
Year and Semester: M. Sc-I, Semester-I	Major Elective
Course Code: PHY-ET101	Course Title: Fundamentals Of Electronics
Credit: 02	

Course Objectives:

5. One of the objectives is to give training of analysis a given electronic circuit in the light of various network theorems.
6. Other objective of the course is to give through understanding of basic structure of transistor along with design aspect of the transistor based circuits.
7. Third objective is to introduce basics concepts related to Differential amplifier.
8. Overall for all above mentioned concepts, problem solving skills with appropriate reason will be nurtured that helps the student to improve their analytical ability in the analysis of the electronic circuits.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	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	Credits: 1	10 L , 5 T
	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).	

Learning Outcomes: Upon completion of the course, the student will be able to,

7. Students will be trained to analyse a given electronic circuit with the help of network theorems.
8. Students will be made aware about basics concepts related to BJT and a design aspect transistor-based circuits will also be developed.
9. Students will also be given understanding of characteristics of differential amplifier and trained for applications based on the same.

Instructional design:

4. Lecture method
5. Tutorial method
6. Seminars

Evaluation Strategies:

3. Descriptive written examinations
4. Assignments

REFERENCES:

1. Electronics Principles, A. P. Malvino, Tata McGraw Hill, New Delhi.
2. Electronics Fundamentals and Applications, J. D. Ryder, John Wiley-Eastern Publications.
3. Integrated Circuits, Milman and Halkias, Prentice-Hall Publications.
4. Digital Principles and Applications, A. P. Malvino, D.P. Leach, McGraw Hill Book Co., 4th Edition (1986).

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Elective
Course Code: PHY-ET102	Course Title: Fundamentals Of Classical Mechanics
Credit: 02	

Course Objectives:

1. To strengthen the basic concepts of classical mechanics and develop a solid understanding of Newtonian mechanics and prerequisite definitions.
2. To introduce important techniques that are necessary to build core concepts in Lagrangian and Hamiltonian dynamics, along with symmetries and constant of motions
3. To develop problem-solving skills with appropriate regior that helps the student to improve their analytical ability in order to grasp the upcoming topic at advanced level.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Review of Newtonian mechanics, 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.	
Module-2	Credits: 1	10 L , 5 T
	Symmetries and Noether's theorem, phase portraits of some simple systems, Poisson brackets. Introduction to central forces: two body problem, application to planetary motion: Kepler's laws.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) have understood the fundamental concepts of classical mechanics subject, including Newtonian mechanics, generalized coordinates, and Hamiltonian mechanics, providing a strong foundation for further studies in physics and related fields.

2) have acquired the problem-solving skills essential to classical mechanics subject, enabling them to analyze and solve intricate problems involving variational calculus, Hamilton's equations, and phase space dynamics.

3) be prepared to undertake advanced topics in classical mechanics subject, allowing them to delve into more complex areas such as celestial mechanics, symplectic geometry, and other specialized branches of classical mechanics, and engage in research and applications in these domains.

Instructional design:
1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:
1. Descriptive written examinations
2. Assignments

REFERENCES:

1. *Classical Mechanics, Goldstein, Poole, & Safko (Pearson).*
2. *Mechanics, Landau & Lifshitz (Butterworth-Heinemann).*
3. *Classical Mechanics, Taylor (University Science Books).*
4. *Classical Mechanics, Rana & Joag (McGraw Hill).*
5. *Classical Mechanics, Gregory (Cambridge University Press).*
6. *Classical Dynamics of Particles and Systems, Marion & Thornton (Cambridge University Press).*
7. *Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, Greiner (Springer).*
8. *Classical Dynamics: A Contemporary Approach, Jose & Saletan (Cambridge University Press).*
9. *Classical Mechanics, Strauch (Springer).*
10. *Classical Mechanics, A.K. Raychaudhuri (Oxford University Press)*

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Elective
Course Code: PHY-ET103	Course Title: Elementary Fluid Mechanics
Credit: 02	

Course Objectives:

1. To introduce students to the basic concepts of fluid dynamics
2. To introduce important techniques that are necessary to build core concepts in fluid dynamics

