Sardar Patel University, Mandi (H.P.)-175001

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Department of Physics

Scheme & Syllabus

of

Bachelor of Science

in

Physical Sciences (Multidisciplinary)

[Three Year Undergraduate Programme]

Based on NEP 2020

Effective from 2026–27 onwards

Aligned with the SPU Curriculum and Credit Framework for UG Programmes (CCFUP)
Prepared for Board of Studies consideration

Contents

PART I

Programme Educational Objectives (PEOs), Programme Specific Outcomes (PSOs), and Programme Outcomes (POs)

1 Programme Educational Objectives (PEOs)

The PEOs will enable students to:

PEO-1: Provide an integrated foundation in Physical Sciences through the combined study of Physics and allied disciplines, enabling students to understand natural phenomena from multidisciplinary perspectives aligned with the goals of NEP 2020.

PEO-2: Equip students with analytical, experimental, computational, and problem-solving skills necessary to investigate scientific questions across Physics, mathematics, chemistry, environmental science, computer science, and allied areas.

PEO-3: Foster critical thinking, scientific temper, ethical values, communication skills, teamwork, and adaptability for effective participation in multidisciplinary academic, research, and professional environments.

PEO-4: Prepare graduates for higher education, research, teaching, public services, scientific laboratories, industries, data-driven sectors, environmental agencies, technology-based careers, and interdisciplinary professional opportunities.

PEO-5: Promote lifelong learning, innovation, sustainability awareness, and social responsibility, enabling graduates to contribute to scientific progress, technological development, and societal well-being.

2 Programme Specific Outcomes (PSOs)

The B.Sc. Physical Sciences (Multidisciplinary) programme is designed to:

PSO-1: Apply fundamental concepts of Physics and allied disciplines to understand matter, energy, motion, fields, materials, measurements, and physical processes in nature and technology.

PSO-2: Demonstrate competence in laboratory methods, scientific measurements, instrumentation, data acquisition or computational techniques, data analysis, and interpretation of experimental observations.

PSO-3: Analyze scientific problems using mathematical reasoning, computational tools, statistical methods, evidence-based thinking, and multidisciplinary frameworks of Physical Sciences.

PSO-4: Evaluate scientific and technological issues relating to energy, environment, materials, electronics, sustainability, and societal development through an interdisciplinary Physical Sciences perspective.

PSO-5: Undertake project work or independent inquiry in a chosen area of Physical Sciences, communicate results effectively in written and oral formats, and adhere to ethical, professional, and safety standards.

3 Programme Outcomes (POs)

After successfully completing the B.Sc. Physical Sciences (Multidisciplinary) programme, the students will be able to:

PO1: Disciplinary Knowledge
Demonstrate knowledge of core concepts, principles, theories, and applications of Physics and related disciplines within the broader domain of Physical Sciences.

PO2: Critical Thinking and Problem Solving
Apply scientific reasoning, analytical thinking, mathematical methods, and quantitative approaches to identify, formulate, and solve scientific problems.

PO3: Research Competency
Design and conduct experiments or projects, collect and analyze data, interpret results, and present scientific findings using appropriate research methodologies.

PO4: Practical and Technical Skills

Demonstrate skills in laboratory techniques, measurement procedures, instrumentation, data recording, uncertainty analysis, and scientific reporting.

PO5: Environmental and Sustainability Awareness
Evaluate issues related to energy, environment, natural resources, climate, materials, and sustainable development from scientific and multidisciplinary perspectives.

PO6: Digital and Technological Competence
Use ICT tools, scientific software, computational methods, statistical packages, and data-analysis techniques in scientific investigations.

PO7: Communication Skills
Communicate scientific ideas, observations, interpretations, and conclusions effectively through oral presentations, technical reports, written assignments, and collaborative discussions.

PO8: Ethics and Professional Responsibility
Apply ethical principles, academic integrity, laboratory safety practices, and professional responsibility in academic and scientific work.

PO9: Leadership and Teamwork
Work effectively as an individual and as a member or leader of multidisciplinary teams in classroom, laboratory, field, project, and professional settings.

PO10: Lifelong Learning
Engage in continuous, self-directed learning and adapt to emerging developments in science, technology, research, innovation, and entrepreneurship.

PO11: Multidisciplinary Integration
Integrate knowledge from Physics, mathematics, chemistry, environmental science, computer science, and allied disciplines to address complex real-world problems.

PO12: Employability and Entrepreneurship
Develop competencies required for higher studies, research, teaching, public services, scientific laboratories, technology-based industries, environmental organizations, data-related professions, and entrepreneurial ventures.

PART II

Semester-wise Course Plan

1 Curriculum and Credit Framework for Undergraduate Programmes

Semester-wise Course Plan (Multidisciplinary): The following plan illustrates a student taking Physics as one of the three core disciplines.

