# 4-YEAR UNDERGRADUATE PROGRAM
# (FYUGP-2023)
# (FYUGP-OLD)

## UNDER THE NEW CURRICULUM AND CREDIT FRAMEWORK, 2022

## 7th and 8th Semester

## UNDERGRADUATE SYLLABUS

in

# PHYSICS

University of North Bengal
2026

## COURSE STRUCTURE
## Major

| Semester | Paper | Title | Credit | Type |
|---|---|---|---|---|
| **VII** | **UPHYMAJ47017** | Mathematical Physics IV | 4 | Theory + Tutorial |
| | **UPHYMAJ47018** | Advanced Quantum Mechanics | 4 | Theory + Tutorial |
| | **UPHYMAJ47019** | Classical Mechanics II | 4 | Theory + Tutorial |
| **VIII** | **UPHYMAJ48020** | Classical Electrodynamics | 4 | Theory + Tutorial |
| | **UPHYMAJ48021*** | Mathematical Physics V | 4 | Theory + Tutorial |
| | **UPHYMAJ48022*** | Computational Physics | 4 | Theory + Practical |
| | **UPHYMAJ48023*** | Project Work with Seminar Presentation and Grand Viva | 2+2 | |

* UPHYMAJ48021, UPHYMAJ48022, and UPHYMAJ48023 are for those students who will pursue only "**Honours Course**". Students who will pursue "**Honours with Research**" will take up ***Research Dissertation*** in lieu of these papers.

## COURSE STRUCTURE
## Minor

| Semester | Paper | Title | Credit | Type |
|---|---|---|---|---|
| **VII** | MIN-007 | Waves and Optics | 4 | Theory + Practical |
| **VIII** | MIN-008 | Waves and Optics | 4 | Theory + Practical |

# Semester-VII

## UPHYMAJ47017 Mathematical Physics IV

| 45 Lectures (Theory) | **(Theory-3 credit; Tutorial-1 credit)** |
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**Complex Analysis**

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected regions. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

**Tensor Analysis**

Cartesian Tensor: Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities.

General Tensor: Transformation of Coordinates. Minkowski Space. Contravariant and Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta. Permutation Tensors.

Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Metric Tensor.

**Reference Books**


- Mathematical Tools for Physics, J. Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, and F. E. Harris, 1970, Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C. D. Cantrell, 2011, Cambridge University Press

- Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicists and Engineers, K. F. Riley, M. P. Hobson, and S. J. Bence, 3rd edition., 2006, Cambridge University Press
- Mathematical Methods for Physicists: A Concise Introduction: T. L. Chow, 2000, Cambridge Univ. Press.
- Introduction to Mathematical Physics: Methods and Concepts, C. W. Wong, 2012, Oxford University Press
- Introduction to Mathematical Probability, J. V. Uspensky, 1937, McGraw Hill.


## UPHYMAJ47018 Advanced Quantum Mechanics

| **45 Lectures (Theory)** | **(Theory-3 credit; Tutorial-1 credit)** |
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**Linear Vector Spaces**

Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Linear Transformations. Representation of Linear Transformations by Matrices. Inner products. Unitary transformations. Matrix representations.

**Symmetry**

Translation in space and time, rotational symmetry, spatial inversion symmetry and time reversal symmetry.

**Matrix Mechanics**

Matrix representation of Kets, Bras and Operators, Pauli matrices, Angular momentum & spin angular momentum in terms of Pauli matrices, Orbital ($L_z$, $L^2$) eigenvalues and eigenstates of spin-1/2 particles, addition of angular momenta, Clebsch-Gordon coefficients.

**Time independent perturbation theory**

Non-degenerate perturbation theory, general formulation, first-order and second-order energy and state corrections. Degenerate perturbation theory, two-fold degeneracy, higher-order degeneracy, removal of degeneracy. Applications in 1-D box system.

**Time dependent perturbation theory**

General formulation, interaction picture, constant and harmonic perturbations, transition probability, emission and absorption of radiation, Fermi's golden rule, applications.

**Variational method**

Rayleigh-Ritz theorem, applications – 1D potential box, linear harmonic oscillator and Hydrogen atom.

