Scheme of Instruction & Syllabi

For

Master of Science

in

Physics

Two Years CBCS M.Sc. Course in Physics

(Academic Session: 2026-27)

Second Year

Department of Applied Sciences & Humanities

INVERTIS UNIVERSITY

Invertis Village

Bareilly-Lucknow NH-24, Bareilly-243123, India

M.Sc. (Physics)

This program provides an ability to identify and solve significant problems across a broad range of application areas, to develop the aptitude to apply the principles of Physics and to articulate an in-depth understanding of advanced knowledge on various areas of Physics. It is designed to help students understand the importance of physical advancements in industry and the role of these in improving the quality of human life.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The program acts as the advanced degree and helps to develop critical, analytical and problem-solving skills at an advanced level. The foundation degree makes the students employable in scientific organizations and also to assume administrative positions in various types of organizations. It also helps the students to pursue a career in academics or scientific organizations as a researcher.

The Program Educational Objectives are to prepare the students to:

PEO-1. **Work independently or in a team with engineering, medical, ICT professionals and scientists in scientific problem solving.**

PEO-2. **Act as administrators in public, private and government organizations or business administrators with further training and education.**

PEO-3. **Pursue Doctoral research degrees to work in colleges, universities as professors or as scientists in research establishments.**

Program Outcomes of M.Sc. (Physics)

PO1: Students will have a firm foundation in the fundamentals and application of current scientific theories in different areas of Physics.

PO2: Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

PO3: Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO4: Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.

PO5: Students will be able to explore new areas of research in both physics and allied fields of science and technology.

PO6: Students will appreciate the pivotal role of physics in our society and use this as a basis for ethical behavior.

PO7: Students will be able to function as a member of an interdisciplinary problem-solving team.

PO8: Students will have specific skills in planning and conducting advanced experiments and applying structural-physical characterization techniques.

PO9: Students will be able to use modern instrumentation and classical techniques, to design experiments, and to properly record the results of their experiment.

PO10: Students will be able to use modern library searching and retrieval methods to obtain information about a topic, techniques, or an issue relating to physics.

PO11: Students should be able to communicate scientific results in writing and in oral presentation.

PO12: Students should become proficient in their specialized area of physics and acquire the basic tools needed to carry out independent cutting-edge research in physics.

M.Sc. Previous (PHYSICS)
Proposed Course Structure

Semester – I

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 1	MPY101	Mathematical Physics	3	1	0	30	70	100	4
2	Paper 2	MPY102	Classical Mechanics	3	1	0	30	70	100	4
3	Paper 3	MPY103	Quantum Mechanics-I	3	1	0	30	70	100	4
4	Paper 4	MPY104	Electromagnetic Theory	3	1	0	30	70	100	4
5	Paper 5	EPC001	AI Based English Proficiency Course - I	0	0	0	0	50	50	2
6	Lab 1	MPY151	Physics Lab I	0	3	6	50	100	150	6
	Total			**12**	**7**	**6**	**170**	**430**	**600**	**24**
L-Lecture, T-Tutorial, P- Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

Semester – II

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 6	MPY201	Condensed Matter Physics	3	1	0	30	70	100	4
2	Paper 7	MPY202	Atomic and Molecular Physics	3	1	0	30	70	100	4
3	Paper 8	MPY203	Nuclear and Particle Physics	3	1	0	30	70	100	4
4	Paper 9	MPY204	Statistical Physics	3	1	0	30	70	100	4
5	Paper 10	EPC002	AI Based English Proficiency Course - II	0	0	0	0	50	50	2
6	Lab 2	MPY251	Physics Lab II	0	3	6	50	100	150	6
	Total			**12**	**7**	**6**	**170**	**430**	**600**	**24**
L-Lecture, T-Tutorial, P- Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

M.Sc. Final (PHYSICS)
Proposed Course Structure
FOR SPECIALIZATION IN ELECTRONICS

Semester – III

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 11	MPY301	Advanced Laser Physics	3	1	0	30	70	100	4
2	Paper 12	MPY302	Computational Physics	3	1	0	30	70	100	4
3	Paper 13	MPY303	Semiconductor Devices and Integrated Circuits	3	1	0	30	70	100	4
4	Paper 14	MPY311	Digital Electronics and Microprocessors	3	1	0	30	70	100	4
5	Lab 3	MPY351	Electronics Laboratory	0	3	6	50	100	150	6
6	Lab 4	MPY352	Computational Physics Laboratory-1	0	0	4	15	35	50	2
7	Field Lab	MPY350	Field Project/Internship	–	–	–	30	70	100	4
	SEMESTER TOTAL			**12**	**7**	**10**	**215**	**485**	**700**	**28**
L-Lecture, T-Tutorial, P- Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

Semester - IV

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 15	MPY401	Quantum Mechanics - II	3	1	0	30	70	100	4
2	Paper 16	MPY411	Modern Communication Electronics	3	1	0	30	70	100	4
3	Paper 17	MPY412	Semiconductor Devices Fabrication	3	1	0	30	70	100	4
4	Lab 5	MPY451	Advanced Electronics Laboratory	0	3	6	50	100	150	6
5	Lab 6	MPY452	Computational Physics Laboratory-II	0	0	4	15	35	50	2
6	Project	MPY450	Project Work	–	–	–	100	100	200	8
	Total			**9**	**6**	**10**	**255**	**445**	**700**	**28**
L-Lecture, T-Tutorial, P- Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

***Student can carry out Field Project/Internship during any semester break of the program**

FOR SPECIALIZATION IN MATERIAL SCIENCES

Semester - III

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 11	MPY301	Advanced Laser Physics	3	1	0	30	70	100	4
2	Paper 12	MPY302	Computational Physics	3	1	0	30	70	100	4
3	Paper 13	MPY303	Semiconductor Devices and Integrated Circuits	3	1	0	30	70	100	4
4	Paper 14	MPY321	Structure of Materials	3	1	0	30	70	100	4
5	Lab 3	MPY353	Material Science Laboratory	0	3	6	50	100	150	6
6	Lab 4	MPY352	Computational Physics Laboratory-1	0	0	4	15	35	50	2
7	Field Lab	MPY350	Field Project/Internship	–	–	–	30	70	100	4
	SEMESTER TOTAL			**12**	**7**	**10**	**215**	**485**	**700**	**28**
L-Lecture, T-Tutorial, P-Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

Semester - IV

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 15	MPY401	Quantum Mechanics - II	3	1	0	30	70	100	4
2	Paper 16	MPY421	Properties of Materials	3	1	0	30	70	100	4
3	Paper 17	MPY422	Nano Materials	3	1	0	30	70	100	4
4	Lab 5	MPY453	Advanced Materials Science Laboratory	0	3	6	50	100	150	6
5	Lab 6	MPY452	Computational Physics Laboratory-II	0	0	4	15	35	50	2
6	Project	MPY450	Project work	–	–	–	100	100	200	8
	Total			**9**	**6**	**10**	**255**	**445**	**700**	**28**
L-Lecture, T-Tutorial, P-Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

*__Student can carry out Field Project/Internship during any semester break of the program__

FOR SPECIALIZATION IN QUANTUM COMPUTING

Semester - III

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 11	MPY301	Advanced Laser Physics	3	1	0	30	70	100	4
2	Paper 12	MPY302	Computational Physics	3	1	0	30	70	100	4
3	Paper 13	MPY303	Semiconductor Devices and Integrated Circuits	3	1	0	30	70	100	4
4	Paper 14	MPY331	Quantum Computing-Theory	3	1	0	30	70	100	4
5	Lab 3	MPY354	Quantum Computing Laboratory-I	0	3	6	50	100	150	6
6	Lab 4	MPY352	Computational Physics Laboratory-I	0	0	4	15	35	50	2
7	Field Lab	MPY350	Field Project/Internship	–	–	–	30	70	100	4
	SEMESTER TOTAL			**12**	**7**	**10**	**215**	**485**	**700**	**28**
L-Lecture, T-Tutorial, P- Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

Semester – IV

S.No	Paper	Code	Subjects	Teaching Scheme			Marks Distribution			Credit
				L	T	P	CA	EE	Total	
1	Paper 15	MPY401	Quantum Mechanics - II	3	1	0	30	70	100	**4**
2	Paper 16	MPY431	Quantum Algorithms & Complexity	3	1	0	30	70	100	4
3	Paper 17	MPY432	Quantum Hardware, Error Correction & Applications	3	1	0	30	70	100	4
4	Lab 5	MPY454	Quantum Computing Laboratory-II	0	3	6	50	100	150	6
5	Lab 6	MPY452	Computational Physics Laboratory-II	0	0	4	15	35	50	2
6	Project	MPY450	Project work	–	–	–	100	100	200	8
	Total			**9**	**6**	**10**	**255**	**445**	**700**	**28**
L-Lecture, T-Tutorial, P- Practical, CA-Continuous Assessment, EE-Examination Evaluation.										

***Student can carry out Field Project/Internship during any semester break of the program**

FOR SPECIALIZATION IN ELECTRONICS

Semester-III

MPY301: Advanced Laser Physics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment - 6 Marks Attendance -12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic understanding of optics, wave nature of light, and electromagnetic radiation.
2. Fundamental knowledge of atomic structure, energy levels, and introductory quantum physics.

Course Objectives:

1. To develop an understanding of laser fundamentals, laser systems, and light–matter interactions.
2. To provide knowledge of holography, optical fibre technology, and advanced spectroscopic techniques using lasers.
3. To familiarize students with the scientific, medical, industrial, and communication applications of lasers and optical technologies.

Detailed Syllabus:

Unit-1: Laser Fundamentals

Spontaneous and stimulated emission; Einstein coefficients; Population inversion, pumping, gain, optical cavities, Properties: Temporal and Spatial Coherence, directionality, Main components of Laser, Principle of Laser action, Introduction to general lasers and their types, Three & four level Lasers, CW & Pulsed Lasers.

Unit-2: Types of Lasers

Atomic, Ionic, Molecular, Excimer, Liquid, Solid State, Semiconductor and fibre laser: Construction, Working principles and applications.

Unit-3: Holography and Fibre Optics

Principle of holography, Recording and reconstruction of holograms, Types and applications of holography, HNDT (Holographic Non-Destructive Testing), Holographic storage, Optical fibre principle, Acceptance angle, Numerical aperture, Types of optical fibres, Fibre losses, Dispersion, Fiber Optical communication, Fibre amplifiers and optical sensors.

Unit-4: Lasers in Science

Saturation spectroscopy, Excited state spectroscopy, Nonlinear spectroscopy, Time domain spectroscopy and its applications, Stimulated Raman Emission, Laser fusion, Medical applications of lasers, Photo-chemical applications.

Unit-5: Lasers in industry

Materials processing; Drilling; Cutting; Welding; Alloying; Thermal Deposition, Laser Chemical Vapour Deposition (LCVD), Laser Hardening, Annealing, LIDAR.

Text and Reference Books:

1. J.T. Cuxon and D.E. Parker, *Industrial Lasers and their Applications,* Prentice Hall of India Pvt. Ltd.
2. F.C. Appard, *Fiber Optics Handbook,* McGraw-Hill.
3. K. Thyagarajan and A.K. Ghatak, *Lasers: Theory and Applications*.
4. K. Koebner (ed.), *Industrial Applications of Lasers*, Wiley.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the fundamentals of laser action, laser systems, holography, and optical fibre communication.
CO2.	**Explain** the working principles and characteristics of different types of lasers, holography, and optical fibres.
CO3.	**Apply** laser principles to spectroscopy, optical communication, and holographic techniques.
CO4.	**Analyze** the performance and applications of lasers, optical fibres, and holographic systems in scientific and technological fields.
CO5.	**Evaluate** the suitability of laser-based techniques for spectroscopy, medical diagnostics, material processing, and communication systems.
CO6.	**Design** laser-based solutions for applications in science, industry, medicine, and optical communication.

MPY302: Computational Physics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment - 6 Marks Attendance - 12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic knowledge of computer programming concepts and mathematical logic.
2. Fundamental understanding of physics and numerical methods for scientific computing.

Course Objectives:

1. To develop programming skills using C++ and Python for scientific and engineering applications.
2. To introduce numerical computing, data analysis, visualization, signal processing, and scientific computing tools in Python.
3. To familiarize students with Particle-in-Cell (PIC) simulation techniques for solving plasma physics problems.

Detailed Syllabus:

Unit-1: C++ Programming

C++ programming basics; Arithmetic operators; Library functions, Data input and output; Relational operators; Control statements; Looping, arrays and functions; Simple programs; User defined functions; Passing arguments; Pointers and pointer declarations; Passing pointers to functions; Structures and classes; Array of structures/objects; Unions; File operations.

Unit-2: Introduction to Python

Python environment; Working with data sets; Data input/output; Logical variables and operators; Arrays and X-Y plotting using NumPy and Matplotlib; Simple graphics; Data types - lists, tuples, dictionaries and arrays; Strings; Manipulating data of different types; File input/output; Python scripts and modules; Simple programs.

Unit-3: Python Scientific Tools

SciPy signal processing module; Digital and analog filter design; Spectral analysis; Filtering and discrete FFTs; Z-transform; DFT and FFT using NumPy/SciPy; PyWavelets for wavelet transform; Instrument control using Python (PyVISA); Solving partial differential equations with Python (FEniCS/finite element method).

Unit-4: Particle-in-cell Codes I

Introduction; Use of PIC code in Plasma Physics: Compute Charge Density, Compute Electric Potential: performed by solving the Poisson equation.

Unit-5: Particle-in-cell Codes II

Compute Electric Field: from the gradient of potential, Move Particles: update velocity and position from Newton's second law, Generate Particles: sample sources to add new particles.

Text and Reference Books:

1. Bjarne Stroustrup, The C++ Programming Language, Addison-Wesley.
2. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw-Hill.
3. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press.
4. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer.

Course Outcomes:

After completing the course, students will be able to achieve the following:

CO1.	**Recall** the basic concepts of C++, including functions, arrays, classes, and Python scientific tools such as NumPy, SciPy, signal processing, and filtering.
CO2.	**Explain** the methods used for signal processing, filtering, and electric field computation in PIC code.
CO3.	**Implement** filtering techniques such as DFT and FFT using Python (NumPy/SciPy) and mathematical methods such as iteration techniques using C++.
CO4.	**Analyze** PIC code using parameters such as charge density, electric potential, and related computational variables.
CO5.	**Evaluate** the performance of signal processing and filtering methods using Python and assess the effectiveness of mathematical methods implemented in C++.
CO6.	**Design** and develop a program to solve computational problems with improved accuracy and efficiency.

MPY303: Semiconductor Devices and Integrated Circuits

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisite:

1. Basic understanding of semiconductor physics and electronic devices.
2. Fundamental knowledge of analog and digital electronic circuits.

Course Objectives:

1. To develop an understanding of semiconductor devices and their physical principles and current-voltage characteristics.
2. To familiarize students with the working principles of bipolar and field-effect transistors and their applications in electronic circuits.
3. To develop knowledge of analog integrated circuits, operational amplifiers, waveform generators, voltage regulators, and special function ICs for electronic system design.

Detailed Syllabus:

Unit-1: Semiconductor Fundamentals and p-n Junction Devices

Carrier concentration and statistics in semiconductors, Generation and recombination processes, Continuity equation, p-n junction diode: formation, energy band diagram, current-voltage characteristics, Diode capacitance, Zener and Avalanche breakdown, Tunnel diode, Varactor diode, LED and photodiode.

