VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS)

MAJOR IN PHYSICS

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes

(CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN PHYSICS
(Under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	2nd	III	**SEMESTER-III**							
			Major-3	PHSHMJ03	T: Waves & Optics with Mathematical Methods I	4	3-1-0	15	60	75
			Major-4	PHSHMJ04	T: Electromagnetic Theory with Mathematical Methods II	4	3-1-0	15	60	75
			SEC	PHSSEC03	P: Technology based Applications (Practical)	3	0-0-3	10	40	50
			AEC	AEC03	Communicative English -2 (***common for all programmes***)	2	2-0-0	10	40	50
			MDC	MDC03	Multidisciplinary Course -3 (***to be chosen from the list***)	3	3-0-0	10	40	50
			Minor-3 (Disc.-I)	PHSMIN03	T: Waves & Optics; P: Practical	4	3-0-1	15	60	75
					Semester-III Total	20				375
		IV	**SEMESTER-IV**							
			Major-5	PHSHMJ05	T: Atomic Physics with Mathematical Methods III	4	3-1-0	15	60	75
			Major-6	PHSHMJ06	T: Classical Mechanics with Special Theory of Relativity & Python Programming; P: Practical	4	3-0-1	15	60	75
			Major-7	PHSHMJ07	P: Experimental Physics-I (Practical)	4	0-0-4	15	60	75
			AEC	AEC04	MIL-2 (***common for all programmes***)	2	2-0-0	10	40	50
			Minor-4 (Disc.-II)	PHSMNI04	T: Electricity & Magnetism; P: Practical	4	3-0-1	15	60	75
			Summer Intern.	INT	Internship/ Apprenticeship - activities to be decided by the Colleges following the guidelines	4	0-0-4	-	-	50
					Semester-IV Total	22				400
					TOTAL of YEAR-2	42				775

MJ = Major, MI = Minor Course, SEC = Skill Enhancement Course, AEC = Ability Enhancement Course, MDC = Multidisciplinary Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical, MIL = Modern Indian Language

MAJOR (MJ)

MJ-3: Waves & Optics with Mathematical Methods I **Credits 04 (Full Marks: 75)**

MJ-3T: Waves & Optics with Mathematical Methods I (Theory) **Credits 04**

Course contents:

UNIT – I: Mathematical Methods I Credit - 1 **Credits 01** **[20L]**

Convergence of infinite series

Convergence of power series. Idea of interval of convergence, Different convergence tests of power series: D'Alembert's ratio test, Cauchy's root test, Integral test. Alternating series test. Absolute and conditional convergence. [3L]

Fourier Series

Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only), Expansion of periodic functions in a series of sine and cosine functions, Fourier coefficients, Complex representation of Fourier series, Expansion of functions with arbitrary period, Expansion of non-periodic functions over an interval, Summation of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval's Identity. [6L]

Fourier Transform

Fourier Integral theorem. Fourier Transform (FT) with examples. FT of trigonometric, Gaussian, finite wave train, and other functions. Inverse Fourier transform, Convolution Theorem, Properties of FT (translation, change of scale, complex conjugation, etc.). Applications of FT in single slit, double slit, rectangular aperture and *N*-slit grating. [5L]

Partial Differential Equations

Solutions to Laplace's equation using separation of variables for cylindrical and spherical polar coordinates, Wave equation and its solution for vibrational modes of a stretched string, Diffusion Equation in one dimension.

UNIT – II: Waves & Optics **Credits 03** **[40L]**

Oscillations

Differential equation of simple harmonic oscillation and its solution. Kinetic energy, potential energy, total energy and their time average values, Damped and forced oscillations: Transient and steady states, resonance, sharpness of resonance; power dissipation and Quality Factor. **[4L]**

Superposition of Harmonic oscillations

Superposition of two collinear Harmonic oscillations having equal frequencies and different frequencies (beats). Superposition of two Perpendicular Harmonic Oscillations for phase difference $\delta = 0, \pi, 2\pi$: Graphical and analytical methods, Lissajous' figures with equal and unequal frequency and their uses. **[4L]**

Wave Motion and Superposition of waves

Superposition of *N* harmonic waves, Phase and Group velocities, Velocity of transverse vibrations of stretched strings, Standing (stationary) waves in a string: fixed and free ends (analytical treatment). Changes with respect to position and time. Energy of vibrating string. Transfer of energy. Normal modes of stretched strings. Plucked and struck strings. [6L]

Wave theory of light: Huygens Principle. Temporal and Spatial Coherence. **[2L]**

Interference: Division of amplitude and wavefront, Young's double slit experiment, Lloyd's Mirror and Fresnel's Biprism, 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. **[10L]**

