MANONMANIAM SUNDARANAR UNIVERSITY,
TIRUNELVELI-12

SYLLABUS

PG - COURSES – AFFILIATED COLLEGES

Course Structure for M. Sc. Physics

(Choice Based Credit System)

(with effect from the academic year 2026-2027 onwards)

Semester-I				
Part	**Subject Status**	**Subject Title**	**Subject Code**	**Credit**
III	CORE I	MATHEMATICAL PHYSICS		5
III	CORE II	CLASSICAL MECHANICS AND RELATIVITY		5
III	CORE III	LINEAR AND DIGITAL ICS AND APPLICATIONS		4
III	CORE PRACTICAL I	GENERAL PHYSICS EXPERIMENTS – I		2
III	CORE PRACTICAL II	ELECTRONICS EXPERIMENTS – I		2
III	ELECTIVE I	SPECTROSCOPY		3

Total Marks: 100 Internal Exam: 25 marks + External Exam: 75 marks

A. **Scheme for internal Assessment**:
Maximum marks for written test: **20 marks**
3 internal tests, each of **I hour** duration shall be conducted every semester.
To the average of the **best two** written examinations must be added the marks scored in. The **assignment** for 5 marks.

The break up for internal assessment shall be:
Written test- 20 marks; Assignment -5 marks Total - 25 marks

B. Scheme of External Examination
3 hrs. examination at the end of the semester
A – Part : 1 mark question two - from each unit
B – Part : 5 marks question one - from each unit
C – Part : 8 marks question one - from each unit

➢ Conversion of Marks into Grade Points and Letter Grades

S.No	**Marks**	**Letter Grade**	**Grade point (GP)**	**Performance**
1	90-100	O	10	Outstanding
2	80-89	A+	9	Excellent
3	70-79	A	8	Very Good
4	60-69	B+	7	Good
5	50-59	B	6	Above Average
6	40-49	C	5	Pass
7	0-39	RA	-	Reappear
8	0	AA	-	Absent

➢ Cumulative Grade Point Average (CGPA)

$$\mathbf{CGPA} = \frac{\mathbf{\Sigma\,(GP \times C)}}{\mathbf{\Sigma C}}$$

- **GP** = Grade point, **C** = Credit
- CGPA is calculated only for Part-III courses
- CGPA for a semester is awarded on cumulative basis

➢ Classification

a) First Class with Distinction : CGPA $\geq$ 7.5*****
b) First Class : CGPA $\geq$ 6.0
c) Second Class : CGPA $\geq$ 5.0 and $<$ 6.0
d) Third Class : CGPA$<$ 5.0

MATHEMATICAL PHYSICS

COURSE OBJECTIVES

- The course aims to equip students with essential mathematical tools required for advanced studies in physics and to develop the ability to apply these tools in solving real physical problems.

UNIT I: LINEAR VECTOR SPACE

Basic concepts – Definitions – examples of vector space – Linear independence – Scalar product – Orthogonality – Gram-Schmidt orthogonalization procedure – linear operators – Dual space – Ket and Bra notation – orthogonal basis – change of basis – projection operator.

UNIT II: COMPLEX ANALYSIS AND GROUP THEORY

Review of Complex Numbers – de Moivre's Theorem – Functions of a Complex Variable – Differentiability – Analytic functions – Harmonic Functions – Complex Integration – Contour Integration – Cauchy–Riemann conditions – Singular points – Cauchy's Integral Theorem and Integral Formula – Laurent's Expansion – Zeros and poles – Residue theorem. Concept of groups – Abelian group – cyclic group – subgroups – classes – conjugate subgroups – Isomorphism and homomorphism – reducible and irreducible representations – character tables and applications.

UNIT III: MATRICES

Types of Matrices and their properties – Rank of a Matrix – Conjugate of a matrix – Adjoint of anmatrix – Inverse of a matrix – Hermitian and Unitary Matrices – Transformation of matrices – Characteristic equation – Eigen values and Eigen vectors – Cayley–Hamilton theorem – Diagonalization.

UNIT IV: FOURIER & LAPLACE TRANSFORMS

Definitions – Fourier series and transform and its inverse – Properties of FT – Fourier transform of derivatives – Cosine and sine transforms – Applications. Laplace transform and its inverse – Transforms of derivatives and integrals – Differentiation and integration of transforms – Properties – Applications.

UNIT V: DIFFERENTIAL EQUATIONS

Power series solutions around ordinary points - Special Functions: generating functions, Rodrigues' formula, Legendre and Hermite polynomials and orthogonality properties; Sturm– Liouville Theory: self-adjoint operators, eigenvalue problems, and the expansion of functions in orthogonal eigenfunctions; Green's Functions: introduction to the Dirac delta function, basic construction of Green's functions for linear ODEs, and the Reciprocity theorem.

