COURSE OF STUDIES	
PHYSICS/M.Sc.	
Programme Level	Master of Science (M.Sc.)
Subject / Discipline	Physics
Faculty	Faculty of Science
University	Universities of Bihar Established under the BSU AC 1976/PU Act 1976.
Duration	Two Years / Four Semesters
NHEQF Level	Level 6.5
Effective from	2026-27 onwards

A PART A — PROGRAMME OVERVIEW & OBJECTIVES

A.1 Graduate Attributes (GAs)

The programme nurtures the following Graduate Attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

1. **Advanced Physics Knowledge**

Comprehensive understanding of classical, quantum, atomic, nuclear, condensed matter, photonics, electronics, energy science, and interdisciplinary applications.

2. **Scientific Inquiry and Problem Solving**

Ability to formulate hypotheses, analyze problems, design experiments, and derive scientifically valid conclusions.

3. **Mathematical and Computational Competence**

Ability to employ advanced mathematical methods, numerical techniques, programming, simulation, and data analytics.

4. **Experimental and Instrumentation Skills**

Proficiency in modern laboratory techniques, instrumentation, measurement systems, and data acquisition.

5. **Research and Innovation**

Capability to undertake independent research, literature review, scientific writing, innovation, and technology development.

6. **Critical Thinking and Knowledge Evaluation**

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Ability to evaluate evidence. distinguish fact from opinion. analyze uncertainty. and make rational decisions.

7. **Digital and Technological Proficiency**

Competence in modern computational tools. AI-assisted scientific analysis. simulations. and digital technologies.

8. **Interdisciplinary and Systems Thinking**

Ability to integrate concepts from physics. biology. environmental science. engineering. education. philosophy. and data science.

9. **Communication and Leadership**

Ability to communicate scientific ideas effectively through writing. presentations. teaching. outreach. and teamwork.

10. **Ethics, Sustainability and Social Responsibility**

Understanding of professional ethics. environmental sustainability. scientific temper. and responsible use of technology.

11. **Lifelong Learning and Employability**

Capacity for self-learning. adaptability. entrepreneurship. and continuous professional development.

A. 2 Programme Outcomes (POs)

The Programme Educational Objectives describe the career and professional accomplishments that graduates are expected to attain within three to five years of graduation.

1. PO 1 — Demonstrate advanced knowledge of fundamental and applied physics.
2. PO 2 — Apply mathematical, computational, and analytical techniques to solve complex physical problems.
3. PO 3 — Design and perform experiments, interpret results, and draw meaningful conclusions.
4. PO 4 — Use modern scientific instruments, software tools, and computational techniques.
5. PO 5 — Develop models for physical, biological, environmental, and technological systems.
6. PO 6 — Conduct independent research and contribute to scientific knowledge.
7. PO 7 — Communicate scientific concepts effectively to specialist and non-specialist audiences.
8. PO 8 — Apply interdisciplinary approaches to emerging scientific and technological challenges.
9. PO 9 — Practice ethical conduct and promote scientific temper and sustainability.
10. PO 10—Demonstrate leadership. teamwork. innovation. and lifelong learning skills.

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A.3 Programme Specific Outcomes (PSOs)

Upon successful completion of this programme, a student shall demonstrate the following learning outcomes:

1. PSO 1 — [Disciplinary Knowledge] Apply advanced concepts of mechanics, quantum physics, atomic physics, condensed matter physics, photonics, electronics, and energy science to solve research problems.
2. PSO 2 — [Critical Thinking & Analysis] Use advanced mathematical and computational methods for theoretical modeling and simulations.
3. PSO 3 — [Research Competence] Employ modern experimental techniques, spectroscopy, instrumentation, and measurement systems.
4. PSO 4 — [Communication] Evaluate scientific information critically and communicate scientific knowledge effectively.
5. PSO 5 — [Ethics & Social Responsibility] Analyze interdisciplinary systems involving biological, environmental, atmospheric, medical, and technological applications. Apply emerging technologies including AI, photonics, renewable energy systems, and embedded systems for societal benefit.

B PART B — COURSE STRUCTURE (CBCS/NHEQF FRAMEWORK)

B. 1 Semester-wise Course Structure

The following table presents the full four-semester course structure. Column headings: L = **Lectures per week**; T = Tutorials per week; P = Practicals per week; CC = Core Course; DSE = Discipline Specific Elective; GE/OE = Generic/Open Elective; SEC = Skill Enhancement Course; PROJ = Project/Dissertation.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
SEMESTER I								
1	MSPHY-CC101	Core Course I: Classical Mechanics and Mathematical Methods	3	1	0	4	100	CC
2	MSPHY-CC102	Core Course II: Solid State Physics	3	1	0	4	100	CC
3	MSPHY-CC103	Core Course III: Modern Atomic, Quantum and Nuclear Physics	3	1	0	4	100	CC
4	MSPHY-PC104	Core Course IV: Practical	0	0	4	4	100	CC

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S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
5	MSPHY-GE105/ GE106/ GE107	Generic Elective I: (One course to be chosen from the basket I)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester I	14	4	**4**	**22**	**600**	
SEMESTER II								
1	MSPHY-CC201	Core Course I: Electronics and Instrumentation	3	1	0	4	100	CC
2	MSPHY-CC202	Core Course II: Molecular Spectroscopy, Lasers and Photonics	3	1	0	4	100	CC
3	MSPHY-CC203	Core Course III: Energy Science and Renewable Energy Technology	3	1	0	4	100	CC
4	MSPHY-PC204	Core Course IV: Practical	0	0	4	4	100	CC
5	MSPHY-GE205/ GE206/GE207	Generic Elective II: (One course to be chosen from the basket II)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester II	**14**	**4**	**4**	**22**	**600**	

Particulars	Semester	Course Code	Course Title
Basket I	I	MSPHY-GE105	Knowledge System, Scientific Thinking and Physics Education
		MSPHY-GE106	Python for Scientific Computing
		MSPHY-GE107	The Physics of Life, Health and Healing
Basket II	II	MSPHY-GE205	Basics of Electronic Circuit Design
		MSPHY-GE206	Science Journalism, Popular Science Writing and Content Creation
		MSPHY-GE207	Climate and Environmental Sciences

C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-CC101
Title of the Paper	Classical Mechanics and Mathematical Methods
Programme / Subject	M.Sc. — Physics
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	00
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Master variational principles, Hamiltonian formalism, and canonical transformations.
COB 2	Analyze physical systems using group theory, probability, and complex analysis.
COB 3	Understand nonlinear dynamics, chaos, and modern perturbation techniques.
COB 4	Apply relativistic and tensor methods to physical systems.

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COB 5	Use computational tools (Python/Matlab/Julia) for simulation and modeling.
COB 6	Prepare for research in theoretical physics, astrophysics, and applied mathematics.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Apply Lagrangian and Hamiltonian methods
CLO 2	Use mathematical physics tools in advanced problem solving.
CLO 3	Analyze central force, rigid body and oscillatory systems.
CLO 4	Understand nonlinear dynamics and chaos.
CLO 5	Apply relativistic and field-theoretic methods.
CLO 6	Perform computational simulations of physical systems.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Classical Mechanics and Mathematical Methods [MSPHY-CC101]		
Unit	**Content**	**Suggested Lectures hours**
I	**Variational Principles & Mathematical Foundations:** • Newton's laws, constraints, generalized coordinates. • Variational calculus, Hamilton's principle, Euler–Lagrange equations. • Cyclic coordinates, conserved quantities, Noether's theorem. • Linear vector spaces, inner product, norm, Schwarz inequality, Gram–Schmidt orthogonalization. • Linear operators, eigenvalues, eigenvectors, Hermitian and unitary operators. • Symplectic manifolds, variational integrators.	12
II	**Hamiltonian Formalism & Statistical Methods:** • Hamiltonian formulation and Hamilton's equations.	12

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	• Poisson brackets, canonical invariants, Jacobi identity, angular momentum algebra. • Canonical transformations and generating functions. • Probability distributions: Binomial, Poisson and Normal. • Central Limit Theorem, hypothesis testing and data analysis. • Symplectic integrators and molecular dynamics.	
III	**Central Force Motion, Complex Analysis & Group Theory:** • Central force motion, effective potential, Kepler problem, virial theorem. • Scattering theory in laboratory and center-of-mass frames. • Complex analysis and residue theorem. • Integral transforms and Green's functions. • Groups, subgroups, cosets, homomorphism and isomorphism. • Post-Newtonian corrections and orbital dynamics.	12
IV	**Rigid Body, Relativity & Representation Theory:** • Rigid body dynamics, Euler angles, symmetric top, torque-free motion. • Stability of rotations and rigid-body perturbations. • Lorentz transformations, four-vectors, relativistic collisions. • Group representations, Schur's lemma and character theory. • Attitude control systems and gravitational waves.	12
V	**Oscillations, Nonlinear Dynamics & Field Theory:** • Small oscillations, normal modes and eigenvalue problems. • Forced oscillations, damping, resonance and mode coupling. • Nonlinear dynamics, Lyapunov exponents and KAM theorem. • Classical field theory, Noether currents and gauge symmetry. • Non-Hermitian dynamics and semiclassical methods.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

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C.6 Prescribed Textbooks

1. N C Rana & P S Joag, Classical Mechanics, McGraw Hill, First Edition 2011.
2. Herbert Goldstein, Charles P. Poole, and John L. Safko, Classical Mechanics, Pearson, Third Edition 2011.

3. John R. Taylor, Classical Mechanics, University Science Books, First Edition 2005.
4. David Morin, Introduction to Classical Mechanics, Cambridge University Press, First Edition 2008.
5. J.C. Upadhyaya, Classical Mechanics, Himalaya Publishing House Pvt. Limited 3rd edition.
6. Kleppner and kolenkow, An Introduction to Mechanics McGraw Hill/ Cambridge University Press 2013.
7. Arfken & Weber, Mathematical Methods for Physicists, Elsevier, Sixth Edition 2012.
8. Murray R. Spiegel, Schaum's Outline of Advanced Mathematics for Engineers and Scientists, McGraw Hill, First Edition 2009.
9. Mary L. Boas, Mathematical Methods in the Physical Sciences, John Wiley, Third Edition 2005.
10. Charlie Harper, Introduction to Mathematical Physics, Prentice Hall India Learning Pvt. Ltd.
11. Gregory, Classical Mechanics, Cambridge University Press
12. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley.

C.7 Reference Books & Readings

1. Ana Cannas Da Silva Lecture on Symplectic Geometry.
2. American Mathematical Society Introductory Articles on Symplectic Manifoldsls.

C.8 Suggested E-Resources / Digital Repositories

1. NPTEL Course on Classical Mechanics (Course 38) by Prof. V. Balakrishnan.
   - https://youtube.com/playlist?list=PL5E4E56893588CBA8&si=Fe5li9cgp4O7NRL8
2. MIT Open Course ware Physics Courses on Classical Mechanics.
   - https://youtube.com/playlist?list=PLUl4u3cNGP61qDex7XslwNJ-xxxEFzMNV&si=8TqPK6QxU9Z9O4MT
3. Introduction to classical mechanics by Prof. Anurag Tripathi, IIT Hyderabad, NPTEL-NOC IITM
   - https://www.youtube.com/watch?v=OyPkN_3jCxQ
4. General Introduction to Classical Mechanics by Prof. Bhawani Prasad Mandal, SWAYAM BHU.
   - https://youtu.be/EuqcOCmGbbQ?si=zGMSxTWbbd4Yuoyr

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

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Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-CC102
Title of the Paper	Solid State Physics
Programme / Subject	M.Sc. — Physics
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	00
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To introduce the fundamental concepts of crystal structure and crystal symmetry.
COB 2	To understand the nature of bonding and lattice dynamics in solids.
COB 3	To explain the electronic properties of solids using free electron and band theories.
COB 4	To study the magnetic, dielectric, and superconducting properties of materials.
COB 5	To develop the ability to correlate microscopic structure with macroscopic material properties.