Course Contents

Module-1	Credits: 1	10 L , 5 T
	General characteristics of a fluid. Velocity field. Flow patterns. Basic hydrostatics. Hydrostatic pressure distribution. Hydrostatic forces on plane and curved surfaces. Buoyancy and stability. Pressure distribution in rigid body motion. Raynold Transport theorem Conservation of mass, linear momentum and angular momentum. Bernoulli equation.	
Module-2	Credits: 1	10 L , 5 T
	Differential equations for mass, linear momentum, angular momentum, and energy. Euler equation and Navier-Stokes equations and their applications. Viscouse flow, flow past immerse bodies. Reynold number and geometry effects.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. understand the fundamental concepts such as Raynold number, Conservation of mass.
2. understand the Euler equation and Navier-Stokes equations.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

1. Fluid Mechanics by F. M White, McGraw-Hill India (2017).
2. Fluid Dynamics for Physicists by T. E. Faber, Cambridge University Press (1995).
3. Fluid Mechanics by Landau & Lifshitz, Butterworth-Heinemann (1987).

Course Information	
Year and Semester: M.Sc-I, Semester-I	Major Elective
Course Code: PHY-ET104	Course Title: Basics Of Electronic Circuit Design
Credit: 02	

Course Objectives:

1. One of the objectives is to give an idea about basic aspects of electricity and electronics. For the analysis of electronic circuits emphasis will be given on various network theorems.
2. Other objective of the course is to give through understanding of basic structure of diode, special diodes and transistor along with design aspect of the transistor based circuits.
3. Overall for all above mentioned concepts, problem solving skills with appropriate reason will be nurtured that helps the student to improve their analytical ability in the analysis of the electronic circuits.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Fundamentals of electricity, Fundamentals of Electronics components and their working, Analysis of Voltage, current, Power in a active circuits in the light of network theorem. Basics of semiconductor, Special purpose diode	
Module-2	Credits: 1	10 L , 5 T
	General Amplifier characteristics, Basics of transistor characteristics, Different configurations of the transistor, Thermal Stability: Transistor biasing and Transistor Dissipation, Hybride equivalent circuit for a transistor, Frequency response, Negative and positive feedback	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. Students will get an understanding of basic aspects of electricity and electronics. Students will be trained for the analysis of electronic circuits with the help of various network theorems.
2. Students will get through understanding of basic structure of diode, special diodes and transistor along with design aspect of the transistor based circuits.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

1. *Electronics Principles, A. P. Malvino, Tata McGraw Hill, New Delhi.*
2. *Electronics Fundamentals and Applications, J. D. Ryder, John Wiley-Eastern Publications.*
3. *Integrated Circuits, Milman and Halkias, Prentice-Hall Publications.*
4. *Digital Principles and Applications, A. P. Malvino, D.P. Leach, McGraw Hill Book Co., 4th Edition (1986).*

Department of Physics
Savitribai Phule Pune University, Pune 411007
Course: M. Sc. (Physics)

SEMESTER-II

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Core
Course Code: PHY-CT201	Course Title: Statistical Mechanics
Credit: 02	

Course Objectives:

1. This course introduces students to statistical mechanics, which is part of the foundation of several branches of physics.
2. It shows how the postulates explain the general laws of thermodynamics as well as properties of classical and quantum gases, other condensed matter systems in equilibrium, and phase transitions.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Canonical Ensemble, Grand canonical ensemble, Gibb's Canonical ensemble, Equivalence of ensembles, Partition function and thermodynamical variables, Density and energy fluctuations, Application to the problem of adsorption. Applications to spin systems, Ising model, Mean Field techniques for calculating partition function. Introduction to phase transitions: First order and second order phase transition, Phase equilibria. Statistics of Identical Particles.	
Module-2	**Credits: 1**	**10 L , 5 T**
	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, Stefan-Boltzmann law. 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. Density matrix. Pure states and statistical mixtures. Density matrices for microcanonical, canonical and grand canonical ensembles.	

