मोहनलाल सुखाड़िया विश्वविद्यालय, उदयपुर

MOHANLAL SUKHADIA UNIVERSITY, UDAIPUR

Curriculum Framework, General Rules and Syllabus of Physics

for

Two -Year Postgraduate (M.Sc.) Program in Physics

(Program Code: PG410XX)

As per the Choice Based Credit System (CBCS)

Designed in accordance with Learning Outcomes-Based Curriculum Framework (LOCF) of National Education Policy (NEP-2020)

The DCC and DSE/GEC courses of M.Sc. Physics of I and II Semesters for Academic Year 2023-2025

(Effective from Academic Year 2023-24)

General Provisions and Rules

1. **Duration of the Course**
   The M.Sc. Physics program will be of four semesters duration under Choice based Credit system as per New Education Policy-2020, which will be conducted in two years.

2. **Eligibility**:
   Candidates seeking admission to the first semester of M.Sc. (CBCS) Physics must have a B.Sc. degree with Physics as one of the optional subjects or as an honor's subject (Level 5.5 or equivalent) with minimum 48% marks from a UGC recognized University.

3. **Admissions**:
   Admissions to the first semester of M.Sc. (Physics) will be made as per admission rules for M.Sc. (CBCS) as prescribed in information bulletin.

4. **Medium of Instruction**
   The medium of instruction and examination shall be English.

5. **No. of Seats**
   Total number of seats: As per information bulletin

6. **Curriculum and Syllabi**
   M.Sc. (Physics) program is of two years (four semesters) as prescribed in course structure and framework approved by the academic council held on June 26, 2023. Course structure is prescribed in Table-I and syllabi are given in Table-II. The program will be governed by the Common Rules and Regulations of Master's degree program under CBCS following NEP-2020 approved by the Academic Council of the University.

7. **Examinations of Practical Papers**
   End of semester (EoS) practical examination will be conducted by a board of examiners (one internal and one external). Internal examination (three hours test) will be conducted at the departmental level.

8. **Internal Examinations of Theory Papers**
   Internal examination (one hour test) of theory papers will be conducted at the departmental level.

9. **Exit and Lateral Entry Policy**
   Exit and Lateral Entry Policy shall be as prescribed in course structure and framework approved by the academic council held on June 26, 2023.

10. **Choice of the DSE Courses**
    The DSE courses listed in the program shall be offered depending upon the resources available in the department. A minimum ten students should opt for such a DSE paper.

Table-I: Course structure

Level	Sem	Course Type	Course Code	Course Title	Delivery Type			Total Hours	Credit	Internal Assessment	EoS Exam	M.M.	Remarks
					L	T	P						
8	I	DCC	PHY8000T	Mathematical Methods in Physics	L	T	-	60	4	20	80	100	
			PHY8001T	Classical Mechanics	L	T	-	60	4	20	80	100	
			PHY8002T	Quantum Mechanics-I	L	T	-	60	4	20	80	100	
			PHY8003T	Electronics	L	T	-	60	4	20	80	100	
			PHY8004P	General Physics Lab	-	-	P	120	4	20	80	100	
			PHY8005P	Electronics Lab	-	-	P	120	4	20	80	100	
	II	DCC	PHY8006T	Computational Methods in Physics	L	T	-	60	4	20	80	100	
			PHY8007T	Electrodynamics	L	T	-	60	4	20	80	100	
			PHY8008T	Quantum Mechanics-II	L	T	-	60	4	20	80	100	
			PHY8009P	Electronics Project and Microprocessor Lab	-	-	P	120	4	20	80	100	
			PHY8010P	Computational Physics Lab	-	-	P	120	4	20	80	100	
		DSE	PHY810XT	0. Statistical Physics 1. Ionospheric Physics 2. Astronomy and Astrophysics 3. Atmospheric Physics 4.	L	T	-	60	4	20	80	100	
9	III	DCC	PHY9011T	Atomic and Molecular Physics	L	T	-	60	4	20	80	100	
			PHY9012T	Solid State Physics	L	T		60	4	20	80	100	
		DSE	PHY910YT	5. Semiconductor Physics and Devices 6. Fundamentals of Nanoscience 7. Industrial Electronics 8. Condensed Matter Physics 9.	L	T	-	60	4	20	80	100	
			PHY911UP	10. Semiconductor Physics Lab 11. Nanoscience Lab 12. Advanced Electronics Lab 13. Data Analysis Techniques in Experimental Physics 14.	-	-	P	120	4	20	80	100	
		GEC	PHY911VT	15. Radiation Physics	L	T	-	60	4	20	80	100	