Sem	Category	Course	Credits	Remarks
I	Physics DSC	Mechanics **(BPHYS-DSC-101)**	4	Core
	Core	Discipline B I	4	
	Core	Discipline C I	4	
	MDC	Multidisciplinary Course	3	
	SEC1	Skill Enhancement Course	3	
	AEC1	Ability Enhancement Course	2	
	Total		**20**	
II	Physics DSC	Electricity and Magnetism **(BPHYS-DSC-201)**	4	Core
	Core	Discipline B II	4	
	Core	Discipline C II	4	
	MDC	Multidisciplinary Course	3	
	SEC2	Skill Enhancement Course	3	
	VAC1	Value-Addition Course	2	
	I/A/P/C	I/A/P/C	4	
	Total		**24**	
III	Physics DSC	Waves and Optics **(BPHYS-DSC-301)**	4	Core
	Core	Discipline B III	4	
	Minor	Discipline C III	4	
	MDC	Multidisciplinary Course	3	
	SEC3	Skill Enhancement Course	3	
	AEC2	Ability Enhancement Course	2	
	VAC2	Value-Addition Course	2	
	Total		**22**	
IV	Physics DSC	Elements of Modern Physics **(BPHYS-DSC-401)**	4	Core
	Physics DSE	Electromagnetic Theory **(BPHYS-DSE-402)** Mathematical Physics **(BPHYS-DSE-401)**	4	Elective (Choose 1)
	Core	Discipline B IV	4	
	Minor	Discipline C IV	4	
	AEC3	Ability Enhancement Course	2	
	VAC3	Value-Added Course	2	

Sem	Category	Course	Credits	Remarks
	Total		**20**	
V	Physics DSC	Thermal and Statistical Physics **(BPHYS-DSC-501)**	4	Core
	DSE		8	Elective(choose 2)
	Core	Discipline B V	4	
	Minor	Discipline C V	4	
	AEC	Ability Enhancement Course	2	Elective
	Total		**22**	
VI	Physics DSC	Solid State Physics and Electronics **(BPHYS-DSC-601)**	4	Core
	DSE		8	Elective
	Core	Discipline B VI	4	
	Minor	Discipline C VI	4	
	Total		**20**	

PART III

Discipline-Specific Core (DSC) Syllabus

1 Physics DSC-1: Mechanics (BPHYS-DSC-101)

Institution	Sardar Patel University (SPU), Mandi
Program	B.Sc. Physical Sciences (Multidisciplinary) Programme
Course Code	BPHYS-DSC-101
Course Title	Mechanics
Semester	I
Credits	04 (3 Theory + 1 Practical)
Total Theory Lectures	45 (1 hour each)
Total Marks / Pass Marks	100 | 40
End Semester (Term-End) Examination	50 Marks (3 Hours)
Internal Assessment (CCA)	30 Marks
Practical	20 Marks

Instructions for Paper Setters and Candidates for DSC and DSE:

1. The question paper will consist of five sections: Section A (compulsory, covering whole syllabus from all the units), Section B from Unit I, Section C from Unit II, Section D from Unit III and Section E from Unit IV. Examiner will set nine questions in all, question number 1 will be compulsory and two questions from each Unit, i.e., I, II, III and IV, respectively. Each question will carry 10 marks. Question Number 1 (Section A) will consist of seven sub-short answer type questions carrying 02 (two) marks each and candidate has to attempt any five (5) questions.
2. Candidate will have to attempt five questions in all, i.e., selecting one question from each section B, C, D & E. From the Compulsory section A candidate has to attempt any five (5) out of seven (7) questions. The duration of the examination will be 3 hours.

Course Outcomes

On completion, students will be able to:

- Apply vector algebra and Newtonian dynamics to analyse motion in inertial and non-inertial frames, evaluating the effects of centrifugal and Coriolis fictitious forces.
- Apply the work-energy theorem and conservation laws to analyse conservative force fields, and formulate elastic and inelastic collision problems in both laboratory and centre-of-mass frames.
- Calculate moments and products of inertia for various rigid bodies, and apply the principles of rotational dynamics to analyse rotation about fixed axes and points.
- Formulate the two-body central force problem as an equivalent one-body problem, and analyse orbital motion using effective potential to derive Kepler's laws.

Theory Syllabus

Unit I: Vectors and Newtonian Dynamics (12 Lectures)

- **Vector Algebra:** Scalar and vector quantities; vector algebra; scalar and vector products (also triple), vector identities. The position vector and infinitesimal displacement in Cartesian, plane polar, cylindrical, and spherical coordinate systems. Velocity and acceleration in plane polar coordinates. The differential operators gradient, divergence, and curl (intuitive level only). (6 Lectures)

- **Newtonian Dynamics:** Review of Newton's Laws. Free-body diagrams. Frame of reference. Galilean transformations and Galilean invariance. Fictitious forces: centrifugal and Coriolis forces. Application: Deflection of a Falling Mass, Motion on the Rotating Earth, Weather Systems, and Foucault Pendulum (qualitative only). (6 Lectures)

Unit II: Work, Energy, and Collisions (11 Lectures)

- **Work and Energy:** Work and kinetic energy theorem. Conservative and non-conservative forces. Potential energy(non-uniqueness of U). Force as the negative gradient of potential. Energy diagrams and stable/unstable equilibrium. (4 Lectures)
- **Systems of Particles and Collisions:** Centre of mass and its motion. Conservation of linear momentum. Impulse. Laboratory and Centre of Mass (COM) frames of reference; velocity and momentum transformations between the two frames. Elastic and inelastic collisions in 1D. Two-dimensional elastic collisions and scattering; relation between the scattering angle in the centre-of-mass frame and the scattering and recoil angles in the laboratory frame. (7 Lectures)

Unit III: Rotational Dynamics (11 Lectures)

- **Rotation about a Fixed Axis:** Angular velocity and angular acceleration. Torque. Angular momentum $L = I\omega$ and the principle of conservation of angular momentum. Kinetic energy of rotation. Moment of inertia: theorems of parallel and perpendicular axes. Derivation of the moment of inertia from first principles for the thin rod, the ring, the disc, the rectangular lamina, the solid cylinder, and the solid sphere. (7 Lectures)
- **Rotation about a Point:** General rotation of a rigid body about a fixed point. non-parallelism of $\vec{L}$ and $\vec{\omega}$. Products of inertia. Principal moments and principal axes of inertia. (4 Lectures)