Interferometer: Michelson Interferometer- Formation of fringes (Principle only), Determination of Wavelength, difference in wavelength, and refractive Index.
Fabry-Perot Interferometer- Formation of fringes (Principle only), Intensity distribution, Visibility and sharpness of fringes, Determination of Wavelength and comparison of wavelength. **[4L]**

Diffraction: Fraunhofer diffraction: Single slit, Double slit, Diffraction grating, Resolving power of grating, Resolving Power of a telescope.
Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel diffraction pattern of a straight edge, a slit and a wire. **[10L]**

Suggested Readings:

Mathematical Methods-

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Introduction to Mathematical Physics, Charlie Harper, 1978, PHI Learning Pvt. Ltd.
3. Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.
4. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
5. Fourier Analysis by M.R. Spiegel, 2004, TataMcGraw-Hill.
6. Differential Equations, George F. Simmons, 2006, TataMcGraw-Hill.
7. Differential Equations, S.L. Ross, 2007, Wiley.
8. Fourier Series and Boundary Value Problems, J.W. Brown and R.V. Churchill, 2017, Mc-Graw Hill Education.
9. Mathematical Physics, P.K. Chattopadhyay, 2014, New Academic Science.
10. Mathematical Physics, H. K. Dass & Rama Verma, 2014, S Chand.
11. Fundamentals of Mathematical Physics, A B Gupta, 2024, Books & Allied.

Waves & Optics-

1. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
2. Advanced Acoustics, D. P. Ray Chaudhuri, 1981, Chayan Publisher.

3. Vibrations and Waves, A. P. French, 2003, CBS.
4. Optics, 4th Edn., Eugene Hecht, 2014, Pearson Education Limited.
5. Optics, Ajoy Ghatak, 8th Edn, 2024, TataMcGraw-Hill.
6. A Text Book on Light, B. Ghosh & K.G. Mazumdar, Shreedhar Publishers.
7. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, TataMcGraw-Hill.
8. Fundamentals of Optics, F.A. Jenkins & H.E. White, 1981, McGraw- Hill.
9. Introduction to Optics, F.L. Pedrotti, L.S. Pedrotti, L.M. Pedrotti, 2014, Pearson Education.
10. A Textbook of Optics, N. Subrahmaniyam, Brij Lal, M N Avadhanulu, S Chand.

MJ-4: Electromagnetic Theory with Mathematical Methods II Credits 04 (Full Marks: 75)

MJ-2T: Electromagnetic Theory with Mathematical Methods II (Theory) Credits 04

Course contents:

UNIT – I: Mathematical Methods II Credits 02 [30L]

Basics of Probability

Random experiments, sample space, events. Definitions of Probability. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications. [4L]

Some special integrals

Beta and Gamma functions and relation between them. Expression of integrals in terms of Gamma functions. Error function (probability integral). [4L]

Linear Vector Space (LVS)

Idea of LVS with 2-d and 3-d Cartesian vectors. Introduction to bra and ket vectors. Definition of LVS with examples : 2-d, 3-d vectors, complex numbers, sinusoidal waveforms.

Dual space. Inner product, Norm (defined in terms of inner product), Cauchy-Schwarz inequality, metric space. Linear independence and dependence of vectors. Completeness of a set of vectors. Dimension and basis. Orthogonality. Gram-Schmidt method for orthogonalization. [5L]

Matrices

Representation of linear operator in terms of matrices. Addition and multiplication of matrices. Null matrices. Diagonal, scalar and unit matrices. Transpose of a matrix.

Symmetric and skew-symmetric matrices. Conjugate of a matrix. Hermitian and skewhermitian matrices. Singular and non-singular matrices. Orthogonal and unitary matrices.

Trace of a matrix. Similarity transformation. Invariance of trace and determinant under similarity transformation. Transformation of basis. Eigenvalues and eigenvectors (degenerate and non-degenerate). Commuting operators and simultaneous eigenvectors for non-degenerate and degenerate eigenvalues. Cayley-Hamilton Theorem. Diagonalization of matrices. Solutions of

coupled linear ordinary homogeneous differential equations. Functions of a matrix, *e.g.*, exponential and trigonometric functions. [13L]

UNIT – II: Electromagnetic Theory **Credits 02** **[30L]**

Alternating current

Mean and r.m.s. values of current and emf with sinusoidal wave form; LR, CR series and parallel LCR circuits, reactance, impedance, phase-angle, power dissipation in AC circuit-power factor, Resonance in a series and parallel LCR circuit, Q-factor. [4L]

Electromagnetic induction

Non-conservative nature of electric field. Faraday's law of induction: simple examples (*e.g.*: Motional EMF, Faraday disc); Lenz's law. Self and mutual inductances in simple cases, energy stored in inductors. [3L]

Maxwell's equations

Maxwell's equations. Gauge transformations: Lorenz and Coulomb Gauge. Wave equations. Poynting Theorem and Poynting vector. Electromagnetic (EM) Energy Density. [4L]

EM Wave Propagation in unbounded media

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. [3L]

Polarization

Description of linear, circular and elliptical polarization. Propagation of electromagnetic waves in birefringent medium, polarization in uniaxial crystals. polarization by double refraction and selective absorption. Nicol prism. Ordinary and extraordinary refractive indices.