				16. Fundamental Quantum Chemistry 17. General Theory of Relativity 18. Biophysics 19. Elements of Quantum Computing									
			PHY912UP	20. Radiation Physics Lab 21. Materials Characterization Lab 22. 23. 24.	-	-	P	120	4	20	80	100	
	IV	DCC	PHY9013T	Nuclear and Particle Physics	L	T	-	60	4	20	80	100	
		DSE	PHY912VT	25. Experimental Techniques in Physics 26. Plasma Physics 27. High Energy Physics 28. Solar Physics 29.	L	T	-	60	4	20	80	100	
		DSE	PHY913UT	30. Materials Science 31. Quantum Theory of Solids 32. Quantum Field Theory 33. Laser and Spectroscopy 34.	L	T	-	60	4	20	80	100	
		DSE	PHY913VT	35. Microwave Electronics 36. Fiber Optics and Communication 37. Non Linear Physics 38. Nanoelectronics 39. Spintronics	L	T	-	60	4	20	80	100	
		DSE	PHY914UP	40. Modern Physics Lab 41. Materials Synthesis Lab 42. 43. 44.	-	-	P	120	4	20	80	100	
		DSE	PHY914VP	45. Microwave Electronics Lab 46. Simulations Lab 47. 48. 49.	-	-	P	120	4	20	80	100	

Table-II: Course Contents

M.Sc. I Sem. (Physics)

M.Sc. (Two Year Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY8000T
Title of the Course	Mathematical Methods in Physics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	B.Sc. or advanced level courses of Physics or Mathematics
Co-requisites	None
Objectives of the course	*The course will help in a deep and integrated understanding of various concepts of physics, which cannot be visualized without understanding their mathematical formulations*
Learning outcomes	Based on the major techniques covered, the course outcomes are understanding and applications of: • Usage of curvilinear coordinate system. • The grammar and simple algebra of Tensors. • The basics of group theory, symmetry and morphism, discrete and continuous groups, types of group and applications.e • Various techniques to solve differential equations. • Properties of special functions enabling applications in various physics problems. Analyticity, residues and poles of Complex functions, Methods of integration of complex functions and related lemmas and theorems. • Introduction, properties and usage of Fourier and Laplace transforms. Related theorems and applications.
Syllabus	

UNIT-I	Coordinate Systems: Curvilinear coordinates, differential vector operations, special coordinate systems – rectangular Cartesian, spherical polar and circular cylindrical coordinates. Expressions of gradient, divergence, curl and Laplacian in terms of curvilinear coordinates. (4+2=6) Tensors: Coordinate transformations, scalars, contravariant and covariant vectors, definition of contravarient, mixed and covariant tensor of second rank, Addition, subtraction and contraction of tensors, quotient rule. (4+2=6)
UNIT -II	Matrices: Orthogonal matrices, Orthognality conditions- two and three dimensional cases, Hermitian and unitary matrices, Pauli matrices, Dirac matrices, Diagonalization of matrices - Eigen value and Eigen vectors.(4+2=6) Elementary Group Theory: Definition of group, isomorphism and homomorphism, Matrix representation- reducible and irreducible groups, subgroup-invariant subgroup, discrete groups-two objects two-fold symmetry axis, three objects-three-fold symmetry axis, continuous groups- orthogonal group O3+, special unitary group SU(2). (4+2=6)
UNIT-III	Second Order Differential Equations: Separation of variables-ordinary differential equations, singular points, series solutions – Frobenius method and its limitations, Wronskian-linear independence and linear dependence.(4+2=6) Special Functions: Bessel functions of the first kind and its integral representation and Legendre functions with their generating function, recurrence relations and orthogonality. Associative Legendre functions, spherical harmonics, Hermite functions and Laguerre functions and their orthogonality.(4+2=6)
UNIT-IV	Complex Variables: Functions of complex variable, Cauchy- Rieman conditions, Cauchy Integral theorem, Cauchy integral formula, Laurent expansion, calculus of residues-poles, essential singularities and branch points, Residue theorem, Jordan's lemma, Singularities on contours of integration, Evaluation of definite integrals. (8+4=12)
UNIT-V	Fourier Series and Fourier Transforms: Fourier series- General properties and uses, Differentiation and integration of Fourier series, Fourier transforms, Fourier integral-exponential form, Fourier transform-inversion theorem, convolution theorem.(4+2=6) Laplace Transform: Elementary Laplace transforms, Laplace transform of derivatives, substitution properties of Laplace transform, use of Laplace transform. (4+2=6)
Text Books	1. Mathematical methods for Physicists G. B. Arfken & Hans J. Weber, Academic Press (1966). 2. Mathematical Physics, B.D. Gupta, Vikas Publishing House, Ghaziabad (U.P.). 3. Mathematical Physics, B.S. Rajput, Pragati Prakashan, Meerut.
Reference Books	1. Mathematical Physics, H.K. Dass and R. Verma, S. Chand Publishing, New Delhi. 2. Applied Mathematics for Physicists and Engineers - L. A. Pipes, Tata McGraw Hill 3. Mathematical Methods in Classical and Quantum Physics, Tulsi Dass and Satish K. Sharma, University Press, Hyderabad.(1990)
Suggested E-resources	1. https://link.springer.com/book/10.1007/978-1-4612-0049-9. 2. https://www.lehman.edu/faculty/anchordoqui/307.html

