

DEPARTMENT OF PHYSICS

MADHABDEV UNIVERSITY

## Course Structure and Syllabus of M.Sc. in Physics (CBCS)



Approved by the Board of Studies in Physics


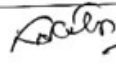
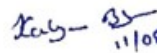
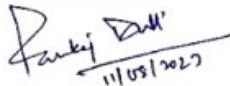
1<sup>st</sup> PG board Meeting held on 11.08.2023

2nd PG board Meeting (online mode) held on 29.01.2024

3rd PG board Meeting held on 26.07.2024

PG Board of Studies  
Department of Physics  
MADHABDEV UNIVERSITY  
Date: 11/08/2023

Members Present:

Sl. no	Name and Designation of the Faculty	Signature
1	Dr. Arindam Phukan Chairman Assistant Professor and HoD Department of Physics Madhabdev University	 11/8/23
2	Dr. Lakhi Nath Borah Assistant Professor Department of Physics Madhabdev University	 11/8/23
3	Prof. Kalyan Bhuyan External Expert Member Department of Physics Dibrugarh University	 11/08/2023
4	Prof. Pankaj Dutta External Expert Member Department of Physics Dibrugarh University	 11/08/2023

## Course Structure M. Sc. in Physics

Details of courses under M.Sc.

Course	*Credits
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Theory /Practical	
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I. Core Course

(12 Papers of 4 credits each)	12X4=48
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II. Discipline Specific Elective Course

(Minimum 5 Papers of 4 credits each)	5X4=20
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III. Ability Enhancement Courses (AEC)

(2 Papers of 2 credits each)	2 X 2=4
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IV. Generic Elective (GE)

(2 Papers of 4 credits each)	4X2=8
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Total credit (Minimum)	<hr style="width: 100%; border: 0.5px solid black; margin-bottom: 5px;"/> 80
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**PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM**

**M. SC. IN PHYSICS**

	CORE Papers (4 Credits each)	DSE (Minimum one for Sem I, one for Sem II, one for Sem III and two for Sem IV) (4 Credits each)	GE (Minimum one in Sem II one in Sem III) (4 Credits each)	AEC (AECC/SEC) (Minimum one in sem I and one in sem III ) (2 Credits each)
Sem-I	Classical Mechanics	DSE I		AEC I
	Mathematical Physics			
	General Lab-I			
Sem-II	Quantum Mechanics-I	DSEII	GE-I	
	Condensed Matter Physics			
	General Lab-II			
Sem-III	Electrodynamics & Plasma Physics	DSE III	GE II	AEC II
	Quantum Mechanics-II			
	General Lab-III			
Sem- IV	Atomic & Molecular Physics	DSE IV		
	Nuclear Physics	DSE V		
	Statistical Mechanics			

<b>SEMESTER</b>	<b>COURSE OPTED</b>	<b>COURSE NAME</b>	<b>Credits</b>
I	Core course-I	Classical Mechanics	4
	Core course-II	Mathematical Physics	4
	Core course-III	General Lab-I	4
	Discipline Specific Elective –I	DSE I	4
	Ability Enhancement Course – I	AEC I	2
II	Core course-IV	Quantum Mechanics-I	4
	Core course-V	Condensed Matter Physics	4
	Core course-VI	General Lab-II	4
	Discipline Specific Elective –II	DSE II	4
	Generic Elective – I	GE I	4
III	Core course-VII	Electrodynamics & Plasma Physics	4
	Core course-VIII	Quantum Mechanics-II	4
	Core course-IX	General Lab-III	4
	Discipline Specific Elective –III	DSE III	4
	Generic Elective – II	GE II	4
	Ability Enhancement Course – II	AEC II	2
IV	Core course-X	Atomic & Molecular Physics	4
	Core course-XI	Nuclear Physics	4
	Core course-XII	Statistical Mechanics	4
	Discipline Specific Elective –IV	DSE IV	4
	Discipline Specific Elective –V	DSE V	4

**Core Papers (C): (Credit: 04 each)**

1. Classical Mechanics (4)
2. Mathematical Physics (4)
3. General Lab-I (4)
4. Quantum Mechanics-I (4)
5. Condensed Matter Physics (4)
6. General Lab-II (4)
7. Electrodynamics & Plasma Physics (4)
8. Quantum Mechanics-II (4)
9. General Lab-III (4)
10. Atomic & Molecular Physics (4)
11. Nuclear Physics (4)
12. Statistical Mechanics (4)

**Discipline Specific Elective Papers (DSE): (Credit: 04 each)**

**(Minimum 5 papers to be selected)- DSE I to V**

**DSE I (Minimum one):**

- A. Electronics
- B. Advanced Mathematical Physics

**DSE II (Minimum one)**

- A. Numerical Methods and Computer Programming
- B. Relativity theory

**DSE III: (Minimum one)**

- A. High Energy Physics I
- B. Condensed Matter Physics I
- C. Digital and Optical Electronics

**DSE IV: (Minimum one)**

- A. High Energy Physics II
- B. Condensed Matter Physics II
- C. Communication Electronics

**DSE V: (Minimum one)**

- A. Condensed Matter Physics lab/Dissertation
- B. Electronics Lab /Dissertation
- C. High Energy Physics-III/Dissertation

**Generic Elective (Minimum 2 papers of 4 credits each)-GE I to GE II**

- A. Fundamentals of Quantum Mechanics
- B. Basic Electronics
- C. Introductory Material Science
- D. Classical Mechanics

**Ability Enhancement Course (AEC): (Minimum 2 papers of 2 credits each)**

- A. Experimental Techniques
- B. Nano Materials
- C. Vacuum Technique

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## SEMESTER-I

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**Course Code: PPH-C101**

**Course Title: Classical Mechanics**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory-4**

**Course Objective:**

- Acquaint the learners with the subject of classical mechanics in the context of the language and methods of modern nonlinear dynamics.
- Enable the learners to make a smooth transition from classical mechanics to quantum mechanics and nonlinear dynamics.

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

**Unit I: (L 8, Marks 15)**

Review of Newtonian mechanics, Mechanics of a system of particles, Constraints of motion and their classification, Generalised co-ordinates, D' Alembert's principle, Lagrange's equations of motion, Hamilton's principle, Symmetries and conservation theorems, Cyclic coordinates.

**Unit II: (L 15, Marks 15)**

Motion in a central potential, Maps, Small Oscillations, Solution of one-dimensional harmonic oscillator problem, Forced oscillations in one dimension, Damped harmonic motion in one dimension, general solution of the problem, Displacement as a function of time, Systems with many degrees of freedom, Eigen value equation and normal co-ordinates.

**Unit III:(L 12, Marks 15)**

Lagrangian dynamics and transformations in configuration space, geometry of motion in configuration space, canonical moment and covariance of Lagrange's equation in configuration space. Hamiltonian dynamics and transformations in phase space, Generating functions, Poisson brackets, Hamilton-Jacobi equation, Action-angle variables.

**Unit IV: (L 15, Marks 15)**

Linear transformations, rotations and rotating frames, similarity transformations, linear transformations and eigen value problem, dynamics in rotating reference frames. Rigid Body Dynamics, Definition of Rigid body, Eulerian Angles, Euler's theorem, Angular momentum and kinetic energy, Moment of inertia tensor, Euler's equation of motion, Symmetrical top,

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20          Written Test: 20

End Semester: 60          Written Test: 60

(Equal weightage to be assigned to each credit)

**After the completion of this course**

- Understand the basic concepts of Lagrangian and Hamiltonian dynamics.
- Understand the basic concepts of modern nonlinear dynamics.

- Understand canonical and noncanonical flows.
- Make a smooth transition from classical to quantum mechanics.

**Suggested Readings:**

1. Classical Mechanics, Joseph L. McCauley, Cambridge University Press.
2. Classical Mechanics, H. Goldstein, Addison Wesley.
3. Classical Mechanics, N.C. Rana & P.S. Joag, Tata McGraw Hill.
4. Classical Mechanics of Particles and Rigid Bodies, Kiran C Gupta, Wiley Eastern Limited.
5. Introduction to Classical Mechanics, R.G. Takwale & P.S. Puranic, Tata McGraw Hill.