Phase Retardation plates: Quarter-wave and Half-wave plates. Production and analysis of polarized light, Rotatory polarization, Biot's laws for rotatory polarization. Fresnel's theory of optical rotation. Calculation of angle of rotation. Specific rotation. [10L]

EM Wave in Bounded Media

Boundary conditions at a plane interface between two media. Reflection and Refraction of plane waves at plane interface between two dielectric media. Laws of reflection and refraction. Fresnel's formulae for perpendicular and parallel polarization cases, Reflection and transmission coefficients, Brewster's law. Total internal reflection, evanescent waves. Metallic reflection (normal incidence). [6L]

Suggested Readings:

Mathematical Methods-

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Introduction to Mathematical Physics, Charlie Harper, 1978, PHI Learning Pvt. Ltd.
3. Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

4. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
5. Mathematical Physics, P.K. Chattopadhyay, 2014, New Academic Science.
6. Mathematical Physics, H. K. Dass & Rama Verma, 2014, S Chand.
7. Fundamentals of Mathematical Physics, A B Gupta, 2024, Books & Allied.
8. Matrix Methods: An Introduction, R. Bronson, 1991, Academic Press
9. Vector Spaces and Matrices in Physics, M.C. Jain, 2018, Narosa.
10. Linear Algebra, S. Lipschutz and M. L. Lipson, Schaum's Outline Series, 2009, McGraw Hill

Electromagnetic Theory:

1. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
2. Introduction to Electrodynamics, D.J. Griffiths, 4th Edn., 2015, Pearson Education.
3. Electricity and Magnetism, D. Chattopadhyay and P. C. Rakshit, 2011, New Central Book Agency, 2011.
4. Fundamentals of Electricity and Magnetism, B. Ghosh, 2015, Books and Allied (P) Ltd., 4th edition, 2015.
5. Electricity and Magnetism, Edward M. Purcell, 1986McGraw-Hill Education.
6. Introduction to Advanced Electrodynamics, Kaushik Bhattacharya and Soumik Mukhopadhyay, 2021, Springer
7. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
8. Optics, 4th Edn., Eugene Hecht, 2014, Pearson Education Limited.
9. Optics, Ajoy Ghatak, 8th Edn, 2024, TataMcGraw-Hill.
10. A Text Book on Light, B. Ghosh & K.G. Mazumdar, Shreedhar Publishers.

MJ-5: Atomic Physics with Mathematical Methods III **Credits 04 (Full Marks: 75)**

Course contents:

Unit I: Atomic Physics Credit – 2 **[30L]**

1. Bohr's Atom Model for hydrogen atom and hydrogen-like atoms, Frank-Hertz experiment, Bohr-Sommerfeld atom model, Vector Atom model: Orbital angular momentum, Electron spin and Spin angular momentum, Space quantization. Larmor's theorem. Spin magnetic moment, Electronmagnetic moment and Magnetic energy, Gyromagnetic ratio and Bohr Magneton, Stern-Gerlach experiment. Spin-orbit coupling in atoms - L-S and J-J couplings. Hund's rule. Spectroscopic term symbols. Spectra of Hydrogen and Alkali Atoms. Normal and Anomalous Zeeman effect. **[15L]**

2. Blackbody Radiation and Ultraviolet catastrophe, Planck's quantum hypothesis, Planck's constant, Planck's formula. Photoelectric effect and Compton scattering — light as a collection of photons. Davisson-Germer experiment. de-Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Double-slit experiment with photons and electrons (difference in associated patterns using classical particles), Linear superposition principle as a consequence. Position measurement, γ-ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations), simple consequences of uncertainty principle, Bohr's Complementarity Principle. **[15L]**

Unit-2: Mathematical Methods III **Credit 02** **[32L]**

1. **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. Singularity and types of singularities, branch points and branch cuts (definitions only). Cauchy's Integral theorem, Cauchy's Integral formula (proof not required). Simply and multiply connected region. Taylor's and Laurent expansions (statements only). Residues and Residue Theorem. Applications in solving simple Definite Integrals. **[17L]**