M.Sc. (Two Year Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY8001T
Title of the Course	Classical Mechanics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*The emphasis of the course is to develop concepts and formulations of the Newton's laws of motion and several of its later metamorphoses like Euler Lagrange formulations, Hamilton Jacobi equations, Poisson brackets etc. It imparts knowledge on different formulations of mechanics; more importantly the Hamiltonian formulation with Poisson bracket prepares the students for quantum mechanics. Moreover, a solid understanding of rigid body dynamics, central force, scattering, small oscillations and special relativity will be developed among students.*
Learning outcomes	The students would be able to understand: • The drawback of Newtonian formulation of mechanics and construct Lagrangian for different physical systems and Lagrange's equation of motion and solve them. • Interpret the notion of degrees of freedom, identify them for a given mechanical system and D' Alembert's principle. • The Hamiltonian formalism and Poisson bracket method in tackling physical problems. • Describe the Canonical transformations and generating functions. • The Hamiltonian-Jacobi formulation and it's applications in solving simple problems based on action-angle variables. • To describe planar and spatial motion of a rigid body and the motion of a mechanical system using Lagrange-Hamilton formalism. • Kinematics and dynamics of rigid body in detail and ideas regarding Euler's equations of motion.

Syllabus	
UNIT-I	Many particle systems; conservation laws, Constraints; their classification; degrees of freedom, D'Alembert's principle, generalized coordinates, Lagrange's equations from D'Alembert's principle, velocity dependent potentials and dissipative forces, Jacobi integral. (8+4=12)
UNIT -II	Gauge invariance, generalized momenta, cyclic coordinates, integrals of motion, Symmetries of space and time with conservation laws (2+1=3) Variational principles: Techniques of the calculus of variations, Example of use of the variational principle to find the shortest distance between two points, Hamiltons principle: derivation of Lagrange's equations from Hamilton's principle, equations of motion. (6+3=9)
UNIT-III	Canonical transformation: generating functions, Hamilton-Jacobi equation; solution: Hamilton's principal function, Solution of harmonic oscillator problem by H-J method. (4+2=6) Poisson brackets: fundamental PB, some properties, Poisson theorems, Angular momentum PBs, Invariance of PB under canonical transformations, relation of PB to quantum mechanics. (4+2=6)
UNIT-IV	Central force: definition and characteristics; properties, closure and stability of circular orbits, Two-body collisions, scattering in laboratory frame, scattering centre-of-mass frame. (3+2=5) Rotating frames: transformation equations, pseudo (fictitious) forces, Rigid body dynamics: Angular momentum and Kinetic energy of motion about a point, Moment of intertia tensor. (5+2=7)
UNIT-V	Types of equilibria, Periodic motion, small oscillations and normal modes, Free vibrations of a symmetric linear triatomic ,Special theory of relativity, Lorentz transformations, Velocity transformations, mass energy equivalence, Four vectors : velocity and acceleration 4 vectors. (8+4=12)
Text Books	1. Classical Mechanics, J.C. Upadhyaya, Himalaya Publishing House, New Delhi (1999). 2. Classical Mechanics, H. Goldstein, C. P. Poole and J. Safko, Classical Mechanics, 3rd Edition, Pearson (2018). 3. Classical Mechanics, P.S. Joag and N.C. Rana, 1st Edition, McGraw Hill (2010). 4. Classical Mechanics, B.D. Gupta and Satya Prakash, Keder Nath Publishers, Meerut, Revised Edition (2015).
Reference Books	1. Classical Mechanics, R.D. Gregory, Cambridge University Press. (2015). 2. Classical Mechanics: An introduction, D. Strauch, Springer. (2009). 3. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, Oxford University Press (2010). 4. Classical Dynamics, D.T. Greenwood, PH International, London (1977). 5. S. N. Biswas, Classical Mechanics, Books and Allied (P) Ltd., Kolkata (2004). 6. Classical mechanics: System of particles and Hamiltonian dynamics, W. Greiner, New York: Springer-Verlag (2004). 7. Classical mechanics - A modern perspective, V. Barger, M. Olsson, 2nd Edition Tata McGraw Hill (1995). 8. Introduction to Classical Mechanics, R.G. Takwale and P.S. Puranik, Tata Mc Graw Hill, New Delhi (1989). 9. Classical Mechanics, S.L. Gutpa, V. Kumar and H.V. Sharma, Pragati Prakashan, Meerut (2016). 10. Classical Mechanics of Particles and Rigid Bodies K.C. Gupta, New Age International Publishers, New Delhi, Third edition (2018). 11. Classical Mechanics, G. Aruldhas, PHI Learning Private Limited, New Delhi (2015).