TEXT BOOKS

1. George Arfken and Hans J Weber, 2012, Mathematical Methods for Physicists – A Comprehensive Guide (7th edition), Academic press.
2. P.K. Chattopadhyay, 2013, Mathematical Physics (2nd edition), New Age, New Delhi
3. A W Joshi, 2017, Matrices and Tensors in Physics, 4th Edition (Paperback), New Age International Pvt. Ltd., India
4. B. D. Gupta, 2009, Mathematical Physics (4th edition), Vikas Publishing House, New Delhi.
5. H. K. Dass and Dr. Rama Verma, 2014, Mathematical Physics,7th Edition, S. Chand

REFERENCE BOOKS

1. E.Kreyszig, 1983, Advanced Engineering Mathematics, Wiley Eastern, New Delhi,
2. D.G. Zill and M. R. Cullen, 2006, Advanced Engineering Mathematics, 3rd Ed. Narosa, New Delhi.
3. S. Lipschutz, 1987, Linear Algebra, Schaum's Series, McGraw - Hill, New York.
4. E.Butkov, 1968, Mathematical Physics Addison Wesley, Reading, Massachusetts.
5. P.R. Halmos, 1965, Finite Dimensional Vector Spaces, 2nd Edition, Affiliated East West, New Delhi.
6. C.R. Wylie and L. C. Barrett, 1995, Advanced Engineering Mathematics, 6th Edition, International Edition, McGraw-Hill, New York

CLASSICAL MECHANICS AND RELATIVITY

COURSE OBJECTIVES

- The course aims to provide a comprehensive understanding of classical and relativistic mechanics and to develop the ability to apply analytical formulations in solving dynamical problems in physics.

UNIT I: LAGRANGIAN FORMULATION

Introduction – Space and Time – Mechanics of a Particle and Mechanics of System of Particles- Coordinate System – Configuration space - Constraints – Generalized coordinates – Principle of Virtual Work - D'Alembert's principle – Lagrange's equations from D'Alembert's Principle – Applications - Variational principle – Hamilton's principle – Lagrange's equations from Hamilton's principle.

UNIT II: HAMILTONIAN DYNAMICS

Generalized Momentum and Cyclic Coordinates – Hamilton Function H – Conservation laws – Hamilton's equations – Examples in Hamiltonian dynamics: Harmonic Oscillator – Motion of a Particle moving in a Central force field - Canonical transformations – Poisson brackets – Hamilton–Jacobi equation.

UNIT III: CENTRAL FORCE AND OSCILLATIONS

Definition and properties of central forces – Reduction of two body problem to equivalent one body problem - Conservation and angular momentum and conservation of energy - Kepler's Problem – Action-angle variables - Small oscillations – Normal mode analysis of system with two and three degree of freedom - Coupled oscillations – Vibrations in a Linear tri atomic molecule.

UNIT IV: RIGID BODY DYNAMICS

Rigid body motion and degrees of freedom – Moment of inertia and inertia tensor - Euler angles and their geometric significance – Rotation matrices and direction cosines – Angular momentum and torque – Euler's equations of motion in a rotating frame and their derivation – Symmetric top – Free rigid body motion.

UNIT V: SPECIAL RELATIVITY

Postulates of Special Relativity – Lorentz transformations – Relativity of simultaneity – Time dilation – Length contraction – Relativistic addition of velocities – Minkowski space-time and space-time interval – Four-vectors and Lorentz covariance – Position, velocity, momentum, acceleration and force in four-vector notation – Transformation properties of four-vectors – Relativistic momentum – Relativistic energy – Mass–energy equivalence – Relativistic dynamics and equations of motion.

TEXT BOOKS

1. H. Goldstein, Classical Mechanics, Pearson.
2. N. C. Rana & P. S. Joag, Classical Mechanics.
3. J. V. Narlikar, Introduction to Relativity.
4. Resnick, Introduction to Special Relativity.

REFERENCE BOOKS

1. Landau & Lifshitz, Mechanics.
2. Marion & Thornton, Classical Dynamics.
3. Ryder, Quantum Field Theory (Relativity sections).

LINEAR AND DIGITAL ICs AND APPLICATIONS

COURSE OBJECTIVES

- The course aims to introduce the fundamental building blocks of linear and digital integrated circuits and to develop the ability to analyze and apply operational amplifiers, waveform generation circuits, and digital IC systems in practical electronic applications.