2. **Solution of 2nd order linear differential equations**
   Second order inhomogeneous differential equation; Linear independence of solutions: Wronskian, Singularity analysis at finite points. Power series solution of 2nd order differential equation. Frobenius method and its applications to differential equations. Legendre, Hermite Differential Equations. Properties of Legendre and Hermite Polynomials: Rodrigues Formula, Generating Function, Orthogonality and completeness relation (Statement only). Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. **[15L]**

Suggested Reading:

Atomic Physics & Quantum Mechanics-

1. Concepts of Modern Physics, Arthur Beiser, S. Mahajan, S Rai Choudhury, 2024, Medtech Science
2. Modern Physics, R. Murugesan and Sivaprasath Kiruthiga, 18th Ed., S. Chand.
3. Introductory Quantum Mechanics, S. N. Ghoshal, Calcutta Book House.
4. Introduction to Quantum mechanics, D. J. Griffiths and D. F. Schroeter, 2019 Cambridge Univ. Press.
5. Foundation of Quantum Mechanics, A. B. Gupta, 2023, Books & Allied.
6. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, 2nd Edition, Wiley.
7. Quantum Mechanics, D. Mcintyre, C. A. Manogue, J. Tate, 2016, Pearson Edu. India.
8. Quantum Mechanics: An Introduction, Walter Greiner, Springer
9. Quantum Mechanics, B.H. Bransden and C.J. Joachain, 2004, Pearson.
10. Problems and Solutions on Quantum Mechanics by Swee Cheng Lim, Choy Heng Lai, Leong Chuan Kwek, 2022, World Scientific

Mathematical Methods-

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Introduction to Mathematical Physics, Charlie Harper, 1978, PHI Learning Pvt. Ltd.
3. Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.
4. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
5. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 9th Ed. 2021, Tata McGraw-Hill.
6. Complex Variable (Schaum's Outlines), M. Spiegel, S. Lipschutz, J. Schiller, D. Spellman, Revised 2nd Edition, 2017, McGraw Hill Education
7. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
8. Differential Equations, George F. Simmons, 2006, TataMcGraw-Hill.
9. Differential Equations, S.L. Ross, 2007, Wiley.

MJ-6: Classical Mechanics with Special Theory of Relativity & Python Programming

Credits 04 (Full Marks: 75)

MJ-6T: Classical Mechanics with Special Theory of Relativity & Python Programming (Theory)

Credits 03

Course contents:

1. Introduction to Tensor analysis: [5L]

Definition of Cartesian tensors in 3 dimensions. Transformation properties. Contravariant and Covariant tensors. Inner Product. Contraction of rank of tensors.

2. Lagrangian formulation: (16L)

A. Lagrange's equation: Degrees of freedom; constraints, holonomic, non-holonomic, scleronomous and rheonomous constraints; generalised coordinates; Virtual displacement and virtual work, principle of virtual work; D' Alembert's principle; Lagrange's equation for holonomic systems (from D' Alembert's principle) – for conservative systems and for systems with velocity dependent potentials, application of Lagrange's equation in simple cases. (12L)

B. Small oscillations: Theory of small oscillations (up to calculation of eigen frequencies and relative amplitudes), simple applications: spring mass systems, diatomic molecules. (4L)

3. Hamiltonian formulation (17L):

A. Hamilton's equations: Generalised momentum, cyclic coordinates and its relation with conservation principles, definition of Hamiltonian, Hamilton's equation, Legendre transformation and derivation of Hamilton's equation by Legendre transformation; kinetic energy in terms of generalised velocities and generalised coordinates, Hamiltonian and total energy for systems with schleronomous-rheonomic constraints, Application of Hamiltonian Formulation to simple cases. (7L)

B. Hamilton's principle: Variational principle, Euler-Lagrange equation; Hamilton's principle, Derivation of Lagrange's equation from Hamilton's principle, Application to brachistochrone problem. (4L)

C. Canonical transformations: Generating function, Conditions for transformation to be canonical, Simple problems. (3L)

D. Poisson bracket: Fundamental properties of Poisson bracket, equations of motion in Poisson bracket form, Poisson bracket and integrals of motion, Poisson bracket of angular momentum components, Poisson bracket and canonical transformation. (3L)

4. Special theory of relativity [7L]:

Results of Michelson-Morley Experiment (derivation not required). Postulates of special theory of relativity. Transformation equations. Length contraction and time dilation, Velocity addition theorem, Variation of mass with velocity and mass-energy equivalence. Relativistic Kinematics using four-vector approach.