Unit IV: Central Forces (11 Lectures)

- **Two-Body Central-Force Motion:** Central and non-central forces. Reduction of the two-body central-force problem to an equivalent one-body problem. Conservation of angular momentum and energy in central-force motion, and their consequences. The effective potential and a qualitative description of the motion. (5 Lectures)
- **Orbits and Kepler's Laws:** The differential equation of the orbit and its solution for the inverse-square-law force. The orbit as a conic section, with a brief primer on the polar form of a conic, and the relation between eccentricity and total energy. Classification of orbits into bounded and unbounded motion (circle, ellipse, parabola, hyperbola) by energy and eccentricity. Kepler's laws of planetary motion. (6 Lectures)

Recommended References for Theory

- D. Kleppner and R. Kolenkow, *An Introduction to Mechanics*.
- C. Kittel et al., *Mechanics: Berkeley Physics Course Vol. 1*.

Practical / Lab Syllabus (30 Hours)

Every experiment is reported using the common laboratory format (aim, theory, apparatus, observations, graph, calculation, uncertainty analysis, result, precautions, viva).

1. To study measuring instruments and estimate least-count error: Vernier Calipers, Screw Gauge, Spherometer.
2. To determine the value of g using a Bar Pendulum, with uncertainty propagation.

3. To determine the value of *g* using a Kater's Pendulum.
4. To determine the Moment of Inertia of a Flywheel.
5. To determine the coefficient of viscosity of water by Poiseuille's method.
6. To determine the Young's Modulus of a wire by the optical lever method.
7. To determine the Modulus of Rigidity of a wire by Maxwell's needle.
8. To study the Motion of a Spring and calculate (a) Spring Constant and (b) Value of acceleration due to gravity.
9. To find the moment of inertia of an irregular body about an axis through its C.G with the torsional pendulum.
10. To compare the moment of inertia of a solid sphere and hollow sphere or solid disc of same mass with the torsional pendulum.
11. To verify (a) the law of conservation of linear momentum and (b) law conservation of kinetic energy in case of one and two dimension elastic collision

Recommended References for Practical

- Geeta Sanon, *B.Sc. Practical Physics*.
- B.L. Flint & H.T. Worsnop, *Advanced Practical Physics for students*, 1971, Asia Publishing House.
- Indu Prakash and Ramakrishna, *A Text Book of Practical Physics*, 11th Edition, 2011, Kitab Mahal, New Delhi.
- S. Panigrahi & B. Mallick, *Engineering Practical Physics*, 2015, Cengage Learning India Pvt. Ltd.
- Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- C.L. Arora, *B.Sc. Practical Physics*, S. Chand and company Ltd.

2 Physics DSC-2: Electricity and Magnetism (BPHYS-DSC-201)

Institution	Sardar Patel University (SPU), Mandi
Program	B.Sc. Physical Sciences (Multidisciplinary) Programme
Course Code	BPHYS-DSC-201
Course Title	Electricity and Magnetism
Semester	II
Credits	04 (3 Theory + 1 Practical)
Total Theory Lectures	45 (1 hour each)
Total Marks / Pass Marks	100 | 40
End Semester (Term-End) Examination	50 Marks (3 Hours)
Internal Assessment (CCA)	30 Marks
Practical	20 Marks

Instructions for Paper Setters and Candidates for DSC and DSE:

1. The question paper will consist of five sections: Section A (compulsory, covering whole syllabus from all the units), Section B from Unit I, Section C from Unit II, Section D from Unit III and Section E from Unit IV. Examiner will set nine questions in all, question number 1 will be compulsory and two questions from each Unit, i.e., I, II, III and IV, respectively. Each question will carry 10 marks. Question Number 1 (Section A) will consist of seven sub-short answer type questions carrying 02 (two) marks each and candidate has to attempt any five (5) questions.
2. Candidate will have to attempt five questions in all, i.e., selecting one question from each section B, C, D & E. From the Compulsory section A candidate has to attempt any five (5) out of seven (7) questions. The duration of the examination will be 3 hours.

Course Outcomes

On completion, students will be able to:

- Apply vector calculus operators and theorems (Gauss, Stokes) to solve electrostatic problems using Coulomb's law, Gauss's law, and Poisson's/Laplace's equations.
- Calculate magnetic fields for steady currents using Biot–Savart and Ampère's laws, and analyse the transient and steady-state responses of AC/DC circuits involving resistors, capacitors, and inductors.
- Formulate the behaviour of electric and magnetic fields in matter using polarization, displacement, magnetization, and auxiliary fields, classifying materials based on their susceptibilities.
- Derive Maxwell's equations in differential and integral forms, and evaluate the propagation, energy transport (Poynting vector), and boundary behaviour of plane electromagnetic waves.