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Understand crystal structures, reciprocal lattices, and X-ray diffraction techniques.
CLO 2	Explain bonding mechanisms and lattice dynamics in crystalline solids.
CLO 3	Analyze electronic properties of materials using free electron and band theories.
CLO 4	Describe magnetic phenomena and classify magnetic materials.
CLO 5	Understand dielectric behavior and superconductivity in condensed matter systems.
CLO 6	Apply experimental techniques such as Hall-effect and four-probe measurements for material characterization.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Solid State Physics [MSPHY-CC102]		
Unit	**Content**	**Suggested Lectures hours**
I	**Crystal Structure and X-ray Diffraction:** • **Crystal Geometry:** Crystalline and amorphous solids, Lattice and basis, Crystal structure, Unit cell and primitive cell, Bravais lattices (two and three-dimensional), Lattice translation vectors • **Crystal Planes and Directions:** Miller indices, Interplanar spacing, Crystal directions and planes, Symmetric Operations • **Reciprocal Lattice:** Reciprocal lattice vectors, Construction of reciprocal lattice, Brillouin zones and their significance • **X-ray Diffraction:** Diffraction of X-rays by crystals, Bragg's law and its applications, Determination of crystal structure using X-ray diffraction	12
II	**Crystal Bonding and Lattice Dynamics:**	12

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	• **Interatomic Bonding in Solids:** Ionic bonding, Covalent bonding, Metallic bonding, Van der Waals bonding, Hydrogen bonding • **Crystal Cohesion:** Cohesive energy of ionic crystals, Madelung constant (elementary idea), Lennard-Jones potential, Binding energy and equilibrium separation • **Lattice Vibrations:** Vibrations of crystal lattice, Monoatomic linear chain, Diatomic linear chain • **Phonons and Thermal Properties:** Acoustic and optical phonons, Dulong-Petit law, Einstein theory of specific heat, Debye theory of specific heat, Low-temperature specific heat and T^3 law	
III	**Free Electron Theory and Band Theory of Solids:** • **Free Electron Model:** Classical free electron theory, Quantum free electron gas, Fermi-Dirac statistics, Fermi energy and Fermi surface, Density of states • **Band Theory of Solids:** Bloch theorem, Kronig-Penney model, Formation of energy bands, Concept of Band Gap • **Classification of Solids:** Conductors, Semiconductors, Insulators • **Semiconductor Physics:** Intrinsic and Extrinsic Semiconductors, P-type and N-type semiconductors, Electrical conductivity of semiconductors, Carrier mobility • **Experimental Techniques:** Four-probe method for conductivity measurement, Hall effect and Hall coefficient, Applications of Hall measurements	12
IV	**Magnetic Properties of Solids:** • **Fundamentals of Magnetism:** Magnetic moment and magnetization, Origin of magnetism in solids • **Types of Magnetic Materials:** Diamagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism, Ferrimagnetism (elementary idea) • **Magnetic Theories:** Langevin theory of diamagnetism, Langevin theory of paramagnetism, Curie law and Curie-Weiss law • **Ferromagnetism:** Weiss molecular field concept, Ferromagnetic domains, Hysteresis curve and magnetic materials, Different kinds of magnetic interactions • **Applications:** Magnetic storage devices, Soft and hard magnetic materials, Spintronics and its applications	12
V	**Dielectric Properties and Superconductivity:**	12

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V	**Dielectric Properties and Superconductivity:** • **Dielectric Properties:** Polarization mechanisms, Electronic, ionic, orientational and space-charge polarization, Electric susceptibility, Polarizability, Local electric field, Depolarization field, Clausius-Mossotti equation, Piezoelectric properties • **Ferroelectric Materials:** Ferroelectricity, Hysteresis loop Applications of ferroelectric materials • **Superconductivity:** Experimental discovery and basic properties, Critical temperature, Critical magnetic field, Meissner effect • **Types of Superconductors:** Type-I and Type-II superconductors, London equations, Penetration depth • **Microscopic Theory:** Isotope effect, Cooper pairs (qualitative idea), Basic concepts of BCS theory, Applications of superconductors	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Charles Kittel, Introduction to Solid State Physics, Wiley.
2. J. P. Srivastava, Elements of Solid State Physics, PHI.
3. A. J. Dekker, Solid State Physics, Macmillan.
4. M. A. Wahab, Solid State Physics, Narosa Publishing.
5. N. W. Ashcroft and N. D. Mermin, Solid State Physics.
6. S. O. Pillai, Solid State Physics, New Age International.
7. Leonard V. Azaroff, Introduction to Solids, McGraw Hill Education

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C.7 Reference Books & Readings

1. Introduction to applied Solid State Physics by R Dalven – Springer Nature.
2. Encyclopedia of Condensed Matter Physics.
3. The Principles of Nuclear Magnetism (Oxford,1961), A. Abragam, B. Bleaney.
4. Ziman, J. M. Principles of the Theory of Solids. Cambridge University Press.
5. Blundell, S. Magnetism in Condensed Matter. Oxford University Press.
6. Cullity, B. D., & Stock, S. R. Elements of X-Ray Diffraction (3rd Edition). Pearson.
7. Poole, C. P., Farach, H. A., Creswick, R. J., & Prozorov, R. Superconductivity (3rd Edition). Academic Press.

C.8 Suggested E-Resources / Digital Repositories

1. NPTEL Course on Solid State Physics by Prof. Nirmal Ganguli. NPTEL-NOC-IITM
   - https://youtu.be/4-FYTEC7gbY?si=fYvG3fAZpeCBag5E
2. NPTEL Course on Symmetry and Structure in the Solid State by Prof. T.N. Guru Row. IISC Bangalore.
   - https://youtu.be/KFtcCNXu0TA?si=bwQuqdfQlU0CKUCd
3. MIT Open Courseware – Solid State Physics
   - https://ocw.mit.edu/courses/8-231-physics-of-solids-i-fall-2006/
4. NPTEL: Electronic Properties of Materials
5. NPTEL: Crystallography and X-ray Diffraction
6. SWAYAM: Condensed Matter Physics
7. SWAYAM: Materials Science and Engineering
8. e-PG Pathshala – Condensed Matter Physics Modules
9. National Digital Library of India (NDLI)
10. Shodhganga (INFLIBNET)
11. Virtual Labs – Solid State Physics and Materials Characterization Experiments

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-CC103
Title of the Paper	Modern Atomic, Quantum and Nuclear Physics
Programme / Subject	M.Sc. — Physics
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	00
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Apply quantum mechanics to atomic structure and spectra.
COB 2	Explain fine, hyperfine and relativistic corrections in atoms.
COB 3	Understand coupling schemes, magnetic interactions and spin technologies.
COB 4	Analyze nuclear structure using modern nuclear models.

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COB 5	Understand particle physics and modern research frontiers.
COB 6	Perform computational and spectroscopic analyses.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain modern atomic and nuclear phenomena.
CLO 2	Solve quantum mechanical problems of atomic systems.
CLO 3	Analyze atomic spectra and magnetic interactions.
CLO 4	Apply nuclear models to explain nuclear structure.
CLO 5	Understand particle physics and contemporary research areas.
CLO 6	Perform computational simulations and spectroscopic analyses.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Modern Atomic, Quantum and Nuclear Physics [MSPHY-CC103]		
Unit	**Content**	**Suggested Lectures hours**
I	**Foundations of Atomic Physics and the Beginning of Quantum Age** • Blackbody radiation, photoelectric effect, atomic spectra, Rutherford and Bohr models. • Wilson–Sommerfeld quantization and old quantum theory. • Fine structure, excitation and ionization potentials. • Precision spectroscopy, atomic clocks, Lamb shift and hyperfine structure.	12
II	**Quantum Mechanics of Atomic Systems:** • Matter waves, Schrödinger equation, wave function and probability. • Hydrogen atom in spherical coordinates and separation of variables. • Legendre, Laguerre and hypergeometric functions.	12

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	• Angular momentum operators, parity and expectation values. General theory of angular momentum and commutation relations • Dirac Bra and Ket notation and its algebra.	
III	**Vector Atom Model, Atomic Structure and Spectroscopy:** • Orbital and spin angular momentum, magnetic moments. • L-S and J-J coupling, spin-orbit interaction. • Zeeman and Paschen–Back effects in one and two electron atomic systems. • Pauli principle and electronic configurations. • Spectra of alkali and alkaline earth metals. • Hyperfine structure of spectral lines. • The breadth of spectral lines. • Electron paramagnetic resonance (EPR). Nuclear magnetic resonance (NMR)	12
IV	**Nuclear Structure and Nuclear Reactions:** • Nuclear properties, binding energy and semi-empirical mass formula. • Liquid drop, shell, collective and Fermi gas models. • Nuclear forces, Yukawa theory and deuteron. • Nuclear reactions, fission, fusion and transmutation. • Particle detectors (GM Counter, Cherenkov detector, Scintillator detector) and gamma spectroscopy.	12
V	**Contemporary Nuclear Physics, Particle Physics and Quantum Technologies:** • Radioactivity, nuclear medicine and radiation safety. • Quarks, leptons and Standard Model. • Cyclotron, synchrotron and particle accelerators. • Neutrino oscillations and experiments. • QED, Bose-Einstein condensates, ultracold atoms and quantum information.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

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C.6 Prescribed Textbooks

1. Bransden, B. H., & Joachain, C. J. *Physics of Atoms and Molecules*. Pearson.
2. Sakurai, J. J., & Napolitano, J. *Modern Quantum Mechanics*. Cambridge University Press.
3. Quantum Physics, Prof. H .C. Verma, Surya Publication.
4. Griffiths, D. J. and Schroeter, D. F., *Introduction to Quantum Mechanics* (3rd Edition), Cambridge University Press, Cambridge, 2018.
5. Eisberg, R. and Resnick, R., *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles* (2nd Edition), John Wiley & Sons, New York, 1985.
6. Mathews, P. M. and Venkatesan, K., *A Textbook of Quantum Mechanics* (2nd Edition), McGraw Hill Education (India), New Delhi, 2010.
7. S. N. Ghoshal, *Nuclear Physics*, S. Chand & Company Pvt. Ltd., New Delhi, 2012.
8. D. C. Tayal, *Nuclear Physics*, Himalaya Publishing House, Mumbai, 2011.
9. Roy, R. R. and Nigam, B. P., *Nuclear Physics: Theory and Experiment*, New Age International Publishers, New Delhi, 2016.
10. K. Gopala Krishnan, Atomic and Nuclear Physics, Mac Million India Ltd)
11. Rajkumar, Atomic and Molecular Physics, Kedarnath and Ramnath Publications.

C.7 Reference Books & Readings

1. Springer Handbook of Atomic, Molecular and Optical Physics
2. Quantum Physics, Mechanics & More, World Scientific Publication.
3. Quantum Mechanics and Quantum Information, World Scientific Publication.
4. Springer Handbook of Atomic, Molecular, and Optical Physics. Springer.
5. Cohen-Tannoudji, C., Dupont-Roc, J., & Grynberg, G. *Atom–Photon Interactions: Basic Processes and Applications*. Wiley.
6. Krane, K. S. *Introductory Nuclear Physics*. Wiley.
7. Griffiths, D. *Introduction to Elementary Particles* (2nd Edition). Wiley-VCH.

