Anekant Education Society's

**TULJARAM CHATURCHAND COLLEGE OF ARTS, SCIENCE AND COMMERCE, BARAMATI**

**(Autonomous Status)**

(Affiliated to Savitribai Phule Pune University, Pune)

Faculty of Science

# Department of Physics

Syllabus

For

## M.Sc.-I in Physics

**From Academic Year 2020-2021**

# INDEX

## PREAMBLE

Physics, a core discipline, is the fundamental and foremost to all natural sciences. It has been significant and influential through advances in its understanding that have translated into new technologies. Physics interact with the society and other discipline such as Medicine, Chemistry, Agriculture, Engineering etc. in many important ways. Physics department in Tuljaram Chaturchand College has highly qualified faculty members and support staffs and is committed towards the development of innovative and handy ways of teaching at graduate, post graduate and developing a core research group for carrying out cutting edge research in various research fields like Condensed Matter Physics, Solid State Physics, Electronics, Theoretical Physics, Atomic & Molecular Physics and Nuclear Physics. The department also offers Doctoral Programme in order to nurture young minds towards embracing various scientific challenges. Extra care is taken to pay individual attention to the students in their laboratory work and tutorial sessions. Project work and problem sessions are encouraged to develop innovative and analytical approach to physics learning.

## GOALS

The goal of the Physics education is to provide the student with a broad understanding of the physical principles of the universe, to help them develop critical thinking and quantitative reasoning skills, to empower them to think creatively and critically about scientific problems and experiments. It's provide training for students and planning careers in physics including research, teaching, industrial jobs, government jobs or other sectors of our society.

## OBJECTIVES

1. To endow with a conducive and friendly environment that nurtures excellence and high standards of professionalism in teaching, learning and research.
2. To augment the level of participation in research, dissemination and preservation of knowledge for both academic and social development.
3. Prepare the student in assets of Physics and the principles of analytical methods required for the conclusion of physical tests.
4. Provide an opportunity for students to deepen his/her knowledge in the branches of Physics so that views on the outskirts of contemporary science.

5. Training the students on the way of scientific research and enable it to contribute to it under the supervision.
6. Continued development of faculty members by sending them for training courses so as to maintain a high degree of efficiency and performance.
7. Support and encourage the scientific cooperation between faculty members in the department and co-operation with other departments in the field of multi-purpose research.
8. Spread the spirit of competition and encouragement and give the opportunity to all members.
9. Preparation of national cadres by basic physics and knowledge that contribute to community service.
10. To establishes collaborations with other eminent institution.

Proposed Structure of M.Sc. degree in Physics and syllabus for first year degree in Physics as follows:

Anekant Education Society's
**TULJARAM CHATURCHAND COLLEGE OF ARTS, SCIENCE AND COMMERCE, BARAMATI**
**(Autonomous Status)**
(Affiliated to Savitribai Phule Pune University, Pune)

# M.Sc. I & II Course Structure

## M.Sc.-I

## Semester-I

| Course Number | Course Code | Course Name | Credit |
|---|---|---|---|
| 1 | PHY4101 | Mathematical Methods in Physics | 4 |
| 2 | PHY4102 | Classical Mechanics | 4 |
| 3 | PHY4103 | Quantum Mechanics-I | 4 |
| 4 | PHY4104 | Electronics | 4 |
| 5 | PHY4105 | Electronics Laboratory-I | 4 |
| 6 | PHY4106 | Basic Physics Laboratory-I | 4 |
| **Total Credit** | | | **24** |

## Semester-II

| Course Number | Course Code | Course Name | Credit |
|---|---|---|---|
| 7 | PHY4201 | Physics of Semiconductor Devices | 4 |
| 8 | PHY4202 | Atoms, Molecules & Laser | 4 |
| 9 | PHY4203 | Quantum Mechanics-II | 4 |
| 10 | PHY4204 | Electrodynamics | 4 |
| 11 | PHY4205 | Electronics Laboratory-II | 4 |
| 12 | PHY4206 | Basic Physics Laboratory-II | 4 |
| **Total Credit** | | | **24** |

# M.Sc.-II

## Semester-III

| Course Number | Course Code | Course Name | Credit |
|---|---|---|---|
| 11 | PHY5301 | Statistical Physics | 4 |
| 12 | PHY5302 | Solid State Physics | 4 |
| 13 | PHY5303 | CB Group –I<br>A) Physics of thin films-I<br>B) Nano-technology-I<br>C) Biomedical Instrumentation-I | 4 |
| 14 | PHY5304 | CB Group –II<br>A) Electronic Instrumentation-I<br>B) Laser-I<br>C) Energy Studies-I<br>D) Microcontroller– I | 4 |
| 15 | PHY5305 | Special Lab-I | 4 |
| 16 | PHY5306 | Project-I | 2 |
| **Total Credit** | | | **22** |

