GURU KASHI UNIVERSITY

Master of Science in Physics (MPY)

Session: 2025-26

Faculty of Sciences, Humanities and Languages

Graduate Attributes of the Programme: -

Type of learning outcomes	**The Learning Outcomes Descriptors**
Graduates should be able to demonstrate the acquisition of:	
Learning outcomes that are specific to disciplinary/interdisciplinary areas of learning	Demonstrate in-depth conceptual clarity and analytical abilities in the chosen field.
	Ability to apply mathematical methods to model and solve complex physical problems.
	Integrate knowledge across multiple domains to solve real-world challenges.
	Adapt emerging technologies and methodologies from diverse scientific and professional fields.
Generic learning outcomes	Ability to analyze, synthesize, and interpret complex scientific problems using logical reasoning.
	Proficiency in technical writing, publishing research articles, preparing reports, and presenting findings at conferences.

Programme Learning outcomes: An Postgraduate Diploma is awarded to students who have demonstrated the achievement of the outcomes located at level 6 :

Element of the Descriptor	**Programme learning outcomes relating to Postgraduate Diploma**
The graduates should be able to demonstrate the acquisition of:	
Knowledge and understanding	Acquire insights into advanced computational methods and digital image processing techniques.
	Gain comprehensive knowledge of Atomic and Molecular Spectroscopy, Electronics, Nuclear and Particle Physics, and Material Science.
	Develop a strong theoretical foundation in Mathematical Physics, Classical Mechanics, Classical Electrodynamics, Quantum Mechanics, and Statistical Physics.
	Learn experimental techniques in Electronics, Spectroscopy, and Nuclear Physics.
General, technical and professional skills required to perform and accomplish tasks	Develop analytical and problem-solving skills by applying physics principles to real-world problems.
	Master the use of laboratory instruments and experimental setups for spectroscopy, electronics, and nuclear physics.
	Enhance technical computing skills for data analysis, numerical simulations, and digital image processing.
Application of knowledge and skills	Apply classical and quantum mechanical principles to understand and predict physical phenomena.
Generic learning outcomes	Adapt to new technologies and methodologies in scientific research and industry.
Constitutional, humanistic, ethical, and moral values	Uphold scientific integrity, ethical research practices, and professional responsibility.
Employability and job-ready skills, and entrepreneurship skills and	Cultivate an entrepreneurial mindset by exploring applications of materials science, electronics, and remote sensing in technology startups.

capabilities/qualities and mindset	
Credit requirements	46 credits
Entry requirements	Bachelor's Degree in Science (B.Sc.) non-medical

Program Structure

SEMESTER: 1st									
Course Code	**Course Title**	**Type of Courses**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MPY1400	Mathematical Physics	Core Course	4	0	0	4	30	70	100
MPY1401	Classical Mechanics	Core Course	4	0	0	4	30	70	100
MPY1402	Classical Electrodynamics	Core Course	3	0	0	3	25	50	75
MPY1403	Electronics	Core Course	3	0	0	3	25	50	75
IKS0018	Astronomy in India	IKS Course	4	0	0	4	30	70	100
MPY1404	Classical Electrodynamics Lab	Core Course	0	0	2	1	10	15	25
MPY1405	Electronics Lab	Core Course	0	0	2	1	10	15	25
Elective-I (Any one of the following)									
MPY1406	Material Science	Discipline Elective Course	4	0	0	4	30	70	100
MPY1407	Reactor Physics								
Total			**22**	**0**	**4**	**24**	**190**	**410**	**600**

SEMESTER: 2nd									
Course Code	**Course Title**	**Type of Courses**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MPY2450	Quantum Mechanics	Core Course	4	0	0	4	30	70	100
MPY2451	Atomic and Molecular Spectroscopy	Core Course	3	0	0	3	25	50	75
MPY2452	Thermodynamics and Statistical Mechanics	Core Course	4	0	0	4	30	70	100
MPY2453	Nuclear and Particle Physics	Core Course	3	0	0	3	25	50	75
MPY2454	Innovation Management and Technology Transfer	Entrepreneurship Skill	2	0	0	2	15	35	50
MPY2455	Nuclear and Particle Physics Lab	Core Course	0	0	2	1	10	15	25
MPY2456	Atomic and Molecular Spectroscopy Lab	Core Course	0	0	2	1	10	15	25
Elective-II (Any one of the following)									
MPY2457	Remote Sensing	Discipline Elective Course	4	0	0	4	30	70	100
MPY2458	Nano Materials								
Total			**20**	**0**	**4**	**22**	**175**	**375**	**550**

Programme learning outcomes: A Postgraduate Degree is awarded to students who have demonstrated the achievement of the outcomes located at level 7:

Element of the Descriptor	**Programme learning outcomes relating to Postgraduate Degree**
The graduates should be able to demonstrate the acquisition of:	
Knowledge and understanding	A strong understanding of Radiation Physics, Renewable Energy Resources, and Experimental Techniques in Physics.
	Research methodologies, including data collection, statistical analysis, and scientific interpretation.
	Computational and numerical techniques applied in Computational Physics and Scientific Research Writing.
	Fundamental and advanced principles of Astronomy and Astrophysics, including celestial mechanics, cosmology, and observational techniques.
Skills required to perform and accomplish tasks	Hands-on experience in computational simulations and data visualization using physics-based software tools.
	Proficiency in experimental techniques and instrumentation for material characterization and plasma physics experiments.
	The ability to apply scientific research methodologies, including literature reviews and hypothesis testing.
Application of knowledge and skills	Skills to implement experimental techniques in physics for designing and analyzing real-world problems in materials science and spectroscopy.
Generic learning outcomes	Adaptability to emerging technologies and global scientific trends in physics and applied sciences.
Constitutional, humanistic, ethical, and moral values	The ability to apply physics knowledge for societal benefit, such as radiation safety, renewable energy applications, and healthcare advancements.
Employability and job-ready skills, and entrepreneurship skills and	Job-ready skills in experimental physics, data science applications, and industrial research.

capabilities/qualities and mindset	
Credit requirements	92 credits
Entry requirements	A Postgraduate Diploma (Level 6) in Physics with minimum of 75% marks in diploma.

SEMESTER: 3rd									
Course Code	**Course Title**	**Type of Courses**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MPY3500	Research Methodology	Core Course	4	0	0	4	30	70	100
MPY3501	Condensed Matter Physics	Core Course	3	0	0	3	25	50	75
MPY3502	Service Learning	Entrepreneurship Skills	0	0	4	2	15	35	50
MPY3503	Condensed Matter Physics Lab	Core Course	0	0	2	1	10	15	25
Elective-III (Any one of the following)									
MPY3504	Radiation Physics	Discipline Elective Course	4	0	0	4	30	70	100
MPY3505	Electronic Communication								
Elective-IV (Any one of the following)									
MPY3506	Astronomy and Astrophysics	Discipline Elective Course	4	0	0	4	30	70	100
MPY3507	Renewable Energy Resources								
Elective-V (Any one of the following)									
MPY3508	Plasma Physics	Discipline Elective Course	4	0	0	4	30	70	100
MPY3509	Advanced Quantum Mechanics								
Total			**19**	**0**	**6**	**22**	**170**	**380**	**550**

SEMESTER: 4th										
Course Code	**Course Title**	**Type of Courses**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MPY4550	Experimental Techniques in Physics	Core Course	4	0	0	4	30	70	100
MPY4551	Scientific Research and Technical Writing	Employability Skill	2	0	0	2	15	35	50
MPY4552	Dissertation	Research Skill	0	0	0	12	200	100	300
Elective-VI (Any one of the following)									
MPY4553	High Energy Physics	Discipline Elective Course	4	0	0	4	30	70	100
MPY4554	Computational Physics								
Total			**10**	**0**	**0**	**22**	**275**	**275**	**550**
Grand Total			**70**	**0**	**16**	**92**	**810**	**1440**	**2250**

SEMESTER – I

Course Title: Mathematical Physics	L	T	P	Cr.
Course Code: MPY1400	4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Solve differential equations like Legendre, Bessel and Hermite that are common in physical sciences.
2. Solve transfer functions in Instrumentation using Laplace transforms.
3. Apply Fourier transforms in Holography.
4. Apply the knowledge of Tensors to understand phenomenon like stress and strain.

Course Content

Unit-I **8 hours**

Complex Analysis: Cauchy theorem, Cauchy integral representation, Taylor and Laurent series. Residues and evaluation of integrals, Cauchy residue theorem and its applications to the evaluation of definite integrals and the summation of infinite series. Integrals involving branch point singularity.

Unit-II **7 hours**

Fourier and Laplace Transforms: Fourier series, Drichlet condition, Fourier transforms, their properties and applications, Laplace transforms, Properties of Laplace transform, Inverse Laplace transform. Group theory: Group postulates, Lie group and generators, representation, Commutation relations, SU(2), O(3).

Unit-III **8 hours**

Vector and Tensors: Linear vector spaces, subspaces, basis and dimension, Tensor analysis, scalars, Covariant and Contravariant tensors. Addition, Subtraction, Outer product, Inner product and Contraction. Symmetric and anti-symmetric tensors. Length and angle between vectors. Raising and lowering of indices. The Christoffel symbols and their transformation laws.

Unit-IV **7 hours**

Differential Equations: Solutions of Hermite, Legendre, Bessel and Laugerre Differential equations, associated Legendre polynomials. Partial differential equations (Laplace, wave and heat equation in two and three dimensions), Boundary value problems and Euler equation. Green's functions for ordinary and partial differential equations of mathematical physics.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion,e-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *Arfken G, Weber H and Harris F., Mathematical Methods for Physicists, Massachusetts, USA: Elsevier Academic Press.*
- *Kreyszig E., Advanced Engineering Mathematics, New Delhi, India: Wiley India Pvt. Ltd.*
- *Pipes L. A., Applied Mathematics for Engineers and Physicist, McGraw-Hill, Noida,India.*
- *Rajput B. S., Mathematical Physics, Pragati Prakashan*
- *Boas M.L. Mathematical Methods in the Physical Sciences, John Wiley & Sons, New York*
- *Harper C. Analytical Mathematics in Physics, Prentice Hall.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs*

Course Title: Classical Mechanics	L	T	P	Cr.
Course Code: MPY1401	**4**	**0**	**0**	**4**

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand basic mechanical concepts related to discrete and continuous mechanical systems.
2. Solve the equations of motion for complicated mechanical systems using Lagrangian and Hamiltonian formulations of classical mechanics.
3. Explore the application of Hamilton's equations in solving the equation of motion of a particle in a central force field, projectile motion of a body.
4. Apply Newton's laws of motion and conservation laws to solve advanced problems involving the dynamic motion of classical mechanical system.