Suggested E-resources	1. https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/ 2. https://www.math.ucla.edu/~laurenst/Resources/classical_mechanics.pdf 3. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html 4. https://users.ox.ac.uk/~math0391/CMlectures.pdf 5. https://www.math.toronto.edu/khesin/biblio/GoldsteinPooleSafkoClassicalMechanics.pdf 6. https://courses.physics.ucsd.edu/2010/Fall/physics200a/LECTURES/200_COURSE.pdf 7. https://www.physics.rutgers.edu/~shapiro/507/book.pdf 8. https://sites.astro.caltech.edu/~golwala/ph106ab/ph106ab_notes.pdf

M.Sc. (Two Year Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY8002T
Title of the Course	Quantum Mechanics-I
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*This course lays the foundations of quantum mechanics covering its need, the basic postulates, the Schrödinger picture, Heisenberg picture, Hilbert space, Dirac notation and quantum mechanical formalism, exactly-solvable problems of simple harmonic oscillator and the hydrogen atom. To give flavor of the strength of the quantum mechanical formalism in quantizing the angular momentum and its role in revealing physics underlying atomic spectra. To understand and apply the perturbation theory as an approximation method. The course also introduces one of the strong alternative path integral method giving rudiments.*
Learning outcomes	At the end of this course learners will be able to: • Demonstrate full grasp of basic concepts in quantum mechanics including wave-particle duality, operators and wavefunctions, and evolution of quantum states. • Use the mathematical apparatus needed to formulate and solve problems using quantum mechanical concepts • Appreciate the new physics resulting from the quantum mechanical formalism. • Acquire foundational knowledge to learn more advanced quantum mechanical techniques and applications.
Syllabus	
UNIT-I	Classical picture and its inadequacy- Black body radiation, Specific heat of solids, Young's double split experiment and its relevance, Hamilton's principle. Schrödinger equation, Normalization, probability interpretation of Ψ, Admissible wave functions.(2+1=3)