C.8 Suggested E-Resources / Digital Repositories

1. MIT Open Courseware 8.04 Quantum Physics I. Spring 2016
   - https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2016/
2. Advance Quantum Mechanics with Applications by Prof. Saurabh Basu, NPTEL IIT Guwahati.
   - https://youtube.com/playlist?list=PLq-Gm0yRYwTi_K9GcIAOggihMePnyF9mj&si=V1VP99-mRdFZ4MD5
3. Fundamentals of Spectroscopy by Dr. Sayan Bagachi, NCL Pune and Dr. Anirban Hazra, IISER Pune, NPTEL-NOC IITM.

- https://www.youtube.com/watch?v=blvNJWuDtQY

4. Atomic and Molecular Physics by Prof. Amal Kumar Das. IIT-Kharagpur. NPTEL Atomic and Molecular Physics. IIT-KGP.
5. SWAYAM: Quantum Physics and Applications
6. SWAYAM: Spectroscopy and Modern Physics
7. e-PG Pathshala – Quantum Physics. Atomic Physics and Nuclear Physics Modules
8. National Digital Library of India (NDLI)
9. Shodhganga (INFLIBNET)
10. Virtual Labs – Spectroscopy. Nuclear Physics and Quantum Physics Experiments

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. ₹qAttendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-PC104
Title of the Paper	Core Course 4: PRACTICAL
Programme / Subject	MSc- PHYSICS
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	0 – 0– 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	6 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	-	—	—	70
Practical / Lab Work	—	70	—	30
Internal Assessment	—	—	30	30
Maximum Marks	**0**	**70**	**30**	**100**
Passing Marks	**0**	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance. class tests. seminars. assignments. and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To develop experimental skills in classical mechanics and oscillatory systems through precise measurements and data analysis.
COB 2	To understand atomic and nuclear phenomena using spectroscopic and radiation detection techniques.
COB 3	To gain practical knowledge of magnetic, dielectric, and ferroelectric properties of materials.
COB 4	To perform characterization of semiconductor materials using Hall effect and four-probe techniques.
COB 5	To cultivate scientific inquiry, experimental design, error analysis, and laboratory safety practices.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain and interpret the principles of oscillations, spectroscopy, radiation physics, and material characterization techniques.
CLO 2	Perform laboratory experiments involving atomic spectra, radioactive measurements, magnetic properties, and semiconductor characterization using standard instrumentation.
CLO 3	Analyze experimental data, estimate uncertainties, and evaluate physical parameters using appropriate theoretical models.
CLO 4	Assess the behavior of materials and physical systems based on experimental observations and compare them with established theories.
CLO 5	Design, conduct, and document experimental investigations independently while adhering to ethical and safety standards.

C.5 Syllabus — Unit-wise Breakdown

Course Name: PRACTICAL-2 (MSPHY-PC204)		
Unit	**Content**	**Suggested Lectures hours**
	1. Study of a Compound (Physical) Pendulum for Determination of the Radius of Gyration and Verification of the Parallel-Axis Theorem 2. Study of coupled oscillations and normal modes using coupled pendulums. 3. Study of torsional oscillations and determination of moment of inertia of regular and irregular bodies. 4. Study of damped harmonic motion and determination of damping coefficient. 5. Determination of e/m of electron using Thomson's method (or simulation-based Millikan experiment). 6. Study of Zeeman Effect and determination of Lande g-factor. 7. Study of Hydrogen Spectrum and determination of Rydberg constant. 8. Study of sodium doublet and determination of fine structure separation. 9. Determination of GM counter characteristics and plateau curve.	120 Hours

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	10. Measurement of absorption coefficient of γ-rays using GM counter. 11. Determination of half-life of a radioactive source using simulation or virtual laboratory. 12. Determination of the Landé g-factor from Zeeman Splitting of Spectral Lines. 13. Measurement of magnetic susceptibility of paramagnetic solution using Quincke's method. 14. Measurement of magnetic susceptibility of solids using Gouy's method. 15. Determination of dielectric constant of dielectric materials as a function of frequency. 16. Study of ferroelectric hysteresis (P-E loop) of ferroelectric materials. 17. Study of B-H hysteresis curve and determination of hysteresis loss. 18. Determination of Hall coefficient and carrier concentration of a semiconductor. 19. Four-probe measurement of resistivity of semiconductor and determination of band gap. 20. Measurement of Curie temperature of a ferromagnetic material.	
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Squires, G. L. (2001). Practical Physics (4th ed.). Cambridge University Press.
2. Chattopadhyay, D., Rakshit, P. C., & Saha, B. (2014). An Advanced Course in Practical Physics (7th ed.). New Central Book Agency.
3. Harnam Singh, P.S. Hemne, Practical Physics, S. Chand & Company Pvt. Ltd.

C.7 Reference Books & Readings

1. Bevington, P. R., & Robinson, D. K. (2003). Data Reduction and Error Analysis for the Physical Sciences (3rd ed.). McGraw-Hill.
2. Taylor, J. R. (1997). An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements (2nd ed.). University Science Books.
3. Preston, D. W., & Dietz, E. R. (1991). The Art of Experimental Physics. Wiley.
4. Kittel, C. (2018). Introduction to Solid State Physics (8th ed.). Wiley.

C.8 Suggested E-Resources / Digital Repositories

1. NPTEL: Experimental Physics. Nuclear Physics. Solid State Physics. Spectroscopy
2. e-PG Pathshala (Physics): https://epgp.inflibnet.ac.in
3. Virtual Labs (MoE, Government of India): https://www.vlab.co.in
4. National Digital Library of India (NDLI): https://ndl.iitkgp.ac.in
5. SHODHGANGA / Shodhgangotri – Research Thesis Repository
6. INFLIBNET Centre: https://www.inflibnet.ac.in

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

Experiment: 45 Marks
Notebook: 15
Viva-voce: 10

Internal Assessment (20 marks) breakdown:

1. Internal Performance and Laboratory Notebook: 15 marks
2. Assignment: 10 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-GE105
Title of the Paper	Knowledge System, Scientific Thinking and Physics Education
Programme / Subject	M.Sc. — Physics
Semester	Semester I
Nature of Course	Generic Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	00
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Explaining major theories of knowledge and inquiry.
COB 2	Analyzing educational practices using cognitive science.
COB 3	Evaluating claims using scientific and philosophical methods.
COB 4	Comparing Indian and Western metaphysical traditions.

COB 5	Understanding consciousness and AI debates.
COB 6	Designing innovative learning environments.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain concepts of epistemology, ontology and phenomenology.
CLO 2	Distinguish facts, beliefs and realities.
CLO 3	Apply critical thinking and scientific reasoning.
CLO 4	Analyze educational practices.
CLO 5	Compare Indian and Western philosophies.
CLO 6	Evaluate AI and consciousness debates.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Knowledge System, Scientific Thinking and Physics Education [MSPHY-GE105]		
Unit	**Content**	**Suggested Lectures hours**
I	**Knowledge, Truth and Reality:** • Epistemology, phenomenology, ontology and sources of knowledge. • Truth, fact, belief, opinion and reality. • Theories of truth. • Scientific method and falsifiability. • Scientific revolutions. • Errors, biases and misinformation.	12
II	Learning, Cognition and Physics Education: • Goals of science education. • Aspects of learning-Learning, Understanding and Metacognition.	12

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	• Grounded theory approach • Knowledge structure and cognition. • Constructivism and social learning. • Inquiry-based learning. • Physics Education Research. • Active learning and NEP-2020 reforms.	
III	**Indian and Western Metaphysics:** • Indian philosophical traditions: Vedanta, Samkhya, Nyaya, Buddhism, Jainism. • Western metaphysics: Plato, Aristotle, Descartes, Kant, Husserl and Heidegger. • Ontology, existence, mind and consciousness. • Science and spirituality. • Reality in modern physics.	12
IV	**Evaluating Knowledge and Scientific Investigation:** • Scientific inquiry and experimental design. • Mathematical modeling of physical situations, approaches to conceptualizing physics, characteristics of theoretical and experimental physics, approaches to problem solving in physics. • Reliability and validity. • Probability and uncertainty. • Statistical significance and data interpretation. • Assessment and evaluation. • Technology-enhanced learning and AI in education.	12
V	**Consciousness, Artificial Intelligence and Contemporary Issues:** • Consciousness studies and mind-body problem. • Neural correlates of consciousness. • Artificial Intelligence and machine learning. • Turing Test and machine intelligence. • AI ethics, virtual reality, transhumanism and digital stress. • Science, society and responsible innovation.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

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C.6 Prescribed Textbooks

1. Karl Popper – The Logic of Scientific Discovery
2. Thomas Kuhn – The Structure of Scientific Revolutions
3. Alan Chalmers – What is this Thing Called Science?
4. S. Radhakrishnan – Indian Philosophy
5. David Chalmers – The Conscious Mind
6. Edward Redish – Teaching Physics with the Physics Suite
7. Rao. Y. V. S. (2018). *Philosophy of Science*. Pearson Education India.
8. Mishra. R. N. (2019). *Educational Philosophy and Sociology of Education*. R. Lall Book Depot.

C.7 Reference Books & Readings

1. Kuhn. T. S. (2012). *The Structure of Scientific Revolutions* (4th ed.). University of Chicago Press.
2. Popper. K. R. (2005). *The Logic of Scientific Discovery*. Routledge.
3. Hestenes. D. (1992). *Modeling Games in the Newtonian World*. American Journal of Physics. 60(8). 732–748.
4. Feynman. R. P. (2011). *The Meaning of It All: Thoughts of a Citizen-Scientist*. Basic Books.
5. Sharma. R. A. (2017). *Philosophical and Sociological Foundations of Education*. Surjeet Publications. *(Indian Author)*
6. Mazur. E. (1997). *Peer Instruction: A User's Manual*. Prentice Hall.
7. How to solve it. George Polya. Princeton Science Library.

C.8 Suggested E-Resources / Digital Repositories

1. Stanford Encyclopedia of Philosophy (SEP)
2. Internet Encyclopedia of Philosophy (IEP)
3. MIT OpenCourseWare
4. NPTEL Courses
5. SWAYAM
6. American Association of Physics Teachers (AAPT)
   - https://www.aapt.org
7. UNESCO Open Educational Resources
   - https://www.unesco.org/en/open-educational-resources.

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C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-GE106
Title of the Paper	Python for Scientific Computing
Programme / Subject	MSc- PHYSICS
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	3 – 0– 1
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	50	0	—	50
Practical / Lab Work	—	20	—	20
Internal Assessment	—	—	30	30
Maximum Marks	**50**	20	**30**	**100**
Passing Marks	23	09	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance. class tests. seminars. assignments. and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To Introduce Python programming for scientific and numerical computations.
COB 2	To Develop computational and problem-solving skills required in modern scientific research
COB 3	To Apply programming techniques to solve mathematical and physical problems.