UNIT I: INTEGRATED CIRCUITS AND OPERATIONAL AMPLIFIER

Introduction, Classification of IC's, Op-Amp 741 and its features, the ideal Operational amplifier, Op-Amp internal circuit diagram, Op-Amp Characteristics – Inverting and Non-Inverting modes of operation – DC and AC performance characteristics.

UNIT II: APPLICATIONS OF OP-AMP

Linear applications of Op-Amp: Solution to simultaneous equations and differential equations, Instrumentation amplifiers, V to I and I to V converters. Non-linear applications of Op-Amp: Sample and Hold circuit, Log and Antilog amplifier, multiplier and divider, Comparators, Schmitt trigger, Multivibrators, Triangular and Square waveform generators.

UNIT III: ACTIVE FILTERS & TIMER AND PHASE LOCKED LOOPS

Active filters: Introduction, Butterworth filters – 1st order, 2nd order low and high pass filters, band pass, band reject and all pass filters – Applications. Timer and Phase Locked Loops: Introduction to IC 555 timer, monostable and astable operations and applications, Schmitt trigger, voltage controlled oscillator (IC 566), PLL – introduction, basic principle, phase detector/comparator, monolithic PLL (IC 565) and applications.

UNIT IV: VOLTAGE REGULATOR & DAC AND ADC

Voltage Regulators: Introduction, Series Op-Amp regulator, IC Voltage Regulators, IC 723 general purpose regulators, Switching regulator. DAC and ADC: Introduction, weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, A to D converters – parallel comparator type ADC, counter type ADC, successive approximation ADC, dual slope ADC, specifications.

UNIT V: CMOS LOGIC AND TTL IC CIRCUITS

CMOS Logic: CMOS logic levels, MOS transistors, CMOS inverter, NAND and NOR gates, CMOS AND-OR-INVERT and OR-AND-INVERT gates, implementation of any function using CMOS logic. Combinational circuits using TTL 74xx ICs: Logic gates, 4-bit parallel adder (IC 7483), comparator (IC 7485), decoder (IC 74138, IC 74154), BCD to 7-segment decoder (IC 7446/7447), encoder (IC 74147), multiplexer (IC 74151), demultiplexer (IC74154). Sequential circuits using TTL 74xx ICs: Flip-flops (IC 7474, IC 7473), shift registers, universal shift register (IC 74194), 4-bit asynchronous counter (IC 7493).

TEXT BOOKS

1. D.Roy Choudhury, Shail B. Jain (2012), Linear Integrated Circuit, 4th edition, New Age International Pvt. Ltd., New Delhi, India.
2. Ramakant A. Gayakwad (2012), OP-AMP and Linear Integrated Circuits, 4th edition, Prentice Hall / Pearson Education, New Delhi.
3. B.L. Theraja and A.K. Theraja, 2004, A Textbook of Electrical Technology, S. Chand & Co.
4. V.K. Mehta and Rohit Mehta, 2008, Principles of Electronics, S. Chand & Co, 12th Edition.

5. V. Vijayendran, 2008, Introduction to Integrated Electronics (Digital & Analog), S. Viswanathan Printers & Publishers Private Ltd, Reprint.

REFERENCE BOOKS

1. Sergio Franco (1997), Design with Operational Amplifiers and Analog Integrated Circuits, McGraw Hill, New Delhi.
2. Gray, Meyer (1995), Analysis and Design of Analog Integrated Circuits, Wiley International, New Delhi.
3. Malvino and Leach (2005), Digital Principles and Applications, 5th Edition, Tata McGraw Hill, New Delhi.
4. Floyd, Jain (2009), Digital Fundamentals, 8th Edition, Pearson Education, New Delhi.
5. Integrated Electronics, Millman & Halkias, Tata McGraw Hill, 17th Reprint (2000).

PRACTICAL – I
GENERAL PHYSICS EXPERIMENTS –I

COURSE OBJECTIVES

- This course aims to provide practical exposure to fundamental concepts in general physics through experimental investigations, develop skills in measurement techniques and scientific instrumentation, enhance the ability to analyze experimental observations and physical parameters, and enable students to apply theoretical concepts in laboratory-based scientific studies.