## Semester-IV

| Course Number | | Course Name | Credit |
|---|---|---|---|
| 17 | PHY5401 | Nuclear & Particle Physics | 4 |
| 18 | PHY5402 | Material Science | 4 |
| 19 | PHY5403 | CB Group –III<br>A) Physics of thin films-II<br>B) Nano-technology-II<br>C) Biomedical Instrumentation-II | 4 |
| 20 | PHY5404 | CB Group –IV<br>A) Electronic Instrumentation-II<br>B) Laser-II<br>C) Energy Studies-II<br>D) Microcontroller– II | 4 |
| 21 | PHY5405 | Special Lab-II | 4 |
| 22 | PHY5406 | Project-II | 2 |
| **Total Credit** | | | **22** |

Anekant Education Society's
TULJARAM CHATURCHAND COLLEGE OF ARTS, SCIENCE AND COMMERCE, BARAMATI
**(Autonomous Status)**
(Affiliated to Savitribai Phule Pune University, Pune)

# M.Sc. I & II Proposed Syllabus Structure

## M.Sc.-I

## Semester-I

| Course Number | Course Code | Course Name | Credit |
|---|---|---|---|
| 1 | PHY4101 | Mathematical Methods in Physics | 4 |
| 2 | PHY4102 | Classical Mechanics | 4 |
| 3 | PHY4103 | Quantum Mechanics-I | 4 |
| 4 | PHY4104 | Electronics | 4 |
| 5 | PHY4105 | Electronics Laboratory-I | 4 |
| 6 | PHY4106 | Basic Physics Laboratory-I | 4 |
| **Total Credit** | | | **24** |

## Semester-II

| Course Number | Course Code | Course Name | Credit |
|---|---|---|---|
| 7 | PHY4201 | Physics of Semiconductor Devices | 4 |
| 8 | PHY4202 | Atoms, Molecules & Laser | 4 |
| 9 | PHY4203 | Quantum Mechanics-II | 4 |
| 10 | PHY4204 | Electrodynamics | 4 |
| 11 | PHY4205 | Electronics Laboratory-II | 4 |
| 12 | PHY4206 | Basic Physics Laboratory-II | 4 |
| **Total Credit** | | | **24** |

**M. Sc-I (Physics) Semester-I**

## PHY4101: MATHEMATICAL METHODS IN PHYSICS

**Credit: 04** **Total No. of Lectures: 60**

## Learning outcomes:

After completion of the course, the student should be able to:

1. From this course, the students are expected to learn some mathematical techniques required to understand the physical phenomena at the postgraduate level.
2. The students are expected to be able to solve simple problems in probability, understand the concept of independent events and work with standard continuous distributions.
3. The students will have idea of the functions of complex variables; solve nonhomogeneous differential equations and partial differential equations using simple methods.
4. The students are expected to be able to solve simple problems on Fourier series and Fourier transform, Laplace transform etc.

**Unit 1: Matrix Algebra (15L)**

Introduction, Matrix representation, Rank of matrix, Similarity transformations, Eigen values and eigenvectors, Inner product, Orthogonality, Gramm-Schmidt orthogonalization procedure, Self adjoint and Unitary transformations, Eigen values & eigenvectors of Hermitian & Unitary transformations, Diagonalization, Problem Solving

**Unit 2: Basic Mathematical Methods and Linear vector spaces (15L)**

Introduction, Plotting of graph, curve fitting, data analysis, Elementary probability theory, random variables, binomial, Poisson and normal distributions, Calculus: vector algebra and vector calculus. Linear algebra. Elementary complex analysis. Vector spaces and subspaces, Linear dependence and independence, Basis and Dimensions, linear operators, Problem Solving

**Unit 3: Fourier series and Integral transforms (15L)**

Introduction, Fourier Series : Linear differential equations, Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseval's identity, Applications to the solution of differential equations, Laplace transform and its properties, Fourier transform & Laplace transform of Dirac Delta function, Introduction to Gamma and Beta Integral, Problem Solving

**Unit 4: Complex Analysis (15L)**

Introduction, Elements of complex analysis: residues and evaluation of integrals; Introduction & types of tensors, Introductory group theory. Elements of computational techniques: roots of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, solution of first ODE using Runge-Kutta method; Finite difference methods, Problem Solving.