Theory Syllabus

Unit I: Vector Calculus and Electrostatics (12 Lectures)

- **Vector Calculus:** Scalar and vector fields; differential (Del operator) and Laplace's operator, gradient, divergence, curl, and their physical significance. Area element, volume element, and solid angle in Cartesian, cylindrical, and spherical coordinate systems. Line, surface, and volume integrals. Gauss's Divergence Theorem, Stokes' Theorem, and Green's Theorem (statement only). (5 Lectures)

- **Electrostatics:** Review of electric charge, Coulomb's law, electric field, lines of force, and electric flux. Gauss's law in integral and differential form. Electrostatic potential; relation between electric field and potential. Calculation of the potential V and recovery of the field from $\mathbf{E} = -\nabla V$ for a uniformly charged ring and a uniformly charged disc along their axes. Dipole moment of a charge distribution; Dipole moment of a charge distribution; calculation of the potential of a dipole and a quadrupole, and derivation of the dipole electric field from its potential .Torque on a dipole in a uniform field and force on a dipole in a non-uniform electric field. Poisson and Laplace's equations. (7 Lectures)

Unit II: Magnetostatics, Induction and AC Circuits (11 Lectures)

- **Magnetostatics:** Review of magnetic field, Biot–Savart's law, Ampere's circuital law and its applications. The divergence and curl of **B**, introduction to vector potential and its derivation; current densities, Lorentz force law and its application to charged particle motion. (6 Lectures)
- **Electromagnetic Induction and Circuit Response:** Faraday's law, energy in a magnetic field. Growth and decay of currents in LR and CR circuits; time constants. Series and parallel LCR AC circuits, resonance, and Q factor. (5 Lectures)

Unit III: Fields in Matter (11 Lectures)

- **Electric Fields in Matter:** Polarization vector **P**; bound charge densities; electric displacement **D**; permittivity and electric susceptibility; Gauss's law in dielectrics; electrostatic boundary conditions. (6 Lectures)
- **Magnetic Fields in Matter:** Magnetization vector **M** and bound current densities. Magnetic intensity **H** and Ampere's law in magnetic materials; permeability and susceptibility. Classification of magnetic materials. (5 Lectures)

Unit IV: Maxwell's Equations and EM Waves (11 Lectures)

- **Maxwell's Equations:** Displacement current: physical motivation and the Ampere–Maxwell law. Maxwell's equations in integral and differential form (vacuum and material media). Equation of continuity. (5 Lectures)
- **Plane Electromagnetic Waves:** Wave equation from Maxwell's equations in vacuum and linear dielectric media. Transverse nature; energy transport: energy density, Poynting vector, Poynting theorem. Reflection and refraction at a dielectric interface. (6 Lectures)

Recommended References for Theory

- D.J. Griffiths, *Introduction to Electrodynamics*.
- E.M. Purcell, *Electricity and Magnetism: Berkeley Physics Course Vol. 2*.
- A.S. Mahajan and A.A. Rangwala, *Electricity and Magnetism*.

Practical / Lab Syllabus (30 Hours)

Perform at least 5 experiments. Common report format and data-analysis tasks (graph fitting, slope/intercept, uncertainty) apply.

1. Use of a Multimeter to measure AC/DC voltage, current, and resistance.
2. To determine unknown resistance using a Carey Foster's Bridge.
3. To determine the time constant of an RC circuit.

4. To determine the self-inductance of a coil using Anderson's bridge.
5. To study the resonance and Q-factor of a Series LCR circuit.
6. To study the resonance and Q-factor of a Parallel LCR circuit.
7. To determine unknown capacitance by flashing and quenching method.
8. To study the induced emf as a function of the velocity of the magnet.

Recommended References for Practical

- Geeta Sanon, *B.Sc. Practical Physics*, R. Chand & Co.
- B.L. Flint & H.T. Worsnop, *Advanced Practical Physics for students*, 1971, Asia Publishing House.
- Indu Prakash and Ramakrishna, *A Text Book of Practical Physics*, 11th Edition, 2011, Kitab Mahal, New Delhi.
- S. Panigrahi & B. Mallick, *Engineering Practical Physics*, 2015, Cengage Learning India Pvt. Ltd.
- Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- C.L. Arora, *B.Sc. Practical Physics*, S. Chand and company Ltd.

PART IV

Skill Enhancement Course (SEC) Syllabus

1 Overall SEC Course Sequence

The two Skill Enhancement Courses run in parallel with the Discipline-Specific Core (DSC) physics courses, developing hands-on measurement, instrumentation, and data-analysis skills that complement the theory taught in each semester. Instruments and procedures already covered in the DSC laboratory are not repeated; the SEC courses focus on quantitative and computational skills that the DSC labs do not formally develop.

Sem	Course Code	Course Title	Aligned DSC	Core Skill Function
I	BPHYS-SEC-101	Physical Measurement and Data Analysis	DSC-1: Mechanics	Error analysis, uncertainty, scientific reporting, and graphical fitting of mechanics data.
II	BPHYS-SEC-201	Instrumentation and Scientific Visualization	DSC-2: Electricity, Magnetism and EM Theory	CRO and circuit instrumentation, electronic component characterisation, and visualization of EM data.
III	BPHYS-SEC-301	Programming and Data Handling with Python	-	Python programming, data handling with pandas, and AI coding assistants.

2 General Instructions

- Both courses are fully laboratory-based (30 hours of lectures/tutorials and 15 Labs of 2 hours).
- Vernier callipers, screw gauge, and spherometer are introduced in the DSC-1 Mechanics laboratory. These courses build on that foundation without repeating instrument introduction.
- Each student must perform a minimum of twelve (12) experiments in BPHYS-SEC-101 and twelve (12) in BPHYS-SEC-201 from the syllabus list, with at least four per unit.
- Each student must maintain a laboratory record book. Every entry must include: aim, brief theory, apparatus, tabulated observations with units and least count, sample calculation with propagated uncertainty, result in standard form (value $\pm$ absolute uncertainty, unit), percentage uncertainty, and precautions.
- The external examiner for the end-semester practical examination shall be deputed by SPU Mandi from a college other than the candidate's own college.
- Pass criteria: 40% aggregate and a minimum of 35% in each component (End Semester Examination, Practical, and CCA).