Course Content

UNIT–I **15 Hours**

Lagrangian formulation: Conservation laws of linear, angular momentum and energy for a single particle and system of particles, Constraints and generalized coordinates, Principle of virtual work, D'Alembert principle, Lagrange's equations of motion, Velocity dependent potential and dissipation function. : Hamilton's principle, Calculus of variations, Lagrange's equations from Hamilton principle. Generalized momentum, Cyclic coordinates, Symmetry properties and Conservation theorems.

UNIT–II **15 Hours**

Hamiltonian formulation: Legendre transformation, Hamilton's equations of motion, Hamilton's equation from Variational principle, Principle of least action. Canonical transformation: Generating function, Poisson brackets and their canonical invariance, Equations of motion in Poisson bracket formulation, Poisson bracket relations between components of linear and angular momenta.

UNIT–III **15 Hours**

Theory of Small Oscillations: Lagrange's equations of motion for small oscillations, Normal modes, Applications to linear triatomic molecule, double pendulum and N-Coupled oscillators. Lorentz transformations and its

Consequences, Relativistic kinematics and mass energy equivalence, Relativistic Lagrangian and Hamiltonian, Four vectors, covariant formulation of Lagrangian and Hamiltonian.

UNIT–IV **15 Hours**

Continuous systems and Hamilton-Jacoby theory: Transition from discrete to continuous systems, Lagrangian formulation, Stress-energy tensor and conservation laws, Hamiltonian formulation, Scalar and Dirac fields (only definitions). Hamilton-Jacobi equations for Hamilton principal and characteristic functions.

Transaction Mode- - Video Based Teaching, Collaborative teaching, Group Discussion, e-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *Goldstein H. Classical Mechanics, Narosa Publishing House, New Delhi.*
- *David Morin,Introduction to Classical Mechanics With Problems and Solutions, Cambridge University Press.*
- *Stephen Thornton, Classical dynamics of particles and systems, Brooks Publishers.*
- *R. Douglas Gregory , Classical mechanics, Cambridge University Press.*
- *Rana N.C., Classical Mechanics, Tata McGraw-Hill, N. Delhi.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Classical Electrodynamics	L	T	P	Cr.
Course Code: MPY1402	3	0	0	3

Total Hours: 45

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Use Maxwell equations in analyzing the electromagnetic field due to time varying charge and current distribution.
2. Describe the nature of electromagnetic wave and its propagation through different media and interfaces.
3. Explain charged particle dynamics and radiation from localized time varying electromagnetic sources.
4. Build a foundation for the students to carry out research in the field of Electrostatics and Magneto-statics.

UNIT–I **10 Hours**

Electrostatics: Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems, examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, dielectrics, polarization of a medium, electrostatic energy.

UNIT–II **13 Hours**

Magnetostatics: Continuity equation, Biot-Savart law, Differential equations of magneto statics and Ampere's law, Vector potential and its calculation, Magnetic moment, Macroscopic equations, Boundary conditions on B and E, Magnetic scalar potential. Time varying fields: Faraday's law of electromagnetic induction, Energy in the Magnetic field, Maxwell equations, Displacement current, Electromagnetic potential, Lorentz and Coulomb gauge. Maxwell equations in terms of electromagnetic potentials, Solution of Maxwell equations in Coulomb Gauge and Lorentz gauge by green function.

UNIT–III **12 Hours**

Electromagnetic waves and wave propagation : Poynting theorem and Maxwell stress tensor, Plane waves in a non-conducting medium, Polarization and Stokes parameter, and Energy flux in a plane wave, Reflection and refraction across a dielectric interface, Total internal reflection, Polarization by reflection, Waves in a conducting medium and skin depth.

UNIT–IV **10 Hours**

Radiating Systems: Advanced and retarded green functions; Lienard-Wiechert potentials; dipole radiation and Larmor's formula; spectral resolution and angular distribution of radiation from a relativistic point charge; synchrotron radiation; Rayleigh and Thomson scattering; collision problems; Bremsstrahlung and Cerenkov radiation. Scattering of electromagnetic waves: Rayleigh and Thomson scattering, radiation damping.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, E-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *Jackson, David, Classical Electrodynamics, Wiley India.*
- *Griffiths, David, "Introduction to Electrodynamics, Cambridge University Press.*
- *Edward Mills Purcell and D. J. Morin, Electricity and Magnetism, (3rd ed.), Cambridge University Press.*
- *J.R. Reitz, F.J. Milford and R.W. Christy, Foundations of Electromagnetic Theory*
- *W.K.H. Panofsky and M. Phillips, Classical Electricity and Magnetism.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Electronics	L	T	P	Cr.
Course Code: MPY1403	3	0	0	3

Total Hours: 45

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Acquire knowledge of operational amplifier circuits and their applications.
2. Analyze the operation of decoders, encoders, multiplexers, adders and subtractors.
3. Understand the working of latches, flip-flops, designing registers, counters, a/d and d/a converters.
4. Design and Analyze synchronous and asynchronous sequential circuits.

Course Content

UNIT–I **12 Hours**

p-n Junction Physics- Fabrication steps; thermal equilibrium condition; depletion capacitance; current-voltage characteristics; charge storage and transient behavior; junction breakdown; hetero junction. Characteristics of some semiconductor devices- BJT, JFET, MOS, LED, Solar cell, Tunnel diode, Gunn diode and IMPATT.

UNIT–II **13 Hours**

Active Circuits: Transistor amplifiers- Basic design consideration; high frequency effect; feedback in amplifiers. Operational amplifiers: device properties, integrator, differentiator, RC active filter, negative and positive feedback, oscillators.

UNIT III **10 Hours**

Number System : Data and number systems, Binary representation, Signed binary number representation with 1's and 2's complement methods, Binary arithmetic. Boolean algebra, Venn diagram, logic gates and circuits, Minimization of logic expressions by algebraic method, K-map method.

UNIT IV **10 Hours**

Combinational and Sequential circuits- adder, subtractor, encoder, decoder, comparator, multiplexer, de-multiplexer, parity generator. Sequential Circuits-Flip Flops, various types of Registers and counters and their design, Irregular counter, State table and state transition diagram, sequential circuits design methodology. Different types of A/D and D/A conversion techniques.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, e team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *Ryder J.D., Electronic Fundamentals and Applications, Prentice Hall of India.*
- *Sze S.M., Semiconductor Devices: Physics and Technology, Wiley Publishers.*
- *Malvino A.P., Digital Principles and Applications, Tata McGraw-Hill, New Delhi.*
- *Hayes & Horowitz, Student Manual for The Analog Electronics; Cambridge University Press.*
- *Boyle'stead & Nashelsky, Electronic Devices & Circuit theory, PHI.*
- *Millman & Halkias: Basic Electronic Principles; TMH.*
- *Tobey & Grame, Operational Amplifier: Design and Applications, Mc Graw Hill.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

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Course Title: Astronomy in India	L	T	P	Cr.
Course Code: IKS0018	4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the historical development of astronomy in India and its cultural and scientific context.
2. Identify key astronomical algorithms developed by Indian astronomers.
3. Explain the mathematical principles underlying these astronomical methods.
4. Explore the practical applications of Indian astronomical knowledge, such as in calendar preparation and timekeeping.

Course Content

Unit – I: **8 Hours**

Astronomy before Āryabhaṭa:

a) Astronomical references in the Vedas
b) Astronomical model and algorithms of the Vedāṅga-jyotiṣa
c) The Pañca-siddhāntikā of Varāhamihira

Unit – II: **7 Hours**

Important astronomers and texts – I

a) A brief historical overview
b) Āryabhaṭīya of Āryabhaṭa

Unit – III: **7 Hours**

Important astronomers and texts – II:

a) Important astronomical instruments described in Indian texts
b) Tantrasaṅgraha of Nīlakaṇṭha Somayājī

Unit – IV: **8 Hours**

Calendrical computations

a) Construction of the Indian luni-solar calendar
b) Indian records of astronomical observations (inscriptions, copper plates, texts etc.

Transactional Mode

Seminars, Group discussion, Team teaching, Focused group discussion, Assignments, Project-based learning, Simulations, reflection and Self-assessment

Suggested Readings

- *The Science of the Śulba, B. Datta, University of Calcutta, 1932*
- *History of Hindu Mathematics: A Source Book, B. Datta and A. N. Singh, Asia Publishing House, 1962*
- *Āryabhaṭīya of Āryabhaṭa, K. S. Shukla and K. V. Sarma, Indian National Science Academy, 1976*
- *Geometry in Ancient and Medieval India, T. A. Sarasvati Amma, Motilal Banarasidass, 2007*
- *Gaṇita-yukti-bhāṣā of Jyeṣṭhadeva, K. V. Sarma et. al., Hindustan Book Agency, 2008*
- *Studies in Indian Mathematics and Astronomy: Selected Articles of Kripa Shankar Shukla, Kolachana et. al. (eds.), Culture and History of Mathematics 12, HBA, 2019*
- *Līlāvatī of Bhāskarācārya, H. T. Colebrooke, ed. by H. C. Banerji, Kitab Mahal, 1967*
- *Mathematics in India: From Vedic Period to Modern Times, M. D. Srinivas and K. Ramasubramanian and M. S. Sriram, NPTEL course*

Course Title: Classical Electrodynamics Lab	L	T	P	Cr.
Course Code: MPY1404	**0**	**0**	**2**	**1**

Total Hours: 15

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Develop experimental and simulation-based problem-solving skills in electromagnetics by conducting hands-on experiments and analyzing real-world physical systems.
2. Apply theoretical knowledge of electromagnetic principles to design, execute, and interpret experiments using modern laboratory instruments and computational tools like MATLAB or Python.
3. Simulate and visualize electromagnetic field behavior and wave propagation to interpret core electromagnetic laws and vector quantities.
4. Demonstrate competency in using electrical measurement tools and instrumentation to study the behavior of passive components in AC and transient circuits.