**Reference Books:**


1. Complex Variables and Applications – J. W. Brown, R. V. Churchill – (7th Edition) - Mc-Graw Hill
2. Complex Variables – Seymour Lipschutz
3. Mathematics for Physical Sciences – Mary Boas, John Wiley & Sons
4. Mathematical methods in Physics – B. D. Gupta
5. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series- Mc-Graw Hill edition
6. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age International
7. Mathematical methods for Physicists – Arfken & Weber – 6th Edition-Academic Press-N.Y.
8. Mathematical methods in Physics – Satyaprakash
9. Fourier Series - Seymour Lipschutz, Schaum Outlines Series
10. Laplace Transform - Seymour Lipschutz, Schaum Outlines Series 11. Fourier Series and Boundary value problems - R. V. Churchill, McGraw Hill
11. Mathematical Physics, Rajput, Pragati prakashan

12 Mathematical Physics, H. K. Dass

**M. Sc-I (Physics) Semester-I**

**PHY4102: CLASSICAL MECHANICS**

**Credit: 04** **No. of Lectures: 60**

## Learning outcomes:

After completion of the course, the student should be able to:

1. The students will introduce about the forces, angular momentum and knowledge about the constraint.
2. This paper enables the students to understand the Lagrangian and Hamiltonian approaches in classical mechanics.
3. The classical background of Quantum mechanics and get familiarized with Poisson brackets and Hamilton -Jacobi equation
4. The students should able to understand Kinematics and Dynamics of rigid body in detail and ideas regarding Euler's equations of motion

**Unit 1: Constrained Motion and Langrangian formulation (15 L)**

Constrained Motion, Constraints and their Classification**,** Degrees of freedom, Generalized coordinates, Virtual Displacement, Principle of Virtual Work, D'Alembert Principle, Configuration space, Lagrange's equation of motion, Theorem on total energy, Cyclic coordinates, Generalized momenta, Invariance under Galilean transformation.

**Problems solving**

**Unit 2: Hamilton's formulation & Variational Principle (15 L)**

Hamilton's function and Hamiltonian equation of motion, Phase space, Jacobi integrals and energy conservation, Lagrangian and Hamiltonian of relativistic particles and light rays, Variational principle, Euler's equation, Applications of Variational principle, Concept of symmetry.

**Problems solving**

**Unit 3: Canonical Transformations and Poisson's Bracket (15 L)**

Introduction- Background and definition, Legendre transformations, Generating function, Conditions for canonical transformation, Poisson's bracket-definition, identities, Poisson's theorem, Jacobi Poisson theorem, Jacobi identity, Invariance of Poisson Bracket under canonical transformation.

**Problems solving**

**Unit 4: Central Force** **(15 L)**

Introduction, definition and properties of Central Force, Two body central force problem, Stability of orbit, Orbits of artificial satellite, Keplers problem, Inertial forces in rotating frame, Coriolis force and its effect, Foucault's pendulum, Virial theorem.

**Problems solving**

**Reference Books:**


1. Classical mechanics by J.C. Upadhyaya, Himalaya Publishing House.
2. Classical mechanics by N.C. Rana and P.S. Joag, Tata Mc-Graw Hill Publishing Company limited, New Delhi.
3. Classical Mechanics by P.V. Panat, Narosa publishing Home, New Delhi.
4. Classical Mechanics by Kumar, Gupta, Sharma.
5. Classical Mechanics by H. Goldstein, Narosa Publishing Home, New Delhi.
6. Classical Mechanics by D. S. Mathur.
7. Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
8. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
9. Analytical Dynamics E.T. Whittaker, Cambridge, University Press.

**M. Sc-I (Physics) Semester-I**

## PHY4103: QUANTUM MECHANICS- I

**Credit: 04** **Total No. of Lectures: 60**

## Learning outcomes:

After completion of the course, the student should be able to:

1. Students should understand the drawbacks of Classical Mechanics and necessity of Quantum mechanics
2. To understand the behaviour of particles under Classical and Quantum conditions.
3. Students should understand the Operators in Quantum Mechanics.
4. Students should Learn about Approximation Methods to solve problems

**Unit 1: Revision and general formalism** **(15 L)**

**Revision: Why QUANTUM MECHANICS?**

Introduction, Inadequacy of classical Physics, wave packets and uncertainty relations, Schrodinger wave equation and probability interpretation, Simple one dimensional problems: potential well, potential barrier and simple harmonic oscillator (1-D, 3-D), Applications of Schrodinger steady state equation: Free particle, Particle in infinitely deep potential well, Barrier penetration and tunneling effect (1-D, 3-D), Particle in three dimension rigid box, Step potential. Spherically symmetric potentials: Schrodinger's equation in spherical polar co-ordinate system. Rigid rotator, Hydrogen atom, Problem solving.

**Formalism of quantum mechanics:**

**Hilbert space and wave function**: The linear Vector Space, Hilbert's Space, Dimension and Basis of vector Space, Square Integral Functions: Wave functions, Dirac's bra and ket notation, **Dynamical variables and linear operators:** projection operators, unit operator, unitary operator, matrix representation of an operator: Change of basis, unitary transformation, Adjoint and self adjoint operators, eigen functions and eigen values, degeneracy, Dirac delta function, Completeness and closure property, Physical interpretation of eigen values, eigen functions and expansion coefficients, Eigen values and Eigen functions of momentum operator. Eigen values and Eigen functions of simple harmonic oscillator by operator method.