Unit-2: Bipolar and Field Effect Transistors

BJT: construction, working, current components, Ebers-Moll model, biasing techniques, small signal equivalent circuits, JFET: construction and working, pinch-off voltage, V-I characteristics, MOSFET: enhancement and depletion type, threshold voltage, output and transfer characteristics, CMOS technology basics.

Unit-3 Integrated Circuits: Op-amp

Classification, chip size and circuit complexity, basic information of Op-amp, ideal and practical Op-amp, General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, modes of operation-inverting, non-inverting, differential, Applications (linear and nonlinear).

Unit-4: Waveform Generators and Special Function ICs:

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, IC 555 Timer and its applications - Block diagram, Monostable and Astable multivibrator, Applications as Frequency divider, Square wave generator; IC 565 Phase Locked Loops and its Applications - Block diagram and operation, Applications as Frequency Multiplier, Frequency Shift Keying, Design of Power Supply - Simple op-amp voltage regulator, Three terminal voltage regulators, Fixed and adjustable voltage regulators (78XX, LM317), Heat sink, Dual power supply (LM320, LM317), Monolithic switching regulator, Frequency to Voltage and Voltage to Frequency converters.

Unit-5: Digital ICs:

TTL and CMOS, Introduction to memory ICs: ROM, RAM, and their classification.

Text and Reference Books:

1. Sze S.M., *Semiconductor Devices Physics and Technology*, Wiley.
2. Streetman Ben G., *Solid State Electronics*, Prentice Hall of India Pvt. Ltd.
3. Robert Boylestad, Louis Nashelsky, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education.
4. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, Prentice Hall of India.
5. Jacob Millman and Christos C. Halkias, *Integrated Electronics*, Tata McGraw-Hill.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** the principles, construction, characteristics, and terminology of semiconductor devices, transistors, operational amplifiers, waveform generators, voltage regulators, and digital ICs.
CO2.	**Explain** the operation, characteristics, and applications of p-n junction devices, BJTs, FETs, operational amplifiers, special function ICs, and memory devices.
CO3.	**Apply** the principles of semiconductor devices and integrated circuits to analyze transistor biasing, op-amp configurations, waveform generation, and regulated power supply circuits.
CO4.	**Analyze** the performance and characteristics of semiconductor devices, amplifier circuits, waveform generators, PLLs, and digital logic families using their equivalent models and characteristics.
CO5.	**Evaluate** the suitability and performance of semiconductor devices, ICs, TTL/CMOS technologies, and voltage regulators for specific electronic applications.
CO6.	**Design** basic analog and digital electronic circuits using semiconductor devices, operational amplifiers, timers, PLLs, voltage regulators, and memory ICs to meet specified functional requirements.

MPY311: Digital Electronics and Microprocessors

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of digital electronics, binary numbers, and logic gates.
2. Fundamental knowledge of electronic circuits and computer organization.

Course Objectives:

1. To develop a strong foundation in number systems, Boolean algebra, logic simplification techniques, and digital logic design.
2. To introduce combinational and sequential logic circuits, logic families, digital memories, and data conversion techniques used in digital electronic systems.
3. To familiarize students with the architecture, instruction set, and basic programming of the Intel 8085 microprocessor and its applications in digital systems.

Detailed Syllabus:

Unit 1: Number Systems, Binary codes and Boolean Algebra:

Review of number systems, binary codes, code conversion, binary addition, subtraction using 1's and 2's complement methods, binary multiplication and division as done by computers, Boolean algebra, basic logic gates (AND, OR, NOT, NAND, NOR) and their realization using diodes and transistors, Ex-OR and Ex-NOR gates and their application in parity generation and checking parity, Representation of Boolean expressions: SOP and POS forms, Product of Sums simplifications, Min-terms and Max-terms, Karnaugh maps (up to six variables), pairs, quads and octets, K-map simplifications.

Unit-2, Logic families

DTL, TTL, ITL, ECL, MOS and CMOS.

Unit 3: Combinational and Sequential Logic

Half adder and full adder, half and full subtractor, comparator; multiplexer and demultiplexer; encoder and decoder.

Flip-flops — RS, JK, JK master–slave, D, T; asynchronous and synchronous counters, Mod counters, shift registers (SISO, SIPO, PISO, PIPO); digital memories —ROM, PROM, RAM RAM & PLA.

Unit 4: Data Converters and Microprocessor

D/A converter — ladder network; A/D converter; basic organisation of a digital computer; Intel 8085 microprocessor — architecture, instruction set and simple illustrative programs.

Text and Reference Books:
1. M. Morris Mano and Michal D. Ciletti, Digital Design (4th Edition), Pearson 2. Donald P Leach & A.P. Malvino, Digital Principles and Applications, Glencoe (1995) 3. A. Anand Kumar, Fundamentals of Digital Circuits, Prentice Hall India (2004) 4. R.P. Jain, Modern Digital Electronics, Mc Graw Hill (2009) 5. Hertbert Taub and Donald L Schilling, Digital Integrated Electronics, Mc Graw Hill

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** the fundamentals of number systems, binary arithmetic, Boolean algebra, logic families, combinational and sequential logic circuits, data converters, and the architecture and instruction set of the Intel 8085 microprocessor.
CO2.	**Explain** the principles of binary code conversion, Boolean simplification, logic gate realization, logic families, combinational and sequential circuits, data conversion techniques, and the functional organization of a digital computer and the Intel 8085 microprocessor.
CO3.	**Apply** Boolean algebra, Karnaugh maps, logic gates, combinational and sequential logic design, data converters, and 8085 assembly language instructions to solve digital electronics and microprocessor-based problems.
CO4.	**Analyze** digital systems by comparing logic families, interpreting combinational and sequential circuit behavior, evaluating timing and memory operations, and examining the execution of 8085 programs.
CO5.	**Evaluate** alternative digital circuit implementations, logic family characteristics, memory devices, data converter performance, and microprocessor-based solutions with respect to functionality, speed, power consumption, and hardware complexity.
CO6.	**Design** and develop optimized digital systems using Boolean algebra, combinational and sequential circuits, memory devices, data converters, and Intel 8085 assembly language to meet specified functional requirements.

MPY351: Electronics Laboratory

Teaching Scheme	Examination Scheme
Practicals: 6hrs./Week, Tutorials: 3hrs./Week	Internal – 50 marks
Credits: 6	End Semester Exam – 100 marks

Prerequisites:

1. Basic knowledge of semiconductor devices, electronic circuits, and network analysis.
2. Familiarity with laboratory practices, electronic measuring instruments, and breadboard circuit implementation.

Course Objectives:

1. To understand the operating principles and characteristics of semiconductor devices, oscillators, amplifiers, timers, and optical communication systems.
2. To develop practical skills in designing, constructing, and testing electronic circuits using breadboards and laboratory instruments.
3. To analyze the performance of electronic circuits and correlate experimental observations with theoretical concepts.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. Study of Diode characteristics
2. Study BJT characteristics
3. Study of characteristics of FET.
4. Study of characteristics of MOSFET.
5. Study of the characteristics of Colpitts oscillator.
6. Study of the characteristics of Hartley oscillator.
7. Study of the characteristics of phototransistor.
8. Study of Fiber optic communication.
9. Design different Clipper and Clamper circuits: positive, negative & bias (using through breadboard).
10. Design of Wein bridge oscillator using IC 741 (using a breadboard).
11. Study of multivibrators & amplifiers.
12. Experiments with 555 timers IC.

Reference Books:

1. B.K. Jones, *Electronics for Experimentation and Research*, Prentice-Hall.
2. P.B. Zbar and A.P. Malvino, *Basic Electronics: A Text-Lab Manual*, Tata Mc-Graw Hill.
3. B.K. Jones, *Electronics for Experimentation and Research*, Prentice-Hall.

Course Outcomes:

After completing the course, students will be able to achieve the following:

CO1.	**Recall** the operating principles, characteristics, symbols, and applications of semiconductor devices, oscillators, multivibrators, amplifiers, optical communication components, and the IC 555 timer.
CO2.	**Explain** the characteristics and working of diodes, BJT, FET, MOSFET, oscillators, phototransistors, fiber optic communication systems, clipper and clamper circuits, multivibrators, amplifiers, and timer circuits.
CO3.	**Perform** laboratory experiments to measure the characteristics of semiconductor devices, construct oscillator and timer circuits, and implement clipper and clamper circuits using breadboards.
CO4.	**Analyze** the experimental characteristics of electronic devices and circuits by interpreting measured data, waveforms, and operating parameters to verify theoretical concepts.
CO5.	**Evaluate** the performance of electronic devices and circuits by comparing experimental results with theoretical expectations and identifying sources of error and performance limitations.
CO6.	**Design** and implement electronic circuits such as clippers, clampers, Wien bridge oscillators, and IC 555 timer applications to meet specified functional requirements.

MPY 352: Computational Physics Laboratory-I

Teaching Scheme	Examination Scheme
Practicals:4hrs./Week	Internal – 15 marks
Credits: 2	End Semester Exam – 35 marks

Prerequisites:

1. Basic knowledge of mathematics, including algebra, calculus, and matrices.
2. Fundamental understanding of programming concepts and the C++ programming language.

Course Objectives:

1. To develop C++ programming skills for implementing numerical methods, matrix operations, and engineering computations.
2. To understand and apply numerical techniques for interpolation, integration, differential equations, and equation solving.
3. To analyze and simulate mathematical and physical systems using computational methods and interpret the obtained results.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. To implement programs in C++ language.
2. Time delay subroutine and a clock program.
3. Newton's and Lagrange's interpolation with algorithm, flow chart, C++ Program and output.
4. Numerical integration by Trapezoidal with algorithm, flowchart, C++ Program & output.
5. Numerical integration by Simpson's rule with algorithm, flowchart, C++ Program & output.
6. Solution of a polynomial equation and determination of roots by Newton Raphson method with algorithm, flowchart, C++ Program and output.
7. Numerical solution of ordinary first order differential equation – Euler's method with algorithm, flowchart, C++ Program and output.
8. Numerical solution of ordinary first order differential equation – Runge-Kutta (RK) methods with algorithm, flowchart, C++ Program and output.
9. Curve fitting - Least square fitting with algorithm, flowchart, C++ program and output.
10. Matrix manipulation - Multiplication, Transpose and Inverse with algorithm, flow-chart, C++ program and output.

11. Iteration method, flowchart, C++ program and output. 12. Gauss Interpolation, flowchart, C++ program and output. 13. Determination of time response of an R-L-C circuit (C++ program and output). 14. Simple Pendulum Simulation – Calculate period for different lengths (C++ program and output). 15. Simple Harmonic Motion (SHM) – Displacement, velocity, and acceleration (C++ program and output).
Reference Books: 1. Bjarne Stroustrup, The C++ Programming Language, Addison-Wesley. 2. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw-Hill. 3. Computational Physics – Nicholas J. Giordano & Hisao Nakanishi

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Explain** the fundamentals of C++ programming and implement programs using basic programming constructs for scientific and engineering applications.
CO2.	**Apply** numerical methods such as interpolation, numerical integration, root-finding, iterative methods, matrix operations, and differential equation solvers by developing C++ programs.
CO3.	**Analyze** computational solutions obtained through C++ programs for curve fitting, interpolation, numerical integration, matrix manipulation, and iterative techniques to solve physics and mathematical problems.
CO4.	**Evaluate** the accuracy, convergence, and numerical performance of computational methods by interpreting the obtained numerical results and comparing different numerical techniques.
CO5.	**Apply** and analyze C++ programming to simulate physical systems such as RLC circuits, simple pendulum, and simple harmonic motion, and interpret their computational behavior.
CO6.	**Design** and develop C++ programs for solving new scientific, mathematical, and research-oriented computational problems using appropriate numerical techniques.

Semester – IV

MPY401: Quantum Mechanics-II

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of quantum mechanics, including wave functions, operators, and the Schrödinger equation.
2. Fundamental knowledge of linear algebra, special relativity, and classical mechanics.

Course Objectives:

1. To introduce the concepts of time-dependent perturbation theory, identical particles, and spin in quantum mechanics.
2. To develop an understanding of relativistic quantum mechanics through the Klein–Gordon and Dirac equations, including their physical applications.
3. To familiarize students with field quantization, symmetry principles, and conservation laws as a foundation for advanced studies and research in quantum field theory.

Detailed Syllabus:

Unit-1: Time-dependent perturbation theory

Sudden and adiabatic approximations, Schrödinger, Heisenberg and interaction pictures. Time-dependent perturbation theory and its Applications to Constant Perturbation, Transition probabilities, Fermi's golden rule.

Unit-2: Identical Particles and Spin

Identical Particles, Exchange Operator, Symmetric and Asymmetric wave functions, Construction of wave function for a system of particles, Pauli Exclusion Principle, Slater Determinant, Spin-statistics connection, Spin wave function for a system of two spin half particles, Distribution of bosons and Fermions in different potential wells/boxes. Scattering of two identical particles, Pauli- spin matrices.

Unit-3: Relativistic Wave Equation in Quantum Mechanics

Klein-Gordon equation, Expression of particle probability density and current density. Reduction of K.G. equation for charge particle in electromagnetic field to non-relativistic Schrödinger equation. Dirac equation, Expressions of Probability and Current densities, negative energy solutions, antiparticles, Plane wave solution, Dirac hole theory, Feynman interpretation of antiparticles, Dirac equation for masses particle: Two component theory of neutrino, Spin & Helicity, Gamma-matrices and their properties, Convariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Relativistic Hydrogen atom problem.

Unit-4: Field Quantization

Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, canonical quantization of the scalar field.

Text and Reference Books:

1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
4. Modern Quantum Mechanics: J.J.Sakurai.
5. Principles of Quantum Mechanics: R. Shankar.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the concepts of time-dependent perturbation theory, identical particles, relativistic wave equations, and field quantization.
CO2.	**Explain** the principles of perturbation theory, exchange symmetry, spin, Klein–Gordon and Dirac equations, and scalar field quantization.
CO3.	**Apply** perturbation theory and relativistic quantum mechanics to solve theoretical physics problems.
CO4.	**Analyze** problems involving identical particles, relativistic quantum systems, and conservation laws.
CO5.	**Evaluate** the applicability of relativistic quantum mechanics and field quantization methods to physical systems.
CO6.	**Design** solutions for advanced problems in relativistic quantum mechanics and quantum field theory.

MPY411: Modern Communication Electronics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment – 6 Marks Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of electronic communication systems, signals, and electromagnetic waves.
2. Fundamental knowledge of analog electronics, semiconductor devices, and wave propagation.

Course Objectives:

1. To introduce an understanding of analog and digital modulation techniques, microwave devices, and radar systems used in modern communication.
2. To develop knowledge of optical fiber communication, cellular networks, and satellite communication technologies for analyzing communication systems.
3. To familiarize students with the analytical and design skills required for solving communication engineering problems and advanced studies.

Detailed Syllabus:

Unit-1: Analog and Digital Modulation Techniques
Review of Amplitude Modulation (AM) and Frequency Modulation (FM). Phase Modulation (PM). Digital modulation techniques: Sampling theorem, Pulse Code Modulation (PCM), Delta Modulation (DM), and Adaptive Delta Modulation (ADM). Digital band pass modulation: Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Quadrature Phase Shift Keying (QPSK).