Learning Outcomes: Upon completion of the course, the student will

1. understand how a probabilistic description of nature at the microscopic level gives rise to deterministic laws at the macroscopic level.
2. Understand thermal properties of classical and quantum gases and other condensed systems
3. be prepared to undertake advanced statistical mechanics and condensed matter courses.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

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

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*
6. *University Press).*
7. *Thermodynamics and Statistical Mechanics, Greiner, Neise, Stocker, Springer, 2010.*
8. *Statistical Mechanics, Reif*
9. *Statistical Physics (Part 1), L.D. Landau and E. M. Lifhsitz (Elsevier)*

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Core
Course Code: PHY-CT202	Course Title: Electrodynamics-I
Credit: 04	

Course Objectives:
This course aims to introduce the student to topics in Electrostatics, Magnetostatics, Maxwell's equations and Electromagnetic waves.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Electrostatics: Applications of Gauss law, conductors, Poisson's and Laplace's equation, Special Techniques: Generic features of solutions of the Laplace's equations, uniqueness theorems, method of images, boundary value problems, Multipole expansion, Green's functions Electrostatics in dielectric media: Polarization, Electric field of a polarized material, Electric displacement, Linear dielectrics.	
Module-2	Credits: 1	10 L , 5 T
	Magnetostatics: Biot-Savart law, Lorentz force, div. and curl of magnetic field, Magnetic vector potential, Multipole expansion. Magnetic fields in matter: Magnetization, Magnetic field of magnetized material, linear and non linear media.	
Module-3	Credits: 1	10 L , 5 T
	Electrodynamics: Electromotive force, Electromagnetic induction, Maxwell's equations, Continuity equation and Poynting theorem, Wave equations for electric and magnetic fields. Vector and scalar potentials, Gauge Transformations : Coulomb Gauge and Lorentz Gauge ,	
Module-4	Credits: 1	10 L , 5 T
	Wave equations: plane waves, Momentum and energy densities associated with electromagnetic wave, Linear, Circular and Elliptic polarizations, Stokes parameters.	

Learning Outcomes: Upon completion of the course, the student will ,
1. have understood the fundamental concepts of electromagnetic theory .
2. have acquired rigorous background to tackle boundary value problems the problems.
3. have thorough knowledge of magnetostatics.
4. be prepared to undertake advanced topics in electrodynamics.

Instructional design:
1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:
1. Descriptive written examinations
2. Assignments

REFERENCES:

1. Classical Electrodynamics, J. D. Jackson (John Wiley).
2. Introduction to electrodynamics, D. J. Griffiths (Prentice Hall).
3. Classical theory of fields, L. D. Landau and E. M. Lifshitz Vol-2 (Elsevier).
4. Electrodynamics of continuous media, L. D. Landau and E. M. Lifshitz, Vol-8 (Elsevier)

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. R. P. Feynman, Leighton and Sands (Narosa).
8. Berkeley Series Volume II, E.M.Purcell (McGraw-Hill).
9. Electricity and Magnetism, Reitz, Milford and Christy (Pearson).
10. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa).

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Core
Course Code: PHY-CT203	Course Title: Quantum Mechanics-II
Credit: 04	

Course Objectives: Main objective of this course is to introduce to students approximation methods in quantum mechanics and application of it to atomic spectra and scattering processes.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	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. Approximation methods: Time-independent perturbation theory. Non-degenerate and degenerate cases.	
Module-2	Credits: 2	20 L , 10 T
	Fine Structure of the Hydrogen atom. Applications such as the Stark effect, Zeeman effect. Variational method and applications such as the Helium Atom. 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. Interaction of classical radiation field with matter: Absorption and induced emission, Electric dipole transitions, Selection rules, Decays and lifetime, Transition probability for spontaneous emission. Adiabatic and sudden approximations.	
Module-3	Credits: 1	10 L , 5 T
	Scattering theory: Scattering amplitude, differential scattering cross section and total scattering cross section, the Lippman-Schwinger equation, the 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.	

Learning Outcomes: Upon completion of the course, the student will

1. understand the formal theory of angular momentum
2. understand the time independent and dependent perturbation theory.
3. understand the quantum mechanical scattering
4. be prepared to undertake advanced quantum mechanics/quantum field theory courses

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

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

Course Information	
Year and Semester: M.Sc-I, Semester-I/II	Major Core
Course Code: PHY-CP105/204	Course Title: Basic Physics Laboratory
Credit: 04	

Course Objectives:

1. To get trained to perform experiments in Physics.
2. To introduce important experimental techniques.
3. To Collect data and revise an experimental procedure iteratively
4. To develop experimental skills.