**Unit 2: Postulates of quantum mechanics:** **(15 L)**

**Basic Postulates of Quantum Mechanics**: The state of System: Probability density, The superposition principle, Observables and operators: Measurement in **Quantum Mechanics**, Time Evolution of the System's State, Symmetries and Conservation Laws, Connecting Quantum Mechanics to Classical Mechanics.

**Unit 3: Angular Momentum** **(15 L)**

Orbital Angular Momentum, General formalism of Angular Momentum, Matrix representation of Angular Momentum, Geometrical Representation of Angular Momentum, Spin Angular Momentum, Eigen function of Angular Momentum: Eigen values and eigen functions of $L^2$ and $L_z$ operators, ladder operators $L_+$ and $L_-$ (Harmonic Oscillator), Pauli's theory of spins (Pauli's matrices) , matrix representation of J in |jm> basis. Rotations in Quantum Mechanics: Infinitesimal rotations, finite rotations, properties of rotations, Eular rotations, Representation of rotation operator, Rotation matrices and Spherical harmonics. Addition of angular momenta: general formalism, Computation of Clebsch-Gordon coefficients in simple cases ($J1=\frac{1}{2}$, $J2=\frac{1}{2}$), Scalar, Vector and Tensor operator, Wigner-Eckart Theorem.

**Unit 4: Approximation Methods** **(15 L)**

Time-independent Perturbation theory: Non degenerate and degenerate perturbation, Stark effect, anharmonic oscillator, Zeeman Effect, Time dependent Perturbation theory: Transition amplitude 1st and 2nd order, Introduction to WKB approximation, Variational method: Basic principles and applications to particle in box, simple harmonic oscillator.

**Reference Books:**


1. Quantum Mechanics by Nouredine Zettili, A John Wiley and Sons, Ltd.
2. Modern Quantum Mechanics by J. J. Sakurai.
3. A Text-book of Quantum Mechanics by P. M. Mathews and K. Venkatesan.
4. Quantum mechanics by A. Ghatak and S. Lokanathan.
5. Quantum Mechanics by L. I. Schiff.
6. Quantum Physics by R. Eisberg and R. Resnick.
7. Introduction to Quantum Mechanics by by David J. Griffiths.

8. Introductory Quantum mechanics by Granier, Springer Publication.
9. Introductory Quantum Mechanics by Li boff, 4th Edition, Pearson Education Ltd.
10. Principles of Quantum Mechanics by Shankar R. IInd Edition (Plenum, 1994).

**M. Sc-I (Physics) Semester-I**

## PHY4104: ELECTRONICS

**Credit: 04** **No. of Lectures: 60**

## Learning outcomes:

After completion of the course, the student should be able to:

1.Manipulate voltage, current and resistances in electronic circuits
2.Demonstrate familiarity with basic electronic components and use them to design simple electronic circuits
3. Design and analyse of electronic circuits,
4. Evaluate frequency response to understand behaviour of Electronics circuits

**Unit 1: Study and applications of Operational Amplifiers (15L)**

Concept of input/output impedance, Input bias current, offset input voltage, slew rate, CMMR, Gain, frequency response, Applications of Operational Amplifiers: Inverting and Non-inverting amplifier, Adder and Substractor, Integrator and Differentiator, Active filters: LPF, HPF, BPF, and Notch filter 1$^{st}$ and 2$^{nd}$ order with designing, Instrumentation Amplifier, Function Generator – Square wave, triangular, saw tooth, sine wave. Half wave and full wave precision rectifiers, Sample and hold circuits.

**Unit 2: Communication Electronics (15L)**

Basic principle of amplitude, frequency and phase modulation, Simple circuits for amplitude modulation and demodulation, Digital modulation (PCM) and demodulation,

Fundamentals of optical communication, Microwave Oscillators (reflex, klystron, magnetron and Gunn diode), Radio detector

**Unit 3: Digital Logic circuits (15L)**

Combinational Logic: Review of Boolean identities and its use to minimize Boolean Expressions, Minimization of Boolean Expressions using Karnaugh map: SOP and POS

Sequential Logic, Flip-flops: RS, JK, MS-JK, D and T, Shift registers using IC 7495: Applications as SISO, SIPO, PISO, PIPO, Counters: Review of synchronous, asynchronous and combinational counters, Decade counter IC 7490 with applications, Up-down counter

**Unit 4: Data Converters** **(15 L)**

Digital to analog Converters, Binary weighted type, R-2R ladder, Study of IC 0808, Analog to digital converters, Single slope, Dual slope, Flash/Simultaneous type, Counter type, Successive approximation type

**Reference Books:**


1. Operational Amplifiers – G.B.Clayton (5th edition ) Newnes
2. Operational Amplifiers Applications – G.B.Clayton
3. Electronic Principles – A. P. Malvino (TMH Publication)
4. Op-amps and Linear Integrated circuits – Gayakwad (Prentice Hall)
5. Linear Integrated circuits – D.Roy Choudhury, Shail Jain
6. Integrated circuits – Botkar
7. Digital Principles and Applications : Leach and Malvino
8. Data Converters – B.S. Sonde.