**Course Code: PPH-C102**

**Course Title: Mathematical Physics**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory-3, Tutorial-1**

Course outcomes

- To impart the knowledge of vector spaces and matrices that is relevant to the study of quantum mechanics.
- To develop the working knowledge on partial differential equations (homogeneous and inhomogeneous).
- To familiarize the learners with the basics of group theory and properties of Lie groups.
- To familiarize the learners with the basics of tensor analysis and to introduce important topics specifically relevant to the theory of relativity.

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Linear Vector Spaces and Matrices (L 14, T 8, Marks 22)

Linear vector spaces- definition and examples, linear independence, basis and dimension, inner product, norm of a vector, orthonormal basis, Gram-Schmidt orthogonalization method, Schwarz's and Bessel's inequalities; linear operators, matrix representation of linear operators; special types of matrices- symmetric and antisymmetric, orthogonal, Hermitian and anti-Hermitian, unitary, normal; eigenvalues and eigenvectors; change of basis, similarity transformation, orthogonal and unitary transformations, diagonalization of matrices; infinite dimensional vector spaces, Hilbert space.

**Unit II:** Partial Differential equations (L 9, T 5, Marks 14)

Partial differential equations, method of separation of variables in cartesian, spherical and cylindrical coordinate systems, Laplace's equation, Poisson's equation, diffusion equation, examples of boundary value problems in physics; inhomogeneous differential equations and Green's function.

**Unit III:** Group Theory (L 8, T 4, Marks 12)

Groups- definition and examples, groups of symmetry transformation- cyclic group, dihedral

group, permutation group; subgroups, Lagrange's theorem, cosets, conjugacy classes; group representation; Continuous or Lie groups, generators of continuous group, special orthogonal groups-  $SO(2)$ ,  $SO(3)$ ; unitary groups-  $U(1)$ ,  $SU(2)$ .

#### **Unit IV: Tensor Analysis (L 8, T 4, Marks 12)**

Basics of tensor algebra, contravariant and covariant tensors, line element and metric tensor, associated tensors, Christoffel's symbols, geodesics, covariant derivatives, Riemannian Christoffel's tensor or curvature tensor, Bianchi identities, parallel transport.

#### **Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20                      Written Test: 20

End Semester: 60              Written Test: 60

(Equal weightage to be assigned to each credit)

#### **Learning Outcome:**

- the student will gain the knowledge of different mathematical methods which are required for better understanding of theoretical physics courses such as classical mechanics, quantum mechanics, classical electrodynamics, condensed matter physics, statistical mechanics etc.
- the student will be able to deal with partial differential equations that appear in physical problems.
- the student will be equipped with Green function technique which will help him to deal with higher level problems in physics.
- the student will gain the knowledge of group theory and tensors. This will help him to learn advanced theoretical physics courses such as quantum field theory, particle physics, general relativity, cosmology etc. and also help him to pursue research in relevant areas.

#### **Suggested Readings:**

1. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, Elsevier Academic Press.
2. Mathematical Method for Physics and Engineering, K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press.
3. Essential Mathematical Methods for the Physical Sciences, K. F. Riley and M. P. Hobson, Cambridge University Press.
4. Mathematical Methods in the Physical Sciences, Mary L. Boas, John Wiley & Sons.
5. Mathematical Physics : Basics, S. D. Joglekar, Universities Press.
6. Mathematical Physics : Advance, S. D. Joglekar, Universities Press.
7. Mathematical Physics with Application, Problems and Solution, U. Balakrishnan, AneBooks Pvt. Ltd.
8. Elements of Group Theory for Physicists, A.W. Joshi, New Age International.
9. Group Theory in Physics, J. F. Cornwell, Academic Press.
10. Group Theory in a Nutshell for Physicists, A. Zee, Princeton University Press.
11. Tensor Calculus, Barry Spain, Radha Publishing House (Kolkata).
12. General Theory of Relativity, P. A. M. Dirac, Prentice-Hall of India.

**Course Code: PPH-C 103**  
**Course Title: General Lab I**  
**Nature of the Course: Core**  
**Total credits assigned: 04**  
**Distribution of credits: Lab-4**

**List of Experiments:**

1. To draw the calibration curve of the Jamin's interferometer and then to find the refractive index of air at room temperature and pressure
2. To determine the wavelength of light from a monochromatic source using Michelson's interferometer and then to determine the difference of wavelength for Sodium D lines.
3. To determine the wavelength of light from a monochromatic source using Fabry-Perot interferometer and then to determine the difference of wavelength for Sodium D lines.
4. To determine the wavelength of He-Ne laser light.
5. To determine the energy band gap of a semiconductor using p-n junction diode.
6. To draw the frequency response curve of a CE transistor amplifier and also to find the input impedance of the amplifier.
7. To determine the velocity of sound using CRO.
8. To draw BH curve of Fe using solenoid and determine energy loss from hysteresis.
9. To study the PE hysteresis loop of a ferro electric crystal
10. Determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method

(Internal BOS of the department is authorized to modify the list of experiments whenever necessary. )

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Viva Voce: 20

End Semester: 60

Laboratory experiments: 60

(One experiment from the list of experiments to be performed)

**Course Code: PPH-D101**  
**Course Title: Electronics**  
**Nature of the Course: DSE**  
**Total credits assigned: 04**  
**Distribution of credits: Theory – 04**

**Course Objectives:**

- To disseminate working knowledge of electronic principle using semiconductor devices
- To allow students to learn the fundamentals of both analog and digital electronic devices

- To allow students to apply their knowledge for designing small electronic systems.
- To introduce students to advanced digital systems like microprocessor and microcontroller
- To imbibe the spirit of application-oriented learning

Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:

**Unit-I Transistor Fundamentals and Special purpose Electronic Devices: (L 20, Marks20)**

BJT amplifier, Emitter follower, impedance matching application, ac models: T and  $\pi$ , analysis, IC circuit current mirror, open collector, pull up resistor. Bootstrapped and Darlington amplifier  
Field effect transistors: JFET, MESFET and MOSFET, structure, working, derivation of the equations of IV characteristics under different conditions, JFET as amplifiers and switch MOSFET, E- MOSFET, Digital switching, active load, introduction to CMOS and FINFET technology. Silicon Controlled Rectifier, Liquid Crystal Display, OLED, Solid State battery

**Unit II: Integrated Circuits: Operational Amplifier (L 15, Marks15)**

Differential amplifier: circuit configuration, dual input, balanced output differential amplifier, DC-AC analysis, inverting and non-inverting inputs, Review of applications of Operational amplifiers

Applications of linear digital ICs Comparator, A/D, D/A, PLL, VCO, interfacing Circuit Instrumentation amplifier, Schmitt Trigger Circuits Active filters (Filter approximation,) Filtering and noise reduction.

**Unit III: Introduction to Memory element, Microprocessor and Microcontroller**

**(L 15, Marks 15)**

RAM and ROM as memory element. Introduction to microprocessor: Architecture of digital computer system, Von Neumann and Harvard architecture, different microprocessors, architecture, pin diagram, different bus, programming model using intel 8085, register set, memory organization, instruction set, simple programming: addition, subtraction, multiplication etc.

Introduction to 8051 microcontroller and embedded systems, instruction set, addressing mode, programming, time delay generation, look up table implementation etc.