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COB 4	To Enable visualization and analysis of scientific data using modern computational tools.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the fundamentals of Python programming, data structures, and file handling.
CLO 2	Apply NumPy tools for array manipulation, matrix algebra, and eigenvalue problems
CLO 3	Develop computational algorithms to solve scientific and numerical problems.
CLO 4	Visualize and interpret scientific data using Python plotting libraries.
CLO 5	Implement numerical methods and computational techniques for applications in physics and mathematics.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Python for Scientific Computing (MSPHY-GE106)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction to Python Programming** Introduction to Python and Scientific Computing, Python installation and development environments (IDLE, Jupyter Notebook, Spyder). Variables, data types, operators, and expressions. Input and output operations. Conditional statements and looping constructs. Functions and modules. Lists, tuples, dictionaries, and sets. Reading from and writing to files	9
II	**Scientific Computing with NumPy** Introduction to NumPy, Creation and manipulation of arrays, Array indexing, slicing, and reshaping. Mathematical operations on arrays, Matrix algebra using NumPy, Matrix addition, multiplication, and transpose, Determinants and inverse of matrices, Eigenvalues and eigenvectors	9

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III	**Data Visualization and Scientific Plotting** Introduction to Matplotlib. Line plots. scatter plots. histograms. and bar charts. Multiple plots and subplot arrangements. Graph customization and annotations. Error bars and scientific graphing. Importing and plotting experimental data. Introduction to Gnuplot and comparison with Python plotting tools	9
IV	**Numerical Methods in Physics** Evaluation of finite and infinite series, Numerical summation techniques, Root-finding methods: Bisection Method, Newton-Raphson Method, Fixed Point Iteration; Numerical differentiation. Numerical integration (Trapezoidal and Simpson's methods), Error estimation and convergence	9
V	**Scientific Applications and Computational Modelling** Solving systems of linear equations. Curve fitting and interpolation. Random number generation and Monte Carlo basics. Simulation of simple physical systems: Projectile motion. Harmonic oscillator. Radioactive decay: Scientific report preparation using Python outputs. Mini-project based on real scientific data.	9
Practical	1. Python programs for arithmetic and logical operations. 2. Programs using conditional statements and loops. 3. User-defined functions and modules. 4. Reading from and writing to text files. 5. Creation and manipulation of NumPy arrays. 6. Plotting mathematical functions using Matplotlib. 7. Root finding using Newton-Raphson Method.	30
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

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C.6 Prescribed Textbooks

Recommended Text Books

1. John M. Zelle, *Python Programming: An Introduction to Computer Science*, Franklin Beedle & Associates.
2. Jesse M. Kinder and Philip Nelson, *A Student's Guide to Python for Physical Modeling*, Princeton University Press.
3. Mark Newman, *Computational Physics*, CreateSpace.
4. E. Balagurusamy, *Introduction to Computing and Problem Solving Using Python*, McGraw Hill India.
5. Reema Thareja, *Python Programming Using Problem Solving Approach*, Oxford University Press India.

C.7 Reference Books & Readings

1. William H. Press et al., *Numerical Recipes: The Art of Scientific Computing*, Cambridge University Press.
2. Wes McKinney, *Python for Data Analysis*, O'Reilly Media.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New Age International.
4. R. Nageswara Rao, *Core Python Programming*, Dreamtech Press.
5. Tao Pang, *An Introduction to Computational Physics*, Cambridge University Press.

C.8 Suggested E-Resources / Digital Repositories

1. Python Documentation: https://docs.python.org/3/
2. NumPy Documentation: https://numpy.org/doc/stable/
3. Matplotlib Documentation: https://matplotlib.org/stable/
4. Jupyter Project: https://jupyter.org/
5. SciPy Documentation: https://docs.scipy.org/doc/scipy/
6. Google Colaboratory: https://colab.research.google.com/
7. Python Data Science Handbook: https://jakevdp.github.io/PythonDataScienceHandbook/
8. Software Carpentry (Python for Scientists): https://software-carpentry.org/lessons/
9. NPTEL: https://nptel.ac.in/
10. SWAYAM: https://swayam.gov.in/

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C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

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Internal Assessment (20 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-GE107
Title of the Paper	The Physics of Life, Health and Healing
Programme / Subject	MSc- PHYSICS
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	0	—	70
Practical / Lab Work	—	0	—	0
Internal Assessment	—	—	30	30
Maximum Marks	**70**		**30**	**100**
Passing Marks	32		**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide an understanding of the physical principles governing biological organization, physiological processes, and living systems.
COB 2	To explain the interaction of radiation, light, and electromagnetic fields with biological tissues and their applications in medical imaging and diagnostics.
COB 3	To develop knowledge of deterministic, stochastic, statistical, and information-theoretic approaches for modeling and analyzing biological systems.

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COB 4	To introduce modern developments in biological and medical physics, including computational biophysics, neural dynamics, active matter, and interdisciplinary research methodologies.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the physical mechanisms underlying biological organization, physiological processes, and living systems using fundamental principles of physics.
CLO 2	Analyze the interaction of ionizing and non-ionizing radiation with biological tissues and evaluate the principles of biomedical imaging and diagnostic instrumentation.
CLO 3	Develop and apply mathematical, computational, deterministic, and stochastic models to investigate biological and physiological processes.
CLO 4	Apply information theory, statistical physics, and quantitative methods to analyze biological systems, experimental observations, and biomedical datasets.
CLO 5	.Critically evaluate contemporary research and emerging developments in biological and medical physics, including bio photonics, computational biology, and neuroscience.

C.5 Syllabus — Unit-wise Breakdown

Course Name: The Physics of Life, Health and Healing **(MSPHY-GE107)**		
Unit	**Content**	**Suggested Lectures hours**
I	**Physical Principles of Living Systems and Biological Organization** Physics of living systems: scope and interdisciplinary nature, Length and time scales in biology: molecules, organelles, cells, tissues, organisms. Dimensional analysis and allometric scaling. Thermodynamics of living systems and biological energy transduction, Diffusion, osmosis, transport processes and Brownian motion, Active matter concepts in cells and tissues, Modern experimental techniques, Single-cell genomics and transcriptomics, Spatial transcriptomics, Cryo-EM and Cryo-ET, Super-resolution microscopy, Optical tweezers and microfluidics	12
II	**Medical Physics, Radiation and Biomedical Imaging** Ionizing and non-ionizing radiations: sources and properties, Interaction of radiation with biological matter, X-rays: Production and properties: Radiography and fluoroscopy, Computed Tomography (CT) and image reconstruction. Radioactive isotopes	12

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	and radionuclides, nuclear medicine and diagnostic applications. Principles of MRI and PET imaging, Radiation safety and dosimetry.	
III	**Biological Dynamics, Pattern Formation and Systems Biology** Deterministic Models: Coupled differential equations, feedback loops, bifurcation and multistability, gene regulatory networks: Stochastic Biological Processes: Chemical Master Equation, Langevin equation, Gillespie algorithm; Reaction-Diffusion Systems and Pattern Formation: Reaction-diffusion models, morphogenesis, biological pattern formation: Cell Signaling and Intracellular Communication: Signal transduction pathways, intracellular communication mechanisms: Ecological Dynamics: Predator-prey models, microbiome dynamics, eco-evolutionary feedback.	12
IV	**Neurophysics, Information Processing and Learning** Neurophysics and Electrophysiology: Electrophysiology, membrane potentials, Hodgkin–Huxley model, integrate-and-fire neuron model. Neural Dynamics and Learning: Neural network dynamics, attractor networks and memory, synaptic plasticity, Hebbian learning, Spike Timing Dependent Plasticity (STDP). Information Processing in Biological Systems: Information theory, entropy, mutual information, information transfer in biological systems. Applications and Emerging Approaches: Neural coding, signaling pathways, applications to genomics, machine learning approaches in neuroscience.	12
V	**Biophotonics, Biomolecular Physics and Computational Biology** Biophotonics and Laser Applications: Optical radiations (UV, Visible, IR and Lasers), laser-tissue interactions including photothermal, photochemical, and photoablative effects, biomedical applications of lasers, laser Doppler blood-flow measurement. Biomolecular Physics: Polymer physics in biological systems, DNA conformations, chromatin organization, random walks, and first-passage processes. Computational Biology and Simulation Techniques: Molecular dynamics simulations, Monte Carlo methods, computational modeling of biological systems. Emerging Trends in Biological Physics: DNA nanotechnology, single-molecule biophysics, artificial intelligence and machine learning applications in biology.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Phillips, Kondev, Theriot & Garcia. *Physical Biology of the Cell.*
2. Philip Nelson. *Biological Physics: Energy, Information, Life.*
3. Cameron. *Medical Physics.*
4. J.R. Greening. *Medical Physics.*
5. M.H. Niemz. *Laser Tissue Interactions.*
6. Dayan & Abbott. *Theoretical Neuroscience.*

C.7 Reference Books & Readings

1. Van Kampen. *Stochastic Processes in Physics and Chemistry.*
2. Rubinstein & Colby. *Polymer Physics.*
3. J.G. Webster. *Medical Instrumentation.*
4. R.S. Khandpur. *Handbook of Biomedical Instrumentation.*

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C.8 Suggested E-Resources / Digital Repositories

1. NPTEL – Biophysics, Systems Biology, Computational Biology, Medical Imaging, Bioinformatics, Neuroscience.
    - https://nptel.ac.in/courses/115105001
    - https://nptel.ac.in/courses/102106068
    - https://nptel.ac.in/courses/108105091
    - https://nptel.ac.in/courses/102106065
2. SWAYAM – Medical Physics, Biomedical Engineering, AI in Healthcare, Computational Biology.
    - https://onlinecourses.swayam2.ac.in/e-learning/preview/ini24_ph03
    - https://swayam-plus.swayam2.ac.in/ai-for-all-courses
3. e-PG Pathshala – Biophysics, Medical Physics, Bioinformatics and Neuroscience modules.
4. National Digital Library of India (NDLI) – Books, journals, theses and multimedia learning resources.
5. Shodhganga (INFLIBNET) – Indian theses and dissertations in Biological and Medical Physics.
6. Virtual Labs (MoE) – Biomedical Engineering and Biotechnology laboratory simulations.
7. Indian Biological Data Centre (IBDC) – National repository for genomics and biological datasets.
8. DBT Bioinformatics Infrastructure Facility (DBT-BIF) – Bioinformatics databases and tools.
9. MOSDAC & ISRO Open Data Resources – Health, environmental and geospatial datasets for interdisciplinary research.

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10. Spoken Tutorial (IIT Bombay) – Python, Data Science and Computational Tools for biological data analysis.