**Reference Books**


- Quantum Mechanics – Nouredine Zettili
- Introduction to Quantum Mechanics – D. J. Griffiths
- Quantum Mechanics: Theory and Applications – Ajoy Ghatak, S. Lokanathan
- Quantum Mechanics – B. H. Bransden and C. J. Joachain
- Problems and Solutions on Quantum Mechanics – Yung Kuo Lim
- Quantum Mechanics, Vol. I & II – C. Cohen-Tannoudji, B. Diu and F. Laloe.
- Quantum Mechanics, Vol. I & II – A. Messiah Modern
- Quantum Mechanics – S. Devnathan
- Prof. S. Lakshmibala – NPTEL Lecture on Quantum Mechanics


## UPHYMAJ47019 Classical Mechanics II

| 45 Lectures (Theory) | (Theory-3 credit; Tutorial-1 credit) |
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| **Recapitulation of Lagrangian and Hamiltonian Mechanics** |
| Lagrangian, Lagrange's equations of motion, application to simple systems, Hamiltonian, Hamilton's equations of motion and application to simple systems. |
| **Rigid Body Kinematics** |
| Kinematics of rigid body motion; degrees of freedom; Euler angles; The Cayley-Klein parameters and spinors; Rigid rotator, Motion of a symmetrical top, motion of a symmetrical top under gravity. |
| **Canonical Transformation** |
| Canonical transformations, generating functions, conditions for canonical transformation, Poisson brackets, Poisson theorem, Canonical transformation in terms of Poisson bracket, Hamilton-Jacobi theorem, Lagrange bracket, Liouville's theorem. |
| **Hamilton-Jacobi Theory** |
| Hamilton-Jacobi equation, separation of variables; Hamilton's principal and characteristic functions; action angle variables. |
| **Small Amplitude Oscillations** |
| Stable and unstable equilibrium, General case of coupled oscillations, General theory of small oscillations, Eigenvectors and Eigen frequencies, Orthogonality of eigenvectors, normal coordinates, Molecular vibrations as example, Loaded string. |
| **Continuous systems** |
| Transition from a discrete to a continuous system; Lagrangian formulation of continuous systems and fields; Hamiltonian formulation – applications. |
| **Introduction to Non-linear system** |
| General idea of dynamical system, order of dynamical system, continuous and discrete, autonomous systems, solution of autonomous systems, (1D and 2D) critical points linear stability |

analysis and classification of critical points.

**Reference Books**

- Classical Mechanics – H. Goldstein, C. Poole & J. Safko
- Classical Mechanics – N. C. Rana & P. S. Joag
- Classical Dynamics – S. T. Thornton & J. B. Marion
- Nonlinear Dynamics & Chaos – S. H. Strogatz

# Semester-VIII

## UPHYMAJ47020 Classical Electrodynamics

| 45 Lectures (Theory) | (Theory-3 credit; Tutorial-1 credit) |
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**Review of electromagnetic theory**

Boundary value problems in different geometries; Multipole expansion of the scalar and the vector potentials in the static scenario; Gauge transformations; Poynting theorem; Stress tensor; Maxwell's equations; Dispersion; Kramer's-Kronig relations; Resonant cavity and wave guide.

**Localized time varying sources**

Solution of inhomogeneous wave equation using Green's function technique; Retarded potentials; Electromagnetic radiation from time dependent localized charge and current distributions; Multipole expansion in the radiation zone; Radiation from center-fed linear antenna; Quadrupole radiation.

**Moving point charge**

Lienard-Wiechert potentials; Electromagnetic fields due to a point charge in uniform motion; Radiation from an accelerated point charge; Generalized Larmor formula for total power radiated by an accelerated point charge in relativistic motion; Angular distribution of radiated power in the linear and circular motion; Bremstrahlung; Synchrotron radiation; Cherenkov radiation; Radiation reaction; Abraham-Lorentz formula, Scattering and absorption of radiation.

**Covariant formulation of electrodynamics**

Four vectors; Lorentz transformation of electromagnetic fields; Electromagnetic field tensor; Dual field tensor; Covariance of Maxwell's equations; Lagrangian formulation of the motion of a charged particle in an electromagnetic field; Covariant equation of motion; Covariant formulation of Lorentz force; Introductory Classical Field Theory: Lagrangian density, Field momentum, Hamiltonian density, Poisson brackets for the fields, Hamiltonian for a system of charged particles in an electromagnetic field.

**Reference Books**

- Classical Electrodynamics – J. D. Jackson
- Classical Theory of Fields – L. D. Landau and E. M. Lifshitz
- Introduction to Electrodynamics – D. J. Griffiths
- Classical Electromagnetic Theory – J. Vanderlinde
- Classical Electricity and Magnetism – W. K. H. Panofsky and M. Phillips

## UPHYMAJ48021 Mathematical Physics V

| **45 Lectures (Theory)** | **(Theory-3 credit; Tutorial-1 credit)** |
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**Laplace Transform**

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along an infinite bar using Laplace transform.