**Unit IV: Digital transmission (L10, Marks 10)**

Sampling theorem, quantization, Dynamic range, Companding, Pulse code modulation (PCM), Delta modulation, granular noise, slope overloading, adaptive delta modulation, differential PCM,

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

The student will be able to

- Critically analyze analog and digital electronic circuits

- Design small electronic systems as per design specifications
- Write assembly language programs for doing simple arithmetic operation in microprocessor and microcontroller.
- Apply their knowledge for real life problems solving in electronic

**Suggested Readings:**

1. Electronic Principles A.P. Malvino Tata McGraw Hill
  2. Op amps and Linear Integrated Circuits R.K. Gaekwad Prentice Hall of India
  3. Modern Digital Electronics, R P Jain, 4th Edition, 2010, TataMcgraw Hill
  4. Integrated Electronics: Analog and Digital Circuit Systems J. Millman and C. Halkias McGraw Hill
  5. Digital Principles and Applications D.P. Leach and A.P. Malvino Tata McGraw Hill
  6. Semiconductor Materials and Devices M.S. Tyagi John Wiley and Sons
  7. Physics of Semiconductor Devices S.M. Sze Wiley Eastern Ltd.
  8. The Art of Electronics P. Horowitz and W. Hill Cambridge University Press
  9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
  10. The 8051 Microcontroller and Embedded system, Mazidi, Mazidi and McKinlay, Pearson Education
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**Course Code: PPH-AEC-101**

**Course Title: Experimental Techniques**

**Nature of the Course: AEC**

**Total Credit assigned: 2**

**Distribution of Credit: (Lecture + Practical/ Tutorial)**

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

Course Objectives:

At the completion of this course, a student will be able to

- Understand the basic concepts of errors in measurements and techniques of data analysis.
- Understand the principle of sensors and transducers and OPAMP

**Unit I: Data analysis techniques (L 8, Marks 8)**

Data interpretation and analysis. systematic and random errors in measurement, expression of uncertainty, propagation of errors, Precision and accuracy, Error analysis, least squares fitting, Linear

and nonlinear curve fitting, chi-square test

**Unit II: Transducers, Sensors and detectors (L 12, Marks 12)**

Resistive (Potentiometer, Strain Gauge-Theory, types, temperature compensation and applications), Capacitive (Variable Area Type-Variable Air Gap Type-Variable Permittivity type) and Inductive (LVDT). Measurement of displacement and velocity (translation and rotational), Particle Detectors, Ionization chamber and Geiger Muller counter.

**Unit III: Electronic instrumentation (L 10, Marks 10)**

Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), Fourier transforms (spectrum analyzer), lock-in detector.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

This course will enable the students to

- Identify the errors in measurement.
- Analyze the working of various sensors and transducers.

**Suggested Readings:**

1. Instrumentation, Measurements and Analysis by BC Nakra and KK Choudhary, McGraw Hill Education India Pvt. Ltd.
2. Electronic Instrumentation and Measurement Techniques by W.D. Cooper and A. D. Helfrick,, Prentice-Hall .
3. Electronic Instrumentation by H. S. Kalsi, Tata McGraw Hill.

4. Nuclear Radiation Detectors, by S.S. Kapoor, V. S. Ramamurthy, Wiley-Eastern Limited, Bombay)

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## SEMESTER II

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**Course Code: PPH-C-20I**

**Course Title: Quantum Mechanics-I**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory-04**

Course Objectives:

- Acquaint the learners Fundamental concepts of Quantum Mechanics.
- Acquaint the learners with Dirac notation.
- Enable the learners to solve simple quantum mechanical problems.
- Introduce the concepts of symmetry and conservation laws
- Introduce the techniques of angular momentum algebra

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Fundamental Concepts (L 25, Marks 25)

Overview of wave mechanics, Schrödinger equation, application to some important physical problems: particle in a box, simple harmonic oscillator, delta function potential, spherical well potential, hydrogen atom. Kets, Bras and Operators, Base Kets and Matrix Representations, Measurements, Observables and Uncertainty Relations, Generalized uncertainty principle, Change of basis, Wave functions in Position and Momentum Space.

**Unit II:** Quantum Dynamics (L 15, Marks 15)

Schrödinger picture, Heisenberg picture, Time evolution and the Schrödinger equation, Heisenberg equation, time evolution of the simple harmonic oscillator, Symmetries, Conservation laws and Degeneracy, Spatial and Time translation, Parity, Time reversal, Density operators and Pure versus Mixed Ensembles.

**Unit III:** Angular Momentum (L 20, Marks 20)

Rotation, Angular Momentum and Unitary groups, commutation relations, Eigenvalues and Eigenstates of Angular Momentum, Ladder operators and their matrix representations, the Stern Gerlach Experiment, Spin angular momentum and Pauli matrices, Addition of Angular momentum, Clebsch Gordon Coefficients, Identical particles, Many particle systems, Symmetric and anti-symmetric wave functions, Slater's determinant, Pauli's exclusion principle, Wigner Eckart theorem, Spherical tensors.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10

Sessional Exam: 30

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

At the completion of this course, a learner is expected to

- Understand the basic concepts of quantum mechanics.
- Solve simple quantum mechanical problems.
- Understand quantum dynamics.
- Write down eigen values and eigen states of angular momentum.

**Suggested readings:**

1. Modern Quantum Mechanics, J.J. Sakurai, Addison Wesley
2. Quantum Mechanics, L.I. Schiff, McGraw Hill
3. Quantum Mechanics, Bransden and Joachain, Pearson Education
4. Quantum Mechanics, Powell and Craseman, Narosa Publishing House
5. Quantum Mechanics, R. Shankar, Kluwer Academic
6. Quantum Mechanics, D.J. Griffiths, Pearson Education
7. Quantum Mechanics, Mathews and Venkatesan, McGraw Hill
8. Quantum Mechanics, Richard L. Liboff, Pearson Education

**Course Code: PPH-C-202**  
**Course Title: Condensed Matter Physics**  
**Nature of the Course: Core**  
**Total credits assigned: 04**  
**Distribution of credits: Theory-4**

Course Objectives:

- At the completion of this course, a student will be able to
- Understand the fundamentals of Condensed Matter Physics.
- Know about different lattice structures, behavior and importance of crystalline state, contribution of X-Ray Diffraction in Crystallography, importance of defects and imperfections in a crystal etc.
- Understand the behavior in solids that depend primarily on the motion of electrons inside the solid and appreciate the important role of electrons.

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Crystallography (L 12, Marks 12)

Bravais lattices (two and three dimensions), typical crystal structures (sc, fcc, bcc, closed-packed structures), reciprocal lattice. Interaction of X-Rays with matter, absorption of X-Rays, Elastic scattering from a perfect lattice, X-Ray diffraction, Bragg's law, Laue, Powder and Rotating Crystal method, Scattering Factor, Structure Factor.

**Unit II:** Imperfections in Crystalline solids (L 10, Marks 10)

Introductory concepts, Point defect; Schottky, Frenkel defects, Color centers, Dislocations, Diffusion, Fick's law.

**Unit III:** Conduction electrons in crystalline solids (L 12, Marks 12)

Periodic potential, Bloch theorem, Kronig Penney model, Electronic energy bands, E-k diagram, Brillouin zone, Effective mass, metals, insulators and semiconductors.

**Unit IV:** Magnetic Properties of Materials (L 14, Marks 14)

Introductory concepts, Langevin diamagnetism, Paramagnetism due to free ions (Quantum Theory) and conduction electrons (Pauli paramagnetism), Molecular field theory of Ferromagnetism, Domains, Hysteresis loop, Antiferromagnetism, Ferrimagnetism.

**Unit V:** Superconductivity (L 12, Marks 12)

Introductory concepts, Meissner Effect, Ideal conductor and Superconductor, London equation, Josephson effect, Thermodynamics of superconducting transition, Isotope effect, introduction to BCS theory, Cooper pair, Basic idea on High temperature superconductivity.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc. : 10

Sessional Exam : 30

End Semester: 60

Written Test : 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

The course will

- Equip a student with basic concepts of Condensed Matter Physics so that the knowledge can be applied for further development of the subject.
- Enable a student to work in both theoretical and experimental aspects of Condensed Matter Physics.
- Help the students in thorough learning of the concepts associated to the course through the numerical, quizzes, assignments, projects etc.