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-CC201
Title of the Paper	Electronics and Instrumentation
Programme / Subject	MSc- PHYSICS
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	0	—	70
Practical / Lab Work	—	0	—	0
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**0**	**30**	**100**
Passing Marks	**32**	0	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of semiconductor devices, electronic components, and their applications in modern electronic systems.
COB 2	To develop knowledge of analog and digital electronic circuits, including amplifiers, oscillators, operational amplifiers, and logic systems.
COB 3	To introduce instrumentation techniques, sensors, transducers, and microcontroller-based electronic systems used in scientific and industrial applications.
COB 4	To develop analytical, design, and problem-solving skills required for electronic circuit analysis, testing, and instrumentation applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the operating principles, characteristics, and applications of semiconductor devices, analog circuits, digital systems, and microcontrollers.
CLO 2	Analyze and design electronic circuits involving transistors, operational amplifiers, oscillators, logic gates, and combinational/sequential systems.
CLO 3	Apply instrumentation techniques, sensors, and transducers for measurement, control, and data acquisition applications.
CLO 4	Evaluate the performance of electronic systems and troubleshoot circuit-related problems using theoretical and practical approaches.
CLO 5	.Develop basic embedded and microcontroller-based solutions for scientific instrumentation, automation, and smart monitoring systems.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Electronics and Instrumentation (MSPHY-CC201)		
Unit	**Content**	**Suggested Lectures hours**
I	**Semiconductor Devices and Electronic Components** Review of semiconductor physics. Intrinsic and extrinsic semiconductors. p-n junction diode and its characteristics. Special purpose diodes: Zener diode, LED, photodiode, solar cell, tunnel diode, and Schottky diode. Bipolar Junction Transistor (BJT), JFET, MOSFET (enhancement and depletion types), UJT and SCR. Construction, working principles, characteristics, and applications of semiconductor devices.	12
II	**Analog Electronics and Amplifier Circuits** Transistor biasing methods and thermal stability. Small-signal transistor model. Common emitter, common base, and common collector amplifiers. Frequency response and bandwidth. Feedback in amplifiers: positive and negative feedback, advantages and applications. Principles of oscillators, Barkhausen criterion, RC phase-shift oscillator, Wien bridge oscillator, and crystal oscillator. Communication systems and signal processing.	12
III	**Operational Amplifiers and Instrumentation** Ideal and practical operational amplifiers. Op-amp characteristics and parameters. Inverting and non-inverting amplifiers, voltage follower, summing amplifier, differential amplifier, integrator, differentiator, active filters, and comparator circuits. Instrumentation amplifiers and signal conditioning techniques.	12

	Introduction to sensors and transducers: temperature sensors, light sensors, Hall-effect sensors, and strain gauges.	
IV	**Digital Electronics** Number systems and binary arithmetic. Logic gates and Boolean algebra. De Morgan's theorems. Logic simplification using Karnaugh maps. Combinational circuits: half adder, full adder, encoder, decoder, multiplexer, and demultiplexer. Sequential circuits: RS, JK, D and T flip-flops, registers, counters, and memory elements. Basic concepts of programmable logic devices and digital system applications.	12
V	**Microcontrollers and Electronic Applications** Basic architecture of microcomputers and system buses. Overview of 8085 microprocessor architecture and instruction classification. 8051 microcontroller architecture, ports, timers, interrupts, and elementary interfacing concepts. Introduction to Arduino and microcontroller-based system design.Basic concepts of data acquisition systems and sensor interfacing. .	12 24/07/26 Kalpana Srivastava Officer on special duty (Judicial)
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Boylestad, R. L., & Nashelsky, L. (2019). Electronic Devices and Circuit Theory (12th ed.). Pearson Education.
2. Millman, J., & Halkias, C. C. (2017). Integrated Electronics: Analog and Digital Circuits and Systems. McGraw-Hill Education.
3. Malvino, A. P., & Bates, D. J. (2018). Electronic Principles (8th ed.). McGraw-Hill Education.
4. Sedra, A. S., & Smith, K. C. (2021). Microelectronic Circuits (8th ed.). Oxford University Press.
5. Chattopadhyay, D., Rakshit, P. C., & Saha, B. (2018). Electronics: Fundamentals and Applications. New Central Book Agency.
6. Mehta, V. K., & Mehta, R. (2020). Principles of Electronics (12th ed.). S. Chand Publishing.
7. Ryder D. John, Electronic Fundamentals and Applications, Prentice-Hall
8. Jain, R. P. (2016). Modern Digital Electronics (5th ed.). McGraw Hill Education India.

C.7 Reference Books & Readings

1. Gayakwad, R. A. (2015). Operational Amplifiers and Linear Integrated Circuits (4th ed.). Pearson Education.
2. Malvino, A. P., Leach, D. P., & Saha, G. (2018). Digital Principles and Applications (8th ed.). McGraw-Hill Education.
3. Hall, D. V. (2016). Microprocessors and Interfacing: Programming and Hardware (3rd ed.). McGraw-Hill Education.
4. Mano, M. M., & Ciletti, M. D. (2018). Digital Design (6th ed.). Pearson Education.
5. Horowitz, P., & Hill, W. (2015). The Art of Electronics (3rd ed.). Cambridge University Press.

C.8 Suggested E-Resources / Digital Repositories

1. NPTEL: Electronic Devices and Circuits, Analog Electronics, Digital Electronics, Microprocessors and Microcontrollers
   - https://nptel.ac.in/courses/108101091
   - https://nptel.ac.in/courses/108106188
2. e-PG Pathshala (Physics and Electronics Modules)
3. SWAYAM: Electronics and Communication Engineering Courses
   - https://swayam-plus.swayam2.ac.in/courses/course-details?id=P_IITMPR
4. National Digital Library of India (NDLI): https://ndl.iitkgp.ac.in
5. Virtual Labs (Electronics and Instrumentation): https://www.vlab.co.in
6. IEEE Xplore Digital Library: https://ieeexplore.ieee.org
7. All About Circuits Learning Portal: https://www.allaboutcircuits.com
8. MIT OpenCourseWare – Electronics and Circuits: https://ocw.mit.edu

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C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting*

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multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-CC202
Title of the Paper	Molecular Spectroscopy, Lasers and Photonics
Programme / Subject	MSc- PHYSICS
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1– 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	-	—	30
Internal Assessment	—	—	30	30
Maximum Marks	70	-	**30**	**100**
Passing Marks	**32**	-	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of the principles of laser physics, light–matter interaction, and the operation of various laser systems and photonic devices..
COB 2	To develop knowledge of optical fiber communication, integrated photonics, optoelectronic devices, and emerging photonic technologies.
COB 3	To explain molecular structure, molecular bonding, and spectroscopic techniques used for the characterization of molecules and materials.
COB 4	To familiarize students with advanced spectroscopic methods, magnetic resonance techniques, and their applications in science, technology, healthcare, and research.

CLO No.	Course Learning Outcome
CLO 1	Explain the fundamental principles of laser physics, photonics, molecular structure, and spectroscopic phenomena governing light–matter interactions.
CLO 2	Apply the concepts of laser systems, optical fibers, photonic devices, and molecular spectroscopy to solve problems in communication, sensing, and scientific instrumentation.
CLO 3	Analyze molecular spectra, magnetic resonance data, and photonic system performance using appropriate theoretical models and computational tools.
CLO 4	Evaluate the capabilities and limitations of modern laser technologies, optical communication systems, and advanced spectroscopic techniques for scientific and industrial applications.
CLO 5	Design and propose innovative solutions involving photonic devices, laser-based technologies, optical sensors, and spectroscopic methods for emerging interdisciplinary applications.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Laser, Photonics and Molecular Spectroscopy (MSPHY-CC202)		
Unit	**Content**	**Suggested Lectures hours**
I	**Fundamentals of Laser Physics** Interaction of radiation with matter. Absorption, spontaneous emission, and stimulated emission processes. Einstein coefficients and their physical significance. Population inversion and optical pumping mechanisms. Two-level, three-level, and four-level laser systems. Gain coefficient and amplification of light. Optical resonators and cavity modes. Threshold condition for laser oscillation. Characteristics of laser radiation including monochromaticity, coherence, directionality, and high intensity. Femtosecond and picosecond LASER pulses.	10
II	**Laser Systems and Applications** Construction, principle, and operation of Ruby Laser, He-Ne Laser, Semiconductor Laser, Nd:YAG Laser, and CO_2 Laser. Pulsed and continuous-wave lasers. Temporal and spatial coherence. Laser beam propagation and Gaussian beam characteristics. Applications of lasers in industrial processing, cutting and welding, holography, optical data storage, barcode readers, laser printers, medical diagnostics, ophthalmology, LASIK surgery, dermatology, defence systems, and scientific instrumentation. Fiber laser technology, diode-pumped solid-state lasers and applications of lasers in autonomous vehicles and remote sensing.	13

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III	**Fiber Optics and Photonics** Basic principles of optical fiber communication. Structure and types of optical fibers. Numerical aperture, acceptance angle, and attenuation mechanisms. Signal transmission through optical fibers. Optical communication systems and components. Fiber optic sensors and their applications. Introduction to integrated photonics. Photonic materials and devices. Light-emitting diodes (LEDs), laser diodes, photodiodes, avalanche photodiodes, Photonic integrated circuits (PICs), silicon photonics and photodetectors.	13
IV	**Molecular Structure and Molecular Spectroscopy** • Concept of molecules, Ionic, covalent, and van der Waals bonding. Molecular orbital theory and valence bond theory. Linear Combination of Atomic Orbitals (LCAO) approximation. Molecular orbitals of diatomic molecules. Hydrogen molecular ion (H_2^+). Potential energy curves and Morse potential. Vibrational motion of molecules. Harmonic and anharmonic oscillators. Rotational spectra of rigid and non-rigid rotators. Vibrational and rotational transitions. UV-Visible, IR and Raman spectroscopy. • Electronic spectra in molecules and Frank-Condon principle. Dissociation energy and molecular stability. Spectroscopy of low-dimensional materials such as graphene and transition metal dichalcogenides (TMDs).	14
V	**Magnetic Resonance and Advanced Spectroscopic Techniques** Basic principles of magnetic resonance. Interaction of magnetic moments with external magnetic fields. Electron Spin Resonance (ESR) spectroscopy. Nuclear Magnetic Resonance (NMR) spectroscopy. Resonance condition and relaxation processes. Instrumentation and applications of ESR and NMR. Introduction to Raman spectroscopy and infrared spectroscopy. Applications of molecular spectroscopy in chemistry, materials science, medicine, environmental science, and nanotechnology. Fluorescence spectroscopy, biomedical imaging, magnetic resonance imaging (MRI).	10
	Total Suggested Lectures	**60 (For 4 Credit Course)**

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C.6 Prescribed Textbooks

1. Thyagarajan, K., & Ghatak, A. (2010). *Lasers: Fundamentals and Applications* (2nd ed.). Springer India.
2. Ghatak, A., & Thyagarajan, K. (2012). *Introduction to Fiber Optics*. Cambridge University Press.
3. Banwell, C. N., & McCash, E. M. (2017). *Fundamentals of Molecular Spectroscopy* (5th ed.). McGraw-Hill Education.
4. Yariv, A., & Yeh, P. (2007). *Photonics: Optical Electronics in Modern Communications* (6th ed.). Oxford University Press.
5. Gupta, S. C. (2018). *Optoelectronic Devices and Systems*. PHI Learning Pvt. Ltd., New Delhi.

C.7 Reference Books & Readings

1. Svelto, O. (2010). *Principles of Lasers* (5th ed.). Springer.
2. Saleh, B. E. A., & Teich, M. C. (2019). *Fundamentals of Photonics* (3rd ed.). Wiley.
3. Silfvast, W. T. (2008). *Laser Fundamentals* (2nd ed.). Cambridge University Press.
4. Hollas, J. M. (2004). *Modern Spectroscopy* (4th ed.). Wiley.