MJ-6P: Practical **Credit - 1**

1. **Introduction to Numerical computation using numpy and scipy**: Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to online graph plotting using matplotlib. Introduction to the scipy module. Uses in optimization and solution of differential equations.
2. Solution of 1st order and 2nd order ordinary differential equations (ODE) using Euler method, like:
    i. Radioactive decay
    ii. Current in RC, LC circuits with DC source
    iii. Newton's law of cooling
    iv. Harmonic oscillator
    v. Damped harmonic Oscillator (Over-damped, critically damped and oscillatory)
    vi. Forced harmonic Oscillator (Transient and Steady state solution)
    vii. Application to LCR circuit
3. Evaluate the Fourier coefficients of a given periodic function (like square wave, triangular wave, saw-tooth wave). Plot the periodic function and the Fourier series.
4. Generating and plotting Legendre and Hermite polynomials. Verification of their Orthogonality relations and recursion relations.
5. Numerical integration using Trapezoidal rule, Simpson's 1/3 rule. Also verify using packages of python.
6. Matrix algebra: addition, Multiplication, Transpose, Inverse, Trace, diagonalisation, Eigen vector, Eigen values problems.
7. Dirac Delta Function:
    Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)dx$, for σ = 1, 0.1, 0.01 and show it tends to 5
8. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
9. Plot Specific Heat of Solids (a) Dulong-Petit Law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

Suggested Reading:

Classical Mechanics-

1. Classical Mechanics, N. C. Rana and P. S. Joag, McGraw Hill Education
2. Classical Mechanics, H. Goldstein, Pearson Education, 3Ed.
3. Classical Mechanics, A. B. Gupta, 2022, Books and Allied Pvt. Ltd.

4. Classical Mechanics, J. C. Upadhyay, 2019 Himalaya Publishing House
5. Classical Mechanics, A. K. Raychaudhuri, 1983 Oxford Univ. Press
6. Introduction to Classical Mechanics, R. G. Takwale, P. S. Puranik, 2017, McGraw Hill Education
7. Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, Walter Greiner, Springer
8. Classical Mechanics: Point Particles and Relativity, Walter Greiner, Springer
9. Introduction to Special Relativity, Robert Resnick, 2005, Wiley
10. The Special Theory of Relativity, Sriranjan Banerjee and Asit Banerji, 2012, Prentice Hall India Learning Private Limited.
11. Special Theory of Relativity; a chapter of Electricity and Magnetism, D. Chattopadhyay, P. C. Rakshit, New Central Book Agency
12. The Special Theory of Relativity: A Mathematical Approach, Farook Rahaman, Springer
13. Mechanics Through Problems Including Special Theory Of Relativity, D. Roy, A. Dasgupta, 2022, Techno World.
14. Classical Mechanics: Problems with solutions by Konstantin K Likharev, 2018, IOP Expanding Physics.
15. Solved Problems in Classical Mechanics: Analytical and Numerical Solutions with Comments by O.L. de Lange, J. Pierrus, 2010, Oxford Univ. Press.

Python Programming-

1. Scientific Computing in Python. Abhijit Kar Gupta, Techno World
2. Computational Physics, Mark Newman, Amazon Digital.
3. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd
4. Numerical Methods, Arun Kr Jalan, Utpal Sarkar, University Press
5. Numerical Mathematical Analysis, J. B. Scarborough, OXFORD and IBH Co. Pvt. Ltd.
6. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition
7. Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
8. Python 2.1 Bible Dave Brueck, Stephen Tanner, Hungry Minds Inc, New York
9. Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A Downey, 2015, Dreamtech Press.
10. Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
11. Effective Computation in Physics-Field guide to research with Python, A. Scopatz and K.D. Huff, 2015, O'Rielly
12. An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press Computational Physics, DarrenWalker,1st Edn., 2015, Scientific International Pvt. Ltd.

MJ-7: Experimental Physics-I (Practical) **Credits 04 (Full Marks: 75)**

List of Practical:

Unit I

1. To determine the moment of inertia of a Flywheel.
2. To determine *g* using Bar Pendulum.
3. To study the Motion of Spring and determine (a) Spring constant, (b) Acceleration due to gravity, and (c) Modulus of rigidity.
4. To determine the damping coefficient of a damped oscillator inside water and thereby calculating the viscosity of water using Tracker
5. To study the variation of refractive index of the material of a prism with wavelengths and hence the Cauchy constants using mercury/helium source.
6. To determine wavelength of sodium light using Fresnel Biprism.
7. To determine wavelength of sodium light/radius of plano-convex lens using Newton's Rings.
8. Measurement of the spacing between the adjacent slits in a grating by plotting sinθ vs wavelength graph for a certain order of grating spectra.
9. To study the diffraction pattern of a thin wire with the help of a LASER source using imageJ software and to determine its wavelength.
10. To study the specific rotation of optically active solution using polarimeter.
11. The Polarization of Light and Malus' Law Using Smartphones.