Suggested Readings:

1. Introduction to Solid State Physics, C. Kittel, John Wiley & Sons.
2. Solid State Physics, A. J. Dekker, Macmillan India Ltd.
3. Elementary Solid State Physics, M. A. Omar, Pearson Education.
4. Crystallography Applied to Solid State Physics, A.R. Verma and O.N. Srivastava, New Age International.
5. Quantum theory of solids, C.Kittel, Wiley
6. Essentials of Solid State Physics Saktipada Kulia, NCBA, 3<sup>rd</sup> Reprint 2018

**Course Code: PPH-C-203**

**Course Title: General Lab II**

**Nature of the Course: Core**

**Total Credit assigned: 4**

**Distribution of Credits: Lab - 04**

**List of Experiments:**

#### **Group A**

1. To design astable and monostable multivibrator using 555 IC.
2. To design and study D/A converter using R-2R Ladder network.
3. To design and study OPAMP as a differentiator and integrator.
4. To draw the frequency response curve of an RC coupled amplifier with and without negative feedback and compare the bandwidth.
5. To design a transistor amplifier for a specific gain using Voltage divider biasing method.
6. To design a RC Oscillator and Wien Bridge Oscillator for generating Sinusoidal oscillation of frequency 200 Hz and 3 KHz.
7. To design and construct basic flip-flops R-S, J-K, J-K Master slave flip-flops using gates and verify their truth tables.
8. To realize One & Two Bit Comparator and study of 7485 magnitude comparator.
9. To realize and study Shift Register.
  - a) SISO (Serial in Serial out)
  - b) SIPO (Serial in Parallel out)
  - c) PIPO (Parallel in Parallel out)
  - d) PISO (Parallel in Serial out)
10. To design and test 3-bit binary asynchronous counter using flip-flop IC 7476 for the given sequence.
11. To study the characteristic curves of JFET and MOSFET.
12. To design 1st and 2nd order low pass active filters for specific roll off and cut off.

#### **Group-B**

1. Application of FORTRAN-77 for solution of linear algebraic equation. Inverse and diagonalization

of matrices

2. Integration by trapezoidal and Simpson rule using Fortran 77.
3. Solution of Ordinary Differential Equations examples: (a)  $\frac{dv}{dt} = -\rho v - g$ , where  $\rho$  is a positive constant viz. air resistance and  $g$  is acceleration due to gravity, b] radioactive decay, c] particle in 1-D box etc.) and partial differential equation (e.g Lagrange's equation, Diffusion equation etc.) using Runge-Kutta method and finite difference method
4. Use of Bisection method, method of false position and Newton-Raphson method in solving linear and quadratic equation.
5. Write a scientific article containing numerical values, tables, graphs and images using Latex.

### **Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ Attendance/ Class room interaction/Quiz etc.: 20

Project work:20

End Semester: 60

Laboratory experiments: 60

(Two experiments from the list of Group (A and B) are to be performed)

Suggested Readings:

1. Electronic Principles by Albert Malvino, McGraw Hill Education
2. Digital Principals and applications by Leach and Malvino, McGraw Hill Education
3. Microelectronics by Jacob Millman and Arvin Grabel, McGraw Hill Education
4. Numerical Recipes in C/Fortran Press et al. :Cambridge University Press
5. Fortran 77 : V. Rajaraman : Prentice Hall of India
6. Fortran 77 and numerical methods, C. Xavier

**Course Code: PPH-D201**

**Course Title: Numerical Methods and Computer Programming**

**Nature of the Course: DSE**

**Total credits assigned: 04**

**Distribution of credits: Theory – 04**

Course Objectives:

After successful completion of the course, the student will

- Get hands on training in problem solving using FORTRAN 77 programming language in LINUX operating system
- Learn various numerical methods to solve physical problems as well as programming of such Methods

**Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and**

**Contact hours:**

**Unit I:** (L 10, 10 marks)

Determination of root of functions, solution of nonlinear equations: Bisection method, method of False Position, Newton-Raphson method. Curve fitting: Interpolation, Lagrange Interpolation, Newton Interpolation, Interpolation with Equidistant Points

**Unit II:** (L 20, 20 marks)

Numerical Differentiation: Finite difference methods, Richardson Extrapolation, Interpolation based

methods.

Numerical Integration by trapezoidal and Simpson's rule  
Solution of Linear Algebraic Equations:  
Iterative Methods, Inverse of a Square Matrix  
Solution of first order ordinary differential equation:  
Runge-Kutta method

**Unit III:** (L 10, 10 marks)

Elementary probability theory, Binomial, Poisson and Normal distributions

**Unit IV:** (L 20, 20 marks)

LINUX commands, FORTRAN 77 programming, integer and floating point arithmetic, expressions, built-in functions, executable and non-executable statements, assignment, control and input, output elements, subroutines and functions, operation with files, Programming examples of numerical methods.

### **Mode of Assessment/ Assessment Tools**

Internal: 40

Assignment /Presentation/Test on LINUX user commands/attendance/ Classroom interaction/quiz etc.: 10

Sessional Exam: 30

Final (End Semester): 60 (Written Test)

### **Expected learner outcome:**

This course will enable the students to

- Apply their knowledge on computer programming and numerical analysis in solving real physical problems
- Deal with scientific computing in different research areas of Physics

### **Suggested readings:**

1. Numerical Recipes in C/Fortran Press et al. :Cambridge University Press
2. Fortran 77 : V. Rajaraman : Prentice Hall of India
3. Fortran 77 and numerical methods, C. Xavier
4. How to Solve it by Computer : H. Drowmey Prentice Hall of India
5. Numerical Mathematical Methods: J.B.Scarborough, Oxford and IBH Publishing.

**Course Code: PPHG 201**  
**Course Title: Foundation of Quantum Mechanics**  
**Nature of the Course: GE**  
**Total Credit assigned: 4**  
**Distribution of Credit: Theory-4**

Course Objectives:

At the completion of this course, a student will be able to

- Know about the development of modern Physics and the theoretical formulation of quantum mechanics.
- Know the applications of quantum mechanics in solving physical problems.

**Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:**

**Unit I:** Origin of Quantum Physics (L 12, Marks 12)

Blackbody radiation, Planck's quantum hypothesis; photo-electric effect; Compton scattering; De Broglie hypothesis, matter waves, Davisson-Germer experiment; wave-particle duality, twoslit experiment with electrons; Heisenberg's uncertainty principle; description of particles by wave packets, group and phase velocities, wave amplitude and wave functions.

**Unit II:** Formulation of Quantum Mechanics (L 18, Marks 18)

Properties of wave function, probabilistic interpretation; conditions for physical acceptability of wave functions; normalization; position, momentum and energy operators, Hamiltonian operator, expectation values; Schrodinger equation and dynamical evolution of a quantum state, stationary states, time independent Schrodinger equation, energy eigenvalues and eigenfunctions; super position principle

**Unit III:** Quantum theory of physical systems (L 20, Marks 20)

One-dimensional infinite square well potential, bound states, energy eigenvalues and eigenfunctions; potential barrier, one-dimensional finite square well potential, Tunneling effect; one-dimensional harmonic oscillator problem; time independent Schrodinger equation in spherical coordinates, separation of variable method; theory of Hydrogen atom

**Unit IV:** Angular momentum (L 10, Marks 10)

Quantum theory of orbital angular momentum; Stern-Gerlach experiment, spin angular momentum

**Mode of Assessment/ Assessment Tools (%)**

In Semester:	40
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.:	10
Sessional Exam:	30
End Semester:	60
Written Test:	60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

The student will be able to

- Understand the applications of quantum mechanics in other areas of science.
- Apply quantum theory to physical problems.

**Suggested readings:**

1. Introduction to Quantum Mechanics, David J. Griffiths, Pearson

2. Quantum Mechanics Concepts and Applications, Nouredine Zettili, Wiley
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, Wiley.
4. Quantum Mechanics, Leonard I. Schiff, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldas, PHI
6. How to teach Quantum Physics to your dog, Chad Orzel, Scribner.

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### SEMESTER –III

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**Course Code: PPY-C-301**

**Course Title: Electrodynamics & Plasma Physics**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory-04**

Course Objectives:

- This course utilizes physical and mathematical principles to provide in-depth analysis of the behaviour of electricity and magnetism in matter.
- To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them in various situations.
- Understand collective nature of plasma dynamics.
- Describe the motion of charged particles in electromagnetic fields to understand plasma confinement processes which is essential for magnetically confined fusion.
- 5. Fluid aspects of plasma and wave generation and propagation in plasmas.
- 6. Description of Kinetic theory of plasma.