**Group Theory**

Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Cosets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of groups. Normal and conjugate subgroups. Application of group theory to study symmetry: 1. Group of symmetries of a square (D4 group) and 2. Group of symmetries of an equilateral triangle (S3 group). Group table of D4 and S3 group.

**Green's Function**

Inhomogeneous boundary value problem and Green's function, eigenfunction expansion of Green's function, Fourier transformation method of constructing Green's function, application to physical problems.

| Reference Books |
|---|
| ► Mathematical Methods for Physicists: Arfken and Weber, 2005, Academic Press<br>► Mathematical Methods for Physicists: A Concise Introduction: T. L. Chow, 2000, Cambridge Univ. Press.<br>► Elements of Group Theory for Physicists, A. W. Joshi, 1997, John Wiley.<br>► Group Theory and its Applications to Physical Problems, M. Hamermesh, 1989, Dover Publication<br>► Introduction to Mathematical Physics : Methods and Concepts, C. W. Wong, 2012, Oxford University Press |

| **UPHYMAJ48022 (Theory + Practical): Computational Physics** | |
|---|---|
| **45 Lectures (Theory)** | **Theory: 3 Credits**<br>**Practical: 1 Credit** |
| **Errors in Numerical Methods** | |
| Introduction; data errors; round off errors; truncation errors, significant digits; absolute and relative errors; general formula of errors; error estimation. | |
| **Interpolation and data fitting** | |
| Newton's forward and backward interpolation, Lagrange interpolation. Regression, Linear least square fitting, applications. | |
| **Root Finding methods** | |
| Bisection Method, Newton-Raphson method, roots of polynomial, applications. | |

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|---|---|
| **System of Linear Simultaneous Equations** | |
| Gauss Jordan Method, applications. | |
| **Numerical Quadrature** | |
| General quadrature formula, Trapezoidal rule, Simpson's 1/3 rule, applications. | |
| **Ordinary Differential Equation** | |
| Solving 1st order and 2nd order ODEs, Euler method, Runge-Kutta methods (RK2 and RK4), and applications. | |
| **Partial Differential Equation** | |
| Solution of PDE using finite difference approximations, Forward-in-time and centered-in-space scheme, Boundary conditions: Dirichlet and Neumann condition, applications. | |
| **Monte-Carlo Methods** | |
| Generation of random numbers using Monte Carlo methods. | |
| **Computational Physics Lab** | **1 Credit** |
| **Practicals:** | |

*(In these practicals, students should be able to cast physical problems into numerical models and then use computer programming to solve those. The programs should be written using core Python functionalities, avoiding using numerical and scientific modules like Numpy and Scipy as much as possible. List of problems given below should be regarded as suggestive of the standard and may not be strictly adhered to. New problems of similar standard may be added and old problems may be omitted whenever felt necessary.)*

- Solving 1st Order and 2nd Order ODEs like radioactive decay, transients in electrical circuits, damped harmonic oscillator, forced harmonic oscillator, coupled oscillator, projectile motion.
- Finding roots of transcendental and algebraic equations, polynomials, zeros of Legendre and Bessel functions of the first kind.
- Solutions of systems of linear equations like mesh equations of electrical circuits etc.
- Interpolation and fitting of data obtained in experiments.
- Integration of functions, magnetic field due to a current carrying conductor, time period of pendulum, etc.
- Solution to Wave equation, diffusion equation, Laplace's equation, Poisson's equation, time independent Schrödinger's equation (harmonic potential & s-wave H-atom).
- Random numbers and Monte Carlo methods – Uniformly distributed, exponentially distributed and Gaussian distributed random numbers, evaluation of integration within finite/infinite limits.
- Monte Carlo technique to simulate physics problems like the alpha-decay problem, random walk problem, diffusion problems.

**Reference Books**


- Introduction to Numerical Analysis, S. S. Sastry, 5th edition, 2012, PHI Learning Pvt. Ltd.
- Computational Physics: An Introduction, R.C. Verma et al., 1999, New Age International Publishers, New Delhi.
- A first course in Numerical Methods, U. M. Ascher and C. Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K. E. Atkinson, 3rd edition, 2007, Wiley India


## UPHYMAJ48023 Project Work with Seminar Presentation and Grand Viva

**Credit: 2+2**

1. Students need to submit project work on a Physics topic as decided by the departmental faculty and present his/her work in a seminar. The project work and seminar will be evaluated by one internal and one external examiner appointed by the university. Project work should be preserved.
2. Students need to appear in front of board of teachers for grand viva. Syllabus for the grand viva will comprise whole Physics FYUGP UG Major Syllabus.