COURSE CONTENT (Any SIX Experiments)

1. **Elastic Properties by Cornu's Method**
   Determination of Young's modulus and Poisson's ratio of a material using Cornu's method by forming elliptical interference fringes. Study the variation of fringe dimensions with applied load and perform graphical analysis for determining elastic constants, rigidity modulus, bulk modulus, Flexural Rigidity and verification of linear elastic behaviour through stress–strain characteristics.
2. **Magnetic Hysteresis Studies**
   Determination of magnetic parameters by tracing the B–H hysteresis loop of a ferromagnetic material. Determine retentivity, coercivity, hysteresis loss, permeability, and energy loss per cycle; compare hysteresis characteristics for different magnetic materials.
3. **Thickness Measurement by Laser Diffraction Method**
   Determination of the thickness of a thin wire, thin film, or narrow object using laser diffraction. Measure diffraction patterns for different objects, study the effect of object position and wavelength, estimate percentage error, and compare experimental values with micrometer measurements.

4. **Band Gap Energy Measurement**
   Determination of the band gap energy of a semiconductor (thermistor) from temperature dependent resistance measurements. Plot resistance–temperature and log resistance versus inverse temperature graphs, determine temperature coefficient of resistance, and compare the experimental band gap with standard values.
5. **Determination of Planck's Constant using LEDs**
   Determination of Planck's constant using LEDs of different wavelengths and a diffraction grating. Determine threshold voltages for multiple LEDs, calculate frequency– voltage relationship and perform graphical determination of Planck's constant.
6. **Ultrasonic Interferometry**
   Determination of ultrasonic velocity and compressibility of two liquid samples using an ultrasonic interferometer. Study temperature dependence of ultrasonic velocity, calculate acoustic impedance and intermolecular interaction parameters, and compare properties of different liquids.
7. **Michelson Interferometer Studies**
   Determination of wavelength and optical path difference using a Michelson interferometer. Determine refractive index of transparent plates or liquids, measure coherence length, analyze fringe visibility, and estimate measurement accuracy.
8. **Magnetic Susceptibility Measurements**
   Determination of the magnetic susceptibility of a weak magnetic liquid using Quincke's method. Study susceptibility variation with magnetic field strength, compare susceptibility for different liquid samples, and perform error analysis.
9. **Self-Inductance Measurement using Bridge Circuits**
   Determination of the self-inductance of a coil using a Maxwell bridge circuit. Determine Q-factor, study frequency dependence of inductance, compare bridge balance conditions for different coils, and estimate measurement sensitivity.
10. **Semiconductor Diode Characteristics**
    Study of the forward and reverse bias characteristics of Si and Ge diodes and determination of parameters such as knee voltage, static resistance, dynamic resistance, reverse saturation current, breakdown voltage, and regulation characteristics of a Zener diode.
11. **Investigation of Viscoelastic Properties**
    Determination of rigidity modulus and internal friction of any two materials using torsional oscillations. Study damping behavior, determine logarithmic decrement and relaxation time, compare viscoelastic properties and analyze energy dissipation.

12. **Determination of RC Time Constant**
    Measurement of the RC time constant through capacitor discharging and verification with theoretical values. Study charging and discharging characteristics for different RC combinations, determine cutoff frequency of RC circuits, compare theoretical and experimental results graphically, and analyze transient response behavior.

PRACTICAL – II
ELECTRONICS EXPERIMENTS – I

COURSE OBJECTIVES

- This course aims to provide practical exposure to analog and digital electronics through circuit design and experimental analysis, develop skills in electronic instrumentation and signal processing, enhance the ability to analyze electronic circuit behavior and performance characteristics, and enable students to design and implement basic electronic systems for scientific and technological applications.

COURSE CONTENT (Any **SIX** Experiments)

Note: Trainer kits are intended for demonstration purposes only and should not be used for performing experiments.

1. **Voltage Regulator Design and Analysis**
   Design and analysis of a regulated DC power supply.
   Study line and load regulation characteristics, ripple factor, efficiency, temperature stability, and compare regulated and unregulated outputs under varying load conditions.
2. **FET Amplifier Characteristics**
   Determination of gain and frequency response characteristics of an FET amplifier.
   Determine bandwidth, input and output impedance, voltage gain variation with biasing conditions, and analyze amplifier performance for different frequencies and load resistances.
3. **Operational Amplifier Parameter Measurement**
   Determination of operational amplifier parameters such as gain, CMRR, and slew rate.
   Measure input offset voltage, input bias current, bandwidth, and frequency response; compare experimental values with datasheet specifications.
4. **Constant Current Source Design**
   Design and characterization of a transistor/FET-based constant current source.
   Study current stability with varying load resistance and supply voltage, determine compliance range, temperature dependence, and compare transistor and FET current sources.
5. **LED Characteristics and Optical Response**
   Determination of electrical and optical characteristics of LEDs of different wavelengths. Measure threshold voltage, power consumption, intensity variation with current, spectral response, and compare efficiencies of LEDs of

different colors.