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I: (L 10, Marks 10)**

Introductory ideas, Propagation of electromagnetic waves in different media, Dispersion, Frequency dependence of  $\sigma$ ,  $\mu$  and  $\epsilon$ , dispersion in non-conductors, anomalous dispersion, free electrons in conductors.

**Unit II: (L 10, Marks 10)**

Electromagnetic radiation: Retarded potentials, electric dipole radiation, radiation from an arbitrary distribution of charges and current, Lienard-Wiechert potentials, fields due to uniformly moving charge, and accelerated charge, Linear and circular acceleration, angular distribution of radiated power

**Unit III: (L 10, Marks 10)**

Magnetism as relativistic phenomena, Potential formulation of relativistic electrodynamics Electromagnetic field tensor, Dual tensor, Covariant formulation of electrodynamics.

**Unit IV: (L 11, Marks 11)**

Concepts of Plasmas: Definition, Plasma parameters, criterion of plasmas, concepts of plasma temperature, Debye shielding, classification of Plasmas, Application of plasmas.

Motion of charged particles in electromagnetic fields: uniform E & B fields, guiding centre, non-uniform fields, grad-B and curvature drift, diffusion across magnetic fields, adiabatic invariants, magnetic mirror

**Unit V: (L 13, Marks 13)**

Plasma as fluids: Introduction, Relation of plasma physics to ordinary electromagnetics, fluid equation of motion, fluid drifts perpendicular and parallel to B, plasma approximation.

Waves in plasmas: Plasma oscillations, electron plasma waves, ion acoustic waves, propagation of waves in presence of magnetic fields, propagation through ionosphere, Van Allen Belts.

**Unit VI: (L6, Marks 6)**

Kinetic theory of plasmas:

Need for kinetic theory, Vlasov equation, MHD as approximation to kinetic theory, Landau Damping

Learning Outcome:

Students will have achieved the ability to

- Describe the nature of electromagnetic wave and its propagation through different media and interfaces.
- Explain charged particle dynamics and radiation from localized time varying electromagnetic sources.
- Understand potential formulation and magnetism in relativistic case.
- Define plasma and its fundamental parameters, distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena
- Determine the velocities (drift velocities) of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time
- Classify the electrostatic and electromagnetic waves that can propagate in magnetised and non-magnetised plasmas, and describe the physical mechanisms generating these waves

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

**Suggested Readings:**

1. 'Introduction to Classical Electrodynamics', D.J. Griffiths, Prentice Hall of India.
2. 'Classical Electrodynamics', J.D. Jackson, John Wiley.
3. 'Electromagnetic waves and Radiating systems', Edward C Jordan and Keith G. Balmain, PHI Pvt. Ltd.
4. 'Electromagnetic Wave and radiating systems', Jordan, E.C. and Balmain, K.G., Prentice Hall of India
5. Introduction to Plasma Physics and Controlled Fusion, F.F.Chen (Plenum Press, 1984)

6. Introduction to Plasma Physics, R.J. Goldston and P.H. Rutherford (IOP, 1995)

**Course Code: PPY-C-302**

**Course Title: Quantum Mechanics II**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of Credits: Theory – 4**

Course objectives

- Acquaint the learners with the approximation methods in Quantum Mechanics.
- Introduce the quantum mechanical treatment of scattering
- Introduce the learners to the relativistic quantum mechanics

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Time Independent Approximation Methods (L 30, Marks 30)

Time independent perturbation theory and its application: Non degenerate case, Degenerate case, Stark effect, Fine structure and Zeeman Effect, Hyperfine splitting, Variational method and its application, Ground state of helium, Hydrogen molecule ion, WKB Approximation and its application.

**Unit II:** Time dependent approximation methods (L 10, Marks 10)

Time dependent potentials: the Interaction picture, Time dependent perturbation theory, Two level systems, Emission and absorption of radiation, Spontaneous emission, Applications to Interactions with Classical Radiation field, Adiabatic approximation, Sudden approximation.

**Unit III:** Scattering Theory (L 8, Marks 8)

The Lipmann-Schwinger Equation, the Born Approximation, Optical Theorem, Eikonal Approximation, Free Particle States: Plane versus Spherical waves, Method of partial waves, Low-energy scattering and Bound states, Resonance scattering, Identical Particles and Scattering.

**Unit IV:** Relativistic Quantum Mechanics (L 12, Marks 12)

Brief overview of Special Theory of Relativity, Four vectors, Klein Gordon Equation, Dirac Equation, Spin angular momentum, Dirac matrices, covariant form of Dirac equation, Ideas of Second Quantization, Quantization of Klein Gordon and Dirac fields.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

**Expected Learning Outcome:**

At the completion of this course, a learner is expected to

- Understand the idea of different approximation techniques in quantum mechanics

- Understand the quantum mechanical approach to scattering
- Understand the consequences of incorporating special theory of relativity in quantum mechanics.

**Suggested readings:**

1. Modern Quantum Mechanics, J.J. Sakurai, Addison Wesley.
2. Quantum Mechanics, L.I. Schiff, McGraw Hill.
3. Quantum Mechanics, Bransden and Joachain, Pearson Education.
4. Quantum Mechanics and Path Integrals, R.P. Feynman, Dover Publications.
5. Advanced Quantum Mechanics, J. J. Sakurai, Prentice Hall of India.
6. Quantum Mechanics, R. Shankar, Kluwer Academic/Plenum Publishers.
7. Relativistic Quantum Mechanics, J. D. Bjorken and S. D. Drell, McGraw Hill.

**Course Code: PPY-C-303**

**Course Title: General Lab III**

**Nature of the Course: Core**

**Total Credit assigned: 4**

**Distribution of Credits: Lab - 04**

List of Experiments:

1. To study the normal and anomalous Zeeman effects.
2. To determine the value of  $e/m$  by bar magnet method.
3. To determine the value  $e/m$  by magnetron method.
4. Hall Effect Experiment
5. G M Counter
6. to analyse elliptically polarised light using Babinet's Compensator
7. ESR experiments
8. Coupling Coefficient of Piezo-electric crystal
9. Resistivity of semiconductor using Four probe method
10. Quinck's tube method to determine magnetic susceptibility

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ Attendance/ Class room interaction/Quiz etc.: 20

Viva Voce: 20

End Semester: 60

Laboratory experiments: 60

(One experiment from the list of experiments to be performed)

**Course Code: PPY-D 301A**

**Course Title: Condensed Matter Physics- I**

**Nature of the Course: DSE**

**Total credits assigned: 04**

**Distribution of credits: Theory – 04**

**Course Objectives:**

At the completion of this course, a student will be able to

- Understand the behaviour in solids that depend primarily on the motion of electrons inside the solid and appreciate the important role of electrons.
- Know about dielectric and ferroelectric properties of matter
- Understand the various magnetic properties of materials in terms of quantum mechanics
- Know the superconductivity and its consequences

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Electron theory (L 16, Marks 16)

Free electron theory, Energy levels and density of states, Fermi energy, Boltzmann equation, relaxation time, electrical and thermal conductivity of metals, Wiedemann Franz law, Tight binding method.

**Unit II:** Dielectric and Ferroelectric Properties (L 16, Marks 16)

Polarization, Langevin's theory, Clausius-Mossotti relation, static dielectric constant of solids, complex dielectric constant & dielectric loss, dielectric relaxation, Debye equation. Ferroelectric effect, dipole theory of ferro-electricity, Piezoelectric effect, Pyroelectric effect, Electrostrictive effect, anti-ferroelectricity.

**Unit III:** Magnetic Properties of a System (L 14, Marks 14)

Magnetic Hamiltonian, Exchange interaction and exchange integral for two-electron system, Heisenberg Hamiltonian, relationship between exchange energy and molecular field, Hartree and Hartree-Fock approximation, Ferromagnetic spin waves

**Unit IV:** Superconductivity (L 14, Marks 14)

Isotope effect, electron-phonon interaction, Cooper Pair, BCS theory, flux quantization in a superconducting ring, superconducting tunneling, Josephson Effect, SQUIDS

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc. : 20

Written Test : 20

End Semester: 60

Written Test : 60

Expected Learning Outcome:

The course will

- Equip a student with basic concepts of Condensed Matter Physics so that the knowledge can be applied for further development of the subject.
- Enable a student to work in both theoretical and experimental aspects of Condensed Matter Physics.
- Help the students in thorough learning of the concepts associated to the course through the numerical, quizzes, assignments, projects etc.