Unit II

1. Measurement of Planck constant using LEDs of three different colours.
2. Verification of Stefan-Boltzmann law using a bulb with tungsten filament.
3. Verification of Thevenin's theorem, Norton's theorem & Maximum power Transfer theorem.
4. To study the ac characteristics of a series RC circuit and calculation of capacitance from current reactance graph.
5. To study series LCR circuit characteristics: resonance curves for two different R, variation with C, plotting of phase angle.
6. Calibration of a thermocouple by direct measurement of the thermo-emf using potentiometer.
7. Determination of the temperature coefficient of resistance by Carey Foster's method.
8. Studies with a transformer: Determination of the relationship between the voltage, current, and power of the primary and secondary coils of a transformer.
9. Determination of the horizontal component of the Earth's magnetic field.
10. To study the variation (with current) of the magnetic field between pole pieces for different distances of an electromagnet using Gaussmeter.

CA: 15, Practical Test: 60 (Exam. – 40, LNB – 5 + 5, Viva – 5 + 5)

Suggested Reading:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. Laboratory Manual of Physics, Vol. 1 & 2 Madhusudan Jana, Books & Allied (P) Ltd., 2022, Kolkata.
5. Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press
6. B. Sc. Practical Physics, C. L. Arora, S Chand and Company Limited
7. Physics in Laboratory, Mandal, Chowdhury, Das, Das, Santra Publication
8. Advanced Practical Physics Vol 1 & 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
9. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
10. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited

MINOR (MI)

MI – 3: Waves & Optics **Credits 04 (Full Marks: 75)**

MI – 3T: Waves & Optics (Theory) **Credits 03 [45L]**

Course contents:

Course contents:

1. Oscillations: Differential equation of simple harmonic oscillations and its solution, Calculation of kinetic energy, potential energy, total energy and their time and space average values, Damped oscillations, Forced oscillations: Transient and steady states; Resonance, amplitude and velocity resonance, sharpness of resonance, power dissipation and Quality Factor. [12L]

2. Superposition of harmonic oscillations: Superposition of two collinear harmonic oscillations having equal frequencies and different frequencies (beats), Superposition of two perpendicular harmonic oscillations, Lissajous figures. [6L]

3. Wave motion: Plane progressive waves, Wave equation for progressive waves, Particle and wave velocities, Speed of transverse vibrations in a stretched string, standing (stationary) waves in a string, Phase and Group velocities, Doppler Effect and Doppler shift. [7L]

5. Interference: Huygens' principle, explanation of the laws of reflection and refraction, Coherent sources, Division of wavefront and division of amplitude, Young's double slit experiment (YDSE), Intensity distribution, conditions of interference, Interference in thin films, Newton's rings: Measurement of wavelength and refractive index. [10L]

6. Diffraction: Fresnel diffraction: Fresnel's half-period zones for plane waves, Theory of Zone Plate: Multiple foci of Zone Plate, Fraunhoffer diffraction: Single and double slits. Concept of diffraction grating with its diffraction pattern. Rayleigh criterion and idea of grating's resolving power. [10L]

Suggested readings:

- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Advanced Acoustics, D. P. Roychowdhury, Promothesh Banerjee and Raghunandan Misra, The New Book Stall.
- Waves and Oscillations, N. K. Bajaj, 2017, Tata McGraw-Hill.
- A textbook of Optics, N. Subramanyam, B. Lal and M. N. Avadhanulu, 2006, S. Chand Publishing.
- Optics, Ajoy Ghatak, 8th Edn, 2024, TataMcGraw-Hill.
- A Text Book on Light, B. Ghosh & K.G. Mazumdar, Shreedhar Publishers.

- স্নাতক পদার্থবিদ্যা (সেমিস্টার IV), দেবনারায়ণ জানা, সুজিত কুমার বেরা, এবং সীতারাম পাল, সাঁতরা পাবলিকেশন।

MI – 3P: Waves & Optics **Credits 01**

List of Practical:

1. Measurement of focal length of a concave lens by combination method.
2. Familiarization with Schuster`s method and determination of angle of prism.
3. Determination of refractive index of material of a prism using sodium source.
4. Determination of unknown frequency of a tuning fork by Sonometer.
5. Determination of wavelength of sodium light/radius of a plano-convex lens using Newton's Rings.
6. To study the specific rotation of optically active solution using polarimeter.

Suggested readings:

1. B. Sc. Practical Physics, C. L. Arora, S. Chand and Company Limited.
2. Advanced Practical Physics, Vol 1, B. Ghosh, K. G. Majumdar, Shreedhar Publishers.
3. An Advanced Course in Practical Physics, D. Chattopadhyay, P. C. Rakshit, New Central Book Agency (P) Ltd.
4. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
5. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.
6. Laboratory Manual of Physics, Vol 1, M. Jana, 2020, Books and Allied (P) Ltd.