**M. Sc-I (Physics) Semester-I**

## PHY4105: ELECTRONICS LABORATORY-I

**Credits: 04** **No of Practicals:10**

**(Students have to perform Any 10 Experiments)**

After successfully completing this laboratory course the students will be able to do the following

1. Acquire technical and manipulative skills by using laboratory equipment, tools and materials

2. Demonstrate a deeper understanding of abstract concept and theories gained by experiencing and visualizing them as authentic phenomena.

3. Understanding the basic design of circuit which related to experiment.

4. Acquire the complementary skills of collaborative learning and teamwork in laboratory settings.

1. Voltage to Frequency Convertor using OP-AMP.
2. Diode pump using UJT.
3. DAC (4 bit R-2R Ladder Type).
4. Active filter- Low pass, High pass, Band pass and Notch Filter using OP-AMP.
5. Function generator using OP-AMP.
6. Study of optocoupler using IC- MCT2E
7. Constant current source using OP-AMP.
8. Crystal oscillator- Millar type.
9. Study of Clocked RSFF and DFF Using NOR/NAND gates.
10. Instrumental amplifier using three op-amps
11. Design, built and test oscillator – Wien Bridge oscillator
12. Study of IC 7490 (Decade counter).
13. Amplitude modulation and demodulation
14. Optical fiber communication.
15. Pulse train generator
16. Op-amp based clipper and clampers

**M. Sc-I (Physics) Semester-I**

## PHY4106: BASIC PHYSICS LABORATORY-I

**Credits: 04**

**(Students have to perform Any 10 Experiments)**

## Learning outcomes:

After completion of the course, the student should be able to:

1. Acquire technical and manipulative skills by using laboratory equipment, tools and materials
2. Demonstrate a deeper understanding of abstract concept and theories gained by experiencing and visualizing them as authentic phenomena.
3. Acquire the complementary skills of collaborative learning and teamwork in laboratory settings.

1. Young's Modulus of steel by Flexural Vibrations of a bar
2. Fabry-Parot Etalon.
3. Hall Effect.
4. Resistivity of Ge at various temperature by Four Probe method and determination of band gap.
5. Determination of Rydberg constant.
6. Michelson Interferometer.
7. Magnetic Susceptibility by Gauoy's method.
8. 'e' by Millikan oil drop method.
9. G.M. Counter – I Counting statistics
10. G.M. Counter –II End point energy and Absorption coefficient using G. M. tube.
11. Determination of Planck's constant
12. Stefan's constant – Black body radiation.
13. Electron Diffraction.
14. Determination of solar constant
15. Coherence and width of spectral lines using Michelson Interferometer.
16. Determination of Seebeck coefficient and understanding of Thermocouple working.

# M.Sc.-II

## Semester-III

| Course Number | Course Code | Course Name | Credit |
|---|---|---|---|
| 11 | PHY5301 | Statistical Physics | 4 |
| 12 | PHY5302 | Solid State Physics | 4 |
| 13 | PHY5303 | CB Group –I<br>A) Physics of thin films-I<br>B) Nano-technology-I<br>C) Biomedical Instrumentation-I | 4 |
| 14 | PHY5304 | CB Group –II<br>A) Electronic Instrumentation-I<br>B) Laser-I<br>C) Energy Studies-I<br>D) Microcontroller– I | 4 |
| 15 | PHY5305 | Special Lab-I | 4 |
| 16 | PHY5306 | Project-I | 2 |
| **Total Credit** | | | **22** |

## Semester-IV

| Course Number | | Course Name | Credit |
|---|---|---|---|
| 17 | PHY5401 | Nuclear & Particle Physics | 4 |
| 18 | PHY5402 | Material Science | 4 |
| 19 | PHY5403 | CB Group –III<br>A) Physics of thin films-II<br>B) Nano-technology-II<br>C) Biomedical Instrumentation-II | 4 |
| 20 | PHY5404 | CB Group –IV<br>A) Electronic Instrumentation-II<br>B) Laser-II<br>C) Energy Studies-II<br>D) Microcontroller– II | 4 |
| 21 | PHY5405 | Special Lab-II | 4 |
| 22 | PHY5406 | Project-II | 2 |
| **Total Credit** | | | **22** |