Unit II: Microwave Electronics and Radar Systems
Microwave characteristics features & applications, Limitations of conventional vacuum tubes at microwave frequencies. waveguides and cavity resonators, two cavity klystron, Reflex Klystron, Magnetron, and Traveling Wave Tubes (TWT). Solid-state microwave devices: Tunnel diode, Gunn diode, IMPATT, and TRAPATT diodes. Introduction to Radar: Radar range equation, Pulsed radar, MTI (Moving Target Indicator), and CW Doppler Radar.

Unit III: Optical Fiber Communication
Principles of light propagation in fibers, total internal reflection, numerical aperture, V-number. Step-index and Graded-index fibers, Single-mode and Multi-mode fibers. Signal degradation: Attenuation, absorption, scattering losses, and bending losses. Dispersion: intermodal and intra-modal dispersion. Optical sources (LED, Laser Diodes) and Photo-detectors (PIN photodiode, Avalanche Photodiode).

Unit IV: Mobile and Satellite Communication

Cellular concept: frequency reuse, handoff strategies, cell splitting, and sectoring. Multiple access techniques: FDMA, TDMA, CDMA, and OFDM. Introduction to GSM and CDMA architectures. Satellite Communication: Kepler's laws, geostationary orbits, satellite transponders, uplink, downlink, and link budget equations.

Text and Reference Books:

1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. G. Kennedy and B. Davis, Electronic Communication Systems, 4th ed. New Delhi, India: Tata McGraw-Hill, 1999.
3. M. S. Roden, Digital and Communication Systems, 2nd ed. Englewood Cliffs, NJ, USA: Prentice-Hall, 1985.
4. P. Chakrabarti, Analog and Digital Communication. New Delhi, India: Dhanpat Rai & Co., 2010.
5. W. Tomasi, Advanced Electronic Communication Systems, 6th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2004.
6. K. S. Shanmugam, Digital and Analog Communication Systems. New York, NY, USA: John Wiley & Sons, 1979.
7. R. F. Coughlin and F. F. Driscoll, Operational Amplifiers and Linear Integrated Circuits, 6th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2001.
8. R. A. Gayakwad, Op-Amps and Linear Integrated Circuits, 4th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2000.
9. R. P. Singh and S. D. Sapre, Communication Systems: Analog and Digital, 3rd ed. New Delhi, India: Tata McGraw-Hill, 2012.
10. S. Y. Liao, Microwave Devices and Circuits, 3rd ed. Upper Saddle River, NJ, USA: Pearson Education, 1990.
11. J. M. Senior, Optical Fiber Communications: Principles and Practice, 3rd ed. Harlow, UK: Pearson Education, 2009.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the fundamentals of analog and digital communication, microwave devices, optical fiber, mobile, and satellite communication systems.
CO2.	**Explain** the principles of modulation techniques, microwave devices, radar systems, optical fiber propagation, and cellular communication.
CO3.	**Apply** communication principles to analyze modulation schemes, microwave devices, optical links, and satellite communication systems.
CO4.	**Analyze** the performance of radar, optical fiber, mobile, and satellite communication systems using appropriate communication parameters.
CO5.	**Evaluate** communication system performance using link budgets, propagation characteristics, and multiple access techniques.
CO6.	**Design** efficient communication links using modern modulation, optical fiber, mobile, and satellite communication technologies.

MP412: Semiconductor Devices Fabrication

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teacher's Assessment - 6 Marks Attendance - 12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic understanding of semiconductor physics and electronic devices.
2. Fundamental knowledge of materials science and solid-state physics.

Course Objectives:

1. To develop an understanding of semiconductor materials, wafer preparation, and cleanroom-based fabrication processes.
2. To introduce knowledge of lithography, thin-film deposition, etching, metallization, and semiconductor device fabrication techniques.
3. To familiarize students with the fabrication and applications of semiconductor devices in microelectronics, optoelectronics, and nanoelectronics.

Detailed Syllabus:

Unit-1: Introduction to Semiconductor Fabrication
Introduction to semiconductor materials, Silicon crystal structure, Semiconductor wafer preparation, Cleanroom technology and contamination control, Crystal growth techniques, Wafer processing, Oxidation and diffusion, Basic concepts of ion implantation.

Unit-2: Lithography and Thin Film Deposition - Photolithography: Photoresists, Masks, Electron beam lithography (introductory concepts), Thin-film deposition techniques: Thermal evaporation, Sputtering, Chemical Vapour Deposition (CVD), Physical Vapour Deposition (PVD).

Unit-3: Etching and Metallization - Wet and dry etching techniques, Plasma etching (basic concepts), Metallization, Ohmic and Schottky contacts, Wire bonding, Passivation, Packaging of semiconductor devices, Process integration.

Unit-4: Fabrication of Semiconductor Devices and Applications - Fabrication of PN junction diode, BJT and MOSFET (basic process flow), CMOS technology (introduction), Fabrication of LEDs and Solar Cells, Applications in Microelectronics and Nanoelectronics.

Text and Reference Books:

1. S.M. Sze & Kwok K. Ng, *Physics of Semiconductor Devices*, John Wiley & Sons.
2. Peter Van Zant, *Microchip Fabrication: A Practical Guide to Semiconductor Processing*, McGraw-Hill Education.
3. Sorab K. Ghandhi, *VLSI Fabrication Principles: Silicon and Gallium Arsenide*, John Wiley & Sons.
4. Stephen A. Campbell, *The Science and Engineering of Microelectronic Fabrication*, Oxford University Press.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the fundamentals of semiconductor materials, wafer preparation, and fabrication processes.
CO2.	**Explain** semiconductor fabrication techniques, including lithography, thin-film deposition, etching, and metallization.
CO3.	**Apply** semiconductor fabrication processes to the manufacturing of basic electronic devices.
CO4.	**Analyze** the fabrication flow of PN junction diodes, BJTs, MOSFETs, LEDs, and solar cells
CO5.	**Evaluate** semiconductor fabrication technologies for applications in microelectronics, optoelectronics, and nanoelectronics.
CO6.	**Design** basic semiconductor device fabrication processes using appropriate microfabrication techniques.

MPY451: Advanced Electronics Laboratory

Teaching Scheme	Examination Scheme
Practicals: 6hrs./Week, Tutorials: 3hrs./Week	Internal-50 marks
Credits: 6	End Semester Exam – 100 marks

Prerequisites:

1. Basic knowledge of analog and digital electronics, including semiconductor devices and logic gates.
2. Fundamental understanding of operational amplifiers, number systems, and microprocessor programming concepts.

Course Objectives:

1. To develop practical skills in designing and analyzing analog and digital electronic circuits using operational amplifiers, logic gates, and ICs.
2. To provide hands-on experience in digital electronics, modulation techniques, and microprocessor (8085/8086) programming and interfacing.
3. To enable students to implement, analyze, and troubleshoot electronic circuits and microprocessor-based applications.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. Study of OP-AMP as a summing and inverting amplifier.
2. Study of OP-AMP as Emitter Follower.
3. Study of OP-AMP as a Difference Amplifier.
4. Study of OP-AMP as differentiator and integrator.
5. Study of OP-AMP as Schmitt Trigger.
6. Study of frequency response of OP-AMP.
7. Study of SR and JK flip flop circuits using logic gates.
8. Study of JK Flip-Flop and up-down counter.
9. Study of IC 7400 as Half adder, Full adder.
10. Study of IC 7400 as Half subtractor, Full subtractor.
11. Study of IC 555 as a stable multivibrator and Voltage Controlled Oscillator.
12. Study of Addition and subtraction using 8086.
13. Study of Multiplication and division using 8086.
14. Study of Addition, Subtraction and Binary to BCD conversion
15. Study of PAM, PWM and PPM Modulation and demodulation.

16. Study of PCM / delta modulation and demodulation. 17. Study of Arithmetic operations using microprocessors 8085 / 8086. 18. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086. 19. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086.
Reference Books: 1. B.K. Jones, *Electronics for Experimentation and Research*, Prentice-Hall. 2. P.B. Zbar and A.P. Malvino, *Basic Electronics: A Text-Lab Manual*, Tata Mc-Graw Hill. 3. B.K. Jones, *Electronics for Experimentation and Research,* Prentice-Hall. 4. P.B. Zbar and A.P. Malvino, *Basic Electronics: A Text-Lab Manual*, Tata Mc-Graw Hill

Course Outcomes:

After completing the course, students will be able to achieve the following

CO1.	**Describe** the operation of OP-AMP circuits, digital logic circuits, modulation techniques, and microprocessor-based systems.
CO2.	**Explain** the working principles of analog and digital electronic circuits, modulation schemes, and 8085/8086 microprocessor operations.
CO3.	**Apply** electronic circuit design and microprocessor programming to perform arithmetic operations, signal processing, and interfacing experiments.
CO4.	**Analyze** the performance of OP-AMP circuits, digital logic circuits, modulation systems, and microprocessor applications through experimental observations.
CO5.	**Evaluate** the functionality and performance of electronic circuits and microprocessor-based systems using experimental results.
CO6.	**Design** and implement basic analog, digital, and microprocessor-based systems for engineering applications.

MPY452: Computational Physics Laboratory-II

Teaching Scheme	Examination Scheme
Practicals: 4hrs./Week	Internal-15 marks
Credits: 2	End Semester Exam – 35 marks

Prerequisites:

1. Basic knowledge of mathematics, including algebra, calculus, matrices, and differential equations.
2. Fundamental understanding of Python programming and scientific computing concepts.

Course Objectives

1. To develop programming skills in Python for implementing numerical methods and scientific computations.
2. To provide hands-on experience in solving mathematical and physical problems using Python, NumPy, and SciPy.
3. To enable students to model, simulate, and analyze scientific systems through computational techniques.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. Newton's and Lagrange's Interpolation with algorithm, flowchart, Python program, and output.
2. Numerical Integration using Trapezoidal Rule / Simpson's Rule with algorithm, flowchart, Python program, and output.
3. Solution of a Polynomial Equation and Determination of Roots using the Newton-Raphson Method with algorithm, flowchart, Python program, and output.
4. Numerical Solution of a First-Order Ordinary Differential Equation using Euler's Method with algorithm, flowchart, Python program, and output.
5. Curve Fitting using the Least Squares Method with algorithm, flowchart, Python program, and output.
6. Matrix Manipulation – Multiplication, Transpose, and Inverse with algorithm, flowchart, Python program, and output.
7. Iteration Method with algorithm, flowchart, Python program, and output.
8. Gauss Interpolation with algorithm, flowchart, Python program, and output.
9. Python (NumPy) – Matrix operations.
10. Python (SciPy/NumPy): Digital Signal Processing.
11. Python (SciPy): Solving Ordinary Differential Equations.

12. Runge-Kutta 4th Order Method (Python/NumPy). 13. Determination of time response of an R-L-C circuit (Python simulation). 14. Simple Pendulum Simulation – Calculate period for different lengths. 15. Simple Harmonic Motion (SHM) – Displacement, velocity, and acceleration.
Reference Books: 1. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press. 2. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer. 3. Computational Physics – Nicholas J. Giordano & Hisao Nakanishi 4. Computational Physics – Mark Newman

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the principles of numerical methods and scientific computing using Python.
CO2.	**Explain** numerical algorithms and Python libraries (NumPy and SciPy) used for scientific computations.
CO3.	**Apply** Python programming to solve numerical problems involving interpolation, integration, differential equations, matrix operations, and curve fitting.
CO4.	**Analyze** computational results obtained from numerical methods and simulations of physical systems.
CO5.	**Evaluate** the accuracy and performance of numerical techniques for solving scientific and engineering problems
CO6.	**Design** Python-based computational models and simulations for mathematical and physical applications.

FOR SPECIALIZATION IN MATERIAL SCIENCES

Semester-III

MPY301: Advanced Laser Physics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment - 6 Marks Attendance -12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic understanding of optics, wave nature of light, and electromagnetic radiation.
2. Fundamental knowledge of atomic structure, energy levels, and introductory quantum physics.

Course Objectives:

1. To develop an understanding of laser fundamentals, laser systems, and light–matter interactions.
2. To provide knowledge of holography, optical fibre technology, and advanced spectroscopic techniques using lasers.
3. To familiarize students with the scientific, medical, industrial, and communication applications of lasers and optical technologies.

Detailed Syllabus:

Unit-1: Laser Fundamentals

Spontaneous and stimulated emission; Einstein coefficients; Population inversion, pumping, gain, optical cavities, Properties: Temporal and Spatial Coherence, directionality, Main components of Laser, Principle of Laser action, Introduction to general lasers and their types, Three & four level Lasers, CW & Pulsed Lasers.

Unit-2: Types of Lasers

Atomic, Ionic, Molecular, Excimer, Liquid, Solid State, Semiconductor and fibre laser: Construction, Working principles and applications.

Unit-3: Holography and Fibre Optics

Principle of holography, Recording and reconstruction of holograms, Types and applications of holography, HNDT (Holographic Non-Destructive Testing), Holographic storage, Optical fibre principle, Acceptance angle, Numerical aperture, Types of optical fibres, Fibre losses, Dispersion, Fiber Optical communication, Fibre amplifiers and optical sensors.

Unit-4: Lasers in Science Saturation spectroscopy, Excited state spectroscopy, Nonlinear spectroscopy, Time domain spectroscopy and its applications, Stimulated Raman Emission, Laser fusion, Medical applications of lasers, Photo-chemical applications. **Unit-5: Lasers in industry** Materials processing; Drilling; Cutting; Welding; Alloying; Thermal Deposition, Laser Chemical Vapour Deposition (LCVD), Laser Hardening, Annealing, LIDAR.

Text and Reference Books:

1. J.T. Cuxon and D.E. Parker, *Industrial Lasers and their Applications,* Prentice Hall of India Pvt. Ltd.
2. F.C. Appard, *Fiber Optics Handbook,* McGraw-Hill.
3. K. Thyagarajan and A.K. Ghatak, *Lasers: Theory and Applications*.
4. K. Koebner (ed.), *Industrial Applications of Lasers*, Wiley.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the fundamentals of laser action, laser systems, holography, and optical fibre communication.
CO2.	**Explain** the working principles and characteristics of different types of lasers, holography, and optical fibres.
CO3.	**Apply** laser principles to spectroscopy, optical communication, and holographic techniques.
CO4.	**Analyze** the performance and applications of lasers, optical fibres, and holographic systems in scientific and technological fields.
CO5.	**Evaluate** the suitability of laser-based techniques for spectroscopy, medical diagnostics, material processing, and communication systems.
CO6.	**Design** laser-based solutions for applications in science, industry, medicine, and optical communication.

MPY302: Computational Physics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment - 6 Marks Attendance - 12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic knowledge of computer programming concepts and mathematical logic.
2. Fundamental understanding of physics and numerical methods for scientific computing.

Course Objectives:

1. To develop programming skills using C++ and Python for scientific and engineering applications.
2. To introduce numerical computing, data analysis, visualization, signal processing, and scientific computing tools in Python.
3. To familiarize students with Particle-in-Cell (PIC) simulation techniques for solving plasma physics problems.

Detailed Syllabus:

Unit-1: C++ Programming

C++ programming basics; Arithmetic operators; Library functions, Data input and output; Relational operators; Control statements; Looping, arrays and functions; Simple programs; User defined functions; Passing arguments; Pointers and pointer declarations; Passing pointers to functions; Structures and classes; Array of structures/objects; Unions; File operations.