6. **Wien Bridge Oscillator using Op-Amp**
   Design and analysis of a Wien bridge oscillator using Op-Amp.
   Determine frequency stability, distortion factor, amplitude stabilization, and study the effect of varying RC components on oscillation frequency.
7. **Phase Shift Oscillator Design**
   Design and study of the performance of an RC phase shift oscillator using Op-Amp.
   Measure gain and frequency stability, analyze phase conditions for oscillation, study waveform distortion, and compare theoretical and experimental frequencies.
8. **Schmitt Trigger Circuits**
   Design and analysis of a Schmitt trigger circuit using Op-Amp.
   Determine upper and lower threshold voltages, hysteresis width, switching speed, noise immunity, and study the effect of feedback resistance variation.
9. **Waveform Generator using Op-Amp**
   Generation and analysis of square and triangular waveforms using Op-Amp circuits.
   Measure frequency range, waveform symmetry, amplitude stability, duty cycle variation, and analyze the effect of RC parameters on generated waveforms.
10. **Pulse and Frequency Divider Circuits**
    Construction of pulse generation and frequency divider circuits.
    Study pulse width, duty cycle, propagation delay, frequency division ratios, and analyze timing characteristics using different divider configurations.
11. **Digital-to-Analog Converter Circuits**
    Construction and testing of digital-to-analog converter circuits using binary weighted and R– 2R ladder networks. Determine resolution, linearity, accuracy, settling time, and compare the performance of binary weighted and R–2R ladder DAC circuits.
12. **Digital Arithmetic Circuits**
    Design of digital arithmetic circuits such as binary adder, subtractor and BCD adder using IC 7483 and logic gates. Verify truth tables. Also cascade the adders for 8 bit arithmetic operation.

SPECTROSCOPY

COURSE OBJECTIVES

- The course aims to provide a comprehensive understanding of various spectroscopic techniques, their theoretical foundations, instrumentation, and applications, and to develop the ability to analyze molecular structure and properties using spectroscopic methods.

UNIT I: MICROWAVE SPECTROSCOPY

Rotational spectra of diatomic molecules – Rigid rotor – Reduced mass – Rotational constant – Effect of isotopic substitution – Non-rigid rotator – Centrifugal distortion – Intensity of spectral lines – Polyatomic molecules (linear, symmetric and asymmetric top molecules) – Instrumentation techniques – Block diagram – Information derived from rotational spectra – Problems.

UNIT II: INFRARED SPECTROSCOPY
Simple harmonic oscillator – Zero-point energy – Anharmonic oscillator – Fundamentals, overtones and combinations – Vibrating rotator – PR branch – PQR branch – Vibrational modes of H_2O and CO_2 – IR spectrophotometer instrumentation (double beam) – Fourier Transform Infrared Spectroscopy – Interpretation of vibrational spectra – Applications.

UNIT III: RAMAN SPECTROSCOPY
Classical and quantum theory – Molecular polarizability – Rotational Raman spectra – Linear and symmetric top molecules – Stokes and anti-Stokes lines – Raman activity of H_2O and CO_2 – Mutual exclusion principle – Structure determination – Instrumentation – FT Raman spectroscopy – Surface enhanced Raman spectroscopy.

UNIT IV: RESONANCE SPECTROSCOPY
NMR: Nuclear spin – Magnetic interaction – Energy levels – Larmor precession – Relaxation times – Chemical shift – Spin-spin interaction – Instrumentation – MRI applications.
ESR: Basic principle – Hyperfine structure – g-factor – Instrumentation – Applications.

UNIT V: UV SPECTROSCOPY
Origin of UV spectra – Laws of absorption – Lambert-Beer law – Absorptivity – Chromophores – Effect of conjugation – Solvent effects – Absorption in organic and inorganic molecules–Instrumentation (double beam spectrophotometer)–Applications.

TEXT BOOKS
1. C. N. Banwell & E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
2. G. Aruldhas, Molecular Structure and Spectroscopy, PHI.
3. D. N. Satyanarayana, Vibrational Spectroscopy and Applications.
4. B. K. Sharma, Spectroscopy, Goel Publishing.
5. Kalsi P. S., Spectroscopy of Organic Compounds.

REFERENCE BOOKS
1. J. L. McHale, Molecular Spectroscopy, Pearson.
2. J. M. Hollas, Basic Atomic and Molecular Spectroscopy.
3. B. P. Straughan & S. Walker, Spectroscopy Vol. I.
4. K. Chandra, Introductory Quantum Chemistry.
5. W. Demtroder, Laser Spectroscopy.