Course Content

1. Study of series resonance and determination of resonance frequency using LCR circuit.
2. Study of parallel resonance and determination of resonance frequency using LCR circuit.
3. To trace B.H curve for fern magnetic materials inning C.R.O and hence to calculate the hysteresis less.
4. To study propagation of wave using Rectangular Waveguide using MATLAB.
5. To map electric field lines and equipotential surfaces using a conducting paper experiment.
6. To determine the permittivity of free space using a parallel plate capacitor.
7. To measure dielectric constant of a material using a capacitance bridge.
8. To verify Gauss's Law using surface charge distribution simulation.
9. To study the charging and discharging of a capacitor through a resistor (RC circuit) and determine time constant.
10. To verify reflection and transmission coefficients at a boundary of two dielectric media (using microwave setup or simulation).

11. To simulate and visualize Maxwell's equations using finite-difference time-domain (FDTD) methods in Python or MATLAB.
12. To simulate field vectors and Poynting vector in electromagnetic wave propagation.
13. To study displacement current and the continuity equation using simulations.

Note : Students will perform any 8 experiments.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, e-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *G. L. Squires, Practical Physics ,Cambridge University Press.*
- *Napier Shaw and Richard Glazebrook, Practical Physics, Nabu Press.*
- *C.L. Arora , Practical Physics, S. Chand &Co.*
- *R.S. Sirohi, Practical Physics,WileyEastern.*

Course Title: Electronics Lab	L	T	P	Cr.
Course Code: MPY1405	**0**	**0**	**2**	**1**

Total Hours: 15

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Experimentally understand the working of optoelectronic devices.
2. Hands-on experience on verification of circuit laws and theorems.
3. Learn experimental skills of instrument handling.
4. Apply the basic ideas to create, solve and analyze the problems of interest.

Course Content

1. Study the gain frequency response of a given RC coupled BJT, CE amplifier.
2. Study of Clipping & Clamping circuits.
3. Study of shunt capacitor filter, inductor filter, LC filter and π filter using Bridge Rectifier.
4. Find the energy gap of a given semiconductor by reverse bias junction method.
5. To calculate the temperature coefficient of Thermistor.
6. Verify De-Morgan's law and various combinations of gates using Logic gates circuit.
7. Study of various types of Flip-Flops.
8. To study various Oscillators (Hartley, Colpitt, RC Phase shift etc.).
9. To study Amplitude Modulation and De-Modulation and calculate modulation index.
10. To study characteristics of FET and determine its various parameters.
11. Study the characteristics of Tunnel Diode.
12. To study 2-bit, 3 bit and 4-bit Adder & Subtractor.
13. Study the characteristics of basic Thyristors (SCR, MOSFET, UJT, TRIAC etc.).
14. Use of Transistor as a push pull amplifier (Class 'A', 'B' and 'AB').
15. Application of transistor as a series voltage regulator.
16. Study of biasing techniques of BJT.
17. To study Frequency Modulation and Demodulation.
18. Study of transistor as CE, CB and CC amplifier.
19. Fourier series analysis of square, triangular and rectified wave signal.

Note : Students will perform any 10 experiments.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, e-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *G. L. Squires, Practical Physics ,Cambridge University Press.*
- *Napier Shaw and Richard Glazebrook, Practical Physics, Nabu Press.*
- *C.L. Arora , Practical Physics, S. Chand &Co.*
- *R.S. Sirohi, Practical Physics,WileyEastern.*

Course Title: Material Science	L	T	P	Cr.
Course Code: MPY1406	4	0	0	4

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Analyze the ideas of basics of structure of material properties and bonding characteristics of materials and their energy.
2. Demonstrate the phase rules and properties of phase diagram
3. Able to understand the mechanical properties of material
4. Get familiarization of different theories of related to magnetic properties of material

Course Content

UNIT I **15 Hours**

Structure of solids: Introduction to engineering materials, Description of materials science tetrahedron, Structure - description of unit cell and space lattices, Coordination number, APF for cubic and hexagonal close packed structures. Significance of structure property correlations in all classes of engineering materials. Diffusion phenomenon: Diffusion in ideal solutions, Kir kendall effect, Rate and mechanism of diffusion, Fick's first and second law of diffusion, Applications of diffusion, Concept of uphill diffusion.

UNIT II **15 Hours**

Principles of solidification and phase equilibria: Concept of free energy and entropy; Structure of liquid metals; Energetics of solidification; Nucleation and growth, Homogeneous and heterogeneous nucleation, Dendritic/Equiaxed growth, Origination of grain and grain boundaries, Cast structure; Significance of alloying, Intermediate alloy phases, solid solutions and its types

UNIT III **15 Hours**

Phase diagrams and phase transformations: Basic definitions; Gibbs phase rule, Introductions to binary, ternary and quaternary system; Construction of binary isomorphous diagram from cooling curves, Time scale for phase diagrams, Transformations in steels, Precipitation process, and recrystallization and growth.

UNIT IV **15 Hours**

Heat treatment: TTT curves, CCT curves, Annealing, Normalising, Hardening, Tempering Ceramics: Introduction to ceramic materials; Classification of ceramics, Crystal structure and bonding of common advanced ceramic materials; Mechanical behavior of ceramics, Glass and glass ceramics: Preparation and characterization of ceramics powders; Applications of ceramics in advanced technologies.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley & Sons.*
- *C. Kittel, Introduction to Solid State Physics, Wiley Eastern Ltd.*
- *V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall.*
- *S.H. Avener, Introduction to Physical Metallurgy Tata McGraw-Hill Education.*
- *V. Raghavan, Materials Science & Engineering: A first course,PHI Learning.*
- *W.D. Kingery, Introduction to Ceramics, John Wiley & Sons.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Reactor Physics	L	T	P	Cr.
Course Code: MPY1407	4	0	0	4

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Study the neutron moderation process
2. Apply diffusion theory for fusion-fission dynamics
3. Select materials relevant for reactor design and energy production
4. Categorize different nuclear reactors and nuclear waste management

Course Content

UNIT I **15 Hours**

Neutron moderation: Inelastic scattering, Elastic collisions, moderating ratio, slowing down Density, Resonance escape, Moderatos.

UNIT II **15 Hours**

Fission Process and diffusion theory: Prompt neutrons, Fast fission, Fission energy, Thermal utilization, Fission products, Chain reaction, and Multiplication factor, Leakage of neutrons, Critical size, Diffusion and slowing down theory, Homogenous and heterogeneous reactors.

UNIT III **15 Hours**

Materials for Nuclear Reactors: Fuel materials, Moderator and Reflectors, Cladding materials, Coolants and control Rods

UNIT IV **15 Hours**

Type of Power reactors: Boiling water reactors, Pressurized water reactors, Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors,, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Plasma production and its diagnosis, status of fusion reactors.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e-team teaching, Group discussion, e-team Teaching, Flipped class room teaching, Quiz, Open talk, Case analysis.

SUGGESTED READING:

- *Glasstons, Sammuel and Sesonske, Alexander, Nuclear reactor Engineer, CBS Publishers & Distributors.*
- *Lamarshs, J.R., Introduction to Nuclear Reactor Theory, Addison-Wesley Publishers.*
- *E.Lewis,Fundamentals of Nuclear Reactor Physics, Academic Press Publishers.*
- *W.M.Stacey, Nuclear Reactor Physics, Wiley-VCH Publishers.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

SEMESTER –II

Course Title: Quantum Mechanics	L	T	P	Cr.
Course Code: MPY2450	**4**	**0**	**0**	**4**

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Design, set up and carry out experiments; analyze data recognizing and accounting for uncertainties; and compare results with theoretical predictions.
2. Analyze the language of quantum mechanics in 1-dimensional and 3-dimensional problems.
3. Solve Schrödinger equation for simple potentials like linear Harmonic oscillator and Hydrogen atoms.
4. Evaluate CG coefficients for different values of total angular momentum vector.

Course Content

UNIT I **15 Hours**

Motion in a Central Potential and Uncertainty Principle: Solution of the Schrodinger equation for the hydrogen atom, Eigen values and Eigen vectors of orbital angular momentum, Spherical harmonics, Radial solutions,rigid rotator, Solution for three-dimensional square well potential. Generalized uncertainty principle; time energy uncertainty principle, Density matrix.

UNIT II **15 Hours**

Linear vector spaces: Fundamental postulates of quantum mechanics, State vectors, Orthonormality, Hilbert spaces, Linear manifolds and subspaces, Hermitian, unitary and projection operators and commutators; Dirac Bra and Ket Notation: Matrix representations of bras and kets and operators; Continuous basis, Change of basis-Representation theory. Coordinate and momentum representations. Schrodinger, Heisenberg and interaction pictures.

UNIT III **15 Hours**

Linear Harmonic Oscillator: Solution of Simple harmonic oscillator; Vibrational spectra of diatomic molecule; anisotropic three-dimensional oscillator in Cartesian coordinates, Isotropic three-dimensional oscillator in spherical coordinates. Matrix mechanical treatment of linear harmonic oscillator: Energy Eigen values and Eigen vectors of SHO, Matrix representation of creation and annihilation operators, Zero-point energy; Coherent states.

UNIT IV **15 Hours**

Angular momentum: Eigen values, Matrix representations of J2, Jz, J+, J-; Spin: Pauli matrices and their properties, Addition of two angular momenta: Clebsch-Gordon coefficients and their properties, Spin wave functions for two spin-1/2 system, Addition of spin and orbital momentum, derivation of C.G. coefficients for ½+1/2 and ½+1, addition, Spherical tensors and Wigner-Eckart theorem (Statement only).

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, e-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:

- *Thankappan,V.K., Quantum Mechanics, New Age International Publications, New Delhi*
- *Greiner W.,Quantum Mechanics, Springer Verlag Publishers, Germany,*
- *Sakurai J.J.,Modern Quantum Mechanics, Addison Wesley Pub., USA.*
- *Robert Eisberg and Robert Resnick ,Quantum Physics, John Wiley and sons.*
- *D. Bohm, Quantum Theory, Prentice-Hall.*
- *A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Macmillan India Ltd.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Atomic and Molecular Spectroscopy	L	T	P	Cr.
Course Code: MPY2451	**3**	**0**	**0**	**3**

Total Hours: 45

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Apply principles of quantum mechanics to the study of atoms and its behavior.
2. Understand spectroscopy of the hydrogen and multi-electron atoms.
3. Understand of quantum behavior of atoms in external electric and magnetic fields.
4. Recognize the general features of atomic and molecular spectroscopic methods in order to apply them in explaining the structure and dynamics of atoms and molecules.