**M. Sc-I (Physics) Semester-II**

## PHY4201: PHYSICS OF SEMICONDUCTOR DEVICES

**Credit: 04** **No. of Lectures: 60**

## Learning outcomes:

After completion of the course, the student should be able to:

1. The students should able to utilize semiconductor models to analyze carrier densities and carrier transport.
2. The students should able to understand and utilize the basic governing equations to analyze semiconductor devices.
3. The students should able to understand and analyze the inner working of semiconductor p-n diodes, Schottky barrier diodes and new semiconductor devices.
4. The students should able to explain how the metal-semi conductor contacts will occur.
5. The students should able to explain the working principle of a junction transistor.
6. The students should able to discuss conduction in semiconductors – charge carriers, intrinsic/extrinsic, p-type, n-type.
7. The students should able to Know the physics of semiconductor junctions, metal-semiconductor junctions and metal-insulator-semiconductor junctions.
8. The students should able to apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices.

**Unit 1: Properties of Semiconductors** **(15L)**

An introduction to semiconductors, their crystal structure and their band structure, Intrinsic and extrinsic semiconductors, Charge carriers and their effective masses. Carrier concentration at thermal equilibrium for intrinsic and doped semiconductors, Carrier energy distribution, applications of Fermi factor to semiconductors, Density of available states, Excess carriers, carrier transport phenomena, Recombination Process, Basic equation for semiconductor device operation.

**Unit 2: PN Junction (15L)**

Basic device technology, Depletion region and depletion capacitance, Current Voltage Characteristics: Ideal case, Shockley Equation, Generation recombination process. High injection condition, Diffusion capacitance, Narrow base diode, Junction breakdown.

**Unit 3: Junction Transistor & Field Effect Devices (15L)**

Formation of transistor, Basic current Voltage relationship, Current gain in transistor, Injection efficiency, base transport factor, Depletion layer and surface recombination, Static characteristics common base and common emitter configurations, Power transistor, General consideration, second breakdown switching transistor, Schottky diode, Semiconductor controlled rectifier, Basic characteristics static characteristics, Dynamic characteristics, Current limiter.

**Unit 4: Metal Semiconductor & Metal Insulator Semiconductor Devices (15L)**

Schottky effect, Energy Band relation at metal semiconductor contact, Ideal condition and surface states depletion Layer, General expression for barrier height Current, Transport Theory in Schottky barrier, Thermionic Emission Theory, Diffusion theory, Measurement of Schottky barrier height current voltage measurement, Forward characteristics, Reverse characteristics.

**Reference Books:**


1. Physics of Semiconductor Devices – S.M. Sze
2. Physics Solid State Devices – Streetman B.B.
3. Semiconductor Physics – Smith
4. Fundamentals of Semiconductor Devices – J. Lindmayer and C.Y. Wrigley
5. Physics of Semiconductor Devices – Michael shur
6. Introduction to Semiconductor devices – K.J.M. Rao

**M. Sc-I (Physics) Semester-II**

## PHY4202: ATOMS, MOLECULES & LASER

**Credit: 04** **No. of Lectures: 60**

On successful completion of this course student will be able to do the followings.

1. Understand the concept of atomic spectra origin of spectral line, fine and hyperfine structure, Zeeman pashen and stark effect.
2. Describe the coupling scheme metastable state, types of pumping and different applications of laser.
3. Understand the concept of Frank Condon principle, ESR, NMR etc.
4. Understand the concept of different types of laser
5. Demonstrate quantitative problem solving skills in all the topics covered.

**Unit 1: Atoms** **(15L)**

Introduction, Atomic structure and spectra, quantum states of an electron in an atom, [Exclusion principle and electronic configuration, electron spin, Hund's rule, Maximum multiplicity], Coupling scheme, origin of spectral lines, spectrum of He and alkali atoms, fine and hyperfine structure, isotropic shift, Zeeman and Paschen effect, Stark effect, Selection rule, Problem solving.

**Unit 2: Molecules and Resonance Spectroscopy** **(15L)**

Introduction, Origin of molecule spectra, Rotational and vibrational spectra for diatomic molecule, vibrational course structure, frank-condon principle, Born–Oppenheimer approximation, electron spectrum and Raman spectrum in diatomic molecule, Electron Spin Resonance (ESR) and Nuclear Magnetic Resonance (NMR) chemical shift , Problem solving.

**Unit 3: Lasers.** **(15L)**

Introduction, Basic of LASERs (Absorption, spontaneous & Stimulated emission, population inversion), metastable state, Types of Pumping, Gain, Einstein's coefficient, threshold condition, Rate equations for Two level, Three level and Four level laser, rate equation, Problem solving.