Suggested Reading:

1. The Theory of transport phenomena in solids, J. M. Ziman, Oxford University Press
2. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Brooks/Cole
3. Intermediate Quantum Theory of Crystalline Solids, A.O.E. Animallu, Prentice Hall
4. Quantum Theory of Solids, C. Kittel, John Wiley International
5. Elements of Solid State Physics, J.P. Srivastava, Prentice Hall India
6. Introduction to Solid State Theory, O. Madelung, Springer-Verlag
7. Quantum Theory of Solid State, J Callaway, Academic Press
8. Theoretical Solid State Physics, A. Huang, Elsevier

**Course Code: PPY-D 301B**

**Course Title: High Energy Physics- I**

**Nature of the Course: DSE**

**Total credits assigned: 04**

**Distribution of Credit: Theory – 4**

Course Objectives:

At the completion of this course, a student will be able to

- Classify the elementary particles and their interactions.
- Analyze the formulation of group theory.
- Apply group theory to quark model and different interactions.
- Express physical quantities in natural units.
- Explain the physics of relativistic wave equations.

**Unit wise distribution of course contents with unit wise distribution of weight age and contact hours:**

Unit I: Introduction to Elementary Particles (L 20, Marks 20)

Historical introduction and classification of elementary particles, intrinsic properties of elementary particles, behaviour of elementary particles under: charge conjugation (C), parity (P), time reversal (T) and G-parity; Gell-Mann-Nakano-Nishijima law, eightfold way (Gell-Mann and Ne'eman classification).

Unit II: Group Theory and The Quark Model (L 25, Marks 25)

Symmetries in physics, Lie groups, unitary and special unitary groups (U(1), SU(2) and SU(3)), Tensor method in SU(n), Young tableaux, Isospin symmetry the quark model, quark-mass formulas, Zweig rule, quark color, hadron wave functions, quark model predictions: magnetic moment, hadron masses.

Unit III: Relativistic Wave Equations (L 15, Marks 15)

Natural units, Lorentz covariance and four vector notation; Klein-Gordon equation; Dirac equation and its covariant form, Dirac gamma matrices, adjoint equation and conserved current, solution of the Dirac equation (free particle spinors), negative energy states, antiparticles, normalization of spinor and the completeness relations, Lorentz covariance of Dirac equation, bilinear covariants, Dirac equation for zero mass particles (the two-component neutrino), helicity states.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

Expected Learning Outcome:

After the completion of this course, it is expected that this course will

- Enable a student to acquire the basic knowledge of elementary particles and their interactions.
- Enable a student to apply the framework of group theory to particle physics.
- Prepare a student for advanced topics in field theory and particle physics.
- Motivate a student to pursue a career in high energy physics.

Suggested Readings:

1. Introduction to Elementary Particles, D. J. Griffiths (John Wiley & Sons).
2. Quarks and Leptons, Francise Halzen and Alan D. Martin (John Wiley & Sons).
3. Introduction to High Energy Physics - Donald H. Perkins (Cambridge University Press).
4. Gauge Theory of Elementary Particle Physics, T. P. Cheng and L. F. Li (Oxford Univ. Press).
5. Physics of Elementary Particles, H. Muirhead (Pergamon Press).

**Course Code: PPY-G 301**

**Course Title: Basic Electronics**

**Nature of the Course: GE**

**Total Credit assigned: 4**

**Distribution of Credit: Theory-4**

Course Objectives:

At the completion of this course, a student will be able to

- Know about the basics of semiconductor PN junction, its various types and its application to different electronic circuits.
- Understand bipolar junction transistor and its applications as amplifier and oscillators.
- Familiarize with operational amplifiers, its applications and analysis.
- Develop knowledge about analog to digital and digital to analog conversion techniques.

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

Unit I: Semiconductor Diodes (L 10, Marks 10)

P and N type semiconductors. Energy Level Diagram .Conductivity and Mobility, Concept of Drift velocity.PN Junction Fabrication (Simple Idea).Barrier Formation in PN Junction Diode Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

Unit II: Two-terminal Devices and their Applications (L 6, Marks 6)

(1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

Unit III: Bipolar Junction transistors (L 6, Marks 6)

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains  $\alpha$  and  $\beta$  Relations between  $\alpha$  and  $\beta$ . Load Line analysis of Transistors. DC Load line and Q-point.Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Unit IV: Amplifiers (L 20, Marks 20)

Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias.Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.Two stage RC coupled Amplifier and its frequency response. Effect of positive and negative feedback on Input impedance, Output impedance, Gain , Stability, Distortion and noise.

Unit V: Sinusoidal Oscillators (L 5, Marks 5)

Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

Unit VI: Operational Amplifiers (Black Box approach) (L 13, Marks 13)

Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain.Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Zero crossing detector, Wein bridge oscillator.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learner Outcomes:

This course will enable the students to

- Learn the foundation knowledge of analog electronic systems.
- Learn the working and applications of PN junction and bipolar junction transistors (BJT).
- Learn to analyze circuits containing PN junction and BJT along with the application of BJT as amplifiers and oscillators.
- Develop basic knowledge of operational amplifier and its applications

Recommended readings:

1. Electronic Principles, A Malvino, Tata Mc-Graw Hill
2. Electronic devices and circuit theory, Robert Boylested, Prentice Hall.
3. Electronics: Fundamentals and Applications, J.D. Ryder, Prentice Hall.
4. Solid State Electronic Devices, B.G. Streetman & S.K. Banerjee, PHI Learning
5. Electronic Devices & circuits, S. Salivahanan & N.S. Kumar, Tata Mc-Graw Hill
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, Prentice Hall

**Course Code: PPY-AEC-301**

**Course Title: Nano-Materials**

**Nature of the Course: AEC**

**Total Credit assigned: 2**

**Distribution of Credit: Theory-2**

Course Objectives:

The aim of the course is to

- Provide a systematic coverage and insight into the promising area of nano materials in order to facilitate the understanding of the nature and prospects for the field.
- Discuss about various types of nanomaterials with specific examples of semiconducting nanomaterials in various dimensions and carbon based nanomaterials, viz., fullerene and carbon nanotubes
- Provide information about various synthesis and characterization techniques of nanomaterials
- Discuss wide applications of nanomaterials

**Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:**

Unit I: (L 10, Marks 20)

Introduction to nano-science and technology, history and scope, interdisciplinary nature, surface to volume ratio, electronic structure. Types of nanomaterials, semiconducting nanomaterials: quantum dot, quantum wire, quantum well, idea of band structure, density of states, variation of density of state and band gap with crystal size, electron confinement in one, two and three dimensions, carbon nanomaterials: fullerene, carbon nanotube.

Unit II: (L 10, Marks 20)

Chemical and physical methods for synthesis of nanostructured materials, Applications of nano structured materials.