Course Content

UNIT I **12 Hours**

Atomic Physics: One electron atom-spin-orbit interaction, fine structure, Lamb shift, Zeeman Effect, Stark effect. Two electron atoms: spin wave functions, approximate handling of electron-electron repulsion. Coupling of angular momenta, multiplet structure, and gyromagnetic effects. Hyperfine and nuclear quadrupole interactions. Many electron atoms: central field approximation, Thomas-Fermi and Hartree-Fock methods.

UNIT II **11 Hours**

Molecular Physics: Born-Oppenheimer approximation, molecular structure, rotation and vibration of diatomic molecules, hydrogen molecular ion, vibrational-rotational coupling, effect of vibration and rotation on molecular spectra. Electronic structure- molecular orbital and valence bond theories.

UNIT III **11 Hours**

UV and IR Spectroscopy: Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, Effect of isotopic substitution. The vibrating diatomic molecule as a simple harmonic and a harmonic oscillator, Diatomic vibrating rotator, the vibration-rotation spectrum of carbon monoxide, the interaction of rotation and vibrations.

UNIT IV **11 Hours**

Raman and Electronic Spectroscopy: Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrational Raman spectra, Electronic Spectroscopy: Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, The Franck Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, Example of spectrum of molecular hydrogen.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion,e- team Teaching, flipped classroom Teaching, Quiz, Open talk, Problem Analysis

SUGGESTED READINGS:

- *H. Haken and H.C. Wolf, Physics of Atoms and Quanta, Springer Publication.*
- *B.H. Bransden and C.J. Joachain, Physics of Atoms and Molecules , Pearson India.*
- *Banwell, Molecular spectroscopy, Tata McGraw Hill Publishers.*
- *Towne and Schawlow, Micorwave Spectroscopy, McGraw-Hill,*
- *Raymond Chang, Basic Principles of Spectroscopy, Mc Graw-Hill, Kogakusha, Tokyo.*
- *D.A. Lang, Raman Spectroscopy, Mc Graw-Hill International, N.Y.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Thermodynamics and Statistical mechanics	L	T	P	Cr.
Course Code: MPY2452	4	0	0	4

Total Hours:60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Analyze and solve simple problems related to fundamental ideas of thermodynamics and statistical Physics at micro level in various media.
2. Comprehend the fundamental differences between classical and quantum statistics and learn about quantum statistical distribution laws.
3. Grasp the basis of ensemble approach in statistical mechanics to a range of situations.
4. Demonstrate knowledge of thermodynamics and statistical Physics at individual particle level.

Course Content

UNIT–I **15 Hours**

Laws of Thermodynamics: Zeroth Law of thermodynamics First law, conversion of heat into work, Applications of First Law, Second law and Entropy, Carnot's cycle & Carnot's theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams. Third law of thermodynamics, unattainability of absolute zero. Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications: Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (C_P and C_V), TdS equations.

UNIT–II **15 Hours**

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases. Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

UNIT–III **15 Hours**

Classical Statistical Mechanics : Postulates, the macroscopic and microscopic states, Liouville's theorem, Van-der Waals equation of state, Phase space, Ensemble, Micro canonical ensemble, Entropy of an ideal gas, Gibb's paradox. Canonical ensemble and its thermodynamics**:** Partition function, Classical ideal gas in canonical ensemble, Energy fluctuations. Equipartition theorem, Grand canonical ensemble and its thermodynamics, Density fluctuations. Equivalence of canonical and the grand canonical ensembles. Ideal gas in grand canonical ensemble. Distribution function, Boltzmann transport equations, Boltzmann's H-theorem, most probable distribution laws, the zero-order approximations, The Navier Stokes equations.

UNIT IV **15 Hours**

Postulates of Quantum Statistical Mechanics: Density matrix, ensembles in quantum statistical mechanics, Ideal Fermi Gas: Equation of state of an Ideal Fermi Gas, Degeneracy, Fermi energy at T=0 and at low temperatures. Bose Gas: Equation of state of an Ideal Bose gas, Bose-Einstein condensation, Density matrix, Equation of motion for density matrix.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion-team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *Huang K, Statistical Mechanics, John Wiley & Sons Publishers.*
- *Patharia R.K , Statistical Mechanics, Butterworth Oxford Publisher*
- *Fowler, R. H., Statistical mechanics: the theory of the properties of matter in equilibrium' Cambridge: University Press.*
- *H. Gould and J. Tobochnik, Thermal and Statistical Physics, Princeton University press.*
- *Reif, Fundamentals of Statistical and Thermal Physics Paperback, Sarat Book Distributors.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Nuclear and Particle Physics	L	T	P	Cr.
Course Code: MPY2453	**3**	**0**	**0**	**3**

Total Hours: 45

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Analyze the ideas of basics of nucleus and their energy.
2. Demonstrate the mechanism of particle accelerators and detector technologies.
3. Able to understand the different types of the radioactive decay and kinetics of nuclear reactions.
4. Build a foundation for the students to carry out research in the field of nuclear physics, high energy physics, nuclear astrophysics, nuclear reactions and applied nuclear physics.

Course Content

UNIT I **12 Hours**

Nuclear properties: radius, size, mass, spin, moments, abundance of nuclei, binding energy, semi-empirical mass formula, excited states; Nuclear forces: deuteron, n-n and p-p interaction, nature of nuclear force. Nuclear Models: liquid drop, shell and collective models; Nuclear decay and radioactivity: radioactive decay, detection of nuclear radiation, alpha, beta and gamma decays.

UNIT II **10 Hours**

Nuclear reactions: Different types of reactions, Quantum mechanical theory, Resonance scattering and reactions - Breit-Wigner dispersion relation, optical model, compound nucleus, direct reactions, resonance reactions, fission and fusion.

UNIT III **13 Hours**

Elementary particles: Masses of elementary particles, Decay modes, Classification of these particles, types of interactions. Conservation laws and quantum numbers, Concepts of isospin. Strangeness, Parity, Charge conjugation. Antiparticles, Gell Man method, Decay and strange Particles. Particle symmetry.

UNIT IV **10 Hours**

Fermions and Bosons: particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions. Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, e- team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *Knoll G.F., Radiation Detection and Measurement, John Wiley & Sons.*
- *Krane K.S., Introductory Nuclear Physics, John Wiley & Sons, New York.*
- *I.S. Hughes, Elementary Particles, Cambridge University Press.*
- *F.E. Close, Introduction to Quarks and Partons, Academic Press.*
- *Perkins D. H., Introduction to High Energy Physics, Cambridge University Press.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Innovation Management and Technology Transfer	L	T	P	Cr.
Course Code: MPY2454	**2**	**0**	**0**	**2**

Total Hours: 30

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Recognize technological opportunities and threats and convert into new products and services.
2. Assess how to integrate science and business knowledge in running business successfully.
3. Develop insights into the competencies required to become an effective innovation manager.
4. Evaluate a variety of theories and concepts relating to innovation.

Content

UNIT I **8 Hours**

Introduction to Innovation Management: Definitions and types of innovation The importance of innovation in today's economy. The innovation process and lifecycle. Theories and Models of Innovation: Schumpeterian theory of innovation, Open innovation model, Disruptive innovation and Diffusion of innovations

UNIT II **7 Hours**

Managing the Innovation Process: Idea generation and screening, Concept development and testing, Prototyping and product development. Sources of Innovation: Internal sources: R&D, intrapreneurship, External sources: partnerships, collaborations, acquisitions, Crowdsourcing and open innovation.

UNIT III **8 Hours**

Technology Transfer Basics: Definition and importance of technology transfer Technology transfer mechanisms, Models and Processes of Technology Transfer, Negotiating Technology Transfer Agreements, Key components of technology transfer agreements.

UNIT IV **7 Hours**

Commercialization of Technology: Pathways to commercialization, Market analysis and feasibility studies, Business models for commercializing technology, Sources of funding for innovation.

Transaction Mode : Discussions, Case Studies, Microteaching, Classroom Observations, Peer Teaching: Video Analysis, Role-Playing, Lecture-cum-demonstration, Classroom Simulations, Reflective Journals/Blogs, Teaching Portfolios and Technology Integration, Flipped Teaching.

SUGGESTED READINGS:

- *Tidd, J., & Bessant, J. (2020). Managing Innovation: Integrating Technological, Market and Organizational Change. Wiley.*
- *Chesbrough, H. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press.*
- *Rogers, E. M. (2003). Diffusion of Innovations. Free Press.*
- *OECD. (2019). Technology and Innovation Report.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Nuclear and Particle Physics Lab	L	T	P	Cr.
Course Code: MPY2455	0	0	2	1

Total Hours: 15

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Acquire knowledge and understanding of fundamental concepts, principles and theories related to nuclear Physics
2. Develop the skill to combine and use knowledge from several disciplines to enter/propose novel ideas that require an analytic and innovative approach, and disseminate course matter and results to both specialists and a broader audience.
3. Collaborate and to lead collaborative work to accomplish a common goal
4. Develop skills to interpret and explain the limits of accuracy of experimental data in terms of significance and underlying theory.

Course Content

1. Study of standard deviation using G-M counter
2. Half-life of ^{40}K using G-M Counter
3. Measurement of mass absorption coefficient of beta rays in given materials
4. To find range and energy of β- particles
5. To find Dead time of a GM Tube
6. Study of energy calibration of NaI (Tl) scintillation detector.
7. Study and analysis of spectrum of ^{137}Cs
8. Verify inverse square law (in case of gamma rays) using scintillation spectrometer
9. Study of Compton scattering law for energy of scattered photons.
10. To study internal conversion coefficient for ^{137}Cs (or suitable gamma source)
11. To determine the source strength of a given radioactive gamma source
12. Study and analysis of spectrum ^{60}Co
13. Photoelectric cross-section measurement for a given target material at known incident gamma photo energy
14. Compton cross-section measurement for known incident gamma photon energy
15. Measurement of Photo-peak (full energy peak) efficiency of Scintillator detector.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

Course Title: Remote Sensing	L	T	P	Cr.
Course Code: MPY2456	4	0	4	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the concepts of Photogrammetry and compute the heights of objects
2. Understand the principles of aerial and satellite remote sensing, Able to comprehend the energy interactions with earth surface features, spectral properties of water bodies.
3. Understand the basic concept of GIS and its applications, know different types of data representation in GIS.
4. Understand and Develop models for GIS spatial Analysis and will be able to know what the questions that GIS can answer.