MI-4: Electricity & Magnetism **Credits 04 (Full Marks: 75)**

MI-4T: Electricity & Magnetism (Theory) **Credits 03 [45L]**

Course contents:

1. **Electrostatics**

Gauss' Law with simple applications. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electric fields inside matter. Bound charges & Electric polarisation, Displacement vector, Linear dielectric medium, electric susceptibility and permittivity. [10L]

2. **Magnetostatics**

Definition of Magnetic Field, B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with an Electric Dipole: no derivation required). Ampere's Circuital Law and its applications to (a) Solenoid, and (b) Toroid. Properties of B: curl and divergence. [10L]

3. Magnetic Properties of Matter

Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis. [4L]

3. **Electromagnetic induction**

Faraday's law of induction: simple examples (eg: motional emf, Faraday disc), Lenz's law. Self and mutual inductances in simple cases, *L* of single coil, *M* of two coils. Energy stored in inductors. [6L]

4. Maxwell's equations and EM waves:

Maxwell's equations and their significance, Equation of continuity of current, Displacement current, Poynting Theorem (Proof not required) & Poynting vector, Electromagnetic wave propagation through vacuum, Transverse nature of EM waves. [6L]

6. **Alternating current**

Mean and rms values of current and emf with sinusoidal wave form, reactance, impedance, power factor, Current and Voltages in LR, CR and series LCR circuits, resonance in a series LCR circuit, Q-factor. [6L]

7. **Network Theorems**

Thevenin's and Norton's theorems, Maximum power transfer theorem. [3L]

Recommended reading

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House
3. Electricity and Magnetism, R. Murugeshan, 2019, S. Chand

4. Introduction to Electrodynamics, D.J. Griffiths, 4th Edn., 2015, Pearson Education.
5. Electricity and Magnetism, D. Chattopadhyay and P. C. Rakshit, 2011, New Central Book Agency, 2011.
6. Fundamentals of Electricity and Magnetism, B. Ghosh, 2015, Books and Allied (P) Ltd., 4th edition, 2015.
7. স্নাতক পদার্থবিদ্যা (সেমিস্টার II), দেবনারায়ণ জানা, সুজিত কুমার বেরা, এবং সীতারাম পাল, সাঁতরা পাবলিকেশন।

MI-4P: Electricity & Magnetism (Practical) **Credits 01**

List of Practical:

1. Determination of horizontal component of Earth's magnetic field using magnetometer.
2. Determination of low resistance of a sample wire using Carey Foster Bridge.
3. To study the ac characteristics of a series RC circuit and calculation of capacitance from current reactance graph.
4. To draw the resonance curve of a series LCR circuit.
5. To study the variation (with current) of the magnetic field between pole pieces for different distances of an electromagnet using Gaussmeter.
6. To determine the value of e/m ratio using magnetic focussing / bar magnets.

Suggested Reading:

1. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
2. B. Sc. Practical Physics, C. L. Arora, S Chand and Company Limited
3. Physics in Laboratory, Mandal, Chowdhury, Das, Das, Santra Publication
4. Advanced Practical Physics Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
5. An Advanced Course in Practical Physics, D. Chattopadhyay, P. C. Rakshit, New Central Book Agency (P) Ltd.
6. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
7. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
8. Laboratory Manual of Physics, Madhusudan Jana, Books & Allied (P) Ltd., 2022, Kolkata.

SKILL ENHANCEMENT COURSE (SEC)

SEC 3P: Technology based Applications (Practical) **Credits 03 (Full Marks: 50)**

BASIC ROBOTICS WITH ARDUINO

Module 1: Introduction to Arduino

Overview of Embedded Systems - Definition and characteristics, Applications and examples; Introduction to Arduino- Arduino board types (Uno, Nano, Mega, etc.); Arduino Hardware Basics - Microcontroller architecture (ATmega328), Structure of Arduino; Basics of C/C++ for Arduino Structure of an Arduino sketch: setup() and loop(). **[6L]**

Module 2: Digital and Analog I/O Operations

Digital I/O Operations - Digital inputs and outputs; Analog I/O Operations - Analog-to-Digital and Digital-to-Analog Conversion - Reading from analog sensors (e.g., potentiometer, LDR sensor) **[4L]**

Module 3: Sensor and Actuator interfacing

Interfacing with Sensors (e.g., temperature, distance, humidity, IR); Data acquisition and processing using Excel; Controlling Actuators - Driving DC motors, servo motor, stepper motor, and relays; Pulse-width modulation (PWM) for control. Load sensor, piezo sensor. **[10L]**

Module 4: Communication Protocols

Serial Communication - Basics of UART (Universal asynchronous receiver / transmitter); I2C Communication - I2C protocol and addressing, Interfacing with I2C devices (e.g., LCDs), Difference between I2C and SPI Communication; Wireless Communication - Bluetooth and Wi-Fi (Using modules like HC-05 and ESP8266) **[5L]**