## Modalities for dissertation for students pursuing ***Honours with Research***

**Credit: 12**

Students need to submit dissertation on a novel Physics topic as decided by his/her departmental supervisor and present a seminar on his/her work in presence of supervisor, and an external examiner. Dissertation should be checked for plagiarism and report should be attached with the dissertation. Dissertation should be preserved.

**Marks Distribution for Evaluation:**

1. **Punctuality and Regular Discussion: 50 marks**
2. **Preparation of Report and Plagiarism check: 25+25 marks**
3. **Evaluation of Report: Average of evaluation by the external in 50 marks and evaluation by the supervisor in 50 marks**
4. **Seminar presentation and evaluation in presence of external: 75 marks**

**Total Marks: 225**

# MINOR

## Semester-VII

### MIN-007 Waves and Optics

| 45 Lecture | 3 Credits |
|---|---|

**Superposition of Two Collinear Harmonic oscillations**

Linearity and Superposition Principle. Oscillations having equal frequencies and Oscillations having different frequencies (Beats).

**Superposition of Two Perpendicular Harmonic Oscillations**

Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

**Wave Motion**

Transverse waves on a string. Traveling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves, Spherical waves, Wave intensity.

**Sound**

Simple harmonic motion-forced vibrations and resonance, Fourier's Theorem-Application to sawtooth wave and square wave–Intensity and loudness of sound-Decibels, Intensity levels, Acoustics of buildings: Reverberation and time of reverberation-Absorption coefficient, Sabine's formula-measurement of reverberation time-Acoustic aspects of halls and auditorium.

**Wave Optics**

Electromagnetic nature of light. Definition and Properties of wave front. Huygen's Principle.

**Interference**

Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Bi-prism. Phase change on reflection: Stokes treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

**Diffraction**

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

**Polarization**

Transverse nature of light waves. Plane polarized light–production and analysis. Circular and elliptical polarization.

**Reference Books**

- Fundamentals of Optics, F. A. Jenkins and H. E. White, 1976, McGraw Hill
- Principles of Optics, B. K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, H. R. Gulati and D. R. Khanna, 1991, R. Chand Publications
- University Physics, F. W. Sears, M. W. Zemansky and H. D. Young, 1986, Addison-Wesley

| Practicals | 1 Credits |
| --- | --- |

**List of Practical**

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2 - T$ Law.
3. To study Lissajous Figures
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury/Helium Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.

10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.
14. To measure the intensity using photo sensor and laser in diffraction patterns of single and double slits.

**Reference Books**


- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash and Ramakrishna,11th edition, 2011, Kitab Mahal, NewDelhi.


## Semester-VIII

### MIN-008 Waves and Optics

| 45 Lecture | 3 Credits |
|---|---|

**Superposition of Two Collinear Harmonic oscillations**

Linearity and Superposition Principle. Oscillations having equal frequencies and Oscillations having different frequencies (Beats).

**Superposition of Two Perpendicular Harmonic Oscillations**

Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

**Wave Motion**

Transverse waves on a string. Traveling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves, Spherical waves, Wave intensity.

**Sound**

Simple harmonic motion-forced vibrations and resonance, Fourier's Theorem-Application to sawtooth wave and square wave–Intensity and loudness of sound-Decibels, Intensity levels, Acoustics of buildings: Reverberation and time of reverberation-Absorption coefficient, Sabine's formula-measurement of reverberation time-Acoustic aspects of halls and auditorium.

**Wave Optics**

Electromagnetic nature of light. Definition and Properties of wave front. Huygen's Principle.

**Interference**

Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Bi-prism. Phase change on reflection: Stokes treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

**Diffraction**

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

**Polarization**

Transverse nature of light waves. Plane polarized light–production and analysis. Circular and elliptical polarization.

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- University Physics, F. W. Sears, M. W. Zemansky and H. D. Young, 1986, Addison-Wesley

| Practicals | 1 Credits |
|---|---|

**List of Practical**

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2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2$ – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury/Helium Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
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11. To determine the wavelength of Laser light using Diffraction of Single Slit.
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