Unit-2: Introduction to Python

Python environment; Working with data sets; Data input/output; Logical variables and operators; Arrays and X-Y plotting using NumPy and Matplotlib; Simple graphics; Data types — lists, tuples, dictionaries and arrays; Strings; Manipulating data of different types; File input/output; Python scripts and modules; Simple programs.

Unit-3: Python Scientific Tools

SciPy signal processing module; Digital and analog filter design; Spectral analysis; Filtering and discrete FFTs; Z-transform; DFT and FFT using NumPy/SciPy; PyWavelets for wavelet transform; Instrument control using Python (PyVISA); Solving partial differential equations with Python (FEniCS/finite element method).

Unit-4: Particle-in-cell Codes I

Introduction; Use of PIC code in Plasma Physics: Compute Charge Density, Compute Electric Potential: performed by solving the Poisson equation.

Unit-5: Particle-in-cell Codes II

Compute Electric Field: from the gradient of potential, Move Particles: update velocity and position from Newton's second law, Generate Particles: sample sources to add new particles.

Text and Reference Books:

1. Bjarne Stroustrup, The C++ Programming Language, Addison-Wesley.
2. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw-Hill.
3. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press.
4. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** the basic concepts of C++, including functions, arrays, classes, and Python scientific tools such as NumPy, SciPy, signal processing, and filtering.
CO2.	**Explain** the methods used for signal processing, filtering, and electric field computation in PIC code.
CO3.	**Implement** filtering techniques such as DFT and FFT using Python (NumPy/SciPy) and mathematical methods such as iteration techniques using C++.
CO4.	**Analyze** PIC code using parameters such as charge density, electric potential, and related computational variables.
CO5.	**Evaluate** the performance of signal processing and filtering methods using Python and assess the effectiveness of mathematical methods implemented in C++.
CO6.	**Design** and develop a program to solve computational problems with improved accuracy and efficiency.

MPY303: Semiconductor Devices and Integrated Circuits

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisite: -

1. Basic understanding of semiconductor physics and electronic devices.
2. Fundamental knowledge of analog and digital electronic circuits.

Course Objectives:

1. To develop an understanding of semiconductor devices and their physical principles and current-voltage characteristics.
2. To familiarize students with the working principles of bipolar and field-effect transistors and their applications in electronic circuits.
3. To develop knowledge of analog integrated circuits, operational amplifiers, waveform generators, voltage regulators, and special function ICs for electronic system design.

Detailed Syllabus:

Unit-1: Semiconductor Fundamentals and p-n Junction Devices

Carrier concentration and statistics in semiconductors, Generation and recombination processes, Continuity equation, p-n junction diode: formation, energy band diagram, current-voltage characteristics, Diode capacitance, Zener and Avalanche breakdown, Tunnel diode, Varactor diode, LED and photodiode.

Unit-2: Bipolar and Field Effect Transistors

BJT: construction, working, current components, Ebers-Moll model, biasing techniques, small signal equivalent circuits, JFET: construction and working, pinch-off voltage, V-I characteristics, MOSFET: enhancement and depletion type, threshold voltage, output and transfer characteristics, CMOS technology basics.

Unit-3 Integrated Circuits: Op-amp

Classification, chip size and circuit complexity, basic information of Op-amp, ideal and practical Op-amp, General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, modes of operation-inverting, non-inverting, differential, Applications (linear and nonlinear).

Unit-4: Waveform Generators and Special Function ICs:

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, IC 555 Timer and its applications - Block diagram, Monostable and Astable multivibrator, Applications as Frequency divider, Square wave generator; IC 565 Phase Locked Loops and its Applications - Block diagram and operation, Applications as Frequency Multiplier, Frequency Shift Keying, Design of Power Supply - Simple op-amp voltage regulator, Three terminal voltage regulators, Fixed and adjustable voltage regulators (78XX, LM317), Heat sink, Dual power supply (LM320, LM317), Monolithic switching regulator, Frequency to Voltage and Voltage to Frequency converters.

Unit-5: Digital ICs:

TTL and CMOS, Introduction to memory ICs: ROM, RAM, and their classification.

Text and Reference Books:

1. Sze S.M., *Semiconductor Devices Physics and Technology*, Wiley.
2. Streetman Ben G., *Solid State Electronics*, Prentice Hall of India Pvt. Ltd.
3. Robert Boylestad, Louis Nashelsky, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education.
4. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, Prentice Hall of India.
5. Jacob Millman and Christos C. Halkias, *Integrated Electronics*, Tata McGraw-Hill.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** the principles, construction, characteristics, and terminology of semiconductor devices, transistors, operational amplifiers, waveform generators, voltage regulators, and digital ICs.
CO2.	**Explain** the operation, characteristics, and applications of p-n junction devices, BJTs, FETs, operational amplifiers, special function ICs, and memory devices.
CO3.	**Apply** the principles of semiconductor devices and integrated circuits to analyze transistor biasing, op-amp configurations, waveform generation, and regulated power supply circuits.
CO4.	**Analyze** the performance and characteristics of semiconductor devices, amplifier circuits, waveform generators, PLLs, and digital logic families using their equivalent models and characteristics.
CO5.	**Evaluate** the suitability and performance of semiconductor devices, ICs, TTL/CMOS technologies, and voltage regulators for specific electronic applications.
CO6.	**Design** basic analog and digital electronic circuits using semiconductor devices, operational amplifiers, timers, PLLs, voltage regulators, and memory ICs to meet specified functional requirements.

MPY321: Structure of Materials

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment – 6 Marks Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of solid-state physics, crystal structures, and atomic bonding.
2. Fundamental knowledge of thermodynamics and materials science.

Course Objectives:

1. To introduce the fundamental concepts and principles of materials science, including crystal structures, defects, diffraction, diffusion, and phase transformations.
2. To develop an understanding of the relationship between atomic and crystal structures and the macroscopic properties of engineering materials.
3. To familiarize students with the thermodynamic and kinetic principles governing phase stability, diffusion, microstructure evolution, and materials processing and heat treatment.

Detailed Syllabus:

Unit-1: Short review of basic structures:

Tetrahedral and octahedral sites and their properties and importance, substitutional and interstitial solid solutions (only definitions), coordination number and Pauling rules, Crystal Structures of metallic alloys, Ceramics, polymers, silicates, composite materials include structures such as NaCl, Rutile, fluorite, Hexagonal and cubic zinc Blende, glass.

Unit-2: Crystal Diffraction

X-ray diffraction by crystals, Laue theory, Interpretation of Laue equations, Bragg’s law, Reciprocal lattice, Ewald sphere construction, Atomic scattering factor, Experimental methods of X-ray diffraction, Neutron and electron diffraction (brief discussion).

Unit-3: Defects in Materials :

Point defects, line defects (dislocations), surface defects (grain boundaries), volume defects (voids), defects formation energies, their impact on physical properties of materials, formation energies, defect creation and annihilation, thermodynamic aspects such as concentration and Interactions, stress fields.

Unit-4: Phase Diagrams

Concepts of solid solubility, Hume-Rothery rules, concept of formation of phase diagrams on basis of entropy and free energy changes for compositions, Phase diagrams of various categories.

Unit-5: Diffusion in solids

Concentration gradients, steady state non steady state flow, Fick's laws, error functions, diffusivity (macroscopic and microscopic diffusion models), importance of diffusion for materials synthesis and processing, examples and applications such as oxidation, corrosion, carborization, decarborization, nitridation, Nernst-Einstein equation, concentration profiles, etc. Heat Treatment and Phase transformations in solids: Variation of free energies, nucleation and growth, surface and volume free-energies, Quenching, Nucleation rate, growth rates derivation of related expressions.

Text and Reference Books:

1. Cahn, R. W., & Haasen, P. (Eds.). (1996). *Physical Metallurgy* (4th revised and enhanced ed., Vols. 1–3). North-Holland Publishing Company.
2. Cahn, R. W., & Haasen, P. (Eds.). (1996). *Physical Metallurgy* (4th revised and enhanced ed., Vols. 1–3). North-Holland Publishing Company.
3. Raghavan, V. (2015). *Materials Science and Engineering: A First Course* (6th ed.). PHI Learning Pvt. Ltd.
4. Shackelford, J. F. (2025). *Introduction to Materials Science for Engineers* (9th global ed.). Pearson.
5. Smallman, R. E., & Ngan, A. H. (2014). *Modern Physical Metallurgy* (8th ed.). Butterworth-Heinemann.
6. Pillai, S. O. (2026). *Solid State Physics* (11th ed.). New Age International.
7. Kittel, C., & McEuen, P. (2018). *Introduction to Solid State Physics* (9th global ed.). John Wiley & Sons.
8. Sze, S. M., & Kwok, K. N. (2021). *Physics of Semiconductor Devices* (4th ed.). John Wiley & Sons.
9. Callister, W. D., Jr., & Rethwisch, D. G. (2018). *Materials Science and Engineering: An Introduction* (10th ed.). John Wiley & Sons.
10. Puri, R. K., & Babbar, V. K. (2010). *Solid State Physics*. S. Chand Publishing.
11. Askeland, D. R., & Wright, W. J. (2020). *The Science and Engineering of Materials* (7th ed.).

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Explain** fundamental crystal structures, bonding, coordination, solid solutions, and defects in different classes of materials.
CO2.	**Apply** Bragg's law, Laue theory, reciprocal lattice concepts, and diffraction techniques to analyze crystal structures.
CO3.	**Analyze** the formation, energetics, and effects of material defects and interpret phase diagrams using thermodynamic principles.
CO4.	**Understand** Phase Diagrams: Demonstrate an understanding of equilibrium phase diagrams and phase transformations.
CO5.	**Apply** Fick's laws and diffusion models to understand atomic transport and its applications in materials processing.
CO6.	**Analyze** nucleation, growth, phase transformations, and heat-treatment processes based on thermodynamic and kinetic principles.

MPY353: Material Science Lab

Teaching Scheme	Examination Scheme
Practicals: 6hrs./Week, Tutorials: 3hrs./Week	Internal-50 marks
Credits: 6	End Semester Exam- 100 marks

Prerequisites:

1. Basic knowledge of semiconductor physics, optics, solid-state physics, and material science.
2. Fundamental understanding of laboratory measurement techniques, data analysis, and the safe handling of scientific instruments.

Course Objectives:

1. To perform experimental characterization of the electrical, optical, magnetic, and structural properties of materials.
2. To determine material parameters using standard characterization techniques and modern laboratory instruments.
3. To interpret experimental data and correlate measured properties with the underlying physical principles.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. To study the temperature dependence of the Hall coefficient of a given semiconductor.
2. Determination of Band gap of a given semiconductor material by four probe Technique.
3. To study the effect of magneto-striction of a given material.
4. Measurements of Brewster angle of a substance and hence determine the refractive index.
5. Measurement of absorption coefficient of a material (supplied) using laser light.
6. Determination of numerical aperture of a fiber by measuring the diameter of laser Beam.
7. To verify the Malus law.
8. Study of porosity and grain size of thin film and powder sample by SEM.
9. Two probes d.c. conductivity and carrier density evaluation of a pellet prepared through cold pressing.
10. Preparation of thin film deposition technique and determination of film thickness by fibre optic spectrophotometer.
11. Determination of band gap of semiconductor sample using UV-VIS spectroscopy.
12. Analyzing the absorption or transmittance spectra of thin films or nanomaterials and applying Tauc's plots to evaluate the optical band.
13. Studying the dielectric properties of ferroelectric ceramics (e.g., $BaTiO_3$) over varying temperatures to observe phase transitions.

Reference Books:

1. B. L. Worsnop and H. T. Flint, Advanced Practical Physics, Asia Publishing House, New Delhi.
2. Indu Prakash and Ramakrishna, A Text Book of Practical Physics, Kitab Mahal, New Delhi.
3. D. P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Publication House, New Delhi.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** the fundamental principles and working concepts of semiconductor, optical, electrical, magnetic, dielectric, and materials characterization techniques.
CO2.	**Explain** the operating principles and applications of various experimental techniques used for material characterization and property measurement.
CO3.	**Perform** experiments using appropriate instruments and techniques to determine electrical, optical, magnetic, dielectric, and structural properties of materials.
CO4.	**Analyze** and interpret experimental data, spectra, and characterization results to evaluate material properties such as band gap, conductivity, carrier density, absorption coefficient, grain size, and film thickness.
CO5.	**Evaluate** experimental results by comparing observations with theoretical concepts and assessing the accuracy and reliability of measurements.
CO6.	**Prepare** clear, concise, and scientifically structured laboratory reports and communicate experimental findings through effective technical presentations.

MPY 352: Computational Physics Laboratory-I

Teaching Scheme	Examination Scheme
Practicals: 4hrs./Week	Internal – 15 marks
Credits: 2	End Semester Exam – 35 marks

Prerequisites:

1. Basic knowledge of C++ programming and programming logic.
2. Fundamental understanding of calculus, matrices, and differential equations.

Course Objectives:

1. To develop C++ programs for solving numerical and engineering problems.
2. To implement standard numerical methods for interpolation, integration, root finding, differential equations, and matrix operations.
3. To simulate engineering systems and analyze computational results using C++.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. To implement programs in C++ language.
2. Time delay subroutine and a clock program.
3. Newton's and Lagrange's interpolation with algorithm, flow chart, C++ Program and output.
4. Numerical integration by Trapezoidal with algorithm, flowchart, C++ Program & output.
5. Numerical integration by Simpson's rule with algorithm, flowchart, C++ Program & output.
6. Solution of a polynomial equation and determination of roots by Newton Raphson method with algorithm, flowchart, C++ Program and output.
7. Numerical solution of ordinary first order differential equation – Euler's method with algorithm, flowchart, C++ Program and output.
8. Numerical solution of ordinary first order differential equation – Runge-Kutta (RK) methods with algorithm, flowchart, C++ Program and output.
9. Curve fitting - Least square fitting with algorithm, flowchart, C++ program and output.
10. Matrix manipulation - Multiplication, Transpose and Inverse with algorithm, flow-chart, C++ program and output.

11. Iteration method, flowchart, C++ program and output.
12. Gauss Interpolation, flowchart, C++ program and output.
13. Determination of time response of an R-L-C circuit (C++ program and output).
14. Simple Pendulum Simulation – Calculate period for different lengths (C++ program and output).
15. Simple Harmonic Motion (SHM) – Displacement, velocity, and acceleration (C++ program and output).

Reference Books:

1. Bjarne Stroustrup, The C++ Programming Language, Addison-Wesley.
2. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw-Hill.
3. Computational Physics – Nicholas J. Giordano & Hisao Nakanishi

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Explain** the fundamentals of C++ programming and implement programs using basic programming constructs for scientific and engineering applications.
CO2.	**Apply** numerical methods such as interpolation, numerical integration, root-finding, iterative methods, matrix operations, and differential equation solvers by developing C++ programs.
CO3.	**Analyze** computational solutions obtained through C++ programs for curve fitting, interpolation, numerical integration, matrix manipulation, and iterative techniques to solve physics and mathematical problems.
CO4.	**Evaluate** the accuracy, convergence, and numerical performance of computational methods by interpreting the obtained numerical results and comparing different numerical techniques.
CO5.	**Apply** and analyze C++ programming to simulate physical systems such as RLC circuits, simple pendulum, and simple harmonic motion, and interpret their computational behavior.
CO6.	**Design** and develop C++ programs for solving new scientific, mathematical, and research-oriented computational problems using appropriate numerical techniques.