Required Materials:

- Arduino starter kit (includes board, sensors, and actuators)
- Breadboard, jumper wires, and basic electronic components
- Computer with Arduino IDE installed

Experimental:

(Use Aduino and related component along with Mobile apps like Phyphox or other)

1. Basic Applications with Arduino (Use of LED, switch, POT, ultrasonic sensor)
2. Sensor and Actuator Coding (Soil sensor, LCD display, Servo motor, DC motor, Relay, 8×8 display)
3. Data Collection and Analysis from embedded Devices using excel or in python.
4. Heat: Using Arduino to read and display data from a temperature sensor (LM35). Collect and log temperature data over time; Measure heat transfer between materials at different temperatures using thermocouple or RTDs (like PT100)
5. Light: Using a light sensor (LDR) to measure light intensity and create a light curve.

6. Motion and Kinematics: Record the speed of a small object using a light gate sensor or ultrasonic sensor (HC04); Measure motor speed; Measure force using a load cell (hence Verify Newton's second law by varying mass and measuring acceleration.)
7. Energy and Power: Measure potential and kinetic energy in a pendulum setup; Use a piezo sensor to measure power in small impacts (e.g., dropping an object from different heights).
8. Networking with embedded system - Communication Protocols and Implements (Bluetooth module like HC-05)

Suggested Readings:

1. "Embedded Systems: Introduction to the MSP432 Microcontroller", Jonathan W. Valvano, CreateSpace Independent Publishing Platform
2. "Embedded Systems: Real-Time Operating Systems for Arm Cortex-M Microcontrollers",
3. Jonathan W. Valvano, CreateSpace Independent Publishing Platform
4. "Practical Electronics for Inventors", Paul Scherz and Simon Monk, McGraw-Hill Education
5. "Arduino Cookbook", Michael Margolis, O'Reilly Media
6. "Arduino Robotics", John-David Warren, Josh Adams, and Harald Molle, Apress
7. "Real-Time Concepts for Embedded Systems" - Qing Li with Caroline Yao, CMP Books
8. "Internet of Things with Arduino Cookbook" - Marco Schwartz, Packt Publishing

N.B. - In the Final PRACTICAL Examination, question will be framed with THEORY (30% weightage), and PRACTICAL Tasks (70% weightage).

OR

PHYSICS EXPERIMENTS USING SOFTWARE/APPLICATIONS

Hands-on training on

1. Use of Phyphox application
2. Use of tracker application
3. Use of ImageJ application
4. Use of ImageMeter application.
5. Use of Time App Add-on with VLC Media Player
6. Use of Gnuplot or Qtgrace application (for graph plotting)
7. Use of Everycircuit/Ltspice/NI Multisim (or similar apps/softwares) for circuits simulation

At least two-third of the experiments should be covered by the students.

Experiments:

1. Study a simple pendulum ($x - t$, $v - t$, $x - v$ plot) using video analysis and modelling tool (Tracker software).
2. Tracking Parabolic Trajectories with a Mobile Phone using Tracker software.
3. Measure the acceleration due to gravity studying the oscillations of a simple pendulum by the use of a smartphone light sensor.
4. Determine the refractive index of a liquid by ImageMeter application (using smartphone).
5. Verify the Inverse-square law for light intensity using a Smartphone and Phyphox.
6. Measure a spring constant with a smartphone magnetic field sensor / LiDAR sensor.
7. Measure of terminal velocity of a magnet falling through a conducting pipe with magnetic sensor and VLC player.
8. Study the effect of electromagnetic damping force on a magnet oscillating near a non-ferromagnetic conducting plate using tracker.
9. Simple determination of Curie temperature using a smartphone magnetometer.
10. Study the variation of lateral shift of light rays passing through water placed in a glass rectangular parallelepiped with the change in angle of incidence and hence determine the refractive index of water using smartphone photography and ImageJ app.
11. Measure the acceleration due to gravity using a magnetic pendulum and a smartphone magnetometer.
12. Study the tilting motion of the smartphone and determine the moment of inertia of it.
13. Measuring the focal length of a camera lens in a smartphone with a ruler.
14. Measure the human respiration rate in various activities using a smartphone's magnetometer sensor.
15. Measure the earth magnetic field using a smartphone magnetometer.
16. Study the V-I characteristics of a resistor and a semiconductor diode (in forward and reverse bias) with simulator apps or software.
17. Verify the truth tables of OR and AND gate with simulator apps or software.

N.B. - In the Final PRACTICAL Examination, question will be framed with THEORY (30% weightage), and PRACTICAL Tasks (70% weightage)