3 BPHYS-SEC-101: Physical Measurement and Data Analysis

Course Details	Value
Institution	Sardar Patel University (SPU), Mandi
Program	B.Sc. Physical Sciences (Multidisciplinary)
Course Code	BPHYS-SEC-101
Semester / Type	I | Skill Enhancement Course (SEC)
Credits	03 (2L + 1P)
Duration / Hours per Week	One Semester (30 Lectures and 15 Labs of 2 hours)
Aligned DSC	Physics DSC-1: Mechanics
Total Marks / Pass Marks	75 | 30
End Semester Examination	50 Marks (3 Hours)
CCA	25 Marks

Examination Pattern

A. End Semester Examination — 50 Marks (2 Hours)

Component	Marks
a) Written spot test by External Examiner (five questions)	10
b) One experiment per unit with observations	25
c) Viva-Voce	15
Sub-total	**50**

B. Continuous Comprehensive Assessment (CCA) — 25 Marks

Component	Marks
a) Internal test / quiz conducted by the teacher	10
b) Assignment / Presentation / Lab Record	10
c) Attendance	05
Sub-total	**25**

Course Description

This course develops the quantitative measurement and data-analysis skills that underpin all experimental physics work. Students learn to quantify and propagate uncertainty, apply statistical methods to repeated measurements, perform graphical analysis, write Python scripts for data manipulation, and compose formally structured laboratory reports.

Laboratory Syllabus

Each unit is 10 hours and is thematically tied to the corresponding unit cluster in DSC-1: Mechanics. Conceptual content listed under each unit is delivered within laboratory hours.

Unit I: Experimental Uncertainty, Error Analysis, and Scientific Reporting (10 Hours) Concepts: Accuracy and precision; systematic, random, and gross errors; least-count error; zero error and its correction; significant figures; error propagation; standard reporting convention. Emphasis is placed on real-world data collection and recognizing equipment limitations.

Experiments / Exercises:

1. Least-count and zero-error audit of measuring instruments.
2. Density with a full error budget: determine the density of a regular solid, propagate uncertainties, and report in standard form.
3. Propagation through a derived quantity: compute the volume/surface area of a cylinder with fully propagated uncertainty.
4. Python/Spreadsheet for error propagation: Write a simple script to automate the calculation of derived uncertainties for complex formulas.
5. Laboratory-record writing workshop: Draft a complete, structured report for a concurrent DSC-1 experiment.

Unit II: Statistical Analysis of Repeated Measurements (10 Hours) Concepts: Measures of central tendency and dispersion. Role of repeated observations in suppressing random error and the $1/\sqrt{N}$ improvement in standard error. Introduction to basic statistical libraries in Python (NumPy/SciPy).

Experiments:

1. Repeated-measurement statistics: Measure a single quantity 20–30 times; compute mean, standard deviation, and standard error using Python/Spreadsheets.
2. Statistical determination of g (simple pendulum): Repeated timing over many oscillations; report $g\pm$ standard error.
3. Histogram and distribution: Plot a histogram of a repeated measurement (e.g., using Matplotlib); comment on shape and spread.
4. Outlier study: Implement an automated rejection criterion in Python to filter anomalous readings.
5. N-dependence of the standard error: Verify the $1/\sqrt{N}$ trend graphically by sub-sampling a large dataset.

Unit III: Graphical Analysis, Linearisation and Least-Squares Curve Fitting (10 Hours) Concepts: Choice of variables and scales; plotting with error bars; physical interpretation of slope and intercept; linearisation methods; least-squares fitting; residuals; R^2; utilizing Python (SciPy/Matplotlib) for rigorous data visualization.

Experiments:

1. T^2 vs L analysis: Perform linear regression in Python/Gnuplot; extract g with uncertainty.
2. Flywheel moment of inertia: Extract I from a fitted graph with residual analysis.
3. Position–time/velocity–time analysis: Track uniformly accelerated motion using video analysis (Tracker software) and extract acceleration.
4. Project: Collect complete data for a mechanical system, execute a full computational analysis, and submit a structured one-page report.

Recommended References

- C. L. Arora, *Practical Physics*, S. Chand and Company.
- J. R. Taylor, *An Introduction to Error Analysis*, University Science Books.
- *SciPy and Matplotlib Documentation*, scipy.org / matplotlib.org.
- B.L. Flint & H.T. Worsnop, *Advanced Practical Physics for students*, 1971, Asia Publishing House.

- Indu Prakash and Ramakrishna, *A Text Book of Practical Physics*, 11th Edition, 2011, Kitab Mahal, New Delhi.
- S. Panigrahi & B. Mallick, *Engineering Practical Physics*, 2015, Cengage Learning India Pvt. Ltd.
- Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- C.L. Arora, *B.Sc. Practical Physics*, S. Chand and company Ltd.

4 BPHYS-SEC-201: Instrumentation and Scientific Visualization

Course Details	**Value**
Institution	Sardar Patel University (SPU), Mandi
Program	B.Sc. Physical Sciences (Multidisciplinary)
Course Code	BPHYS-SEC-201
Semester / Type	II | Skill Enhancement Course (SEC)
Credits	03 (2L + 1P)
Duration / Hours per Week	One Semester (30 Lectures and 15 Labs of 2 hours)
Aligned DSC	Physics DSC-2: Electricity, Magnetism, and EM Theory
Total Marks / Pass Marks	75 | 30
End Semester Examination	50 Marks (2 Hours)
CCA	25 Marks

Examination Pattern

A. End Semester Examination — 50 Marks (2 Hours)

Component	**Marks**
a) Written spot test by External Examiner (five questions)	10
b) One experiment per unit with observations	25
c) Viva-Voce	15
Sub-total	**50**

B. Continuous Comprehensive Assessment (CCA) — 25 Marks

Component	**Marks**
a) Internal test / quiz conducted by the teacher	10
b) Assignment / Presentation / Lab Record	10
c) Attendance	05
Sub-total	**25**

Course Description

This course develops practical skills in modern electronic instrumentation, microcontroller-based data acquisition, and scientific visualization. Students learn to operate standard circuit instruments, characterize electronic components, interface sensors with Arduino platforms, and leverage Python for automated data fitting and visualization.