Semester – IV

MPY401: Quantum Mechanics-II

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of quantum mechanics, including wave functions, operators, and the Schrödinger equation.
2. Fundamental knowledge of linear algebra, special relativity, and classical mechanics.

Course Objectives:

1. To introduce the concepts of time-dependent perturbation theory, identical particles, and spin in quantum mechanics.
2. To develop an understanding of relativistic quantum mechanics through the Klein–Gordon and Dirac equations, including their physical applications.
3. To familiarize students with field quantization, symmetry principles, and conservation laws as a foundation for advanced studies and research in quantum field theory.

Detailed Syllabus:

Unit-1: Time-dependent perturbation theory

Sudden and adiabatic approximations, Schrödinger, Heisenberg and interaction pictures. Time-dependent perturbation theory and its Applications to Constant Perturbation, Transition probabilities, Fermi's golden rule.

Unit-2: Identical Particles and Spin

Identical Particles, Exchange Operator, Symmetric and Asymmetric wave functions, Construction of wave function for a system of particles, Pauli Exclusion Principle, Slater Determinant, Spin-statistics connection, Spin wave function for a system of two spin half particles, Distribution of bosons and Fermions in different potential wells/boxes. Scattering of two identical particles, Pauli- spin matrices.

Unit-3: Relativistic Wave Equation in Quantum Mechanics

Klein-Gordon equation, Expression of particle probability density and current density. Reduction of K.G. equation for charge particle in electromagnetic field to non-relativistic Schrödinger equation. Dirac equation, Expressions of Probability and Current densities, negative energy solutions, antiparticles, Plane wave solution, Dirac hole theory, Feynman interpretation of antiparticles, Dirac equation for masses particle: Two component theory of neutrino, Spin & Helicity, Gamma-matrices and their properties, Convariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Relativistic Hydrogen atom problem.

Unit-4: Field Quantization

Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, canonical quantization of the scalar field.

Text and Reference Books:

1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
4. Modern Quantum Mechanics: J.J.Sakurai.
5. Principles of Quantum Mechanics: R. Shankar.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the concepts of time-dependent perturbation theory, identical particles, relativistic wave equations, and field quantization.
CO2.	**Explain** the principles of perturbation theory, exchange symmetry, spin, Klein–Gordon and Dirac equations, and scalar field quantization.
CO3.	**Apply** perturbation theory and relativistic quantum mechanics to solve theoretical physics problems.
CO4.	**Analyze** problems involving identical particles, relativistic quantum systems, and conservation laws.
CO5.	**Evaluate** the applicability of relativistic quantum mechanics and field quantization methods to physical systems.
CO6.	**Design** solutions for advanced problems in relativistic quantum mechanics and quantum field theory.

MPY421: Properties of Materials

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of solid-state physics, crystal structures, and atomic bonding.
2. Fundamental knowledge of thermodynamics, electromagnetism, and materials science.

Course Objectives:

1. To develop a strong foundation in the mechanical, thermal, electrical, magnetic, and optical properties of engineering materials.
2. To introduce the fundamental mechanisms governing material behavior, including deformation, heat transfer, electrical conduction, magnetism, and optical phenomena.
3. To familiarize students with modern materials characterization techniques and their applications in analyzing the structure and properties of materials.

Detailed Syllabus:

Unit-1

Mechanical Properties of Materials - Elasticity: stress-strain relationship, elastic constants, Plastic deformation, Dislocations: edge and screw dislocations, Burger's vector, Dislocation multiplication, Work hardening, Fracture: brittle and ductile fracture, Fatigue and Creep, Hardness testing methods.

Unit-2

Thermal Properties of Materials - Specific heat of solids: Einstein and Debye models, Thermal expansion, Thermal conductivity: lattice and electronic contributions, Thermal diffusivity, Phase transformations, Thermal analysis techniques: DTA, DSC, and TGA.

Unit-3

Electrical and Magnetic Properties of Materials - Electrical conductivity of metals and semiconductors, Temperature dependence of conductivity, Dielectric properties and polarization mechanisms, Ferroelectricity, Elementary ideas of dia, para and ferro magnetism, Magnetic domains and hysteresis, Applications of magnetic materials.

Unit-4

Optical Properties and Characterization Techniques - Optical absorption and emission in solids, Luminescence: photoluminescence and electroluminescence, Color centers, Characterization techniques: X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), UV-Visible spectroscopy.

Text and Reference Books:

1. C. Kittel, *Introduction to Solid State Physics*, Wiley.
2. M.A. Wahab, *Solid State Physics (Structure and Properties of Materials)*, Narosa Publishing House.
3. William D. Callister, *Materials Science and Engineering: An Introduction*, Wiley.
4. S.O. Pillai, *Solid State Physics*, New Age International, New Delhi.
5. Raghavan V., *Materials Science and Engineering*, Prentice Hall of India.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the mechanical, thermal, electrical, magnetic, and optical properties of materials.
CO2.	**Develop** an understanding of the relationship between the structure and properties of materials.
CO3.	**Apply** the concepts of elasticity, thermal analysis, and magnetism to solve numerical problems on the properties of materials.
CO4.	**Analyze** the behavior of dislocations, phase transformations, and domain structures in materials.
CO5.	**Evaluate** the properties of materials using different experimental characterization techniques such as XRD, SEM, and TEM.
CO6.	**Classify** materials based on their mechanical, thermal, electrical, magnetic, and optical properties.

MPY422: Nano-Materials

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment – 6 Marks Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of nano materials, semiconductor physics, and quantum mechanics.
2. Fundamental knowledge of materials science and crystallography.

Course Objectives:

1. To develop a comprehensive understanding of nanoscience, nanomaterials, quantum confinement effects, and their size-dependent physical properties.
2. To introduce the synthesis methods and characterization techniques used for the structural and optical analysis of nanomaterials.
3. To familiarize students with the applications of nanomaterials, including graphene, conducting polymers, carbon nanotubes, and semiconductor nanostructures in modern electronic and optoelectronic devices.

Detailed Syllabus:

UNIT-I: Introduction to Nanostructure Materials

Nano science & nanotechnology , Size dependence of properties, Moor's law, Surface energy and Melting point (quasi melting) of nanoparticles, Conducting polymers, Graphene.

Change band structure of nanomaterials: Change in energy gap, Density of Structure distribution, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, and Variation of density of states with energy and Size of crystal.

UNIT-II:Quantum Size Effect

Quantum confinement, Nanomaterials structures, two dimensional quantum system, Quantum well, Quantum wire and Quantum dot, Fabrication techniques,

UNIT-III: Characterization techniques of Nanomaterials:

Structure and Size, Determination of particle size, XRD (Scherrer's formula), Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, Shift in photoluminescence peaks, Electron Microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Scanning Tunneling Electron Microscopy (STEM), and Atomic Force Microscopy (AFM).

UNIT-IV: Optical Characterization
Absorption- UV-VIS.-N.I.R, PL (Photo luminescence).

UNIT- V: Synthesis of Nanomaterials:
Key issue in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Cluster beam evaporation, Ball Milling, Chemical bath deposition with capping agent, Carbon nanotubes (CNT)- Synthesis, Properties and Applications(LED, Solar cells, FET).

Text and Reference Books:

1. Callister, W. D., Jr., & Rethwisch, D. G. (2018). Materials Science and Engineering: An Introduction (10th ed.). John Wiley & Sons.
2. Raghavan, V. (2015). Materials Science and Engineering: A First Course (6th ed.). PHI Learning Pvt. Ltd.
3. Poole, C. P., Jr., & Owens, F. J. (2020). Introduction to Nanoscience and Nanotechnology (Indian Adapted ed.). Wiley India.
4. Bertino, M. (2023). Introduction to Nanotechnology. World Scientific Publishing.
5. Das, A. K., Das, M., Das, A., & Das, U. (2024). An Introduction to Nanomaterials and Nanoscience (2nd ed.). CBS Publishers
6. Pradeep, T. (2020). Nanoscience and Nanotechnology: A Textbook. McGraw Hill Education.
7. Kulkarni, S. (Ed.). (2026). Next-Generation Nanomaterials for Sustainable Engineering. Springer Nature.
8. Chattopadhyay, K. K., & Banerjee, A. N. (2019). Introduction to Nanoscience and Nanotechnology. PHI Learning.
9. Sapuan, S. M., Siddiqui, V. U., & Mohammadsalih, Z. G. (2026). Nanocomposites: Preparation, Characterization and Applications. Royal Society of Chemistry.
10. Cao, G., & Wang, Y. (2019). Nanostructures and Nanomaterials: Synthesis, Properties, and Applications (3rd ed.). World Scientific Publishing.
11. Shah, M. A., & Ahmad, T. (2020). Principles of Nanoscience and Nanotechnology (2nd ed.). Narosa Publishing House.
12. Rogers, B., Adams, J., & Pennathur, S. (2024). Nanotechnology: Understanding Small Systems (4th ed.). CRC Press.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the physical effects of size reduction on surface energy, melting points, and Moore's law, while identifying the electronic properties of conducting polymers and graphene.
CO2.	**Develop** electronic band structure modifications, tuning energy gaps and the density of states across zero-, one-, and two-dimensional quantum-confined structures.
CO3.	**Apply** structural characterization tools by using Scherrer’s formula for XRD peak

	broadening and interpreting topographical data from SEM, TEM, and atomic force microscopes.
CO4.	**Analyse** the physical mechanisms behind optical shifts in nanomaterials by evaluating UV-Vis-NIR absorption profiles and photoluminescence emission spectra.
CO5.	**Evaluate** chemical and physical synthesis methodologies—including ball milling, chemical bath deposition, and cluster beam evaporation—to fabricate carbon nanotubes for functional devices.
CO6.	**Design** and fabricate simple experiments based on the applications of these materials.

MPY453: Advanced Material Science Lab

Teaching Scheme	Examination Scheme
Practical: 6hrs./Week, Tutorials: 3hrs./Week Credits: 6	Internal-50 marks End Semester Exam – 100 marks

Prerequisites:

1. Basic knowledge of thermal physics, optics, solid-state physics, and materials science.
2. Familiarity with laboratory instruments, experimental techniques, and error analysis.

Course Objectives:

1. To perform experiments for determining the thermal, optical, electrical, and structural properties of materials.
2. To synthesize and characterize advanced materials using standard experimental techniques and characterization tools.
3. To analyze experimental data and correlate material properties with the underlying physical principles.

List of Experiments

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. To determine the coefficient of thermal conductivity of copper by Searle's apparatus.
2. To verify Stefan's law and to determine the value of Stefan's constant.
3. To determine the wavelength and the angular spread of a He-Ne laser.
4. To determine the value of Planck's constant by using LEDs of at least 4 different wavelengths.
5. To study the characteristics of a Photo-diode.
6. To verify inverse square law for light using a photocell as a photometer.
7. To determine the conductivity of the material by LCR method.
8. To determine the curie temperature of a given ferroelectric material.
9. Preparation of nano-crystalline powder specimen by chemical route: analysis of their x-ray spectra and particle size estimation by sherrer formula.
10. Measurement of variation of micro-hardness of sintered specimens with sintering temperatures.
11. Determination of Miller indices and lattice parameter of an unknown powder material by x-ray diffraction.
12. Phase identification of an unknown sample by an x-ray diffraction.
13. Synthesis by chemical route and sol-gel and characterization of thin film by x-ray diffraction.

Reference Books:

1. B. L. Worsnop and H. T. Flint, Advanced Practical Physics, Asia Publishing House, New Delhi.
2. Indu Prakash and Ramakrishna, A Text Book of Practical Physics, Kitab Mahal, New Delhi.
3. D. P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Publication House, New Delhi.

Course Outcomes:

After completing the course, students will be able to achieve the following:

CO1.	**Recall** the fundamental principles and concepts related to thermal, optical, electronic, magnetic, dielectric, and structural properties of materials.
CO2.	**Explain** the working principles and applications of experimental techniques used for investigating and characterizing materials.
CO3.	**Perform** experiments to determine thermal, optical, electrical, magnetic, dielectric, and structural properties of materials using appropriate techniques.
CO4.	**Analyze** experimental data and X-ray diffraction patterns to determine parameters such as lattice constants, Miller indices, phase composition, particle size, and crystallinity.
CO5.	**Evaluate** the experimental results and correlate the observed properties with the structure, composition, and processing conditions of materials.
CO6.	**Prepare** and characterize nanomaterials and thin films using suitable synthesis techniques and present experimental findings through concise scientific reports.

MPY452: Computational Physics Laboratory-II

Teaching Scheme	Examination Scheme
Practicals: 4hrs./Week	Internal-15 marks
Credits: 2	End Semester Exam – 35 marks

Prerequisites:

1. Basic knowledge of mathematics, including algebra, calculus, matrices, and differential equations.
2. Fundamental understanding of Python programming and scientific computing concepts.

Course Objectives

1. To develop programming skills in Python for implementing numerical methods and scientific computations.
2. To provide hands-on experience in solving mathematical and physical problems using Python, NumPy, and SciPy.
3. To enable students to model, simulate, and analyze scientific systems through computational techniques.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. Newton's and Lagrange's Interpolation with algorithm, flowchart, Python program, and output.
2. Numerical Integration using Trapezoidal Rule / Simpson's Rule with algorithm, flowchart, Python program, and output.
3. Solution of a Polynomial Equation and Determination of Roots using the Newton-Raphson Method with algorithm, flowchart, Python program, and output.
4. Numerical Solution of a First-Order Ordinary Differential Equation using Euler's Method with algorithm, flowchart, Python program, and output.
5. Curve Fitting using the Least Squares Method with algorithm, flowchart, Python program, and output.
6. Matrix Manipulation – Multiplication, Transpose, and Inverse with algorithm, flowchart, Python program, and output.
7. Iteration Method with algorithm, flowchart, Python program, and output.
8. Gauss Interpolation with algorithm, flowchart, Python program, and output.
9. Python (NumPy) – Matrix operations.
10. Python (SciPy/NumPy): Digital Signal Processing.
11. Python (SciPy): Solving Ordinary Differential Equations.

12. Runge-Kutta 4th Order Method (Python/NumPy). 13. Determination of time response of an R-L-C circuit (Python simulation). 14. Simple Pendulum Simulation – Calculate period for different lengths. 15. Simple Harmonic Motion (SHM) – Displacement, velocity, and acceleration.
Reference Books: 1. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press. 2. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer. 3. Computational Physics – Nicholas J. Giordano & Hisao Nakanishi 4. Computational Physics – Mark Newman

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the principles of numerical methods and scientific computing using Python.
CO2.	**Explain** numerical algorithms and Python libraries (NumPy and SciPy) used for scientific computations.
CO3.	**Apply** Python programming to solve numerical problems involving interpolation, integration, differential equations, matrix operations, and curve fitting.
CO4.	**Analyze** computational results obtained from numerical methods and simulations of physical systems.
CO5.	**Evaluate** the accuracy and performance of numerical techniques for solving scientific and engineering problems
CO6.	**Design** Python-based computational models and simulations for mathematical and physical applications.

FOR SPECIALIZATION IN QUANTUM COMPUTING
Semester – III

MPY301: Advanced Laser Physics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment - 6 Marks Attendance -12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic understanding of optics, wave nature of light, and electromagnetic radiation.
2. Fundamental knowledge of atomic structure, energy levels, and introductory quantum physics.