Course Contents

	List of experiments	
	The proposed list of the experiments for Basic Physics Laboratory I (Any 12 experiments) 3. Characteristics of operational amplifier 4. UJT and FET characteristics 5. Magnetic Susceptibility 6. Temperature transducer (T to F converter) 7. Thermionic emission 8. Mass Absorption 9. Counting Statistics 10. Zeeman Effect 11. Fabry Perot Interferometer 12. Michelson interferometer 13. Absorption spectra of I2 molecule 14. Determination of Seebeck coefficient and understanding of Thermocouple working. 15. Recording and analysis of B-H curve 16. Millikan Oil drop method 17. Determination of e/m ratio 18. Frank-Hertz experiment	

Learning Outcomes: Upon completion of the course, the student would

1. learn to formulate hypotheses and devise and perform experiments to test a hypothesis. as individuals and in a team.
2. have gained training in conducting experiments in Physics
3. learn to apply scientific methodologies for problem solving.
4. have learned important techniques in Experimental Physics
5. have developed skills in designing and conducting experiments in Physics

Instructional design:
1) Lecture method
2) Laboratory sessions
3) Seminars

Evaluation Strategies:

1) Assesment of experimental skills and outcomes
2) Viva-Voce

REFERENCES:

1. Atomic Spectra and Atomic Structure by G. Herzberg, New York Dover Publication.
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, Tata, McGraw-Hill Publishing Company Limited.
3. Electronics Principles, A. P. Malvino, Tata McGraw Hill, New Delhi.
4. Fundamentals of Statistical and Thermal Physics, F. Reif (International Student Ed.) McGraw Hill..
5. Introduction to electrodynamics, D. J. Griffiths, Prentice Hall.
6. Solid State Physics, A. J. Dekkar, Prentice Hall.
7. Fundamentals of Optics, Jenkins and White, McGraw-Hill, International Edition.
8. Physics Lab. Experiments, Jerry D. Wilson, D. C. Heath and Company.
9. Elementary Solid State Physics, M. Ali Omar, (Addision-Wesely).
10. Foundations of Experimental Physics, Shailaja Mahamuni, Deepti Sidhaye, Sulabha Kulkarni, CRC Press.
11. Nuclear radiation detectors, S. S. Kappor and V. S. Rmanurthy. (Wiley Eastern Limited, New Delhi)
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Course Information	
Year and Semester: M.Sc-I, Semester-I/II	Major Core
Course Code: PHY-CP 106/205	Course Title: Computer Programming And Numerical Methods
Credit: 04	

Course Objectives:

1. To train the students to gain knowledge on numerical analysis and understand the basics of FORTRAN 90/95 programming language.
2. To introduce important numerical and programming techniques.
3. To develop numerical and algorithmic skills using FORTRAN 90/95 programming language.

Course Contents

	A. Basic Linux commands, text editors and gnuplot (in Lab); FORTAN Commands and Computer basics. B. Exercises for acquaintance (only some experiments are listed here): (Using FORTRAN 90/95): 1. To find the largest or smallest among a set of numbers. 2. To arrange a given set of numbers in ascending/descending order using Bubble sort algorithm. 3. To generate and print first hundred prime numbers. 4. Matrix addition and multiplication using subroutine. 5. Transpose of a square matrix using only one array. 6. Evaluate a polynomial using Horner's method. C. Numerical Methods: 1. Root finding methods (i) Bisection Method (ii) Newton-Raphson Method (iii) Secant method and applications. 2. Regression models: (i) Linear fit, (ii) Spline fit and applications. (a) Fit a given data set as well as find the standard deviation or error. 3. Lagrange Interpolation and Divided difference interpolation and its uses. 5. Numerical differentiation using forward, backward and mean difference method 6. Numerical Integration : (i) Simpson's rule, (ii) Gaussian Quadrature and applications. 7. Numerical solution of a first order differential equation. (Euler's methods) and applications. 8. Solution of simultaneous equations : (i) Gaussian Elimination method and applications. (Note: The course is expected to comprise 20 exercises).	

Learning Outcomes: Upon completion of the course, the student would

1. have gained training in numerical analysis and write their own FORTRAN programs.
2. have learned important techniques in numerical and programming techniques
3. have developed numerical and algorithmic skills
4. have developed enough skills to implement knowledge in quickly learning other programming languages.