**Unit 4: Lasers and its applications. (15L)**

Introduction, Different types of lasers, He-Ne laser, $CO_2$ laser, Nd-YAG, Ruby, Excimer laser, Dye laser, semiconductor laser, Applications of Lasers , Industrial applications-Cutting, molding, melting, welding, drilling, Medical applications-Skin therapy, Laser eye surgery, Holography- principle & construction.

**Reference Books**


1. Molecular structure and spectroscopy, G. Aruldas
2. Fundamentals of molecular spectroscopy, Collin N, Banwell & Elaine M.
3. Atomic and molecular Physics, J. B. Rajam
4. Principles of Laser and their applications, Rhods
5. An introduction to laser theory and application, M. N. Avdhanulu-S. Chand Publication
6. Lasers, A. G. Sigman-Oxfaord University Press 1986.

**M. Sc-I (Physics) Semester-II**

## PHY4203: QUANTUM MECHANICS II

**Credit: 04** **Total No. of Lectures: 60**

## Learning outcomes:

After completion of the course, the student should be able to:

1. Students should understand the concept of central forces and scattering phenomena
2. Students should learn about partial wave analysis.
3. Students should understand and learn theoretical aspects at Quantum Level.
4. Students should know more about the insight of the microscopic world.
5. Students should understand the behaviour of particles under Classical and Quantum conditions.

**Revision and general formalism:**

Time-independent Perturbation theory: Non degenerate, degenerate, Introduction to Time-dependent Perturbation theory.

**Unit 1: Approximation Methods II** **(15 L)**

Introduction, Time dependent Perturbation theory: Transition amplitude, $1^{st}$ and $2^{nd}$ order, selection rules, Fermi's golden rule, Harmonic perturbation, dipole approximation, Einstein coefficient for spontaneous emission.

Variational method: Basic principles and application to hydrogen atom, helium atom, deuteron problem, Vander walls interaction.

WKB approximation: General formalism, Bound states for potential wells – with no rigid walls, with one rigid wall, with two rigid walls. Bohr's quantization condition, Application to tunneling, field emission

**Unit 2: Theory of Scattering** **(15 L)**

Introduction, Collisions in 3-D and scattering: Laboratory and CM reference frames; scattering amplitude, differential scattering cross section and total scattering cross section: scattering by spherically symmetric potentials, Method of partial waves, Phase shift, Ramsauer-Townsend effect, scattering by a perfectly rigid sphere and by square well potential, Yukawa potential. The Born approximation, Lippman-Schwinger equation, applications and validity of the Born approximation.

**Unit 3: Symmetries in quantum mechanics and Identical Particles (15 L)**

Conservation laws and degeneracy associated with symmetries; Continuous symmetries, space and time translations, rotations; Rotation group, homomorphism between SO (3) and SU (2); Explicit matrix representation of generators for $j = \frac{1}{2}$ and j = 1; Rotation matrices; Irreducible spherical tensor operators, Wigner-Eckart theorem; Discrete symmetries, parity and time reversal.

**Identical Particles:**

Meaning of identity and consequences, Symmetric and antisymmetric wave functions, Slater determinant, Symmetric and antisymmetric spin wave functions of two identical particles, Collisions of identical particles, Pauli's exclusion principle and Slater determent.

**Unit 4: Relativistic Quantum Mechanics (15 L)**

Klein-Gordon equation, Feynman-Stuckelberg interpretation of negative energy states and concept of antiparticles, Dirac equation, covariant form, adjoint equation, Plane wave solution and momentum space spinors, Spin and magnetic moment of the electron, Non relativistic reduction, Helicity and chirality, Properties of $\gamma$ matrices, Charge conjugation, Normalisation and completeness of spinors.

**What NEXT with Quantum Mechanics? : Anti communication numbers, Quantisation of electromagnetic field, 'reverse time' using algorithm on a computer, past and future.**

**Reference Books:**


1. Quantum Mechanics by Nouredine Zettili, A John Wiley and Sons, Ltd.
2. Modern Quantum Mechanics by J. J. Sakurai.
3. A Text-book of Quantum Mechanics by P. M. Mathews and K. Venkatesan.
4. Quantum mechanics by A. Ghatak and S. Lokanathan.
5. Quantum Mechanics by L. I. Schiff.
6. Quantum Physics by R. Eisberg and R. Resnick.
7. Introduction to Quantum Mechanics by by David J. Griffiths.

8. Introductory Quantum mechanics by Granier, Springer Publication.
9. Introductory Quantum Mechanics by Li boff, 4th Edition, Pearson Education Ltd.
10. Principles of Quantum Mechanics by Shankar R. IInd Edition (Plenum, 1994).