Course Objectives:

1. To develop an understanding of laser fundamentals, laser systems, and light–matter interactions.
2. To provide knowledge of holography, optical fibre technology, and advanced spectroscopic techniques using lasers.
3. To familiarize students with the scientific, medical, industrial, and communication applications of lasers and optical technologies.

Detailed Syllabus:

Unit-1: Laser Fundamentals

Spontaneous and stimulated emission; Einstein coefficients; Population inversion, pumping, gain, optical cavities, Properties: Temporal and Spatial Coherence, directionality, Main components of Laser, Principle of Laser action, Introduction to general lasers and their types, Three & four level Lasers, CW & Pulsed Lasers.

Unit-2: Types of Lasers

Atomic, Ionic, Molecular, Excimer, Liquid, Solid State, Semiconductor and fibre laser: Construction, Working principles and applications.

Unit-3: Holography and Fibre Optics

Principle of holography, Recording and reconstruction of holograms, Types and applications of holography, HNDT (Holographic Non-Destructive Testing), Holographic storage, Optical fibre principle, Acceptance angle, Numerical aperture, Types of optical fibres, Fibre losses, Dispersion, Fiber Optical communication, Fibre amplifiers and optical sensors.

Unit-4: Lasers in Science

Saturation spectroscopy, Excited state spectroscopy, Nonlinear spectroscopy, Time domain spectroscopy and its applications, Stimulated Raman Emission, Laser fusion, Medical applications of lasers, Photo-chemical applications.

Unit-5: Lasers in industry

Materials processing; Drilling; Cutting; Welding; Alloying; Thermal Deposition, Laser Chemical Vapour Deposition (LCVD), Laser Hardening, Annealing, LIDAR.

Text and Reference Books:

1. J.T. Cuxon and D.E. Parker, *Industrial Lasers and their Applications,* Prentice Hall of India Pvt. Ltd.
2. F.C. Appard, *Fiber Optics Handbook,* McGraw-Hill.
3. K. Thyagarajan and A.K. Ghatak, *Lasers: Theory and Applications*.
4. K. Koebner (ed.), *Industrial Applications of Lasers*, Wiley.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the fundamentals of laser action, laser systems, holography, and optical fibre communication.
CO2.	**Explain** the working principles and characteristics of different types of lasers, holography, and optical fibres.
CO3.	**Apply** laser principles to spectroscopy, optical communication, and holographic techniques.
CO4.	**Analyze** the performance and applications of lasers, optical fibres, and holographic systems in scientific and technological fields.
CO5.	**Evaluate** the suitability of laser-based techniques for spectroscopy, medical diagnostics, material processing, and communication systems.
CO6.	**Design** laser-based solutions for applications in science, industry, medicine, and optical communication.

MPY302: Computational Physics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers Assessment - 6 Marks Attendance - 12 Marks
Credits: 4	End Semester Exam - 70 marks

Prerequisites:

1. Basic knowledge of computer programming concepts and mathematical logic.
2. Fundamental understanding of physics and numerical methods for scientific computing.

Course Objectives:

1. To develop programming skills using C++ and Python for scientific and engineering applications.
2. To introduce numerical computing, data analysis, visualization, signal processing, and scientific computing tools in Python.
3. To familiarize students with Particle-in-Cell (PIC) simulation techniques for solving plasma physics problems.

Detailed Syllabus:

Unit-1: C++ Programming

C++ programming basics; Arithmetic operators; Library functions, Data input and output; Relational operators; Control statements; Looping, arrays and functions; Simple programs; User defined functions; Passing arguments; Pointers and pointer declarations; Passing pointers to functions; Structures and classes; Array of structures/objects; Unions; File operations.

Unit-2: Introduction to Python

Python environment; Working with data sets; Data input/output; Logical variables and operators; Arrays and X-Y plotting using NumPy and Matplotlib; Simple graphics; Data types — lists, tuples, dictionaries and arrays; Strings; Manipulating data of different types; File input/output; Python scripts and modules; Simple programs.

Unit-3: Python Scientific Tools

SciPy signal processing module; Digital and analog filter design; Spectral analysis; Filtering and discrete FFTs; Z-transform; DFT and FFT using NumPy/SciPy; PyWavelets for wavelet transform; Instrument control using Python (PyVISA); Solving partial differential equations with Python (FEniCS/finite element method).

Unit-4: Particle-in-cell Codes I

Introduction; Use of PIC code in Plasma Physics: Compute Charge Density, Compute Electric Potential: performed by solving the Poisson equation.

Unit-5: Particle-in-cell Codes II

Compute Electric Field: from the gradient of potential, Move Particles: update velocity and position from Newton's second law, Generate Particles: sample sources to add new particles.

Text and Reference Books:

1. Bjarne Stroustrup, The C++ Programming Language, Addison-Wesley.
2. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw-Hill.
3. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press.
4. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer.

Course Outcomes:

CO1.	**Recall** the basic concepts of C++, including functions, arrays, classes, and Python scientific tools such as NumPy, SciPy, signal processing, and filtering.
CO2.	**Explain** the methods used for signal processing, filtering, and electric field computation in PIC code.
CO3.	**Implement** filtering techniques such as DFT and FFT using Python (NumPy/SciPy) and mathematical methods such as iteration techniques using C++.
CO4.	**Analyze** PIC code using parameters such as charge density, electric potential, and related computational variables.
CO5.	**Evaluate** the performance of signal processing and filtering methods using Python and assess the effectiveness of mathematical methods implemented in C++.
CO6.	**Design** and develop a program to solve computational problems with improved accuracy and efficiency.

MPY303: Semiconductor Devices and Integrated Circuits

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4	End Semester Exam – 70 marks

Prerequisite: -

1. Basic understanding of semiconductor physics and electronic devices.
2. Fundamental knowledge of analog and digital electronic circuits.

Course Objectives:

1. To develop an understanding of semiconductor devices and their physical principles and current-voltage characteristics.
2. To familiarize students with the working principles of bipolar and field-effect transistors and their applications in electronic circuits.
3. To develop knowledge of analog integrated circuits, operational amplifiers, waveform generators, voltage regulators, and special function ICs for electronic system design.

Detailed Syllabus:

Unit-1: Semiconductor Fundamentals and p-n Junction Devices

Carrier concentration and statistics in semiconductors, Generation and recombination processes, Continuity equation, p-n junction diode: formation, energy band diagram, current-voltage characteristics, Diode capacitance, Zener and Avalanche breakdown, Tunnel diode, Varactor diode, LED and photodiode.

Unit-2: Bipolar and Field Effect Transistors

BJT: construction, working, current components, Ebers-Moll model, biasing techniques, small signal equivalent circuits, JFET: construction and working, pinch-off voltage, V-I characteristics, MOSFET: enhancement and depletion type, threshold voltage, output and transfer characteristics, CMOS technology basics.

Unit-3 Integrated Circuits: Op-amp

Classification, chip size and circuit complexity, basic information of Op-amp, ideal and practical Op-amp, General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, modes of operation-inverting, non-inverting, differential, Applications (linear and nonlinear).

Unit-4: Waveform Generators and Special Function ICs:

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, IC 555 Timer and its applications - Block diagram, Monostable and Astable multivibrator, Applications as Frequency divider, Square wave generator; IC 565 Phase Locked Loops and its Applications - Block diagram and operation, Applications as Frequency Multiplier, Frequency Shift Keying, Design of Power Supply - Simple op-amp voltage regulator, Three terminal voltage regulators, Fixed and adjustable voltage regulators (78XX, LM317), Heat sink, Dual power supply (LM320, LM317), Monolithic switching regulator, Frequency to Voltage and Voltage to Frequency converters.

Unit-5: Digital ICs:

TTL and CMOS, Introduction to memory ICs: ROM, RAM, and their classification.

Text and Reference Books:

1. Sze S.M., *Semiconductor Devices Physics and Technology*, Wiley.
2. Streetman Ben G., *Solid State Electronics*, Prentice Hall of India Pvt. Ltd.
3. Robert Boylestad, Louis Nashelsky, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education.
4. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, Prentice Hall of India.
5. Jacob Millman and Christos C. Halkias, *Integrated Electronics*, Tata McGraw-Hill.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** the principles, construction, characteristics, and terminology of semiconductor devices, transistors, operational amplifiers, waveform generators, voltage regulators, and digital ICs.
CO2.	**Explain** the operation, characteristics, and applications of p-n junction devices, BJTs, FETs, operational amplifiers, special function ICs, and memory devices.
CO3.	**Apply** the principles of semiconductor devices and integrated circuits to analyze transistor biasing, op-amp configurations, waveform generation, and regulated power supply circuits.
CO4.	**Analyze** the performance and characteristics of semiconductor devices, amplifier circuits, waveform generators, PLLs, and digital logic families using their equivalent models and characteristics.
CO5.	**Evaluate** the suitability and performance of semiconductor devices, ICs, TTL/CMOS technologies, and voltage regulators for specific electronic applications.
CO6.	**Design** basic analog and digital electronic circuits using semiconductor devices, operational amplifiers, timers, PLLs, voltage regulators, and memory ICs to meet specified functional requirements.

MPY331: Quantum Computing-Theory

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4 (3L + 1T)	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of linear algebra, quantum mechanics, and probability theory.
2. Fundamental knowledge of Python programming and classical computing concepts.

Course Objectives

1. To develop a strong foundation in quantum information science, quantum computation, quantum circuits, and quantum algorithms.
2. To introduce quantum programming frameworks, quantum hardware platforms, noise models, and benchmarking techniques for practical quantum computing.
3. To familiarize students with IBM Quantum services, Qiskit tools, and the implementation and execution of quantum algorithms on real quantum hardware.

Detailed Syllabus

Unit 1: Foundations of Quantum Information

Classical vs quantum computation; historical milestones (Feynman, Shor, Grover); Hilbert spaces, Dirac notation, tensor products, density matrices; the four fundamental principles — linearity, reversibility, superposition, entanglement; measurement theory and the no-cloning theorem; introduction to Qiskit and the Bell-state program.

Unit 2: Quantum Gates, Circuits and Programming Frameworks

Single-qubit gates (Pauli, Hadamard, phase, rotation) and Euler decomposition; multi-qubit gates (CNOT, CZ, SWAP, Toffoli, Fredkin) and universality; circuit depth/width, transpilation and Qiskit PassManager; comparative survey of Qiskit, Cirq, Q#, QuTiP, TKET and PennyLane.

Unit 3: Quantum Algorithms — Foundational

Oracle model and phase kickback; Deutsch, Deutsch-Jozsa and Bernstein-Vazirani algorithms; Quantum Fourier Transform; Quantum Phase Estimation; Grover's search algorithm and amplitude amplification; variational quantum algorithms (VQE, QAOA).

Unit 4: Quantum Hardware and Noise

Physical qubit platforms — superconducting, trapped-ion, photonic and spin qubits; transmon qubit and microwave control; coherence times T1/T2; quantum channels and Kraus operators; Qiskit Aer noise models; Quantum Volume and CLOPS as benchmark metrics.

Unit 5: Accessing IBM Quantum Hardware

IBM Quantum account setup and API access via QiskitRuntimeService; backend selection and calibration data; transpilation to ISA circuits; Qiskit Runtime Sampler and Estimator primitives; job submission and management; comparing hardware and simulated results.

Text Books and Reference Books:

1. Michael A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, 10th Anniversary Ed., 2010)
2. Jack D. Hidary, Quantum Computing: An Applied Approach (Springer, 2nd Ed., 2021)
3. S. K. Jain, Quantum Computers: Principles, Qubits, Circuits, Algorithms and Hardware (S Publishing House, 2026 Ed.)
4. Phillip Kaye, Raymond Laflamme & Michele Mosca, An Introduction to Quantum Computing (Oxford University Press, 2007)
5. Eleanor G. Rieffel & Wolfgang H. Polak, Quantum Computing: A Gentle Introduction (MIT Press, 2011)
6. Qiskit Documentation, docs.quantum.ibm.com (IBM Quantum, online resource)

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Explain** the postulates of quantum mechanics relevant to quantum information — superposition, entanglement, reversibility and linearity — using correct Dirac notation.
CO2.	**Construct** and analyse quantum circuits using single- and multi-qubit gates and verify results using Qiskit statevector simulation.
CO3.	**Compare** quantum programming frameworks (Qiskit, Cirq, Q#, QuTiP, TKET) and implement solutions in Qiskit.
CO4.	**Implement** and analyse the Deutsch-Jozsa, Grover, QFT and QPE algorithms, explaining the quantum advantage in each case.
CO5.	**Access** IBM Quantum hardware, transpile and submit circuits, and compare hardware output with ideal simulation.
CO6.	**Design** quantum circuits.

MPY354: Quantum Computing Laboratory-I

Teaching Scheme	Examination Scheme
Practicals: 6hrs./Week, Tutorials:3hrs./Week Credits: 6 Lab Software: AQLL v3.0 + Qiskit 1.x Co-requisite: MPY331 (QC — Theory)	Internal-50 marks End Semester Exam – 100 marks

Course Objectives:

1. To provide guided, visualised exploration of qubit states, entanglement, density matrices and noise using the AQLL v3.0 simulation software.
2. To develop independent Qiskit programming skills through hands-on implementation of foundational quantum algorithms.
3. To execute selected experiments on real IBM Quantum hardware and interpret hardware-vs-simulation results.

List of Experiments:

Note1 : *Minimum 10 experiments (5 from phase 1 and five from phase 2) should be performed, (Experiments may be added /deleted subject to availability of time and facilities)*

1. **Phase 1 - AQLL-Guided Simulation (Experiments 1–8)**:
   1. GHZ+i state evolution;
   2. density matrix & von Neumann entropy;
   3. entanglement quantification & Schmidt decomposition;
   4. purity tracking & quantum fidelity;
   5. noise & decoherence channel analysis;
   6. shot-noise sampling statistics;
   7. quantum teleportation protocol;
   8. CHSH inequality with QFT & Grover's algorithm.
2. **Phase 2 - Independent Qiskit Programming (Experiments 9–15):**
   9. single-qubit states & Bloch sphere;
   10. all four Bell states with CHSH test;
   11. Deutsch-Jozsa algorithm;
   12. Quantum Fourier Transform circuit;
   13. Grover's search (2- and 4-qubit);
   14. quantum random number generator;
   15. IBM hardware execution & noise analysis.

Text Books and Reference Books:

1. S. K. Jain, Quantum Computing Laboratory Manual, Vol. I (S Publishing House, 2026 Ed.)
2. IBM Qiskit Documentation & Textbook, docs.quantum.ibm.com/learning (IBM Quantum, online resource)

3. Jack D. Hidary, Quantum Computing: An Applied Approach (Springer, 2nd Ed., 2021)
4. Michael A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, 10th Anniversary Ed., 2010)

NOTE: (IBM Hardware Requirement): Experiments 10, 11, 13, 14 and 15 must be executed on real IBM Quantum hardware, with job IDs and calibration screenshots submitted in the lab record.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Simulate** and visualise multi-qubit entangled states, density matrices and decoherence using AQLL v3.0 software.
CO2.	**Quantify** entanglement using Schmidt decomposition and von Neumann entropy, and analyse noise channels affecting fidelity.
CO3.	**Independently** write and execute Qiskit programs implementing Bell states, Deutsch-Jozsa, QFT and Grover's algorithm.
CO4.	**Generate** and statistically validate quantum random numbers using the Born rule
CO5.	**Execute** quantum circuits on IBM Quantum hardware, retrieve job results, and compare them with ideal simulation.
CO6.	**Design** quantum circuits.