C.8 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL: Laser Physics, Fiber Optics and Photonics Courses
2. e-PG Pathshala: Physics Portal – https://epgp.inflibnet.ac.in
3. Virtual Labs (MoE, Govt. of India) – https://www.vlab.co.in
4. National Digital Library of India (NDLI) – https://ndl.iitkgp.ac.in
5. SPIE Digital Library – https://www.spiedigitallibrary.org

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic*

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interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-CC203
Title of the Paper	Energy Science and Renewable Energy Technology
Programme / Subject	MSc- PHYSICS
Semester	Semester
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	-	—	0
Internal Assessment	—	—	30	30
Maximum Marks	**70**	0	**30**	**100**
Passing Marks	**32**	0	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of renewable energy resources, sustainable energy systems, and global energy challenges in the context of environmental sustainability.
COB 2	To develop fundamental knowledge of modern energy storage technologies, including batteries, supercapacitors, hydrogen energy systems, and fuel cells.
COB 3	To explain the principles, operation, and applications of solar thermal, photovoltaic, geothermal, and emerging renewable energy technologies.
COB 4	To cultivate analytical and problem-solving skills for evaluating advanced energy materials and designing sustainable solutions for future energy generation, storage, and utilization.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the concepts of energy resources, sustainability, energy conversion processes, and environmental impacts of conventional and renewable energy technologies.
CLO 2	Apply the principles of batteries, supercapacitors, hydrogen production, fuel cells, and electrochemical energy storage systems to practical energy applications.
CLO 3	Analyze the performance, efficiency, and operational characteristics of renewable energy systems, fuel cells, and photovoltaic devices.
CLO 4	Evaluate the suitability of various renewable energy technologies and advanced energy materials for sustainable development and energy security.
CLO 5	Design innovative and sustainable energy solutions by integrating modern energy storage systems, smart grids, hydrogen technologies, and next-generation renewable energy devices.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Energy Science and Renewable Energy Technology (MSPHY-CC203)		
Unit	**Content**	**Suggested Lectures hours**
I	**Energy Resources, Sustainability and Energy Harvesting** **Global Energy Perspective** Energy need and goals for sustainable development: global energy scenario: Indian energy scenario: energy demand and supply: energy security: future energy challenges: sustainable energy development strategies: greenhouse gas emissions and climate change: environmental impacts of conventional energy technologies. **Renewable Energy Resources** Conventional and non-conventional energy resources: advantages and limitations of renewable energy technologies: global renewable energy requirements and probable solutions for sustainable growth. Wind energy, hydroelectric energy, tidal energy, energy from biomass (bio gas, bio diesel). Nuclear energy. Thermoelectric energy (TEG) systems. **Fundamental Concepts of Energy Devices**	12

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	Introduction to energy conversion and storage devices: classification of energy devices: fundamental mechanisms governing energy harvesting, energy conversion, and energy storage systems. **Thermodynamics of Energy Systems** Basic thermodynamic principles of energy conversion; energy efficiency; exergy concept; theoretical models of energy harvesting and storage devices. **Advanced Energy Materials** Introduction to functional materials for energy applications; advanced materials for batteries, fuel cells, supercapacitors, and solar cells.	
II	**Energy Storage Technologies** **Fundamentals of Electrochemical Energy Storage** Electrochemical principles; oxidation-reduction reactions; electrode-electrolyte interface; electrochemical kinetics; current-voltage characteristics. **Capacitors, Batteries and Supercapacitors** Conventional capacitors; Battery fundamentals; lithium-ion batteries; sodium-ion batteries; solid-state batteries; battery management systems, Supercapacitor fundamentals, electrical double-layer capacitors; pseudocapacitors; hybrid supercapacitors; charge storage mechanisms and performance parameters. **Advanced Energy Storage Systems** Metal-air batteries; lithium-sulfur batteries; sodium-sulfur batteries; emerging battery technologies. **Transport Phenomena** Diffusion, migration, and convection processes; ion transport in electrochemical devices; factors affecting battery and supercapacitor performance.	12
III	Hydrogen Energy and Fuel Cell Technology **Hydrogen Economy** Hydrogen as a clean energy carrier; hydrogen production, storage, transportation, and utilization; green hydrogen technologies. **Fuel Cell Fundamentals**	12

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	Basic principles of fuel cells: thermodynamics and electrochemistry of fuel cells: cell efficiency and performance analysis. **Types of Fuel Cells** Hydrogen-oxygen fuel cells: alkaline fuel cells: proton exchange membrane fuel cells (PEMFC): phosphoric acid fuel cells (PAFC): molten carbonate fuel cells (MCFC): solid oxide fuel cells (SOFC): direct methanol fuel cells (DMFC): biochemical fuel cells. **Electrolyzer Systems** Water electrolysis: electrolyzer technologies: hydrogen generation using renewable energy systems. **Applications and Future Prospects** Fuel cell vehicles: stationary power generation: portable power systems: challenges and future opportunities.	
IV	**Solar Thermal and Geothermal Energy Systems** **Solar Radiation** Solar spectrum: solar constant: solar charts: measurement of direct, diffuse, and global solar radiation. **Solar Thermal Energy Conversion** Flat plate collectors: evacuated tube collectors: solar air heaters: solar concentrators: central receiver systems. **Solar Thermal Applications** Solar water heating systems: solar refrigeration: solar heat pumps: solar cookers: solar dryers: solar kilns: solar ponds: solar furnaces: solar greenhouses: passive solar heating and cooling. **Geothermal Energy** Origin of geothermal resources: hydrothermal, geopressured, hot dry rock, and magma resources: geothermal exploration methods. **Geothermal Applications** Geothermal power plants: geothermal heat pumps: heating and cooling applications: geothermal resources in India and worldwide.	12
V	**Solar Photovoltaics and Emerging Renewable Energy Technologies** **Semiconductor Fundamentals**	12

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Semiconductor materials; p-n junctions; interaction of light with semiconductors; photovoltaic effect.

Solar Cell Physics

Solar cell structure; working principles; equivalent circuit; I-V characteristics; efficiency and efficiency limits; losses and optimization.

Solar Cell Technologies

Crystalline silicon solar cells; amorphous silicon solar cells; CdTe solar cells; CIGS solar cells; GaAs solar cells; CZTS solar cells; dye-sensitized solar cells; organic/polymer solar cells; multi-junction solar cells; hot-carrier solar cells; thermophotovoltaic (TPV) systems.

Solar PV Systems

Balance-of-system components; stand-alone and grid-connected photovoltaic systems; solar power plants.

Emerging Renewable Energy Technologies

Hybrid renewable energy systems; smart grids; energy harvesting technologies; next-generation photovoltaic materials and devices.

	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. G. D. Rai. (2022). *Non-Conventional Energy Sources* (7th ed.). Khanna Publishers, New Delhi.
2. Twidell, J., & Weir, T. (2021). *Renewable Energy Resources* (4th ed.). Routledge.
3. Boyle, G. (2019). *Renewable Energy: Power for a Sustainable Future* (4th ed.). Oxford University Press.
4. Khan, B. H. (2022). *Non-Conventional Energy Resources* (4th ed.). McGraw Hill Education India.
5. Sukhatme, S. P., & Nayak, J. K. (2017). *Solar Energy: Principles of Thermal Collection and Storage* (4th ed.). McGraw Hill Education.

C.7 Reference Books & Readings

1. Conway, B. E. (2013). *Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications*. Springer.
2. Linden, D., & Reddy, T. B. (2019). *Handbook of Batteries* (5th ed.). McGraw-Hill.
3. Nelson, J. (2003). *The Physics of Solar Cells*. Imperial College Press.

4. Kothari, D. P., Singal, K. C., & Ranjan, R. (2011). *Renewable Energy Sources and Emerging Technologies* (2nd ed.). PHI Learning.

C.8 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL: **Renewable Energy Engineering, Solar Energy Engineering, Energy Storage Systems, Hydrogen Energy and Fuel Cells**
2. e-PG Pathshala: Energy Studies and Physics Portal – https://epgp.inflibnet.ac.in
3. National Digital Library of India (NDLI) – https://ndl.iitkgp.ac.in
4. Virtual Labs (MoE, Government of India) – https://www.vlab.co.in
5. SHODHGANGA / Shodhgangotri – Research Thesis Repository
6. INFLIBNET Centre – https://www.inflibnet.ac.in
7. Ministry of New and Renewable Energy (MNRE), Government of India – https://mnre.gov.in
8. International Energy Agency (IEA) – https://www.iea.org
9. National Renewable Energy Laboratory (NREL) – https://www.nrel.gov
10. International Renewable Energy Agency (IRENA) – https://www.irena.org
11. IEEE Xplore Digital Library – https://ieeexplore.ieee.org
12. ScienceDirect Energy Collection – https://www.sciencedirect.com
13. Nature Energy Journal – https://www.nature.com/nenergy
14. Energy Education (University of Calgary) – https://energyeducation.ca

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

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Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-PC204
Title of the Paper	PRACTICAL
Programme / Subject	MSc- PHYSICS
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	0 – 0– 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	6 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	-	—	—	70
Practical / Lab Work	—	70	—	30
Internal Assessment	—	—	30	30
Maximum Marks	**0**	**70**	**30**	**100**
Passing Marks	**0**	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To develop practical skills in the characterization and analysis of semiconductor devices, analog electronic circuits, and instrumentation systems.
COB 2	To provide hands-on experience with renewable energy devices such as solar cells, supercapacitors, fuel cells, and energy auditing techniques.
COB 3	To familiarize students with laser systems, fiber-optic components, photonic devices, and modern optical communication technologies.
COB 4	To cultivate experimental competence, data analysis skills, scientific reporting ability, and research aptitude through laboratory investigations.

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the operating principles and performance characteristics of semiconductor devices, electronic circuits, lasers, optical fibers, and renewable energy devices.
CLO 2	Perform experiments involving electronic circuits, photovoltaic cells, supercapacitors, fuel cells, laser sources, and fiber-optic communication systems using standard laboratory procedures.
CLO 3	Analyze experimental data, evaluate device parameters, estimate uncertainties, and interpret the results using appropriate theoretical models and computational tools.
CLO 4	Assess the efficiency, performance, and practical applications of electronic, photonic, and energy-related devices in scientific and technological contexts.
CLO 5	Design, execute, document, and communicate experimental investigations independently while following laboratory ethics and safety practices.

C.5 Syllabus — Unit-wise Breakdown

Course Name: PRACTICAL (MSPHY-PR204)		
Unit	**Content**	**Suggested Lectures hours**
	1. Study of I-V characteristics of a PN junction diode and determination of static and dynamic resistance. 2. Study of Zener diode characteristics and design of a voltage regulator. 3. Characteristics of BJT in Common Emitter (CE) configuration. 4. Characteristics of JFET/MOSFET and determination of device parameters. 5. Design and study of RC-coupled transistor amplifier and gain measurement. 6. Frequency response and bandwidth determination of transistor amplifier. 7. Construction and analysis of Wien Bridge Oscillator. 8. Operational Amplifier applications: Inverting, Non-inverting, Integrator and Differentiator circuits.	120 Hours

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9. Measurement of I-V characteristics and efficiency of a solar photovoltaic cell.
10. Determination of internal resistance of rechargeable batteries
11. Determination of specific capacitance of supercapacitors.
12. Measurement of charge-discharge characteristics of a supercapacitor.
13. Study of fuel-cell characteristics using PEM fuel cell demonstration kit/software.
14. Energy Audit of laboratory/classroom and estimation of energy consumption and savings.
15. Study of laser diode characteristics and threshold current.
16. Determination of wavelength of He-Ne laser using diffraction grating.
17. Measurement of numerical aperture of an optical fiber.
18. Determination of attenuation coefficient of optical fiber.
19. Demonstration and analysis of fiber-optic communication link.
20. Study of LED and photodiode characteristics for optoelectronic applications.

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	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Chattopadhyay, D., Rakshit, P. C., & Saha, B. (2014). An Advanced Course in Practical Physics (7th ed.). New Central Book Agency.
2. Arora, C. L. (2018). Practical Physics. S. Chand & Company Pvt. Ltd.
3. Worsnop, B. L., & Flint, H. T. (2008). Advanced Practical Physics. CBS Publishers & Distributors.
4. Squires, G. L. (2001). Practical Physics (4th ed.). Cambridge University Press.

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C.7 Reference Books & Readings

1. Horowitz, P., & Hill, W. (2015). *The Art of Electronics* (3rd ed.). Cambridge University Press.
2. Wilson, J., & Hawkes, J. F. B. (2018). *Optoelectronics: An Introduction* (3rd ed.). Pearson Education.
3. Senior, J. M., & Jamro, M. Y. (2009). *Optical Fiber Communications: Principles and Practice* (3rd ed.). Pearson Education.