Laboratory Syllabus

Each unit is 10 hours and is directly tied to the corresponding topic cluster in DSC-2. Conceptual content is delivered within laboratory hours.

Unit I: Signal Measurement and Data Acquisition (10 Hours) **Concepts:** Block diagram of CRO and Digital Storage Oscilloscope (DSO). Calibration; measurement of AC signals. Introduction to microcontrollers (Arduino) for digital data acquisition: analog-to-digital conversion (ADC), sampling rates, and serial communication.

Experiments:

1. Measure amplitude, frequency, and phase difference of waveforms using a DSO, capturing data to a USB drive for analysis.
2. Compare frequencies using Lissajous figures on a CRO.
3. Interfacing Arduino: Program an Arduino to read an analog sensor (e.g., LDR or thermistor) and transmit the data to a PC via serial port.
4. Data Logging: Write a Python script to log the Arduino serial data stream into a CSV file in real-time.

Unit II: Circuit Instruments and Advanced Measurement (10 Hours) **Concepts:** Galvanometer principles; conversion to ammeters/voltmeters. Digital Multimeter internals. AC and DC bridge principles for high-precision component measurement.

Experiments:

1. Use of a multimeter: measure complex impedances and identify faulty components.
2. Determine an unknown resistance accurately using a Carey Foster bridge or a digital LCR meter.
3. Determine the self-inductance of a coil using an Anderson bridge.
4. Automated V-I measurement: Use Arduino to step voltage across a component and log the corresponding current, automating the Ohm's law verification.

Unit III: Electronic Components, LCR Behaviour, and Visualization (10 Hours) **Concepts:** PN junction diode and Zener diode mechanisms. Half/full-wave rectifiers. Phasor representation of AC; series/parallel LCR resonance. Using Python to visualize AC transient and steady-state responses.

Experiments:

1. I-V characteristics: Trace diode curves. Use Python (SciPy) to perform a non-linear fit to the Shockley diode equation and extract the ideality factor.
2. Rectifiers: Capture input/output waveforms of a bridge rectifier using a DSO, and compute the ripple factor programmatically.
3. RC Transients: Study the charging/discharging of an RC circuit using a DSO or Arduino. Fit the exponential decay in Python to find the time constant.
4. LCR Resonance: Study series/parallel resonance. Plot the frequency response using Matplotlib, finding the resonant frequency, bandwidth, and Q-factor computationally.

Recommended References

- M. L. Anand, *Electronic Instruments and Measurements*, S. K. Kataria and Sons.
- Paul Scherz and Simon Monk, *Practical Electronics for Inventors*, McGraw-Hill.
- *Python Data Science Handbook*, Jake VanderPlas, O'Reilly Media.
- B.L. Flint & H.T. Worsnop, *Advanced Practical Physics for students*, 1971, Asia Publishing House.
- Indu Prakash and Ramakrishna, *A Text Book of Practical Physics*, 11th Edition, 2011, Kitab Mahal, New Delhi.
- S. Panigrahi & B. Mallick, *Engineering Practical Physics*, 2015, Cengage Learning India Pvt. Ltd.
- Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

- C.L. Arora, *B.Sc. Practical Physics*, S. Chand and company Ltd.

PART V

Multi Disciplinary Course (MDC) Syllabus

About the Multidisciplinary Courses (MDC)

Under the NEP 2020 framework and the SPU CCFUP, Multidisciplinary Courses (MDCs) are broad-based, accessible papers open to students of any discipline. A Physics MDC carries 3 credits, delivered as 45 theory lectures (one credit = 15 lectures), and must differ from a student's Major and Minor. These papers require no specialised physics prerequisite; they build physical intuition through everyday, recognisable contexts rather than through formal derivation.

Sem	Course Code	Course Title	Credits
I	BPHYS-MDC-101	Physics in Everyday Life	3
II	BPHYS-MDC-201	Astronomy and Astrophysics	3
III	BPHYS-MDC-301	Physics of Sports and Music	3

General structure. Each MDC is theory-only, organised into three units of 15 lectures each (3 units × 15 = 45 lectures). Per-sub-part lecture allocations are shown against each topic.

Examination Pattern (Common to All MDC Papers)

Total Marks: 100. Pass mark: 40% in aggregate.
A. End Semester (Term-End) Examination — 70 Marks (3 Hours). A written theory paper covering all three units, with internal choice; a mix of short-answer and descriptive (conceptual) questions. The treatment is qualitative, with only simple relations, suiting students from any discipline.
B. Continuous Comprehensive Assessment (CCA) — 30 Marks:

Component	Marks
Internal test / quiz	10
Assignment / seminar / model or demonstration	15
Attendance	05
Sub-total	**30**

1 BPHYS-MDC-101: Physics in Everyday Life

Course Details	Value
Institution	Sardar Patel University (SPU), Mandi
Program	B.Sc. Physical Sciences (Multidisciplinary)
Course Title	Physics in Everyday Life
Course Code	BPHYS-MDC-101
Semester / Type	I | Multidisciplinary Course (MDC)
Credits	03
Duration / Contact Hours	45 Lectures
Eligibility	Open to all disciplines.
Total Marks / Pass Marks	100 | 40
End Semester Examination	70 Marks (3 Hours)
CCA	30 Marks

Course Description

Have you ever wondered why the sky is blue, how a microwave heats food, or why seatbelts save lives? This course reveals the physics hidden in ordinary experience — in the kitchen, the home, vehicles, gadgets, and the natural world. Designed for students of any discipline, it explains familiar phenomena and household technology through mechanics, heat, light, sound, and electricity, using an entirely conceptual and example-driven approach with no advanced mathematics. The aim is scientific literacy: the ability to understand and reason about the devices and effects encountered every day, with curiosity and confidence.