MPY 352: Computational Physics Laboratory-I

Teaching Scheme	Examination Scheme
Practicals: 4hrs./Week	Internal – 15 marks
Credits: 2	End Semester Exam – 35 marks

Prerequisites:

1. Basic knowledge of C++ programming and programming logic.
2. Fundamental understanding of calculus, matrices, and differential equations.

Course Objectives:

1. To develop C++ programs for solving numerical and engineering problems.
2. To implement standard numerical methods for interpolation, integration, root finding, differential equations, and matrix operations.
3. To simulate engineering systems and analyze computational results using C++.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. To implement programs in C++ language.
2. Time delay subroutine and a clock program.
3. Newton's and Lagrange's interpolation with algorithm, flow chart, C++ Program and output.
4. Numerical integration by Trapezoidal with algorithm, flowchart, C++ Program & output.
5. Numerical integration by Simpson's rule with algorithm, flowchart, C++ Program & output.
6. Solution of a polynomial equation and determination of roots by Newton Raphson method with algorithm, flowchart, C++ Program and output.
7. Numerical solution of ordinary first order differential equation – Euler's method with algorithm, flowchart, C++ Program and output.
8. Numerical solution of ordinary first order differential equation – Runge-Kutta (RK) methods with algorithm, flowchart, C++ Program and output.
9. Curve fitting - Least square fitting with algorithm, flowchart, C++ program and output.
10. Matrix manipulation - Multiplication, Transpose and Inverse with algorithm, flow-chart, C++ program and output.

11. Iteration method, flowchart, C++ program and output. 12. Gauss Interpolation, flowchart, C++ program and output. 13. Determination of time response of an R-L-C circuit (C++ program and output). 14. Simple Pendulum Simulation – Calculate period for different lengths (C++ program and output). 15. Simple Harmonic Motion (SHM) – Displacement, velocity, and acceleration (C++ program and output).
Reference Books: 1. Bjarne Stroustrup, The C++ Programming Language, Addison-Wesley. 2. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw-Hill. 3. Computational Physics – Nicholas J. Giordano & Hisao Nakanishi

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Explain** the fundamentals of C++ programming and implement programs using basic programming constructs for scientific and engineering applications.
CO2.	**Apply** numerical methods such as interpolation, numerical integration, root-finding, iterative methods, matrix operations, and differential equation solvers by developing C++ programs.
CO3.	**Analyze** computational solutions obtained through C++ programs for curve fitting, interpolation, numerical integration, matrix manipulation, and iterative techniques to solve physics and mathematical problems.
CO4.	**Evaluate** the accuracy, convergence, and numerical performance of computational methods by interpreting the obtained numerical results and comparing different numerical techniques.
CO5.	**Apply** and analyze C++ programming to simulate physical systems such as RLC circuits, simple pendulum, and simple harmonic motion, and interpret their computational behavior.
CO6.	**Design** and develop C++ programs for solving new scientific, mathematical, and research-oriented computational problems using appropriate numerical techniques.

Semester – IV

MPY401: Quantum Mechanics-II

Teaching Scheme	Examination Scheme
Lectures: 3 hrs./Week	Class Test -12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4 (3L + 1T)	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of quantum mechanics, including wave functions, operators, and the Schrödinger equation.
2. Fundamental knowledge of linear algebra, special relativity, and classical mechanics.

Course Objectives:

1. To introduce the concepts of time-dependent perturbation theory, identical particles, and spin in quantum mechanics.
2. To develop an understanding of relativistic quantum mechanics through the Klein-Gordon and Dirac equations, including their physical applications.
3. To familiarize students with field quantization, symmetry principles, and conservation laws as a foundation for advanced studies and research in quantum field theory.

Detailed Syllabus:

Unit-1: Time-dependent perturbation theory

Sudden and adiabatic approximations, Schrödinger, Heisenberg and interaction pictures. Time-dependent perturbation theory and its Applications to Constant Perturbation, Transition probabilities, Fermi's golden rule.

Unit-2: Identical Particles and Spin

Identical Particles, Exchange Operator, Symmetric and Asymmetric wave functions, Construction of wave function for a system of particles, Pauli Exclusion Principle, Slater Determinant, Spin-statistics connection, Spin wave function for a system of two spin half particles, Distribution of bosons and Fermions in different potential wells/boxes. Scattering of two identical particles, Pauli- spin matrices.

Unit-3: Relativistic Wave Equation in Quantum Mechanics

Klein-Gordon equation, Expression of particle probability density and current density. Reduction of K.G. equation for charge particle in electromagnetic field to non-relativistic Schrödinger equation. Dirac equation, Expressions of Probability and Current densities, negative energy solutions, antiparticles, Plane wave solution, Dirac hole theory, Feynman interpretation of antiparticles, Dirac equation for masses particle: Two component theory of neutrino, Spin & Helicity, Gamma-matrices and their properties, Convariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Relativistic Hydrogen atom problem.

Unit-4: Field Quantization

Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether’s theorem, canonical quantization of the scalar field.

Text and Reference Books:

5. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
6. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
7. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
8. Modern Quantum Mechanics: J.J.Sakurai.
5. Principles of Quantum Mechanics: R. Shankar.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the concepts of time-dependent perturbation theory, identical particles, relativistic wave equations, and field quantization.
CO2.	**Explain** the principles of perturbation theory, exchange symmetry, spin, Klein–Gordon and Dirac equations, and scalar field quantization.
CO3.	**Apply** perturbation theory and relativistic quantum mechanics to solve theoretical physics problems.
CO4.	**Analyze** problems involving identical particles, relativistic quantum systems, and conservation laws.
CO5.	**Evaluate** the applicability of relativistic quantum mechanics and field quantization methods to physical systems.
CO6.	**Design** solutions for advanced problems in relativistic quantum mechanics and quantum field theory.

MPY431: Quantum Algorithms & Complexity

Teaching Scheme	Examination Scheme (CA: 30 | EE: 70 | Total: 100)
Lectures: 3 hrs./Week	Mid-Semester Exam - 12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4 (3L + 1T)	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of quantum mechanics, linear algebra, and quantum computation.
2. Fundamental knowledge of Python programming and quantum programming frameworks such as Qiskit.

Course Objectives:

1. To develop an advanced understanding of quantum algorithms, quantum complexity theory, and quantum error correction techniques.
2. To introduce fault-tolerant quantum computing, variational quantum algorithms, hybrid quantum-classical methods, and their applications in optimization and quantum chemistry.
3. To familiarize students with the principles of quantum machine learning, quantum data encoding, and the integration of quantum computing frameworks with modern machine learning libraries.

Detailed Syllabus:

Unit 1: Advanced Quantum Algorithms
Shor's factoring algorithm — order-finding, QPE-based period finding, continued fractions, and post-quantum cryptography implications; generalised amplitude amplification and quantum walks; HHL algorithm for linear systems; quantum simulation algorithms (Trotter-Suzuki, VQE for quantum chemistry).

Unit 2: Quantum Complexity Theory
Complexity classes P, NP, BPP, BQP, QMA and their known relationships; query complexity, adversary bounds and the polynomial method; the BBBV theorem establishing optimality of Grover's algorithm; evidence for quantum advantage — quantum supremacy and boson sampling.

Unit 3: Quantum Error Correction and Fault Tolerance
Why classical repetition codes fail; 3-qubit bit-flip and phase-flip codes, the Shor 9-qubit code; stabiliser formalism, [[n,k,d]] codes, CSS and Steane codes; surface codes, the threshold theorem and magic state distillation.

Unit 4: Advanced Variational and Hybrid Algorithms
QAOA for MaxCut, portfolio optimisation and the travelling salesman problem; VQE for molecular systems using Qiskit Nature; barren plateaus in deep variational circuits and mitigation strategies.

Unit 5: Quantum Machine Learning — Foundations
Quantum kernels and feature maps; quantum neural networks as parameterised universal function

approximators; data encoding strategies (amplitude, angle, basis); dequantisation results; PennyLane integration with PyTorch.

Text Books and Reference Books::

1. Phillip Kaye, Raymond Laflamme & Michele Mosca, An Introduction to Quantum Computing (Oxford University Press, 2007)
2. Michael A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, 10th Anniversary Ed., 2010)
3. Jain S K, Quantum Algorithms & Complexity (S Publishing House, 2026 Ed.)
4. John Preskill, Lecture Notes on Quantum Computation (California Institute of Technology, updated ed.)
5. Daniel A. Lidar & Todd A. Brun (Eds.), Quantum Error Correction (Cambridge University Press, 2013)
6. Mark M. Wilde, Quantum Information Theory (Cambridge University Press, 2nd Ed., 2017)

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Define** quantum algorithms and understand quantum complexity theory.
CO1.	**Design** and implement Shor's factoring algorithm — period finding via QFT, modular exponentiation, continued fractions — and analyse its cryptographic implications.
CO2.	**Apply** amplitude amplification and quantum-walk frameworks to generalise Grover's algorithm beyond the oracle model.
CO3.	**Classify** computational problems within P, NP, BQP, QMA and PSPACE and articulate their known relationships.
CO4.	**Describe** the principles of quantum error correction, stabiliser codes, the threshold theorem and surface-code architecture.
CO6.	**Implement** VQE and QAOA for real-world optimisation and chemistry problems in Qiskit and evaluate performance on IBM hardware.

MPY432: Quantum Hardware, Error Correction & Applications

Teaching Scheme	Examination Scheme (CA: 30 | EE: 70 | Total: 100)
Lectures: 3 hrs./Week	Mid-Semester Exam - 12 Marks
Tutorials: 1 hrs./Week	Teachers' Assessment – 6 Marks, Attendance – 12 Marks
Credits: 4 (3L + 1T)	End Semester Exam – 70 marks

Prerequisites:

1. Basic understanding of quantum mechanics, quantum computation, and linear algebra.
2. Fundamental knowledge of quantum programming and quantum information concepts.

Course Objectives

1. To develop an in-depth understanding of quantum hardware technologies, noise characterization, error mitigation, and quantum communication systems.
2. To introduce quantum cryptography, quantum networking, quantum internet technologies, and secure quantum communication protocols.
3. To familiarize students with emerging applications of quantum computing in chemistry, finance, materials science, and the evolving global quantum technology ecosystem.

Detailed Syllabus

Unit 1: Quantum Hardware Technologies — Deep Dive

Superconducting transmon qubits — Josephson junctions, microwave control, IBM Eagle/Heron processors; trapped-ion qubits — Paul traps and Mølmer-Sørensen gates; photonic, silicon-spin, topological and neutral-atom platforms compared on coherence time, fidelity and scalability.

Unit 2: Noise Characterisation and Error Mitigation

Noise sources — gate/SPAM errors, crosstalk, leakage; randomised benchmarking and gate-set tomography; zero-noise extrapolation, probabilistic error cancellation and Pauli twirling; readout-error mitigation and Qiskit Estimator resilience levels.

Unit 3: Quantum Cryptography and Communications

BB84 and E91 QKD protocols with security proofs; twin-field and measurement-device-independent QKD; post-quantum cryptography (CRYSTALS-Kyber, Dilithium, SPHINCS+); quantum random number generation; superdense coding and quantum secret sharing.

Unit 4 — Quantum Networks and Long-Range Communication

Quantum network architecture, nodes and channels; quantum repeaters, entanglement swapping and distillation protocols; the staged quantum-internet roadmap; satellite-based QKD (Micius) and India's National Quantum Science and Technology programme.

Unit 5 — Quantum Computing Applications

Quantum chemistry — VQE and Jordan-Wigner/Bravyi-Kitaev mappings; finance and optimisation — Markowitz-to-QAOA pipelines and quantum amplitude estimation; quantum materials simulation (Ising, Hubbard models); the global quantum industry and career landscape.

Text Books and Reference Books:

1. Jack D. Hidary, Quantum Computing: An Applied Approach (Springer, 2nd Ed., 2021)
2. Daniel A. Lidar & Todd A. Brun (Eds.), Quantum Error Correction (Cambridge University Press, 2013)
3. Jain S K, Quantum Hardware, Error Correction & Applications (S Publishing House, 2026 Ed.)
4. Mark M. Wilde, Quantum Information Theory (Cambridge University Press, 2nd Ed., 2017)
5. Nicolas Gisin & Rob Thew, Quantum Communication, Nature Photonics, Vol. 1, pp. 165–171 (2007)
6. Michael A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, 10th Anniversary Ed., 2010)

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Define** basic physical quantities needed to understand Quantum Cryptography and Communications, Quantum Networks and Long-Range Communication.
CO2.	**Compare** the physics, gate fidelities, coherence times and scalability of superconducting, trapped-ion, photonic, spin and topological qubits.
CO3.	**Apply** quantum error-mitigation techniques (ZNE, PEC, twirling, readout correction) to reduce effective noise on NISQ hardware.
CO4.	**Describe** the quantum cryptography landscape — BB84/E91 security proofs, post-quantum standards and QRNG.
CO5.	**Apply** quantum computing to chemistry, finance and logistics problems, implementing solutions in Qiskit.
CO6.	**Explain** quantum network architecture, satellite-based QKD, and India's National Quantum Mission goals.

MPY454: Quantum Computing Laboratory-II

Teaching Scheme	Examination Scheme
Practicals: 6hrs./Week, Tutorials:3hrs./Week Credits: 6 Hardware: IBM Quantum Cloud (min. 8/15 experiments) Co-requisite: MPY431, MPY432	Internal-50 marks End Semester Exam – 100 marks

Course Objectives

1. To develop and execute advanced quantum algorithms (Shor's, VQE, QAOA, HHL, QKD) through simulation and on IBM Quantum hardware.
2. To provide quantum state tomography, randomised benchmarking and error-mitigation experiments on real hardware.
3. To enable an independent quantum computing mini-project executed entirely on IBM Quantum hardware.

List of Experiments

Phase I: Experiments 1–7:

1. quantum state tomography (2-qubit);
2. randomised benchmarking of IBM hardware qubits;
3. zero-noise extrapolation;
4. Shor's algorithm — period finding (N=15);
5. quantum phase estimation;
6. VQE for the H2 molecule;
7. QAOA for MaxCut.

Phase II: Experiments 8–14:

8. 3-qubit quantum error-correcting codes;
9. Steane [[7,1,3]] code syndrome measurement;
10. BB84 QKD protocol simulation with QBER analysis;
11. noise-aware transpilation & hardware mapping;
12. quantum machine learning binary classifier;
13. Ising-model quantum simulation (Trotter dynamics);
14. expectation-value sweeps & correlation functions.

Experiment 15 — Independent Mini-Project: a student-designed quantum circuit or protocol, executed on IBM Quantum hardware with a minimum of 1000 shots, submitted with a written report, Qiskit code repository, job IDs and a departmental presentation.

NOTE: IBM Hardware Requirement: a minimum of 8 of the 15 experiments must be executed on real IBM Quantum hardware; the mini-project is compulsorily hardware-executed.