Course Content

UNIT I **15 Hours**

Introduction To Photogrammetry : Principles and types of aerial photographs, geometry of vertical and aerial photograph, Scale and Height measurement on single and vertical aerial photograph, Height measurement based on relief displacement, Fundamentals of Stereoscopy, fiducial points, parallax measurement using fiducial line.

UNIT II **15 Hours**

Remote Sensing: Basic concepts and foundation of Remote Sensing elements, Data information, Remote sensing data collection, Remote sensing advantages and Limitations, Remote sensing process. Electromagnetic spectrum, Energy interaction with atmosphere and with earth surface features (soil, water, and vegetation) Indian Satellites and Sensors characteristics, Map and Image false color composite, introduction to digital data, elements of visual interpretations techniques.

UNIT III **15 Hours**

Geographic Information Systems : Introduction to GIS, Components of GIS, Geospatial data: Spatial Data – Attribute Data- Joining Spatial and Attribute Data, GIS Operations: Spatial Data input- Attribute Data Management-Data

Display-Data Exploration-Data Analysis. COORDINATE SYSTEMS: Geographic Coordinate system; Approximation of Earth, Datum: Map Projections: Types &Parameters.

UNIT IV **15 Hours**

Vector data model: Representation of simple features- Topology and its importance: coverage and its data structure, shape file: data models for composite features Object Based Vector Data Model; Classes and their Relationships: The geo-based data model: Geometric representation of Spatial feature and data structure: Topology rules.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, E team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis

SUGGESTED READINGS:

- *John R. Jensen, Remote Sensing of the environment- An earth resource perspective, Pearson Education.*
- *Chor Pang Lo, Concepts & Techniques of GIS, Prentice Hall Publications.*
- *Avery, T.E., Interpretation of aerial Photographs. Minneapolis, Minnesota: Burgess Publishing Company.*
- *Bakker, Wim H., et al., Principles of Remote Sensing : An Introductory Textbook. Enschede, The Netherlands: ITC.*
- *Campbell, James B., Introduction to Remote Sensing (Second Edition). London: Taylor & Francis.*
- *Colwell, Robert N.,Manual of Remote Sensing, Second Edition, Volume 1 and 2. Falls Church, Virginia: American Society of Photogrammetry.*
- *S.Kumar, Basics of Remote Sensing and GIS, Laxmi Publications.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Nano Materials	**L**	**T**	**P**	**Cr.**
Course Code: MPY2457	**4**	**0**	**4**	**4**

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Analyze the internal structure of materials, atoms and Crystals.
2. Conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
3. Demonstrate the application of diffusion in sintering and doping of semiconductors.
4. Interpret mechanical properties of materials and optical properties of Materials.

Course Content

UNIT I **15 Hours**

Introduction: Definition of a nano system - classification of nanocrystals - dimensionality and size dependent phenomena; Quantum dots, Nanowires and Nanotubes, 2D films; Nano & mesopores – top down and bottom up- Misnomers and misconception of Nanotechnology importance of the nanoscale materials and their devices -size dependent variation in mechanical, physical and chemical, magnetic, electronic transport, reactivity.

UNIT II **15 Hours**

Synthesis Of Nanomaterials: Physical Vapour Deposition (PVD), Inert gas condensation, Arc discharge, DC sputtering, Ion sputtering, RF & Magnetron sputtering ,Pulse Laser Deposition (PLD), Ball Milling, Molecular beam epitaxy, Electro-deposition, Metal nanocrystals by reduction, Sol- gel, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Liquid-liquid interface.

UNIT III **15 Hours**

Nano-Electronic Technologies: Nano capacitors, Quantum tunneling, Single electron transistors, Coulomb blockade, Nano lithography, Data storage, Nano-photonics, Nano electronic and Magnetic devices, Spintronic, Carbon based materials: Carbon Nano-tube (CNC), Graphene. Sensors & Nano-sensors.

UNIT IV **15 Hours**

Application of Nanomaterial : Sustainable energy technologies Solar energy, Hydrogen energy and Nano-materials, Carbon nanotube fuel cells, Hydrogen storage, Thermoelectricity, Re-chargeable batteries, Energy savings, Nano-lubricants, Nano-composites and Nano-catalysts.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, ted talks, E team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis

SUGGESTED READINGS:

- *S. Shanmugam, Nanotechnology, TBH Edition.*
- *T. Pradeep, Nano-the essential, Mc graw hill education, Chennai.*
- *Kenneth J. Klabunde, Nanoscale Materials, Wiley& Sons Publication.*
- *Masaru Kuno, Introductory Nanoscience, Garland Science Publications.*
- *Bharatbhushan, Handbook of Nanotechnology, Springer Publications.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

SEMESTER –III

Course Title: Research Methodology	L	T	P	Cr.
Course Code: MPY3500	**4**	**0**	**4**	**4**

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:
1. Understand the fundamentals of research, including different methodologies, problem formulation, and ethical considerations.
2. Develop skills in literature review, research design, and experimental techniques for scientific investigations.
3. Apply statistical methods for data analysis and interpretation in scientific research.
4. Enhance their ability to write research reports, papers, and theses, and present their findings effectively.

Course Content

UNIT I **15 Hours**

Fundamentals of Research Methodology: Meaning, objectives, and significance of research, Types of research: Fundamental, applied, experimental, theoretical, and computational research. Exploratory, descriptive, and experimental research designs. Identifying research problems and formulating hypotheses. Literature survey techniques: Use of research databases (Scopus, Web of Science, Google Scholar)

UNIT II **15 Hours**

Experimental and Computational Research Techniques: Principles of experimental research: Measurement techniques, error analysis, and uncertainty estimation. Data acquisition and processing: Signal conditioning, filtering, and noise reduction. Computational research: Basics of simulation, modeling, and numerical methods.

UNIT III **15 Hours**

Statistical Methods in Research: Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (variance, standard deviation). Probability distributions: Normal, Poisson, and binomial distributions.

Hypothesis testing and significance levels: t-test, chi-square test, ANOVA. Regression analysis and correlation methods

UNIT IV **15 Hours**

Application of Python for Statistical Data Analysis: Overview of Python's role in scientific computing, Introduction to python libraries, Loading and managing datasets (CSV, Excel), Measures of central tendency and dispersion, Probability distributions, Hypothesis testing (t-test, chi-square test) using SciPy, Data visualization using Matplotlib and Seaborn, Hands-on statistical analysis using real-world datasets

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, ted talks, E team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis

SUGGESTED READINGS

- *"Research Methodology: Methods and Techniques" – C.R. Kothari & Gaurav Garg (New Age International Publishers).*
- *"An Introduction to Research Methodology" – Wayne Goddard & Stuart Melville (Juta and Company Ltd.)*
- *"Statistics for Research" – Sher Muhammad Chaudhry & S. Kamal (Saeed Book Bank)*
- *"Experimental Methods for Science and Engineering Students" – Les Kirkup (Cambridge University Press)*
- *"Think Stats: Exploratory Data Analysis in Python" – Allen B. Downey, O'Reilly Media*

Course Title: Condensed Matter Physics	L	T	P	Cr.
Course Code: MPY3501	**3**	**0**	**0**	**3**

Total Hours: 45

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Analyze the crystal structures, crystal systems and understand the various techniques available using X-Ray crystallography.
2. Learn the skills to synthesize different materials and utilize these materials in different applications according to their properties
3. Identify the source of a materials magnetic behavior and be able to distinguish types of magnetism and their properties.
4. Describe the phenomenon of superconductivity: key experiments, some attempts to explain superconductivity, the BCS model.

Course Content

UNIT I **12 Hours**

Diffraction methods, Lattice vibrations, Free electrons: Diffraction methods, Scattered wave amplitude, Reciprocal lattice, Brillouin zones, Structure factor, Quasi crystals, Form factor and Debye Waller factor, Bonding of solids, Lattice vibrations of mono-atomic and diatomic linear lattices, IR absorption, Free electron gas in 1-D and 3-D,Heat capacity of metals, Thermal effective mass, Drude model of electrical conductivity, Wiedman-Franz law, hall effect, Quantized Hall effect.

UNIT II **13 Hours**

Semiconductors and Fermi-surfaces in Metals: Band gap, Equation of motion, properties of holes, Effective mass of electrons(m*), m* in semiconductors, Band structure of Si Ge and GaAs, Intrinsic carrier concentration, Intrinsic and extrinsic conductivity, Thermoelectric Effects, Semimetals, Different zone schemes, Constructions of Fermi surfaces, Experimental methods in Fermi surface studies, Quantization of orbits in a magnetic field, De Hass-Van Alphen effect, External orbits, Fermi surfaces for Cu and Au, Magnetic breakdown

UNIT III **10 Hours**

Magnetic properties: Langevin diamagnetism equation, Quantum theory of diamagnetism, Paramagnetism, Quantum theory of para-magnetism, cooling by adiabatic demagnetization, Ferromagnetism, Ferromagnetic domains, Bloch wall, Origin of domains. Magnetization at absolute zero and its temperature dependence, ferrimagnetic order and iron garnets, Anti ferromagnetic order and susceptibility, Anti ferromagnetic magnons.