Course Outcomes

On completion, students will be able to:

1. Describe in everyday language why objects move, float, or stay balanced, and explain how these principles keep us safe in vehicles.
2. Recognise how heat moves in cooking, clothing, and household appliances, and explain why some materials feel warmer or colder than others.
3. Connect common visual experiences — rainbows, mirages, spectacles, and optical fibres — to basic ideas about how light travels, reflects, and bends.
4. Describe everyday sound phenomena, including echo, reverberation, ultrasound, and noise pollution, and identify their real-world applications.
5. Explain domestic electricity and electrical safety, and describe how common electronic gadgets — mobile phones, Wi-Fi, GPS, LEDs, and medical devices — work in simple terms.

Theory Syllabus

Unit I: Mechanics and Heat in Daily Life (15 Lectures)

- **Forces and Motion Around Us:** Everyday forces — gravity, friction, and tension; balance and stability. Pressure in daily life (why a knife is sharp; why snowshoes work; why high heels damage floors); fluids — floating and sinking, swimming, the hydraulic lift, and why ships made of steel float. Motion safety in vehicles: inertia, seatbelts, and airbags through impulse and momentum (qualitative; no equations). (8 Lectures)

- **Heat in the Home:** Temperature and heat — what they mean and how they differ. Conduction, convection, and radiation in cooking, clothing, and buildings. The thermos flask and the pressure cooker; the refrigerator and air conditioner (qualitative); why metals feel colder than wood at the same temperature. (7 Lectures)

Unit II: Light and Sound in Daily Life (15 Lectures)

- **Light and Vision:** Reflection and everyday mirrors (rear-view mirrors and vanity mirrors — why they are shaped differently). Refraction — the bending of light that makes a straw look broken in a glass of water; lenses, spectacles, and the human eye and its defects. Total internal reflection: optical fibres and the mirage. Dispersion and the rainbow; colour, and why the sky is blue and sunsets are red. (8 Lectures)
- **Sound in Daily Life:** Production and hearing of sound; echo and reverberation in halls and valleys. Ultrasound and its uses: cleaning, medical imaging, and sonar (qualitative). Musical sound versus noise; noise pollution and its control; sound in phones and earphones (microphone and speaker). (7 Lectures)

Unit III: Electricity, Electronics and Modern Gadgets (15 Lectures)

- **Electricity in the Home:** Current, voltage, resistance, and electric power (qualitative; analogies to water flow). Domestic wiring; fuses, MCBs, and earthing; electrical safety. Reading the electric meter and understanding the bill; common appliances — heater, incandescent/CFL/LED lamps, electric motor, and fan. (8 Lectures)
- **Electronics and Communication:** Semiconductors, the diode, and the LED (qualitative); the transistor as a switch. How a microwave oven works; remote controls and sensors. The basics of mobile communication, Wi-Fi, and GPS (qualitative); everyday medical and smart gadgets — pulse oximeters, digital thermometers, smartwatches. (7 Lectures)

Suggested Activities / Demonstrations

Optional, non-examined activities that may be used within lecture hours. Several require no equipment.

- Demonstrate pressure and buoyancy with simple floating/sinking objects and a Cartesian diver.
- Compare cooling/heating using different materials (metal spoon vs. wooden spoon in hot water) to show conduction and insulation.
- Trace image formation with a lens and a candle; examine spectacles for short and long sight.
- Split white light with a prism and observe dispersion; explain the blue sky with a scattering demonstration (torch through milky water).
- Identify the rating, fuse, and earthing of a household appliance and discuss its safety.
- Watch a cooking video and identify three heat-transfer methods visible in it.
- Observe the home electricity meter for one week and calculate units consumed.
- List five smart gadgets used at home and identify the physics principle behind each.

Recommended References

- L. A. Bloomfield, *How Things Work: The Physics of Everyday Life*, Wiley.
- P. G. Hewitt, *Conceptual Physics*, Pearson.
- J. Walker, *The Flying Circus of Physics*, Wiley.
- H. R. Verma, *Physics in Daily Life* / standard B.Sc. general-physics texts.
- *NCERT Physics (Classes XI–XII)* for conceptual background.
- Richard Feynman, *The Feynman Lectures on Physics*, Volume 1, selected chapters (free online at feynmanlectures.caltech.edu).

2 BPHYS-MDC-201: Astronomy and Astrophysics

Course Details	**Value**
Institution	Sardar Patel University (SPU), Mandi
Program	B.Sc. Physical Sciences (Multidisciplinary)
Course Title	Astronomy and Astrophysics
Course Code	BPHYS-MDC-201
Semester / Type	II | Multidisciplinary Course (MDC)
Credits	03
Duration / Contact Hours	45 Lectures
Eligibility	Open to all disciplines.
Total Marks / Pass Marks	100 | 40
End Semester Examination	70 Marks (3 Hours)
CCA	30 Marks

Course Description

Have you ever looked up at a clear night sky and wondered what you were seeing? This course is an invitation to understand the universe — from the Moon and planets visible to the naked eye, to distant galaxies billions of light-years away. The approach is entirely conceptual and descriptive; no advanced mathematics is used. Students develop the ability to read the night sky, understand how astronomers study the cosmos, and appreciate the grand story of how the universe formed and evolved — from the Big Bang to the search for life on other worlds. The course also celebrates India's remarkable astronomical heritage, from the ancient astronomer Aryabhata and the Jantar Mantar observatories to ISRO's modern missions and the AstroSat space telescope.