Text Books and Reference Books:

1. S. K. Jain, Quantum Computing Laboratory Manual, Vol. II — Advanced Experiments

(Narosa Publishing House, New Delhi, 2026 Ed.)
2. IBM Qiskit Documentation & Textbook, docs.quantum.ibm.com/learning (IBM Quantum, online resource)
3. Phillip Kaye, Raymond Laflamme & Michele Mosca, An Introduction to Quantum Computing (Oxford University Press, 2007)
4. Jack D. Hidary, Quantum Computing: An Applied Approach (Springer, 2nd Ed., 2021)

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Define** quantum states via tomography and characterise hardware qubit performance using randomised benchmarking..
CO2.	**Compare** zero-noise extrapolation to mitigate errors and recover higher-fidelity results on NISQ hardware.
CO3.	**Apply** Shor's algorithm, QPE, VQE and QAOA and execute them on IBM Quantum hardware.
CO4.	**Implement** quantum error-correcting codes and simulate the BB84 QKD protocol with security analysis.
CO5.	**Design**, execute and report an independent quantum computing project on real IBM Quantum hardware.

MPY452: Computational Physics Laboratory-II

Teaching Scheme	Examination Scheme
Practicals: 4hrs./Week	Internal-15 marks
Credits: 2	End Semester Exam – 35 marks

Prerequisites:

1. Basic knowledge of mathematics, including algebra, calculus, matrices, and differential equations.
2. Fundamental understanding of Python programming and scientific computing concepts.

Course Objectives

1. To develop programming skills in Python for implementing numerical methods and scientific computations.
2. To provide hands-on experience in solving mathematical and physical problems using Python, NumPy, and SciPy.
3. To enable students to model, simulate, and analyze scientific systems through computational techniques.

List of Experiments:

Note: *Minimum 10 experiments should be performed. (Experiments may be added /deleted subject to availability of time and facilities)*

1. Newton's and Lagrange's Interpolation with algorithm, flowchart, Python program, and output.
2. Numerical Integration using Trapezoidal Rule / Simpson's Rule with algorithm, flowchart, Python program, and output.
3. Solution of a Polynomial Equation and Determination of Roots using the Newton-Raphson Method with algorithm, flowchart, Python program, and output.
4. Numerical Solution of a First-Order Ordinary Differential Equation using Euler's Method with algorithm, flowchart, Python program, and output.
5. Curve Fitting using the Least Squares Method with algorithm, flowchart, Python program, and output.
6. Matrix Manipulation – Multiplication, Transpose, and Inverse with algorithm, flowchart, Python program, and output.
7. Iteration Method with algorithm, flowchart, Python program, and output.
8. Gauss Interpolation with algorithm, flowchart, Python program, and output.
9. Python (NumPy) – Matrix operations.
10. Python (SciPy/NumPy): Digital Signal Processing.
11. Python (SciPy): Solving Ordinary Differential Equations.

12. Runge-Kutta 4th Order Method (Python/NumPy). 13. Determination of time response of an R-L-C circuit (Python simulation). 14. Simple Pendulum Simulation – Calculate period for different lengths. 15. Simple Harmonic Motion (SHM) – Displacement, velocity, and acceleration.
Reference Books: 1. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press. 2. Hans Petter Langtangen, A Primer on Scientific Programming with Python, Springer. 3. Computational Physics – Nicholas J. Giordano & Hisao Nakanishi 4. Computational Physics – Mark Newman

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Describe** the principles of numerical methods and scientific computing using Python.
CO2.	**Explain** numerical algorithms and Python libraries (NumPy and SciPy) used for scientific computations.
CO3.	**Apply** Python programming to solve numerical problems involving interpolation, integration, differential equations, matrix operations, and curve fitting.
CO4.	**Analyze** computational results obtained from numerical methods and simulations of physical systems.
CO5.	**Evaluate** the accuracy and performance of numerical techniques for solving scientific and engineering problems
CO6.	**Design** Python-based computational models and simulations for mathematical and physical applications.

MPY350: FIELD PROJECT/INTERNSHIP

MPY 350: Field Project/Internship
Credits 4
Semester III
The Marking will be based on Seminar & Viva (30 minutes): 100 Marks

For students to enter into the preliminary research field both in theory and experiment, the concept of Field Project/Internship has been introduced in the third Semester. In Field project/Internship the student will have to visit various institutions for a period of minimum 6 weeks to complete the research project on the topic of their choice and submit a report of the same to the office of HoD physics at Invertis University.

General Points for Preparing Field Project/Internship Report:

1. The report should be typed on A4 sheet, paper of 70–90 GSM.
2. Margins: Left 1.5 inches; Right 0.5 inches; Top 1 inch; Bottom 1 inch (excluding footer, if any).
3. Printing should be only on one side of the paper.
4. Font for normal text: Times New Roman, 14 size for text and 16 size for headings, typed in double space. References may be printed in italics or a different font.
5. Total report should not exceed 50 pages including top cover and blank pages.
6. A CD of the report should be pasted/attached on the bottom page of the report.
7. A hard copy of the presentation should be attached along with the report, and a soft copy included in the CD.
8. Three completed copies are to be submitted to the HoD Physics: one for the departmental, one for University Library, one returned to the student.

MPY450: Project Work
(Credits 8)

Project Title:

To introduce students to the field of preliminary research, both in theory and in experiments, the concept of the Project has been introduced in the final semester. In the Project, the student will explore new developments from books and journals, collect literature/data, and write a Dissertation based on their work and studies. The Project Work can also be based on experimental work in industries/research laboratories.

Selection of Topic:

1. Students will make a project which should preferably be a working of the thoughts based on their subject.

2. The student will be assigned a faculty guide who guides the Supervisor of the students. The faculty would be identified before the end of the III semester.

3. The assessment of the performance of the students should be made at least twice in the semester. The students shall present the final Project live, using an overhead projector and a PowerPoint presentation on an LCD, to the internal Committee and the external examiner in the form of a seminar.

4. The evaluation committee shall consist of faculty members constituted by the college, which would be of at least three members, comprising the department Coordinator, Class Coordinator, and a nominee of the Director. The student's guide would be a special invitee to the presentation. The seminar session shall be an open house session. The internal marks would be the average of the marks each member of the Committee separately gave to the Director in a sealed envelope.

The Marking shall be as follows.

Internal: 100 marks

By the Supervisor – 50 marks

By a committee appointed by the Director – 50 marks

External: 100 marks

By External examiner – 100 marks

Dissertation

Selection of Topic:

1. All students pursuing M.Sc. shall select and propose a topic of dissertation in the first week of the semester. Care should be taken that the topic selected is not directly related to the subjects of the course being pursued or thesis work, if any. The proposed topic (Quantum Computing) should be submitted to the course coordinator.
2. The course coordinator shall forward the list of topics to the coordinator of the concerned department, who will consolidate the list, including some more topics, in consultation with the faculty of the department. The topics will then be allocated to the students, along with the name of the faculty guide, and forwarded to the Director for approval.
3. On approval by the Director, the list shall be displayed on the notice board, and the students will also be accordingly informed by the course coordinator within three weeks of the commencement of the semester.

Preparation of Dissertation:

1. The student shall meet the Supervisor for the necessary guidance for their preparation for the seminar.
2. During the next two to four weeks, the student will read the primary literature related to the topic (Quantum Computing) under the guidance of the Supervisor.
3. After the necessary collection of data and literature survey, the students must prepare a report. The report shall be arranged in the sequence as per the following format & layout plan: -

a. Top Sheet of transparent plastic.

b. Top cover.

c. Preliminary pages.

(i) Title page

(ii) Certification page.

(iii) Acknowledgment.

(iv) Abstract.

(v) Table of Contents.

(vi) List of Figures and Tables.

(vii) Nomenclature.

d. Chapters (Main Material).

e. Appendices, if any.

f. Bibliography/ References.

g. Evaluation Form.

h. Back Cover (Blank sheet).

i. Back Sheet of Plastic (May be opaque or transparent).

(a). Title Page: The Title Page cover shall be as follows:

............................Title of Dissertation..........................

Submitted in Partial fulfilment of the requirements for the degree of

Master of Science

in

Physics

By

Name of Student in Capital Letters

(Roll No……..)

Under the Supervision of

(Name of Supervisor with designation)

Department of Physics

Invertis Institute of Applied Sciences & Humanities

Invertis University

Bareilly (U.P.)-243123, India

MONTH AND YEAR

(b) Certification page: This shall be as under:

The dissertation Report and Title "Quantum Computing" submitted by Mr./Ms. (Name of the student) (Roll No.) may be accepted for being evaluated -

Date: **Signature Place:**

Name of Supervisor:

Note:

For Supervisor: If you choose not to sign the acceptance certificate above, please indicate reasons for the same from amongst those given below:

I. The amount of time and effort put in by the student is not sufficient;

II. The amount of work put in by the student is not adequate;

III. The report does not represent the actual work that was done/expected to be done;

IV. Any other objection (Please elaborate)

(c) Abstract: A portion of the dissertation grade will be based on the abstract. The abstract will be graded according to adherence to accepted principles of English grammar and according to adherence to the format described below. The dissertation abstract is an important record of the coverage of your topic (Quantum Computing) and provides a valuable source of leading references for students and faculty alike. Accordingly, the abstract must serve as an introduction to your dissertation topic. It will include the key hypotheses, the major scientific findings, and a brief conclusion. The abstract will be limited to 500 words, excluding figures, tables, and references. The abstract will include references to the research articles upon which the dissertation is based, as well as research articles that have served as key background material.

(d) Table of Contents:

This shall be as under: SAMPLE SHEET FOR TABLE OF CONTENTS

TABLE OF CONTENTS

3 ....

4 References/Bibliography

(e). List of Figures and Tables:

This will be as follows. List of Figures and Tables - sample entries are given below:

List of Figures

List of Tables

(f). Main Pages

The Main report should be divided into chapters (1, 2, 3, etc.) and structured into sections (1.1, 1.2, etc.) and subsections (1.2.1, 1.2.2, etc.). Suitable titles should be given for sections and subsections, where necessary.

Referencing style - wherever a reference is given in the main pages, it should have the following format.

The values reported for a variety of quantum systems have been reported by Varma (1982). For quantum error correction, however, the information is more limited, and some recent reviews have attempted to fill the gaps (Batchelor and Shah, 1985).

For two authors - (Batchelor and Kapur, 1985)

For more than two authors - (Batchelor et al., 1986)

By the same author/combination of authors in the same year – (Batchelor, 1978a; Batchelor, 1978b; Batchelor et al., 1978)

(g) Bibliography/References

In the bibliography/ references list, standard formats must be used. The typical formats are given below -

Journal articles: - David, A.B., Pandit, M.M., and Sinha, B.K., 1991, "Measurement of surface viscosity by densiometric methods", Chem. Engng Sci. 47, 931-945.

Books: - Doraiswamy, L.K. and Sharma, M.M., 1984, "Heterogeneous Reactions- Vol 1", Wiley, New York, pp 89-90.

Edited books/Compilations/Handbooks: - Patel, A.B., 1989, "Liquid-liquid dispersions", in Dispersed Systems Handbook, Hardy, L.C. and Jameson, P.B. (Eds.), McGraw-Hill, Tokyo, pp 165-178. Lynch, A.B. (Ed.), 1972, "Technical Writing", Prentice Hall, London.

Theses/Dissertations: - Pradhan, S.S., 1992, "Hydrodynamic and mass transfer characteristics of packed extraction columns", Ph.D. Thesis, University of Manchester, Manchester, U.K.

Citations from abstracts: -Lee, S. and Demlow, B.X., 1985, US Patent 5,657,543, Cf C.A. 56, 845674.

Personal Communications: - Reddy, A.R., 1993, personal communication at private meeting on 22 October 1992 at Physics Department, Indian Institute of Technology, Delhi.

Electronic sources (web material and the like)- For citing web pages and electronic documents, use the APA style given at: http://www.apastyle.org/elecsource.html

(h) Evaluation Form:

Three sheets of the evaluation form should be attached to the report as follows.

a. Evaluation form for the Supervisor and other Internal Examiner.

b. Evaluation form for external examiners.

c. Summary Sheet.

(i) Evaluation form for Guide & Internal

EVALUATION SHEET

(To be filled by Supervisor & Internal Examiners only)

Name of Candidate: ____________________________________

Roll No: ____________________

Class and Section: ____________________

Project Title: ____________________

S. No.	Details	Marks (10) Supervisor	Marks (10) Internal Examiner
1.	OBJECTIVE IDENTIFIED UNDERSTOOD		
2.	LITERATURE REVIEW (Organization, Critical review)		
3.	DISCUSSION/CONCLUSIONS (Clarity, Exhaustive)		
4.	SLIDES/PRESENTATION SUBMITTED (Readable, Adequate)		
5.	FREQUENCY OF INTERACTION (Timely submission, Interest shown, Depth, Attitude)		
	Total (Out of 50)		
	Total (Out of 100)		

Name & Signature: **Name & Signature:**

Date: **Date:**

EVALUATION SHEET FOR EXTERNAL EXAMINER

(To be filled by the External Examiner only)

Name of Candidate: ____________________________________

Roll No: ____________________

Project Title: ____________________

I. For use by External Examiner ONLY

S.No.	**Details**	**Marks (10)**
1.	OBJECTIVE IDENTIFIED & UNDERSTOOD	
2.	LITERATURE REVIEW / BACKGROUND WORK (Coverage, Organization, Critical review)	
3.	DISCUSSION/CONCLUSIONS (Clarity, Exhaustive)	
4.	POWER POINT PRESENTATION (Clear, Structured)	
5.	SLIDES (Readable, Adequate)	
	Total (Out of 50)	

Name & Signature:

Date:

EVALUATION SUMMARY SHEET (To be filled by External Examiner)

Name and Roll No.	**Internal Examiner (100)**	**External Examiner (100)**	**Total (200) Result**	**(Pass/Fail)**

Note: - The summary sheet is to be completed for all students, and the same shall also be compiled for all students examined by the External Examiner. The format shall be provided by the course coordinator.

(j) General Points for Dissertation

1. The report should be typed on an A4 sheet. The paper should be of 70-90 GSM.
2. Each page should have minimum margins as under -
   a. Left 1.5 inches
   b. Right 0.5 Inches
   c. Top 1 Inch
   d. Bottom 1 Inch (Excluding Footer, If any)
3. The printing should be only on one side of the paper
4. The font for normal text should be Times New Roman, 14 size for text and 16 size for heading,

and should be typed in double space. The references may be printed in Italics or in different fonts.

5. The Total Report should not exceed 50 pages, including the top cover and blank pages.

6. A CD of the report should be pasted/ attached to the bottom page of the report.

7. Similarly, a hard copy of the presentation (Two slides per page) should be attached along with the report, and a soft copy should be included on the CD.

8. Three copies completed in all respects as given above are to be submitted to the Supervisor. One copy will be kept in the departmental/University Library, one will be returned to the student, and a third copy will be for the Supervisor.

9. The power point presentation should not exceed 30 minutes which include 10 minutes for discussion/Viva.

Viva-voce

Students will prepare the viva, which should be based on their subject (Quantum Computing). The student will be assigned a faculty guide who will supervise the student. The faculty would be identified before the end of the III semester. The faculty will take full responsibility for preparing the viva for the students.

The evaluation committee shall consist of faculty members appointed by the college, comprising at least three members: the department Coordinator, the Class Coordinator, and a nominee of the Director. The student's Supervisor would be a special invitee to the viva. The viva session shall be an open house session. The internal marks would be the average of the marks each member of the Committee submitted in a sealed envelope.