UNIT IV **10 Hours**

Superconductivity: Survey of traditional and high Tc superconductors, Meissner effect, Heat capacity, Energy gap, Isotope effect, Stabilization energy density, London equations, Coherence length, Some basic ideas of BSC theory, Flux quantization in superconducting ring, Duration of persistent, currents, type II Superconductors, Estimation of HC1 and HC2, Single particle tunneling, DC and AC Josephson effects.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, ted talks, E team Teaching, Flipped Teaching, Quiz, Open talk, Case analysis

SUGGESTED READINGS:-

- *C. Kittel, Introduction to Solid State Physics, Wiley Eastern.*
- *Omar, M.A., Elementary Solid State Physics, Pearson Education.*
- *Srivastva, J.P., Elements of Solid State Physics, Prentice Hall of India.*
- *Ashcroft, N.W. and Mermin, N.D., Solid State Physics, Cengage Learning.*
- *Dekker, A.J., Solid State Physics, Macmillan.*
- *S.H. Patil, Elements of Modern Physics, Springer Cham.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Service Learning	L	T	P	Cr.
Course Code: MPY3502	0	0	4	2

Total Hours: 30

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Participate in community activities to establish connections and build relationships.

2. Evaluate community needs through conversations with community members.

3. Develop and implement initiatives that address community needs.

4. Reflect on personal growth, community impact and ethical considerations related to service activities.

Course Content

This course aims to engross students in meaningful service-learning activities that foster community linking. Students will actively participate in community-based projects, collaborate with community members and organizations and reflect on the impact of their service activities. Through this experiential learning approach, students will develop a deep understanding of community needs, build relationships with diverse stakeholders and contribute to community development. In this course, students are expected to be present in the community throughout the semester and reflect on their experiences regularly after working with them. The students will use experiential learning for providing service learning. They will be able to analyze and have understanding of the key theoretical, methodological and applied issues.

Select 10 community related activities which are to be performed in nearby villages. Students in groups of 8-10 shall work on one activity.

Evaluation Criteria

1. Every activity shall be evaluated on the same day out of 10 marks.

2. Total 10 activities out of 100 shall be evaluated and submitted to Examination branch.

Activity Evaluation

1. Type of activity- 2 marks
2. Participation of student- 2 marks
3. Engagement in the activity- 2 marks
4. Outcome of the activities- 2 marks
5. Attendance- 2 marks

Transaction Mode: Problem-solving learning, Blended learning, Gamification, Cooperative learning, Inquiry-based learning, Visualization, Group discussion, Experiential learning, Active participation.

Course Title: Condensed Matter Physics Lab	L	T	P	Cr.
Course Code: MPY3503	0	0	2	1

Total Hours:15

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Develop hands-on experience in performing experiments related to solid-state physics, semiconductor physics, and material science.
2. Utilize various measurement techniques for analyzing electrical, magnetic, and optical properties of materials.
3. Compare experimental results with theoretical models and interpret discrepancies.
4. Design and conduct experiments systematically, troubleshoot technical issues, and refine experimental setups.

Course Content

1. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap.

2. To determine the Hall coefficient of a semiconductor sample.

3. Determination of carrier concentration and mobility in semiconductors from Hall Effect.

4. Study of forward and reverse bias characteristics of a PN junction diode

5. Analysis of Zener breakdown and voltage regulation.

6. To measure the band gap of a semiconductor (Ge crystal) using four probe method.

7. To determine Planck's constant using photocell.

8. Preparation of thin films using physical or chemical deposition techniques.

9. Demonstration of magnetic levitation due to the expulsion of magnetic flux using Meissner's effect.

10. Study of polarization versus electric field behavior in ferroelectric materials.

11. Measurement of thermoluminescence response in irradiated materials.

12. Determination of magnetic susceptibility of paramagnetic materials using Quinke's method.

Note: Students will perform any 10 experiments.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e-team teaching, Group discussion, e-team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:-

- *G. L. Squires, Practical Physics, Cambridge University Press.*
- *Napier Shaw and Richard Glazebrook, Practical Physics, Nabu Press.*
- *C.L. Arora, Practical Physics, S. Chand &Co.*
- *R.S. Sirohi, Practical Physics, Wiley Eastern.*

Course Title: Radiation Physics	L	T	P	Cr.
Course Code: MPY3504	4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand properties of ionizing radiation and their applications
2. Explain the fundamental principles and working of dosimeters
3. Analyze the effects of radiations on human body
4. Learn the basics of radiation shielding and its applications.

Course Content

UNIT I **15 Hours**

Ionizing Radiations and Radiation Quantities: Types and sources of ionizing radiation, fluence, energy fluence, kerma, exposure rate and its measurement – The free air chamber and air wall chamber. Absorbed dose and its measurement; Bragg Gray Principle, Radiation dose units- rem, rad, Gray and Sievert dose commitment, dose equivalent and quality factor.

UNIT II **15 Hours**

Detectors and Dosimeters: Pocket dosimeter, films, solid state dosimeters such as TLD, SSNTD, chemical detectors and neutron detectors, Radiation detectors - Gas filled counters - general features - ionization chamber, proportional counter and GM counter.Radiation quantities and units - radiation exposure, absorbed dose, equivalent dose and effective dose

UNIT III **15 Hours**

Radiation Interaction with Matter : Interactions of electrons with matter - Specific energy loss, Coulombic mode of interactions, radiative mode of energy loss, electron range and transmission curves.Interaction of gamma rays with matter - Elastic scattering, photoelectric effect, Compton scattering, Klein-Nishina formula (qualitative) and pair production processes, cross section, gamma ray attenuation, linear and mass absorption coefficients.

UNIT IV **15 Hours**

Radiation Shielding and Protection : Thermal and biological shields, shielding, shielding materials, radiation attenuation calculations – The point kernal technique, radiation attenuation from a uniform plane source. Radiation attenuation from a line and plane source. Relative Biological Effectiveness (RBE), Linear energy transformation (LET), Dose response characteristics. Permissible dose to occupational and non-occupational workers, maximum permissible concentration in air and water, safe handling of radioactive materials.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, E-team teaching, Group discussion, ted talks, E team Teaching, Flipped Teaching, Quiz, Open talk, Case analysis.

SUGGESTED READING:

- *S.Glasstone and A. Seasonke, Nuclear Reactor Engineering, Springer Publications.*
- *Frederic Alan Smith, Primer In Applied Radiation Physics, World Scientific Publishers.*
- *Knoll G F, Radiation Detection and Measurement, John Wiley*
- *Eisenbud M, Environmental Radioactivity, Academic Press.*
- *Greening J R, Bristol, Adam Hilger, Fundamentals of Radiation Dosimetry, Medical Physics Hand Book.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Electronics Communication	L	T	P	Cr.
Course Code: MPY3505	4	0	0	4

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the basic concepts of the analog communication systems.
2. Evaluate modulation index, bandwidth and power requirements for various analog modulation schemes including AM,FM and PM.
3. Analyze various analog continuous wave modulation and demodulation techniques including AM, FM and PM.
4. Understand the influence of noise over Analog Modulation schemes through random process and noise theory and applications of Analog communication techniques.

Course Content

UNIT I **15 Hours**

Introduction to communication systems: Information, transmitter, channel noise, receiver, need for modulation, bandwidth requirements. Noise and its types. Evolution and description of single side band, suppression of carrier, the balanced modulator, suppression of unwanted side band, pilot carrier systems, ISB systems, VSB transmission, single and independent side band receivers.

UNIT II **15 Hours**

Amplitude Modulation : Representation of AM, frequency spectrum, power relations in AM wave, techniques for generation of AM, AM transmitter, AM receiver types, single and multi-superhetrodyne receivers, communication receivers.

UNIT III **15 Hours**

Frequency Modulation : Description of FM systems, mathematical representation, frequency spectrum, phase modulation, intersystem comparison, pre-emphasis and de-emphasis, comparison of wide band and narrow band FM, stereophonic FM multiplex system, FM generation techniques, FM demodulators, FM receivers.

UNIT IV **15 Hours**

Pulse Communication: Information theory, pulse modulation, types of pulse modulation, pulse amplitude modulation (PAM), pulse width modulation (PWM), pulse position modulation (PPM) and pulse code modulation (PCM), PWM transmission system, PCM transmission system, telegraphy and telemetry.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, E-team teaching, Group discussion, ted talks, E team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *Simon Haykin,An Introduction to Analog and Digital Communications, John Wiley Sons Publishers.*
- *G. Kennedy and B. Devis, Electronic communication systems, Tata McGraw Hill Publishers.*
- *W. Tomasi, Electronic communication systems, Pearson Education Asia.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Astronomy and Astrophysics	L	T	P	Cr.
Course Code: MPY3506	**4**	**0**	**0**	**4**

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Attain the knowledge of evolution, classification, formation of, stars, planets, satellites, and theory of interstellar medium.
2. Get familiar with the structure and population of the Milky Way galaxy, properties of galaxies and its classifications.
3. Learn theoretical and practical aspects of modern observational astronomy.
4. Understand and apply basic physics and computational techniques to solve problems in astrophysics, and interpret the results.

Course Content

UNIT I **15 Hours**

Introduction: Basic concepts of celestial sphere, Co-ordinate systems; Alt-azimuth, Equatorial, Right Ascension, Ecliptic, Basic stellar properties; Luminosity, apparent and absolute magnitude, photo visual and photographic magnitude system, estimation of distance using parallax method and Cepheid variables, stellar masses in binary system. Spectral classification of stars, Origin of emission and absorption spectra, Doppler Effect and its applications.

UNIT II **15 Hours**

Astronomical observations in Interstellar medium and molecular clouds: Structure of our galaxy, Globular clusters, velocity distribution of stars, origin of 21-cm radiation and interstellar gas, fine structure of Carbon, Origin of spiral arms and its basic features, Interstellar dust and theory of extinction of stellar light, molecules and molecular clouds, the galactic magnetic field, the active star forming molecular clouds.

UNIT III **15 Hours**

Stellar evolution and nucleo-synthesis: Pre-main sequence collapse, origin of the solar system, Jean's criteria, Shedding excess of angular momentum and magnetic field, T Tauri phase, Quasi-hydrostatic equilibrium, Virial theorem, Radiative and convective heat transfer, the sun on the main sequence, rates of nuclear energy generation, the standard solar model, evolution of low, intermediate and high mass stars on HR diagram.

UNIT IV **15 Hours**

Cosmology: Simple extragalactic observations, Olber's paradox, Hubble's constant and its implications, the steady state universe, Evolution of the Big Bang, hadron era, lepton era, primordial nucleosynthesis, the radiation era, the matter era, time evolution of the future universe. Tutorials: Relevant problems pertaining to the topics covered in the course.