Instructional design:

1) Lecture method
2) Laboratory sessions
3) Seminars

Evaluation Strategies

1) Assesment of numerical and programming skills and outcomes
2) Viva-Voce

REFERENCES:

1. Programming in Fortran 90/95 V. Rajaraman (Prentice-Hall of India).
2. A first course in Computational Physics, 2nd Ed., P. L. DeVries & J. E. Hasbun (Jones & Bartlett)
3. Computer Oriented Numerical Methods, V. Rajaraman (Prentice Hall of India).
4. Numerical Methods for Scientist and Engineers, H. M. Antia (Tata McGraw Hill).
5. Numerical Methods with Fortran IV case studies, Dorn & McCracken (John Wiley & Sons).
6. Numerical Recipes in FORTRAN (2nd Edn.), W. H. Press, S. A. Teakalsky, W. T. Vellerling, B. P.Flannery (Cambridge University Press).

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Elective
Course Code: PHY-ET201	Course Title: Essentials Of Statistical Physics
Credit: 02	

Course Objectives:

1. To strengthen the basic concepts of thermodynamics and statistical physics
2. To introduce important techniques that are necessary to build core concepts in statistical physics

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Elementary probability theory: Preliminary concepts, Random walk problem, Binomial distribution, mean values, standard deviation, various moments, Gaussian distribution, Poisson distribution, mean values. Probability density, probability for continuous variables The laws of thermodynamics and their consequences. A brief revision of the laws of thermodynamics. Thermodynamical work for magnetic, dielectric, elastic systems. Legendre transformation, Thermodynamic potentials. Statistical basis of thermodynamics.	
Module-2	**Credits: 1**	**10 L , 5 T**
	Elements of ensemble theory. Microcanonical ensemble (MCE). Macroscopic and microscopic states. Classical phase space, Statistical distribution function, Liouville's theorem, Statistical origin of entropy. Central postulates of Statistical Mechanics. Derivation of the laws of thermodynamics from the central postulates. Application to the ideal gas. Quantum states and the phase space. MCE applications: (a) Two level system, (b) Ideal gas. Gibbs paradox and Gibbs correction term.	

Learning Outcomes: Upon completion of the course, the student will

1. understand the application of probability to statistical physics
2. understand the thermodynamic potentials.
3. understand the Microcanonical

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

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

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*
6. *University Press).*
7. *Thermodynamics and Statistical Mechanics, Greiner, Neise, Stocker, Springer, 2010.*
8. *Statistical Mechanics, Reif*
9. *Statistical Physics (Part 1), L.D. Landau and E. M. Lifhsitz (Elsevier)*

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Elective
Course Code: PHY-ET202	Course Title: Atomic And Molecular Physics
Credit: 02	

Course Objectives:

1. This course is an introduction to atomic and molecular physics in order to understand the atomic structure and atomic spectra as well as molecular structure and molecular spectra.

2. This course of lectures is designed to develop the skills to solve real physical problems using atomic and molecular physics.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	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	Credits: 1	10 L , 5 T
	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.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. Explain the atomic spectra of one and two valance electron atoms.
2. To calculate the spectroscopic ground state term symbols for single and multi-electron system.
3. Understand the importance of Pauli's exclusion principle and spectroscopic transition selection rules.
4. Explain the change in behaviour of atoms in external applied electric and magnetic field.
   Explain rotational, vibrational, electronic spectra of molecules.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

1. Quantum Physics, Robert Eisberg and Robert Resnick, (John Wiley and Sons).
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, (Tata, McGrawHill Publishing Company Limited)
3. Introduction to Atomic Spectra, H. E. White, (McGraw Hill International Ed.)
4. Perspectives of Modern Physics, Arthur Beiser, (McGraw Hill International Ed.)
5. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain (Pearson).
6. The Physics of Atoms and Quanta Introduction to Experiments and Theory Authors: Haken, Hermann, Wolf, Hans Christoph
7. Molecular Spectra and Molecular Structure, Gerhard Herzberg, (D. Van Nostrand Company, Inc.)
8. Molecular Spectroscopy – J.M. Brown, Oxford University Press (1998).
9. Molecular Quantum Mechanics, P.W. Atkins and R. Freidman (Oxford University Press)
10. Quantum Chemistry, I. N. Levine (Wiley).
11. Atoms, Molecules and photons by Wolfgang Demtröder, Springer -2005

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Elective
Course Code: PHY-ET203	Course Title: Thermal Physics
Credit: 02	

Course Objectives:

1. To strengthen the basic concepts of thermodynamics
2. To introduce important techniques that are necessary to build core concepts in statistical physics

Course Contents

Module-1	Credits: 1	10 L , 5 T
	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, Statistical distribution function, 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	Credits: 1	10 L , 5 T
	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.	