Unit III: (L 10, Marks 20)

Nanomaterials characterization, instruments, principle of measurements, measurement techniques: X-ray diffraction, scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, optical and vibrational spectroscopy.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

Expected Learning Outcome:

This course will enable the students to

- Know the underlying principles governing the fascinating behavior of nanomaterials
- Gather knowledge about some of the modern promising nanomaterials such as quantum dots, carbon nanotubes etc.
- Learn the various methods for synthesis and characterization of nanomaterials as well as their wide variety of applications

**Suggested readings:**

1. Updated materials/notes on individual topics will be provided during classes.
2. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley–Interscience.
3. Nano: The Essentials, T. Pradeep, McGraw Hill Education (India) Private Limited
4. Textbook of Nanoscience and Nanotechnology, B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath and James Murday, Universities Press-IIM

**Course Code: PPY-C401**

**Course Title: Atomic and Molecular Physics**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory-04**

Course Objectives:

The objective of this course is to make a student

- Learn the physics of the atoms and molecules
- Become familiar with various branches of spectroscopy and their applications
- Equip with basic spectroscopic techniques and instrumentation
- Learn to use spectroscopic techniques to identify materials
- Learn theoretical background of laser and its application in various disciplines

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Atomic Physics (L 23, Marks 23)

Fine structure of hydrogen atom, relativistic correction, Lamb shift, Spectra of alkali atoms, spinorbit interaction and fine structure in alkali atoms, level scheme of two electron atoms-equivalent and nonequivalent electrons, ground and excited states of two electron atoms, interaction energy in L-S and j-j coupling for two electrons, Zeeman effect, Paschen-Back effect, Stark effect, hyperfine structure of hydrogen and alkali atoms, spectra of multi electron atoms, X-ray spectra, width and shape of spectral lines

**Unit II:** Molecular Physics (L 25, Marks 25)

Regions of the spectrum, types of molecules, Rotational Spectra for rigid and non rigid rotators, isotopic effect in rotational spectra, intensity of spectral lines, information derived from rotational spectra, microwave spectrometer, Vibrational spectra for anharmonic oscillator, vibration-rotation spectra, Infra-red spectrometer, Electronic spectra of molecules-Born Oppenheimer approximation, vibrational analysis of electronic band spectra, fine structure of electronic band spectra, Fortrat Diagram, Raman spectra, Raman spectrometer, Photoelectron spectroscopy, Spin resonance spectroscopy- NMR, ESR, Mössbauer spectroscopy, Fourier Transform Spectroscopy

**Unit III:** Lasers (L 12, Marks 12)

Fundamentals of Lasers-properties, basic elements, threshold condition, rate equations: two, three and four levels. Population inversion, Laser resonator and modes, Ammonia Masers, types of laser: solid state laser, gas laser, semi conductor laser, applications of laser spectroscopy, Laser Cooling.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcomes:

After completing this course a student can

- Determine the atomic and molecular structures
- Analyze and demonstrate a spectra to identify and quantify information about atoms and molecules
- Demonstrate the interaction of electromagnetic spectra with matter and the associated type of spectroscopy
- Identify elements present in a sample and in the universe using spectroscopic techniques
- Apply knowledge of spectroscopy or laser spectroscopy in various disciplines of Physics, Chemistry, Atmospheric Science, Astronomy, Laser Communication, remote sensing etc

**Suggested Readings:**

1. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain, 2nd Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia.
2. Atomic Spectra, H.E. White McGraw Hill.
3. Atomic Physics, Max Born, Dover Publications, Inc., New York.
4. Molecular spectroscopy, Banwell and McCash Tata McGraw Hill
5. Molecular Structure and Spectroscopy G. Aruldas Prentice Hall of India
6. Molecular Spectra and Molecular Structure G. Herzberg, McGraw Hill
7. Lasers and Nonlinear Optics, B.B. Laud New Age International
8. Laser Spectroscopy-Basic Concepts and Instrumentation, Wolfgang Demtröder, Springer
9. Modern Spectroscopy, J M Hollas, John Wiley & Sons
10. Elements of Laser and Non-Linear Optics, G D Baruah, Prakashan, Meerut

**Course Code: PPY-C 402**

**Course Title: Nuclear Physics**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory – 04**

Course Objectives:

After successful completion of the course, the student will

- Have a basic knowledge of the nuclear force and its properties
- Be able to visualize the nature of interaction of nucleons inside deuteron nucleus as well as in general nucleon-nucleon scattering
- Be acquire knowledge about different theoretical models regarding nucleus as well as to apply those in determining nuclear properties
- Grasp knowledge about nuclear reactions and their various mechanisms along with an wide understanding of the decay process

- Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail
- Know about the basic working principles of various nuclear detectors

**Unit-wise distribution of Course contents with Unit-wise distribution of Weightage and Contact hours:**

**Unit I:** (L 6, Marks 8)

Review of nuclear properties, Nuclear Forces: properties of nuclear forces, isotopic spin formalism, generalized Pauli's exclusion principle, meson theory of nuclear forces.

**Unit II:** (L 15, Marks 15)

Two body problem: General form of nucleon-nucleon forces, the deuteron problem (ground states and excited states), central and tensor forces, nucleon-nucleon scattering at low energies. Nuclear models: Review of liquid drop model and its applications, shell model, L-S coupling, magnetic moment and Schmidt lines.

Unit III: (L 15, Marks 15)

Nuclear reactions: Reaction channels, nuclear reaction mechanisms, scattering cross-section, compound nucleus, partial wave analysis of nuclear reaction, resonance, Breit-Wigner single level formula, B-W formula incorporating spin, neutrino hypothesis and general features of  $\beta$ -ray spectrum, Fermi's theory of  $\beta$ -decay, Curie plot, selection rules.

Unit IV: (L 12, Marks 12)

Elementary Particle Physics: Fundamental forces, Elementary particles and their classification, characteristics of the elementary particles, quantum numbers, behaviour under charge conjugation, time reversal and parity operation, Isotopic multiplet and Gellmann-Nishijima scheme, SU (3) classification and Quark model, Standard model.

**Unit V:** (L 12, Marks 10)

Detection of radiations: gas filled counters, scintillation detectors, semiconductor detectors.

**Mode of Assessment/ Assessment Tools**

Internal: 40

Assignment /Presentation/ attendance/ Classroom interaction/quiz etc.: 20

Written Test: 20

Final (End Semester): 60 (Written Test)

**Expected Learning Outcomes:**

This course will enable the students to

- Develop knowledge regarding nucleus, its properties, nuclear force, nuclear reactions and mechanisms, nuclear detectors as well as elementary particles and the properties related to them

- Successfully apply the same knowledge in solving problems in the field of nuclear and particle Physics

**Suggested readings:**

1. Nuclear Structure Vol. 1(1969), A. Bohr and B.R Motteison
2. Nuclear Structure Vol. 2(1975), Benjamin and Reading A
3. Introductory Nuclear Physics, Kenneth S. Krane, Wiley, New York,1988
4. Atomic and Nuclear Physics Vol. 2, S.N. Ghosal, S. Chand and Co
5. Introduction to High Energy Physics, P.H. Perkins, Addison Wesley London,1982
6. Nuclear Physics Vol. 1 & 2, Shirokov Yudin, Mir Publishers Moscow 1982
7. Introduction Elementary Particles, D.J. Griffiths, Harper and Row New York,1987
8. Introduction to Nuclear Physics, H.A. Enge Addison-Wesley,1975
9. Nucleon-Nucleon Interaction, G.E. Brown and A.D. Jackson North- Holland, Amsterdam, 1976
10. Theory of Nuclear Structure, M.K. Pal, Affiliated East-West Madras,1982
11. Introductory Nuclear Physics, Y.R. Wagnmare, Oxford University Press, Bombay,1981
12. Elementary Particles, J.N. Longo, McGraw Hill, New York,1971
13. Atomic Nucleus, R.D. Evans, McGraw Hill, New York, 1955
14. Nuclear Physics 2nd ed., I. Kaplan, Narosa, Madras,1989
15. Concepts of Nuclear Physics, B.L. Cohen, Tata McGraw Hill, Bombay,1971
16. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International
17. Radiation Detection and Measurement, Glenn F. Knoll, John Wiley & Sons, Inc.

**Course Code: PPY-C403**

**Course Title: Statistical Mechanics**

**Nature of the Course: Core**

**Total credits assigned: 04**

**Distribution of credits: Theory-4**

**Course Objectives:**

The Statistical Mechanics is one of the most important branches of physics which is required to understand the properties matter in bulk on the basis of the dynamical behaviors of its microscopic constituents. As such the objectives of this course are:

- To introduce the advance concepts of Statistical Mechanics so that students will be equipped with a sufficient knowledge of the subject.
- To develop the critically thinking ability of students to understand the diverse physical phenomena.
- To develop the interest and ability among students to solve challenging physical problems by the application of techniques of Statistical Mechanics in future.

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Introduction and formulation of Quantum Statistics (L 10, Marks 10)

Historical introduction of statistical mechanics, ergodic hypothesis, ensembles, partition function, grand partition function, postulates of quantum statistical mechanics, density matrix, pure and mixed states, density matrix and partition function of a system of free particles, classical limit of the partition function, BE and FD statistics.