C.8 Suggested E-Resources / Digital Repositories

1. NPTEL – Electronics, Photonics and Renewable Energy Courses
   https://nptel.ac.in
2. Virtual Labs (Ministry of Education, Government of India)
   https://www.vlab.co.in
3. e-PG Pathshala – Physics
   https://epgp.inflibnet.ac.in
4. National Digital Library of India (NDLI)
   https://ndl.iitkgp.ac.in
5. SPIE Digital Library (Photonics and Optical Engineering)
   https://www.spiedigitallibrary.org
6. IEEE Xplore Digital Library
   https://ieeexplore.ieee.org
7. OSA/Optica Publishing Group
   https://opg.optica.org
8. MIT OpenCourseWare – Electronics and Optics
   https://ocw.mit.edu
9. CERN Open Data Portal
   https://opendata.cern.ch
10. PhET Interactive Simulations
    https://phet.colorado.edu

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C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

Experiment: 45 Marks

Notebook: 15

Viva-voce: 10

Internal Assessment (20 marks) breakdown:

1. Internal Performance and Laboratory Notebook: 15 marks
2. Assignment: 10 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students*

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of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-GE205
Title of the Paper	Basics of Electronic Circuit Design
Programme / Subject	M.Sc. — Physics
Semester	Semester II
Nature of Course	Generic Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	00
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To introduce the fundamental principles of electrical and electronic circuits, network analysis, and electronic components used in modern systems.
COB 2	To develop an understanding of semiconductor devices, analog electronics, operational amplifiers, and sensor-based instrumentation circuits
COB 3	To provide knowledge of digital electronics, embedded systems, microcontrollers, and Arduino-based hardware interfacing.

COB 4	To familiarize students with electronic system design, circuit simulation, testing, troubleshooting, and modern electronic technologies.
COB 5	To develop problem-solving and application-oriented skills for designing electronic systems used in communication, automation, renewable energy, healthcare, robotics, and IoT applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Understand the fundamentals of electronic components and circuit analysis.
CLO 2	Analyze semiconductor devices and analog electronic circuits.
CLO 3	Design operational amplifier and sensor-based instrumentation circuits.
CLO 4	Develop digital circuits and basic embedded systems.
CLO 5	Implement Arduino/Raspberry Pi-based automation and monitoring projects.
CLO 6	Apply electronic circuit design principles to scientific, industrial, and IoT applications.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Basics of Electronic Circuit Design [MSPHY-GE205]		
Unit	**Content**	**Suggested Lectures hours**
I	**Fundamentals of Electronic Circuits:** Basic electrical quantities, Ohm's law, Kirchhoff's laws, AC and DC circuits. Resistors, capacitors, inductors, transformers, and relays. Series and parallel circuits. Voltage and current divider rules. Network theorems: Thevenin's, Norton's, Superposition, and Maximum Power Transfer theorem. Circuit symbols, schematic diagrams, breadboards, PCB basics, and electrical safety.	12
II	**Semiconductor Devices and Analog Electronics**: Intrinsic and extrinsic semiconductors, PN junction diode and rectifier circuits. Zener diode, LED photodiode, solar cell, and optoelectronic devices, BJT characteristics, transistor biasing.	12

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	amplifier configurations frequency response, bandwidth, and feedback amplifiers, Introduction to analog signal processing and applications.	
III	**Operational Amplifiers and Sensors:** Operational amplifier characteristics and applications, Inverting and non-inverting amplifiers, voltage follower, summing amplifier, differential amplifier, integrator, differentiator, and active filters, Instrumentation amplifiers and signal conditioning, Sensors and transducers: temperature, pressure, humidity, light, gas, and Hall-effect sensors. Data acquisition and sensor interfacing.	12
IV	**Digital Electronics and Embedded Systems:** Number systems, Boolean algebra, logic gates, Karnaugh maps, Combinational and sequential circuits. Adders, multiplexers, decoders, flip-flops, counters, and registers, Introduction to microcontrollers and embedded systems, Arduino architecture, Programming basics, sensor interfacing, and actuator control.	12
V	**Electronic System Design and Modern Applications:** Electronic system design methodology, Circuit simulation, PCB layout concepts, testing and troubleshooting, Power supplies, rectifiers, filters, voltage regulators, and SMPS. Applications in communication, healthcare, renewable energy, automation, robotics, smart sensors, IoT, Industry 4.0, and environmental monitoring.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

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C.6 Prescribed Textbooks

1. Gayakwad, R. A. (2015). *Operational Amplifiers and Linear Integrated Circuits* (4th ed.). Pearson Education India.
2. Bhargava, N. N., Kulshreshtha, D. C., & Gupta, S. C. (2016). *Basic Electronics and Linear Circuits* (2nd ed.). McGraw Hill Education India.
3. Chattopadhyay, D., Rakshit, P. C., & Saha, B. (2018). *Electronics: Fundamentals and Applications*. New Central Book Agency.
4. Mehta, V. K., & Mehta, R. (2020). *Principles of Electronics* (12th ed.). S. Chand Publishing.
5. Bakshi, U. A., & Bakshi, A. V. (2018). *Electronic Devices and Circuits*. Technical Publications.

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C.7 Reference Books & Readings

1. Malvino. A. P., & Bates. D. J. (2018). *Electronic Principles* (8th ed.). McGraw-Hill Education.
2. Sawhney. A. K. (2019). *Electrical and Electronic Measurements and Instrumentation.* Dhanpat Rai Publications.
3. Khandpur. R. S. (2021). *Handbook of Biomedical Instrumentation* (4th ed.). McGraw-Hill Education India.
4. Jain. R. P. (2016). *Modern Digital Electronics* (5th ed.). McGraw-Hill Education India.

C.8 Suggested E-Resources / Digital Repositories

1. NPTEL – Electronic Devices and Circuits. Analog Electronics. Digital Electronics. Sensors and Instrumentation https://nptel.ac.in
2. SWAYAM – Electronics and Embedded Systems Courses https://swayam.gov.in
3. Virtual Labs (Ministry of Education. Government of India) https://www.vlab.co.in
4. e-PG Pathshala – Electronics and Physics Modules https://epgp.inflibnet.ac.in
5. National Digital Library of India (NDLI) https://ndl.iitkgp.ac.in
6. IEEE Xplore Digital Library https://ieeexplore.ieee.org
7. All About Circuits Learning Portal https://www.allaboutcircuits.com
8. MIT OpenCourseWare – Circuits and Electronics https://ocw.mit.edu

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

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Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-GE206
Title of the Paper	Science Journalism, Popular Science Writing and Content Creation
Programme / Subject	MSc- PHYSICS
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	4 – 0– 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	0	—	70
Practical / Lab Work	—	0	—	0
Internal Assessment	—	—	30	30
Maximum Marks	**70**		**30**	**100**
Passing Marks	32		**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance. class tests. seminars. assignments. and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To Understand the principles. scope. and significance of science communication. science journalism. and their role in society and public engagement.
COB 2	To Develop effective science writing and communication skills for diverse audiences. including policymakers, media professionals, and the general public.
COB 3	To Apply interviewing. reporting. and storytelling techniques to communicate scientific concepts accurately and engagingly through various media formats.

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COB 4	To Create, optimize, and disseminate digital and multimedia content using contemporary communication tools, platforms, and AI-assisted technologies.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	**Explain** the fundamentals of science communication, science journalism, science news reporting, and the societal impact of scientific information dissemination.
CLO 2	**Demonstrate** effective science writing, audience-specific messaging, and science outreach skills for print, digital, and community media platforms.
CLO 3	**Apply** interviewing, questioning, reporting, and storytelling techniques to produce engaging and accurate science communication content.
CLO 4	**Develop** multimedia and digital content by utilizing content creation frameworks, audience analysis, and platform-specific communication strategies.
CLO 5	**Evaluate and optimize** digital content using content marketing principles, analytics, ethical communication practices, and AI-based content creation tools.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Science Journalism, Popular Science Writing and Content Creation (MSPHY-GE107)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction to Science Communication** Science and Communication • Understanding Science Communication/Science Journalism • 3Es of Sci-Comm • Science News. Role of Science Journalism in the Society	12
II	**Basics of Scientific Writing** Science Writing for Society & Media • Covering Science. Challenges in Science Communication and overcoming them • Science resonating with policymakers and politicians • Skills required for Science journalism, Different types of media for scientific writing	12

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III	**Talking and Writing Science** Writing About Science Using Special Techniques (Painting a picture, telling a Tale): Preparing and asking questions • Interviewing Science professionals – Practical Assignment (Interviewing Scientists on their work and presenting their interviews in writing and/or in audio-visual form) • Drafting audience-specific messages: Using written form as a tool for Science outreach – Articles for community media or mainstream media	12
IV	**Understanding Digital Landscape and Content Creation** Introduction to content creation, Different platforms and digital ecosystem, understanding audience, Content Creation Process, Content creation process, Developing Effective Content, Presenting topics among masses: Popular science, Basic Science, Research and Development, etc.	12
V	**Scientific content and use of AI** Content Creation Practices and Optimization • Multimedia content production • Content Optimization and Marketing • AI and Content Creation, Plagiarism of content, scientific illustrations	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Communicating Science: A Practical Guide for Engineers and Physical Scientists
   David Bennett and Richard Jennings
   Publisher: McGraw-Hill Education
2. A Field Guide for Science Writers (2nd Edition)
   Deborah Blum, Mary Knudson and Robin Marantz Henig (Eds.)
   Publisher: Oxford University Press
3. Science Communication: An Introduction
   Richard Holliman, Elizabeth Whitelegg, Eileen Scanlon, Sam Smidt and Jeff Thomas (Eds.)
   Publisher: Routledge
4. Science Journalism: An Introduction
   Martin W. Angler
   Publisher: Routledge
5. Digital Media and Society
   Simon Lindgren
   Publisher: Sage Publications

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C.7 Reference Books & Readings

1. Science Communication in India: Current Trends and Future Strategies
   Manoj Kumar Patairiya
   Publisher: Vigyan Prasar, Department of Science & Technology (DST), Government of India
2. Science Journalism in India
   Manoj Kumar Patairiya
   Publisher: Vigyan Prasar
3. Science Communication Through Mass Media
   Vigyan Prasar Publications
   Publisher: Vigyan Prasar, Government of India
4. Popular Science Writing in India
   National Council for Science and Technology Communication (NCSTC)
   Publisher: Department of Science & Technology (DST)
5. Communicating Science to Society
   Vigyan Prasar Resource Series
   Publisher: Vigyan Prasar

C.8 Suggested E-Resources / Digital Repositories

1. **SWAYAM** https://swayam.gov.in
2. **NPTEL Online Courses** https://nptel.ac.in
3. **Vigyan Prasar (DST, Government of India)** https://vigyanprasar.gov.in
4. **The Open Notebook – Science Writing Resources** https://www.theopennotebook.com
5. **Journal of Science Communication (JCOM)** https://jcom.sissa.it
6. **National Digital Library of India (NDLI)** https://ndl.iitkgp.ac.in
7. **Shodhganga (INFLIBNET)** https://shodhganga.inflibnet.ac.in
8. **e-PG Pathshala** https://epgp.inflibnet.ac.in

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic*

interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSPHY-GE207
Title of the Paper	Climate and Environmental Sciences
Programme / Subject	M.Sc. — Physics
Semester	Semester II
Nature of Course	Generic Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	00
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance. class tests. seminars. assignments. and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide an understanding of the structure. composition. and dynamics of the Earth's atmosphere.
COB 2	To introduce atmospheric processes responsible for weather and climate variability.
COB 3	To understand atmospheric waves. remote sensing techniques. and environmental monitoring tools.
COB 4	To develop awareness regarding climate change. air pollution. aerosols. and their societal impacts.