Learning Outcomes: Upon completion of the course, the student will be able to,
1. have understand the fundamental concepts of elementary statistical mechanics subject.
2. be prepared to undertake major statistical mechanics course.

Instructional design:
1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:
1. Descriptive written examinations
2. Assignments

REFERENCES:

1. *Statistical Mechanics, Pathria and Beale (Academic Press).*
2. *Statistical Mechanics, Huang (Wiley).*
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*
6. *University Press).*
7. *Thermodynamics and Statistical Mechanics, Greiner, Neise, Stocker, Springer, 2010.*
8. *Statistical Mechanics, Reif*
9. *Statistical Physics (Part 1), L.D. Landau and E. M. Lifhsitz (Elsevier)*

Course Information	
Year and Semester: M.Sc-I, Semester-II	Major Elective
Course Code: PHY-ET204	Course Title: Basics Of Atoms And Molecules
Credit: 02	

Course Objectives: This course of lectures is designed to develop the skills to solve real physical problems using atomic and molecular physics with the help of quantum mechanics.

Course Contents

Module-1	Credits: 1	10 L , 5 T
	Atomic Models, basics hydrogen atom (wave functions, orbital and spin angular momentum, quantum states of an electron in an atom, magnetic dipole moment, electron spin, spin-orbit interaction, fine structure, spectroscopic terms). spectral lines, selection rules, Stern Gerlach experiment, Relativistic corrections for energy levels of hydrogen atom. Multi-electron atoms: Central field approximation, Hartree-Fock theory, Self-consistent fields, Exchange symmetry of wave functions, electron configurations, Pauli`s exclusion principle, electron configuration, Exchange force, Russell-Saunders (L-S) coupling, Hund's rule, atomic ground state determination, J-J coupling. Atoms in an electromagnetic field: Selection rules, fine structure spectra, hyperfine structure spectra, Mosley law, X-ray spectra, Stark effect, Zeeman effect and Paschen-Back effect.	
Module-2	Credits: 1	10 L , 5 T
	Bonding mechanism, Types of Bonds: Covalent, ionic and van der Waal bonding, Types of molecules, Molecular orbital and valance bond theories. H_2^+ and H_2 molecule, heteronuclear diatomic molecules, hybridization, ionic bonding, electro-negativity, electron affinity. Electronic structure of polyatomic molecules: Molecular electronic configurations and energy level diagrams, molecular term symbols, magnetic and non-magnetic nature of diatomic molecules. Molecular Spectra: Rotational levels in diatomic and polyatomic molecules: Born – Oppenheimer approximation, Rigid and non-rigid rotation, selection rules. Vibrational levels in diatomic and polyatomic molecules: Morse oscillator model for vibrational levels. Vibration spectrum of diatomic molecule, vibration-rotation spectra (P, Q, R branches). Electronic spectra of diatomic molecules: Frank-Condon principle.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1. Explain the atomic spectra of one and two valance electron atoms.
2. To calculate the spectroscopic ground state term symbols for single and multi-electron system.
3. Understand the importance of Pauli's exclusion principle and spectroscopic transition selection rules.
4. Explain the change in behaviour of atoms in external applied electric and magnetic field.
   Explain rotational, vibrational, electronic spectra of molecules.

Instructional design:

1. Lecture method
2. Tutorial method
3. Seminars

Evaluation Strategies:

1. Descriptive written examinations
2. Assignments

REFERENCES:

1. Quantum Physics, Robert Eisberg and Robert Resnick, (John Wiley and Sons).
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, (Tata, McGrawHill Publishing Company Limited)
3. Introduction to Atomic Spectra, H. E. White, (McGraw Hill International Ed.)
4. Perspectives of Modern Physics, Arthur Beiser, (McGraw Hill International Ed.)
5. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain (Pearson).
6. The Physics of Atoms and Quanta Introduction to Experiments and Theory Authors: Haken, Hermann, Wolf, Hans Christoph
7. Molecular Spectra and Molecular Structure, Gerhard Herzberg, (D. Van Nostrand Company, Inc.)
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11. *Atoms, Molecules and photons by Wolfgang Demtröder, Springer -2005*