**Unit II:** Ideal Bose and Fermi systems (L 15, Marks 15)

Ideal Bose gases, Bose-Einstein condensation, thermodynamic behaviour of an ideal Fermi gas, Pauli paramagnetism, Landau diamagnetism.

**Unit III:** Statistical Mechanics of Interacting systems (L 18, Marks 18)

Clusters, classical cluster expansion, formalism of second quantization, creation and annihilation operators and their properties for bosons and fermions, Hamiltonian in terms of second quantized operators, imperfect Bose and Fermi gases.

**Unit IV:** Phase transitions (L 10, Marks 10)

Dynamical model of phase transition, the Ising model (one dimension), liquid helium, He-4 and He-3, the lambda-transition, Tisza's two-fluid model, the theories of Landau and Feynman, equilibrium properties near absolute zero, superfluidity.

**Unit V:** Fluctuations (L 7, Marks 7)

Mean square deviation, fluctuation in ensembles, thermodynamic fluctuations, spatial correlation in a fluid, Einstein-Smoluchowski theory of Brownian motion, approach to equilibrium: the Fokker-Planck equation.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

**Expected Learning Outcome:**

After the completion of this course it is expected that:

- The students will be equipped with a sufficient knowledge of the Statistical Mechanics and hence will be able to look critically for analyzing any physical phenomena.
- May motivate students to solve any challenging physical problem in future.

- Will draw interest to the subject to pursue further higher study in future and will ultimately help to contribute new knowledge.

### **Suggested Readings:**

1. Statistical Mechanics, R. K. Patharia, Butterworth Heinemann.
2. Statistical Mechanics, K. Huang, John Wiley and Sons.
3. Statistical Mechanics, K. M. Khanna, Today and Tomorrow, New Delhi.
4. Statistical Mechanics, B. K. Agarwal, M. Eisner, New Age International Publishers.
5. Fundamentals of Statistical Mechanics, B.B. Laud, New Age International Publishers.
6. A Primer of Statistical Mechanics, R. B. Singh, New Age International Publishers

**Course Code: PPY-D 401A**

**Course Title: Condensed Matter Physics II**

**Nature of the Course: DSE**

**Total credits assigned: 04**

**Distribution of credits: Theory – 04**

Course Objective:

- The course will provide basic knowledge on Lattice vibration and some properties of solid related to lattice vibration.
- It will develop the basic knowledge of the thin film Physics. It will provide the knowledge of preparation and characterization of thin films and its application in devices.
- It will enhance the knowledge on semiconducting properties and optical effect in semiconductors.

### **Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

**Unit I:** Lattice vibrations (L 15, Marks 15)

Harmonic approximation, monatomic and diatomic linear lattices, dispersion relations, normal modes, Phonons, infrared absorption in ionic crystals, lattice dynamics in three dimensions (harmonic & diabatic approximation), Normal modes of a monatomic 3-dimensional Bravais lattice. Quantum theory of harmonic crystal, lattice specific heat, anharmonic effects, thermal expansion, the Grueneisen parameter, normal and umklapp processes.

**Unit II:** Thin films (L 20, Marks 20)

Introductory concepts, methods of preparation of thin films (vacuum evaporation, chemical vapour deposition, sputtering), thickness determination, conductivity of thin films, effect of

thickness on transport properties, Thomson's theory and Fuch's theory, elementary concepts of surface crystallography, surface structure analysis of thin films (SEM, TEM and AFM)

**Unit III: Semiconductors (L 10, Marks 10)**

Introductory Concepts, Rectifying properties of barriers, Schottky theory of M.S contact, surface states, p-n junction rectifiers Photovoltaic device principles, solar cell, temperature effect, solar cell materials, efficiency.

**Unit IV: Optical Properties (L 15, Marks 15)**

Optical and high frequency effects in semiconductors, optical constants, free carrier absorption, fundamental absorption, direct and indirect transitions. Electronic interband and intraband transitions, relation between optical properties and band structure, optical constants, luminescence.

**Mode of Assessment/ Assessment Tools (%)**

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

Expected Learning Outcome:

- The students will be able to use the knowledge in fabrication of different thin film semiconductor devices.
- The students will be able undertake some research or project work on semiconducting thin film device.
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**Suggested readings:**

1. Introduction to Solid State Theory, O. Madelung, Springer-Verlag
2. Quantum Theory of Solid State, J Callaway, Academic Press
3. Theoretical Solid State Physics, A. Huang, Elsevier
4. Handbook of Thin Film Technology, Michelle and Glang, McGraw Hills
5. Semiconductors, R.A. Smith, Cambridge university Press
6. Thin Film Fundamentals, A. Goswami, New Age International
7. Physics of Semiconductor Devices, S. M. Sze, Wiley

**Course Code: PPY-D 401B**

**Course Title: High Energy Physics II**

**Nature of the Course: DSE**

**Total credits assigned: 04**

**Distribution of credits: Theory – 04**

Course Objectives:

- At the completion of this course, a student will be able to
- Use the formulation of quantum field theory in a number of fields.
- Apply the concepts of quantum field theory to quantum electrodynamics.
- Explain the physics of fundamental particles and their interactions.

**Unit wise distribution of course contents with unit wise distribution of weightage and contact hours:**

Unit I: Quantum Field theory (L 25, Marks 25)

Concept of field and quantization, Lagrangian of a field, Schwinger's action principle, Fock space states and their eigen values, method of second quantization, canonical quantization of scalar, vector and spinor fields, energy, momentum and charge of the field, vacuum in field theory, propagators; C, P, T transformation properties of scalar and vector fields.

Unit II: Quantum Electrodynamics (L 20, Marks 20)

S-matrix, covariant perturbation theory, path integral formalism, Feynman diagram (rules in momentum space), Wicks theorem, calculation of second order process, electron interaction with electromagnetic field, Mott scattering, Compton scattering (Klein-Nishima formula), Møller scattering, Bhaba scattering, bremsstrahlung, vacuum polarization, self-energy of electron.

Unit III: Particle Interactions (L 15, Marks 15)

Fundamental interactions (electromagnetic, weak, strong and gravitational) and their characteristics, conservation laws and decay modes, charged leptonic weak interactions, decays of muon, neutron and charged pions, neutral weak interactions, Fermi theory of weak interaction, V-A interaction, Cabibbo angles, weak mixing angles, CP violation, CPT theorem.

Mode of Assessment/ Assessment Tools (%)

In Semester: 40

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 20

Written Test: 20

End Semester: 60

Written Test: 60

(Equal weightage to be assigned to each credit)

**Expected Learning Outcome:**

After the completion of this course, it is expected that this course will

- Enable a student to acquire the basics of quantum field theory and realize its importance.
- Enable a student to apply the framework of field theory to quantum electrodynamics.
- Prepare a student for advanced topics in field theory and particle physics.
- Motivate a student to pursue a career in high energy physics.

**Suggested Readings:**

1. Introduction to Elementary Particles, D. J. Griffiths (John Wiley & Sons).
2. Quarks and Leptons, Francis Halzen and Alan D. Martin (John Wiley & Sons).
3. Introduction to High Energy Physics, Donald H. Perkins (Cambridge University Press).
4. Gauge Theory of Elementary Particle Physics, T. P. Cheng and L.F. Li (Oxford Univ. Press).
5. Physics of Elementary Particles, H. Muirhead (Pergamon Press).
6. Quantum Field Theory, Lewis H. Ryder (Cambridge University Press).
7. An Introduction to Quantum Field Theory, M. E. Peskin and D.V. Schroeder (Levant Books).
8. Field Quantization, W. Greiner and J. Reinhardt (Springer).
9. A First Book of Quantum Field Theory, A. Lahiri and P.B. Pal (Narosa).

**Course Code: PPY-D 402**

**Course Title: Dissertation**

**Nature of the Course: DSE**

**Total credits assigned: 04**

In Semester: 40

Assignment /Lab work/ attendance/ interaction/: 20

Presentation: 20

End Semester: 60

External evaluation: 60