Transaction Mode- Video Based Teaching, Collaborative teaching, Group Discussion, e- team Teaching, flipped classroom Teaching, Quiz, Open talk, Problem Analysis

SUGGESTED READINGS:

- *H.S. Goldberg and M.D. Scadron, Physics of stellar evolution and cosmology, Gordon and Breach publishers.*
- *A.E. Roy and D. Clarke, Astronomy: Principles and Practice, Adam Hilger Publishers.*
- *T. Padmanabhan, Theoretical Astrophysics (Vol. I, II, III), Cambridge University Press.*
- *BW Carroll & DA Ostlie, An Introduction to Modern Astrophysics, Latest Edition, Addison-Wesley.*
- *Frank Shu, The Physical Universe, Latest Edition, University Science Books*
- *Martin Harwit, Astrophysical Concepts, Latest Edition, Springer.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Renewable Energy Resources	L	T	P	Cr.
Course Code: MPY3507	**4**	**0**	**0**	**4**

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Design and assess the small wind turbine and its performance.
2. Enumerate the Small mini-Hydro plants for Energy generation.
3. Select the Hydro power plant capacity for the given circumstances.
4. Develop the basic technological idea about various New & Renewable energy conversion Technology.

Course Content

UNIT I **15 Hours**

Wind Energy Conversion - Wind energy conversion principles; Types and classification of WECS; Site Selection Criteria– Advantages – Limitations – Wind Rose Diagram – Indian Wind Energy Data –Organizations like NIWE etc., Wind Energy Conversion System - Design – Aerodynamic design principles; Aerodynamic theories; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss correction.

UNIT II **15 Hours**

Design of Wind Turbine - Wind turbine design considerations; Theoretical simulation of wind turbine characteristics; Test methods. Wind Energy Application – Wind pumps: Performance analysis, design concept and testing; Principle of WEG; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy utilization; Wind energy in India.

UNIT III **15 Hours**

Small Hydropower Systems - Overview of micro, mini and small hydro systems; Hydrology; Elements of pumps and turbine; Selection and design criteria of pumps and turbines; Site selection and civil work

UNIT IV **15 Hours**

Other energy conversion- Speed and voltage regulation; Investment issues load management and tariff collection; Distribution and marketing issues: case studies; Potential of small hydro power in India. –SHP – Renovation and Modernization – Testing Methods. OTEC- Tidal Energy- Geothermal- MHD - Thermionic- Thermoelectric energy conversion system- Fuel Cells – Batteries – Micro Alge – Biodiesel from Algae

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e-team teaching, Group discussion, e- team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:

- *G L Johnson, Wind Energy Systems, Prentice Hall Inc, New Jersey, 1985.*
- *David A. Spera, (Editor) Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, American Society of Mechanical Engineers; (1994)*
- *Erich Hau, Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer Publications.*
- *Paul Gipe , Karen Perez, Wind Energy Basics: A Guide to Small and Micro Wind Systems, Chelsea Green Publishing Company.*
- *J. F. Manwell, J. G. McGowan, A. L. Rogers, Wind Energy Explained, John Wiley & Sons.*
- *Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi, Wind Energy Handbook, John Wiley & Sons.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Plasma Physics	L	T	P	Cr.
Course Code: MPY3508	**4**	**0**	**0**	**4**

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Define plasma state, give examples of different kinds of plasma and explain the parameters characterizing them
2. Analyze the motion of charged particles in electric and magnetic fields
3. Make estimates of various parameters in plasmas
4. Explain the properties of the most important wave modes in plasma.

Course Content

UNIT I **15 Hours**

Basics of Plasmas: Occurrence of plasma in nature, Debye shielding and plasma parameter. Single particle motions in uniform E and B, non-uniform magnetic field, grad B and curvature drifts, invariance of magnetic moment and magnetic mirror. Boltzman equation: Fluid model of a plasma, Two fluid and one fluid equations, Collision less Boltzman equation, Moment equations and conservation laws, Transport phenomena in plasma: Fokker Planck equations.

UNIT II **15 Hours**

Motion of charged particles: Motion of charged particles in a constant uniform magnetic field, Constant and uniform electric and magnetic fields, Inhomogeneous magnetic field. Constant non-electromagnetic forces, Time varying magnetic field, constant magnetic and time varying electric field, Adiabatic invariants, Magnetic mirrors.

UNIT III **15 Hours**

Magneto hydrodynamics: Generalized Ohm's law, MHD equations, MHD equilibrium, Force free fields. MHD Stability: Normal mode technique, Sausage and kink instability in a linear pinch, Energy principle, interchange instabilities, Cusp configuration, two stream, Ion-acoustic drift, Firehose instabilities.

UNIT IV **15 Hours**

Waves in Plasma: Plasma oscillations, Electron plasma waves, Ion waves, Electrostatic electron and ion oscillations in a magneto-plasma, Electromagnetic waves propagation through a plasma and magneto-plasma, Alfven waves and magneto-sonic waves.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, E-team teaching, Group discussion, ted talks, E team Teaching, Flipped Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *Donald A. Gurnett, Introduction to Plasma Physics, Cambridge University Press.*
- *S.N.Sen,Plasma Physics, Pragati Publications.*
- *Basudev Ghosh,Basic Plasma Physics,Narosa Publishing House.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Advanced Quantum Mechanics	L	T	P	Cr.
Course Code: MPY3509	4	0	0	4

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Apply time independent and time dependent perturbation theories to solve different problems.
2. Take up research in frontier areas like quantum information, quantum computation, quantum entanglement, quantum fields and quantum gravity.
3. Demonstrate basic concepts of scattering amplitude, symmetries in scattering and to solve scattering problems, to work with partial wave analysis.
4. Use approximate method in Quantum Mechanics to treat molecules.

Course Content

UNIT I 15 Hours

Perturbation Theory: Time independent perturbation theory for non-degenerate levels, first order Zeeman Effect in H-atom, second order Zeeman Effect in H-atom, Hydrogen Molecule─ Heitler-London Treatment Time dependent perturbation theory, Fermi Golden Rule, Harmonic perturbation, Application of Time dependent theory to Alpha-Scattering and ionization of Hydrogen atom, Adiabatic and Sudden perturbations.

UNIT II 15 Hours

W.K.B. Approximation and Scattering Theory: The W.K.B. Approximation, validity of W.K.B. Approximation, Turning points and Connection formulae, The Variational Method, Applications of Variational Method─ Ground state energy of hydrogen atom, normal state of helium atom. Scattering Amplitude of Spinless Particles, Scattering Amplitude and Differential Cross Section, First Born Approximation, Validity of the First-Born Approximation.

UNIT III 15 Hours

Relativistic Quantum mechanics: Schrodinger's Relativistic equation, Probability and current densities, Klein-Gorden equation in presence of electromagnetic field, Application of Klein-Gorden equation to hydrogen atom. Dirac's Relativistic equation for a free electron, Free particle solution, Negative energy states, Probability and current densities, Dirac's equation in electromagnetic field, Dirac's equation in a central field─ the electron spin, spin orbit energy, Covariance of Dirac's equation.

UNIT IV **15 Hours**

Quantum Computation: Classical vs. quantum computation, Qubits and superposition, Single-qubit and multi-qubit gates, Quantum circuits representation. Measurement postulates and wavefunction collapse, Bell states and quantum teleportation. Introduction to Quantum Algorithms : Deutsch's Algorithm, Grover's Search Algorithm (conceptual)

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *Thankappan, V.K. , Quantum Mechanics, New Age International Publications, New Delhi,*
- *Mathews P.M. and Venkatesh K.,Quantum Mechanics, Tata-McGraw Pub., New Delhi.*
- *Greiner W., Quantum Mechanics, Springer Verlag Publishers, Germany.*
- *Sakurai J.J., Modern Quantum Mechanics, Addison Wesley Pub., USA.*
- *Nielsen, M. A., & Chuang, I. L. (2010). Quantum computation and quantum information (10th Anniversary ed.). Cambridge University Press.*
- *Mermin, N. D. (2007). Quantum computer science: An introduction. Cambridge University Press.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Semester – IV

Course Title: Experimental Techniques in Physics	**L**	**T**	**P**	**Cr.**
Course Code: MPY4550	**4**	**0**	**0**	**4**

Total Hours 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Enhance in depth about thin film preparation and production controlling techniques and the application of thin films in the field of science & Technology.
2. Acquire knowledge about different material analysis techniques and applications.
3. Obtain employment in research and development, in the scientific or engineering industries.
4. Explain about XRD, TEM and other techniques for thin film characterization.

Course Content

UNIT I **15 Hours**

Introduction and Preparation Methods: Basic of Thin films and nanostructures, Role of thin films in Devices .Physical methods: Thermal evaporation, Cathodic sputtering, Molecular beam epitaxy and Laser ablation methods. Chemical methods: Electrolytic deposition, Chemical vapor deposition.

UNIT II **10 Hours**

Thickness Measurement and Characterization: Electrical, Mechanical, Optical, Microbalance, Quartz crystal methods and Analytical techniques of characterization: X-ray diffraction, Electron microscopy, High and low energy electron diffraction, Auger emission spectroscopy.

UNIT III **10 Hours**

Transducers and Temperature Measurements: Classification of transducers, Selecting a transducer, qualitative treatment of strain gauge, capacitive transducers, inductive transducers, linear variable differential transformer (LVDT), photoelectric transducers, piezoelectric transducers, temperature measurements (Resistance thermometer, thermocouples, Thermistors).

UNIT IV **10 Hours**

Vacuum& Low Temperature Techniques: Vacuum techniques, Basic idea of conductance, pumping speed, Pumps: Mechanical pumps, Diffusion pumps, Ionization pumps, turbo molecular pumps, gauges; Penning, Pirani, Hot cathode, Low temperature: Cooling a sample over a range up to 4 K and measurement of temperature.