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COB 5	To familiarize students with modern atmospheric observation systems and data analysis techniques.
COB 6	

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the structure, composition, and thermodynamic processes of Earth's atmosphere.
CLO 2	Analyze atmospheric circulation, weather systems, and climate variability using fundamental physical principles.
CLO 3	Understand atmospheric waves, remote sensing techniques, and modern meteorological observation systems.
CLO 4	Evaluate the role of aerosols, air pollutants, and environmental factors in climate and public health.
CLO 5	Apply atmospheric science concepts to climate change studies, environmental monitoring, and sustainability-related problems.
CLO 6	Interpret meteorological and environmental datasets using basic analytical and computational tools

C.5 Syllabus — Unit-wise Breakdown

Course Name: Climate and Environmental Sciences [MSPHY-GE207]		
Unit	**Content**	**Suggested Lectures hours**
I	**Earth's Atmosphere and Weather Systems:** • Origin and evolution of Earth's atmosphere. • Composition and vertical structure of the atmosphere. Troposphere, stratosphere, mesosphere, thermosphere, and ionosphere.	12

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	• Atmospheric pressure, hydrostatic equilibrium, potential temperature, atmospheric thermodynamics, greenhouse effect, Earth's radiation balance, global warming, ozone layer and ozone depletion. • Meteorological phenomena including local winds, monsoons, sea breeze, land breeze, fog, clouds, precipitation, thunderstorms, cyclones, anticyclones, and weather forecasting methods. • Climate change indicators, extreme weather events, urban heat island effect, and climate resilience.	
II	**Atmospheric Dynamics and Climate Processes:** • Fundamental forces acting in the atmosphere. Scale analysis of atmospheric motion. • Conservation of mass, momentum, and energy. Atmospheric circulation, vorticity, atmospheric oscillations, quasi-biennial oscillation, El Niño Southern Oscillation (ENSO), monsoon dynamics, tropical circulation, and mesoscale weather systems. • General circulation of the atmosphere and its role in climate regulation • Climate modelling, numerical weather prediction, global climate circulation models, and climate variability over the Indian subcontinent.	12
III	**Atmospheric Waves and Remote Sensing:** • Introduction to wave phenomena in the atmosphere. • Acoustic waves, gravity waves, buoyancy waves, Lamb waves, Rossby waves, and wave propagation in the atmosphere. Wave dispersion, wave absorption, and non-linear atmospheric processes. • .Principles of atmospheric remote sensing. Radar equation, Doppler radar, weather radar, signal processing, and atmospheric observations. • LIDAR principles and applications in atmospheric studies. • Satellite meteorology, remote sensing for disaster management, GIS applications in atmospheric science, and atmospheric data visualization.	12

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IV	**Aerosols, Air Pollution and Environmental Monitoring:** • Atmospheric aerosols: sources, classification, production and removal mechanisms. Aerosol size distribution and optical properties. Scattering and absorption of solar radiation. Rayleigh scattering, Mie scattering, and Bouguer-Lambert law. Radiative forcing and aerosol-climate interactions. • Air pollution sources and impacts. Indoor and outdoor air quality. Atmospheric pollutants and particulate matter (PM2.5 and PM10). Environmental monitoring techniques and air quality indices • Carbon footprint assessment, sustainable cities, aerosol impacts on climate, environmental sensors, and smart air-quality monitoring systems.	12
V	**Climate Change, Sustainability and Atmospheric Applications:** • Scientific basis of climate change. Greenhouse gases and their global impact. Carbon cycle and climate feedback mechanisms. • Renewable energy and atmospheric interactions. Climate adaptation and mitigation strategies. • Atmospheric science applications in agriculture, aviation, renewable energy forecasting, environmental planning, disaster risk reduction, and public health. • Artificial intelligence in weather forecasting, machine learning applications in climate science, climate data analytics, smart environmental monitoring systems, and sustainable development goals (SDGs).	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

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Officer on special duty (Judicial)

C.6 Prescribed Textbooks

1. Wallace, J.M. & Hobbs, P.V., *Atmospheric Science: An Introductory Survey*.
2. Lutgens, F.K., Tarbuck, E.J., & Tasa, D., *The Atmosphere: An Introduction to Meteorology*.
3. Andrews, D.G., *An Introduction to Atmospheric Physics*.
4. Salby, M.L., *Fundamentals of Atmospheric Physics*.

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5. Seinfeld, J.H. & Pandis, S.N., *Atmospheric Chemistry and Physics*.
6. IPCC Assessment Reports (Latest Editions).
7. India Meteorological Department (IMD) Manuals and Publications.

C.7 Reference Books & Readings

1. Seinfeld, J. H., & Pandis, S. N. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change* (3rd Edition). Wiley.
2. World Bank. *Climate Change Knowledge Portal Reports and Technical Assessments*.
3. National Action Plan on Climate Change (NAPCC). Government of India.

C.8 Suggested E-Resources / Digital Repositories

1. **NPTEL** – Atmospheric Physics, Remote Sensing, Climate Science, Environmental Engineering, Air Pollution and Control.
   - https://nptel.ac.in/courses/115107129
   - https://nptel.ac.in/courses/105103193
   - https://nptel.ac.in/courses/120108558
   - https://nptel.ac.in/courses/109105203
2. **SWAYAM** – Climate Change and Sustainable Development, Environmental Studies, Disaster Management.
   - https://onlinecourses.swayam2.ac.in/e-learning/preview/ini25_hs01
   - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec19_hs20
3. **e-PG Pathshala** – Atmospheric Science, Environmental Science, Climate Change and Sustainability Modules.
4. **National Digital Library of India (NDLI)** – Atmospheric Sciences, Environmental Studies, Remote Sensing and GIS Collections.
5. **Shodhganga (INFLIBNET)** – Theses and dissertations in Climate Science, Meteorology, Environmental Physics and Sustainability.
6. **Indian Meteorological Department (IMD) Knowledge Portal** – Weather, climate and meteorological datasets.
7. **MOSDAC (ISRO Meteorological & Oceanographic Satellite Data Archive Centre)** – Satellite observations and atmospheric datasets.
8. **Bhuvan Geoportal (ISRO)** – GIS, remote sensing and environmental monitoring applications.
9. **Indian Institute of Tropical Meteorology (IITM Pune)** – Climate modelling, monsoon and atmospheric research resources.
10. **Virtual Labs (MoE)** – Environmental Science, Remote Sensing and Data Analysis simulations.

C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

1. Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)

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2. Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
3. Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

1. Written Test(s): 20 marks
2. Seminar / Assignment / Project: 05 marks
3. Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

D PART D — GENERAL REGULATIONS & PROVISIONS

D.1 Attendance & Eligibility

1. A student must have a minimum of 75% attendance in each paper to be eligible to appear in the Semester / Annual Examination.
2. Condonation of attendance deficiency shall be governed by the Regulation.
3. A student detained due to shortage of attendance may appear to the examinations of same semester in the next academic session subject to payment of prescribed fees.

D.2 Examination & Promotion Rules

1. A student is required to clear **at least** 60% (4 out of 6) papers of a particular Semester before being promoted to the succeeding Semester.
2. Back / Ex-Student candidates shall be governed by the rules in force at the time of their original admission unless otherwise specifically notified.
3. A candidate who fails in one or more papers shall be required to appear only in the failed paper(s) (Carry Forward System) in subsequent examinations of the same Semester.
4. A candidate is required to clear all his papers within a maximum of **Five Years of duration** to qualify for the degree.

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D.3 Grading System (CBCS)

Letter Grade	% Range	Grade Point	Performance Description	Remarks
O	≥90-100	10	Outstanding	Pass
A+	≥80<90	9	Excellent	Pass
A	≥70<80	8	Very Good	Pass
B+	≥60<70	7	Good	Pass
B	≥55<60	6	Above Average	Pass
C	≥50<55	5	Average	Pass
P	≥45<50	4	Pass	Pass
F	<45	0	Fail	Fail
Ab/M	0	0	Absent/Malpractice	Fail / Reappear

Mapping of Graduate Attributes (GAs), Programme Outcomes (POs), Programme Specific Outcomes (PSOs), Course Objectives (COBs), and Course Outcomes (COs/CLOs)

1. COB–GA Mapping

COBs	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
COB1	3	2	3	-	2	2	-	-	-	-	1
COB2	3	3	3	-	2	3	-	1	-	-	1
COB3	2	3	2	-	2	3	-	-	-	-	1
COB4	3	2	3	-	2	2	-	-	-	-	1
COB5	2	3	3	-	2	2	3	-	-	-	2
COB6	3	2	2	-	3	3	2	1	1	-	3

2. COB–PO–PSO Mapping

COBs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
COB1	3	3	-	-	2	2	-	-	-	-	3	3	-	-	-
COB2	2	3	-	-	2	2	-	-	-	-	2	3	-	-	-
COB3	2	3	-	-	2	2	-	-	-	-	2	3	-	-	-
COB4	3	3	-	-	2	2	-	-	-	-	3	3	-	-	-
COB5	1	3	-	3	2	2	-	-	-	-	2	3	-	-	1

N Kumar

COB 6	2	2	-	2	2	3	1	1	-	2	2	2	-	1	1

3. CO–COB Mapping

COs	COB1	COB2	COB3	COB4	COB5	COB6
CO1	3	2	-	-	-	-
CO2	2	3	-	-	1	-
CO3	2	2	3	-	-	-
CO4	-	1	3	-	-	1
CO5	-	-	-	3	-	1
CO6	-	-	1	-	3	2

4. CO–PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	-	-	2	-	-	-	-	-
CO2	2	3	-	-	2	-	-	-	-	-
CO3	3	3	-	-	2	-	-	-	-	-
CO4	2	3	-	-	1	1	-	-	-	-
CO5	3	3	-	-	2	1	-	-	-	-
CO6	1	3	-	3	2	2	-	-	-	1

5. CO–PSO Mapping

COs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	-
CO2	2	3	-	-	-
CO3	3	2	-	-	-
CO4	2	3	-	-	-
CO5	3	3	-	-	-
CO6	2	3	-	-	1

Scale

- **3 = High Correlation**
- **2 = Moderate Correlation**
- **1 = Low Correlation**
- Blank = No Significant Correlation

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E PART E — ABBREVIATIONS & AUTHENTICATION

E.1 List of Abbreviations

Abbr.	Expansion	Abbr.	Expansion
CC	Core Course	**DSE**	Discipline Specific Elective
GE	Generic Elective	**OE**	Open Elective
AEC	Ability Enhancement Course	**VAC**	Value Added Course
SEC	Skill Enhancement Course	**IKS**	Indian Knowledge System
L	Lecture (hours per week)	**T**	Tutorial (hours per week)
P	Practical (hours per week)	**IA**	Internal Assessment
CCA	Continuous & Comprehensive Assess.	**CLO**	Course Learning Outcome
PLO	Programme Learning Outcome	**GA**	Graduate Attribute
NHEQF	National HE Qualifications Framework	**PROJ**	Project / Dissertation

E.2 Authentication

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Date: 15/06/2026

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Nkumar

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Date: 15/06/2026

Subject Expert-3

[Name of the University]
Date: _____

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