Course Outcomes

On completion, students will be able to:

1. Describe the celestial sphere, the daily and yearly motions of the sky, and explain in everyday language why seasons change, what causes eclipses, and how calendars are constructed.
2. Outline the structure of the solar system and describe the distinctive features of each planet, along with the roles of moons, comets, and asteroids, and the origin of the solar system.
3. Explain how telescopes and the different regions of the electromagnetic spectrum (radio, infrared, ultraviolet, X-ray) are used to study the universe, and how astronomers measure the distances and brightnesses of stars.
4. Describe how stars are born, how they shine, how they age, and what they leave behind, including white dwarfs, neutron stars, pulsars, and black holes.
5. Discuss the Milky Way and the variety of galaxies; the expanding universe, the Big Bang, and the cosmic microwave background; the ideas of dark matter and dark energy; exoplanets; and India's contributions to astronomy.

Theory Syllabus

Unit I: The Sky and the Solar System (15 Lectures)

- **Understanding the Sky:** The celestial sphere; constellations and the zodiac. Altitude–azimuth and equatorial coordinate systems (qualitative). Diurnal and annual motion of the sky; phases of the Moon; solar and lunar eclipses; cause of the seasons. Why the Northern and Southern hemispheres have opposite seasons. Timekeeping: sidereal and solar day; the basis of calendars; India's traditional lunisolar calendar. (8 Lectures)

- **The Solar System:** The Sun as a typical star — composition, energy, and sunspots. Terrestrial and Jovian planets and their main features, with everyday comparisons. Kepler's laws of planetary motion (qualitative, conceptual). Moons, asteroids, comets, meteors, and meteorites; the difference between a meteor and a meteorite. Formation of the solar system: the nebular hypothesis (qualitative). (7 Lectures)

Unit II: Telescopes and the Lives of Stars (15 Lectures)

- **Tools of Astronomy:** The electromagnetic spectrum in astronomy — why different "eyes" reveal different universes. Refracting and reflecting telescopes; magnification and resolving power (qualitative). Radio, infrared, ultraviolet, and X-ray astronomy; space telescopes (Hubble, James Webb). India's GMRT and AstroSat. Measuring the sky: apparent and absolute magnitude scale; stellar parallax and the measurement of distance. (7 Lectures)
- **Stars and Their Lives:** Brightness, colour, temperature, and spectral classification of stars (OBAFGKM, qualitative); the Hertzsprung–Russell diagram. Stellar energy from nuclear fusion (qualitative). The life cycle of stars: birth in nebulae, the main sequence, red giants, white dwarfs, supernovae, neutron stars, pulsars, and black holes (qualitative). Cosmic recycling: how the atoms in our bodies were forged in stars. (8 Lectures)

Unit III: Galaxies and Cosmology (15 Lectures)

- **Galaxies and the Universe:** The Milky Way and our place in it; the interstellar medium and stellar nurseries. Types of galaxies: spiral, elliptical, and irregular; galaxy clusters and the large-scale structure of the universe (the "cosmic web"); the idea of dark matter (qualitative). (8 Lectures)
- **Cosmology and Modern Topics:** The expanding universe and Hubble's law (qualitative); the Big Bang and the cosmic microwave background; the idea of dark energy and the accelerating universe. Exoplanets, the habitable zone, and the search for life beyond Earth. Indian contributions to astronomy: Aryabhata, the Jantar Mantar observatories, ISRO, GMRT, AstroSat, and the Chandrayaan and Aditya-L1 missions. (7 Lectures)

Suggested Activities / Demonstrations

Optional, non-examined activities that may be used within lecture hours. Several require no equipment.

- Identify major constellations and planets using a printed star chart or a free sky-map app (e.g. Stellarium).
- Observe and sketch the Moon's phases every few days over a month.
- Use a small telescope or binoculars to view the Moon's craters, Jupiter's moons, or sunspots (with proper solar filter).
- Build a scale model of the solar system on the campus grounds.
- Plot a simple Hertzsprung–Russell diagram from supplied star data.
- Watch a NASA or ISRO documentary and write a brief reflection on one surprising fact.
- Use a free online tool (e.g. NASA Eyes on the Solar System) to compare two planets of your choice.

Recommended References

- J. M. Pasachoff and A. Filippenko, *The Cosmos: Astronomy in the New Millennium*, Cambridge University Press.

- N. DeGrasse Tyson, *Astrophysics for People in a Hurry*, Norton (popular reading; recommended for non-science students).
- P. G. Hewitt, *Conceptual Physics*, Pearson (selected chapters on light, gravity, and nuclear energy).
- B. W. Carroll and D. A. Ostlie, *An Introduction to Modern Astrophysics*, Pearson (selected qualitative sections).
- K. S. Krishnasamy, *Astrophysics: A Modern Perspective*, New Age International.
- Carl Sagan, *Cosmos: A Personal Voyage* (book/TV series, popular reading).
- *NASA and ISRO educational web resources* (www.nasa.gov; www.isro.gov.in); Stellarium (www.stellarium.org).