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:

- *Cooper W.D. and Helfrick A.D.,Electronic Instrumentation and Measurement Techniques, Prentice Hall of India Pvt. Ltd.*
- *Herzberg G., Molecular Spectra and Molecular Structure, Van Nostrand Publishers.*
- *Dr. PatilShriram B, Experimental Physics, Wordit Content Design & Editing Services Pvt Ltd.*
- *Rao, V. V., Gosh, T. B., & Chopra, K. L.,Vacuum science and Technology, Allied Publishers.*
- *Glang, R., Maissel, L. I.,Handbook of Thin Film Technology, Leon*
- *I. Maissel and Reinhard Glang, McGraw-Hill Book Company.*
- *Chopra, K. L.,Thin film phenomena. R. E. Krieger Publishing Company.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
- *George, J., Preparation of thin films. CRC Press.*

Course Title: Technical Writing for Scientific Communication	L	T	P	Cr.
Course Code: MPY4551	2	0	0	2

Total Hours 30

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the fundamentals of scientific research, including research methodologies, problem formulation, and ethical considerations.
2. Develop proficiency in technical writing, enabling them to effectively communicate scientific concepts through research papers, reports, and proposals.
3.Gain expertise in data visualization, citation management, and the use of digital tools for organizing research work.
4.Enhance their ability to present scientific research through oral presentations, posters, and dissertations with clarity and professionalism.

Course Content

UNIT I **7 Hours**

Introduction to Scientific Research: Definition and scope of scientific research, Types of research: Theoretical, experimental, and computational. Identifying research problems, setting objectives, and formulating hypothesis. Importance of literature review and sources of information (journals, books, online databases). Plagiarism, falsification, fabrication, and authorship guidelines.

UNIT II **8 Hours**

Technical Writing for Scientific Communication : Structure and components of research papers, reports, and proposals, Writing abstracts, introductions, methodology, results, and discussions. Citation styles and referencing: APA, IEEE, Chicago, and Harvard. Tools for scientific writing: LaTeX vs. Microsoft Word. Formatting, structuring, and referencing in a thesis or dissertation. Importance of proofreading and peer review in scientific writing

UNIT III **8 Hours**

Data Presentation and Visualization: Principles of effective data representation in research, Tables, figures, and graphs: Selection and proper formatting. MATLAB, Origin, Python (Matplotlib, Seaborn). Writing effective figure captions and explanations. Common mistakes in data presentation and how to avoid them. Best practices for reporting statistical results and uncertainties.

UNIT IV **7 Hours**

Scientific Presentation and Research Dissemination: Techniques for preparing effective PowerPoint presentations for seminars and conferences, Layout, content selection, and visual appeal of scientific poster, structuring content, clarity, and audience engagement for oral presentation skills. Handling Q&A sessions and responding to critical feedback, writing research summaries and press releases for wider dissemination, peer review process and impact factors

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READINGS:

- *Kumar, R. (2019). Research methodology: A step-by-step guide for beginners (5th ed.). SAGE Publications.*
- *Turabian, K. L., Booth, W. C., Colomb, G. G., & Williams, J. M. (2018). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (9th ed.). University of Chicago Press.*
- *Alley, M. (2013). The craft of scientific presentations: Critical steps to succeed and critical errors to avoid (2nd ed.). Springer.*
- *Lamport, L. (1994). LaTeX: A document preparation system (2nd ed.). Addison-Wesley.*
- *McKinney, W. (2022). Python for data analysis: Data wrangling with pandas, NumPy, and Jupyter (3rd ed.). O'Reilly Media.*
- *Hunter, J. D., & Droettboom, M. (2021). Matplotlib for Python developers. Packt Publishing.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Dissertation	L	T	P	Cr.
Course Code: MPY4552	**0**	**0**	**0**	**12**

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Gain in-depth knowledge and use adequate methods in the major subject/field of study.
2. Create, analyze and critically evaluate different technical/research solutions
3. Clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings
4. Identify the issues that must be addressed within the framework of the specific dissertation in order to take into consideration

Course Content

The aim of dissertation in M.Sc. 4th semesters is to expose of the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc. Dissertation can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department before the end of the 3rd semester. A report of about 30 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the GKU.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per guidelines prepared by the GKU.

Credits for Final Dissertation Report & Viva Voce: 20

All the candidates of MCA final project are required to submit a project report based on the work done by him/her during the project period. A student will submit his/her project report in the prescribed format. A student has to submit:

two hard copies of the project report, and a soft copy of project on CD/DVD in a thick envelope pasted inside of the back cover of the dissertation report.

Prescribed outline for the Dissertation Report

1. Title Page (format as in Anenxure-1)
2. Declaration (format as in Anenxure-1)
3. Certificate from the Project Guide on letter head of an organization (format as in Anenxure-1)
4. Acknowledgement
5. Abstract
6. Index
7. List of Figures
8. List of Tables
9. List of acronyms and abbreviations
10. Introduction to the project
11. Statement of the Problem
12. Theoretical Background / Literature review
13. Experimental details.
14. Results
15. Conclusions and Future Work
16. References
17. Annexure (optional)

Formatting Instructions:

Margins: Left margin-1.3 inch, Right margin-1 inch, Top margin: 1 inch, Bottom margin:1 inch Page numbers–All pages should be numbered at the bottom center of the pages.

Normal Body Text: Font Size: 12, Times New Roman, 1.5 Spacing, Justified. 6 point above and below paragraph spacing. Section Heading: Font Size: 14, Times New Roman, Underlined, Left Aligned. 12 point above & below spacing.

Chapter Heading: Font Size: 20, Times New Roman, Centre Aligned, 30 point above and below spacing.

Figure and Table Captions: Font Size: 12, Times New Roman, centered.

Coding Font: size: 10, Courier New, Normal Good quality white paper A4 size should be used for typing and duplication.

Course Title: High Energy Physics	L	T	P	Cr.
Course Code: MPY4553	4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand that all leptons and quarks have corresponding antiparticles.
2. Appreciate that quarks and anti-quarks combine to form baryons, anti-baryons and mesons.
3. Write balanced strong interactions, understanding the role of gluons
4. Write balanced weak interactions, understanding the role of W and Z bosons

Course Content

UNIT I **15 Hours**

Symmetry properties: General features of conservation laws in quantum theory, Parity conservation, Operators and transformation, Isospin, G-parity, Conservation of Isospin, Generalized Pauli principle; Conservation laws: Baryon and lepton and flavor non-conservation. Positronium decay, Application of Isospin conservation to NN interaction and strong-decays.

UNIT II **15 Hours**

Resonances: Observation and properties of Resonances; Tau-theta problem , Observation of Tau-lepton and new flavors., Parity violation in weak interaction, K^0-K bar mixing, C and CP violation, CPT theorem (statement only).

UNIT III **15 Hours**

Gauge theories of fundamental interactions: Higgs Mechanism and its application in gauge theories, Elements of QED, Global and local gauge invariance, Feynman diagrams, Successes of QED; Current-current interaction and V-A theory, Cabibbo modification. Introduction to GSW model and limitations of QED. Strong interaction theory of quarks and gluons (QCD),

UNIT IV **15 Hours**

Recent developments in high energy physics: Supersymmetry, extra dimensions, neutrino oscillations and link with cosmology (QUALITATIVE TREATMENT ONLY).

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *D.J. Griffiths, Introduction to Elementary Particles, Wiley-VCH Publishers.*
- *D.H.Perkins, Introduction to High Energy Physics,Cambridge University Press.*
- *F. Halzen and A D Martin, Quarks and Leptons, John Wiley & Sons.*
- *T Ferbal, Experimental Techniques in High Energy Nuclear and particle Physics:World Scientific Press.*
- *F. Sauli, Instrumentation in High Energy Physics, World Scientific Press.*
- *D.M. Ritson,Techniques of High Energy Physics, Interscience Publishers.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Computational Physics	L	T	P	Cr.
Course Code: MPY4554	4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the fundamentals of numerical methods and their applications in solving physical problems.
2. Develop programming skills using computational tools such as Python, MATLAB, or C++.
3. Apply computational techniques to solve problems in classical mechanics, electrodynamics, quantum mechanics, and statistical physics.
4. Gain hands-on experience in visualizing and analyzing simulation results for various physical systems.

Course Content

UNIT I **15 Hours**

Introduction to Computational Physics and Numerical Methods: Role of computation in physics and comparison with analytical methods, Basics of programming languages for computational physics (Python, MATLAB, C++), Errors in numerical computation: Round-off errors, truncation errors, and numerical stability, Root-finding methods: Bisection method, Newton-Raphson method, Secant method, Interpolation and curve fitting: Lagrange interpolation, least-square fitting.

UNIT II **15 Hours**

Numerical Differentiation and Integration: Finite difference methods for numerical differentiation, Numerical integration techniques: Trapezoidal rule, Simpson's rule, Gaussian quadrature, Applications of numerical differentiation and integration in physics, Solving boundary value problems and applications in electrodynamics and quantum mechanics

UNIT III **15 Hours**

Solution of Ordinary and Partial Differential Equations : Euler and Runge-Kutta methods for solving ordinary differential equations (ODEs), Finite difference method for solving partial differential equations (PDEs), Applications:

Motion of a pendulum, damped and driven oscillators, Schrödinger equation. Introduction to Monte Carlo methods for solving physics problems

UNIT IV **15 Hours**

Simulation of Physical Systems: Simulation of one- and two-body problems in classical mechanics, Random number generation and its applications in statistical physics. Role of AI in computational physics, Supervised vs. unsupervised learning, Neural networks for solving physical equations, AI-enhanced Monte Carlo simulations, Pattern recognition and anomaly detection, Feature extraction techniques (PCA, t-SNE)

Transaction Mode- Video Based Teaching, Collaborative teaching, Project based learning, e--team teaching, Group discussion e- team Teaching, Flipped classroom Teaching, Quiz, Open talk, Problem Analysis.

SUGGESTED READING:

- *Computational Physics – Mark Newman (Princeton University Press)*
- *Numerical Recipes in C: The Art of Scientific Computing – William H. Press et al. (Cambridge University Press).*
- *An Introduction to Computational Physics – Tao Pang (Cambridge University Press).*
- *Computational Physics: Problem Solving with Python – Rubin H. Landau, Manuel J. Páez, and Cristian C. Bordeianu (Wiley)*
- *Carleo, G., Cirac, I., Cranmer, K., Daudet, L., Schuld, M., Tishby, N., Vogt-Maranto, L., & Zdeborová, L. (2019). Machine learning and the physical sciences. Reviews of Modern Physics, 91(4), 045002.*
- *Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.*