**M. Sc-I (Physics) Semester-II**

## PHY4204: ELECTRODYNAMICS

**Credit: 04** **No. of Lectures: 60**

**Learning Outcomes:**

On successful completion of this course students will be able to do the following

1. Understand the concept of multipole expansions and deeper meaning of Maxwell's equations
2. Understand the technique of deriving formulae for the electromagnetic waves in stationary and conducting medium
3. Calculate the electromagnetic radiations from moving charges ,taking into account retardation effects and make a detailed account for Gauge transformations
4. Embracing the concepts of special relativity as emerged through the laws of electrodynamics
5. To formulate and solve the electromagnetic problems skills In all the topics covered

**Unit 1: Multiple Expansions and Time Varying Fields (15 L)**

Multiple expansions for a localized charge distribution in free space, linear quadrapole potential and field, static electric and magnetic fields in material media, boundary conditions, Time dependent fields, Faraday's law for stationary and moving media, Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium.

**Unit 2: Energy, Force, Momentum Relations and Electromagnetic Wave Equations (20 L)**

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth, wave guides , Dispersion relations(solid, liquid, gas)

**Unit 3: Inhomogeneous Wave Equations (15 L)**

Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields. Radiation from moving charges, radiation from a dipole.

**Unit 4: Relativistic Mechanics and Covariance (10 L)**

Galilean Transformation, Lorentz transformations, Relativistic velocity addition, Minkowski's space-time diagram, Four vector potential, electromagnetic field tensor, Lorentz force on a charged particle.

**References:**


1) Introduction to Electrodynamics, (3rd Edition) by David J. Griffith Publication: Prentice-Hall of India, New Delhi.
2) Introduction to Electrodynamics, by A.Z. Capri and P.V. Panat Narosa Publishing House.
3) Foundations of Electromagnetic theory by Reitz & Milford, World student series Edition.
4) Classical Electrodynamics, by J.D. Jackson, 3rd Edition John Wiley.
5) Electromagnetic theory and Electrodynamics by Satya Prakash, Kedar Nath and Co-Meerut.
6) Electromagnetics by B.B. Laud, Willey Eastern.
7) Matrices and Tensors in Physics by A. W. Joshi, 3rd Edition, New Age International.
8) Electrodynamics by Kumar Gupta and Singh.
9) Electromagnetic Theory by Umesh Sinha, Satya prakashan tech. India Publication.

**M. Sc-I (Physics) Semester-II**

## PHY4205: ELECTRONICS LABORATORY-II

**Credits: 04**

**(Students have to perform Any 10 Experiments)**

**Learning Outcomes:**

After successfully completing this laboratory course the students will be able to do the following

1. Acquire technical and manipulative skills by using laboratory equipment, tools and materials

2. Demonstrate a deeper understanding of abstract concept and theories gained by experiencing and visualizing them as authentic phenomena.

3. Understanding the basic design of circuit which related to experiment.

4. Acquire the complementary skills of collaborative learning and teamwork in laboratory settings.

1. Precision rectifier.
2. Frequency to voltage converter using OP-AMP.
3. Sample and hold circuits.
4. Shift Register using 7495.
5. Class-B push pull amplifier using Dual power supply and OP-AMP.
6. Fold back power supply.
7. Design, built and test oscillator-phase shift oscillator.
8. Study of voltage controlled oscillator using IC-566.
9. Frequency multiplier using PLL-565.
10. CVCC using OP-AMP.
11. Study of multiplexer and Demultiplexer.
12. Frequency modulation and demodulation.
13. Pulse code modulation and demodulation.
14. FSK modulation and demodulation.
15. 8-bit ADC.
16. Design, built and test oscillator – LC oscillator

**M. Sc-I (Physics) Semester-II**

## PHY4206: BASIC PHYSICS LABORATORY-II

**Credits: 04**

**(Students have to perform Any 10 Experiments)**

**Learning Outcomes:**

After completion of the course, the student should be able to:

1. Acquire technical and manipulative skills by using laboratory equipment, tools and materials

2. Demonstrate a deeper understanding of abstract concept and theories gained by experiencing and visualizing them as authentic phenomena.

3. Acquire the complementary skills of collaborative learning and teamwork in laboratory settings.

1. Skin depth in Al using electromagnetic radiation.
2. Franck – Hertz Experiment.
3. Thermionic Emission.
4. Electron Spin Resonance (ESR).
5. Study of Hysteresis (B-H curve)
6. Ionic Conductivity of NaCl.
7. Zeeman Effect.
8. Study of electromagnetic damping
9. Study of the characteristics of a laser beam (Beam Divergence).
10. Determination of wavelength of He-Ne LASER by Reflection grating
11. Energy gap of semiconductor.
12. e/m by Thomson's method
13. Measurement of the focal length of a given convex lens using a laser.
14. Determination of wavelength of He-Ne LASER by transmission grating
15. Determination of Polarisation
16. G.M. counter: Determination of dead time of GM tube by Double source method