	Linear Vectors Space: Definition and properties, examples, norm of a vector, orthonormality and linear independence, Basis and dimensions, Completeness (Closure property), Hilbert space, subspace, Inequalities. Operators: Equality, product, sum, power, function, inverse of operators, eigen values and eigenvectors of an operator, Positive definite, continuous and bounded operators, Linear operators, Hermitian operators, Unitary operators, Projection operators.(3+2=5)
	Dirac space: Completeness of eigen functions, Bra and Ket notation for vectors, Dirac-Delta function, Matrix elements of change of basis, Unitary transformation. Representation Theory: Representation theory, Coordinate and momentum representations and Fourier transform. (3+1=4)
UNIT -II	Postulates of Quantum Mechanics & Uncertainty Relations: Postulates of Quantum mechanics, Uncertainty relations, States with minimum uncertainty product, Commutators, Theorem of simultaneous eigenfunctions. (3+1=4)
	Quantum Dynamics: The equations of motion, Schrodinger picture, Heisenberg picture, Linear Harmonic Oscillator: Solutions from Schrodinger and Heisenberg Pictures, the method of second quantization. (3+1=4)
	The Hydrogen Atom:Two body equation, Separation of variables for spherically symmetric potential, Radial wave equation, Radial wavefunctions and energy states. (2+2=4)
UNIT-III	Quantization of Angular Momentum: Definition, angular momentum of a system of particles, Matrix representation, Pauli matrices, the spin eigenvectors. Orbital angular momentum: Solutions, Spherical harmonics and properties, addition theorem (no proof). Matrices of $J=\hbar/2$ and $\hbar$. (4+2=6)
	Addition of angular momenta: Clebsch-Gordan coefficients, the selection rules, properties of CG coefficients (without proof): symmetry, orthogonality and recursion relations. Examples- $J_1=\hbar/2$ and $J_2=\hbar/2$; $J_1=\hbar/2$ and $J_2=\hbar$. (4+2=6)
UNIT-IV	Perturbation Theory (Non-degenerate case):Basic formulation of the method and applications: Anharmonic oscillator (x^4), linear harmonic oscillator, infinite square well.(4+2=6)
	Degenerate case: Formulation and applications: Stark and Zeeman effects in H, Infinite cube well, Relativistic correction. (4+2=6)
UNIT-V	Path Integrals in Quantum Theory: Interaction picture, Path Integral-Perspective and recipe, Approximation of U(t) for a free particle, Path integral evaluation of a free particle propagator, Equivalence to the Schrodinger equation. Potentials of the form $V=a+bx+cx^2+d(dx/dt)+ex(dx/dt)$. (4+2=6)
	Derivation of Path Integrals: Configuration space path integrals (no application), Phase space path integral (No application), Coherent state path integral (No application), Path integral of the imaginary time propagator. Illustrative example of simple harmonic oscillator. (4+2=6)
Text Books	1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern Ltd. (1986). 2. Principles of Quantum Mechanics, R. Shankar, Plenum Press, New York (1994) (for V Unit also) 3. Quantum Mechanics and Path Integrals, Emended Edition, R.P. Feynman, A.R. Hibbs and D.F. Styler, Dover Publications, Mineola, USA (2005). (For V Unit)
Reference Books	1. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson Education Inc. (2005). 2. Modern Quantum Mechanics, J.J. Sakurai, Addison and Wesley (1994).
Suggested E-resources	1. https://www.youtube.com/watch?v=jANZxzetPaQ 2. https://youtube.be/22g_tbl191 ; https//youtube.be/HEV_3k4avh

M.Sc. (Two Year Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY8003T
Title of the Course	Electronics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lectures and tutorials, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving etc.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics.
Co-requisites	None
Objectives of the course	*The emphasis of the course on the basic understanding of analog and digital electronics along with microprocessor and their applications for the development of user & eco-friendly multifunctional electronic devices.*
Learning outcomes	The students would be able to understand the basics of pure and applied electronics: • Design and operation of prototype amplifiers and function generators • Design and operation of prototype digital systems • Elementary assembly language programming on microprocessor kit • Design and operation of low voltage power supply
Syllabus	

UNIT-I	Basics of Operational Amplifier (OP-AMP): Differential amplifier: circuit configurations, dual input, balanced output differential amplifier, DC analysis and AC analysis, inverting and non inverting inputs, Block diagram of typical OP-AMP, constant current-bias level translator. OP-AMP Parameters: input offset voltage, bias currents, input offset current, output offset voltage, CMRR, Slew rate. (4+2=6) Open loop configuration, inverting and non-inverting amplifiers, frequency response of OP-AMP. OP-AMP with negative feedback, effect of feed-back on closed loop gain, input and output resistance, band width, voltage series feedback OP-AMP, voltage shunt feedback OP-AMP. (4+2=6)
UNIT -II	OP-AMP based instrumentations and their application: DC and AC amplifier, voltage follower, adder, subtractor, multiplier, phase changer, active filters, active Integrator and active differentiator. (4+2=6) Oscillators and wave shaping Circuits: Oscillator Principle, Oscillator types, Frequency stability criterion, Phase shift oscillator, Wien bridge oscillator, LC tunable oscillators, multivibrators: monostable and astable, comparators, square and triangle wave form generators. (4+2=6)
UNIT-III	Voltage regulators: Block diagram of Power supply, fixed voltage regulators, adjustable voltage regulators, switching regulators. Clipping and clamping circuits. (2+1=3)
	Boolean algebra and logic gates: Canonical and standard forms, IC logic families, Simplification of Boolean functions: Karnaugh map of up to 4 variables, don't care conditions, NAND and NOR implementation. (2+1=3) Combinational logic circuits: Adders, subtractors, binary parallel adders, magnitude comparator, decoders/Demultiplexers encoders/multiplexers. (4+2=6)
UNIT-IV	Sequential Logic systems: Basic flip-flop, clocked RS flip-flop, T flip-flop, D flip-flop, J-K flip flop, triggering of flip-flops, JK master slave flip-flops; Synchronous and asynchronous counters: Binary counters, Decade counters, Registers. (6+2=8)
	Basics of Microprocessors: Organization of a Microcomputer based system, Microprocessor architecture and its operations, Memory, memory map. The 8085 microprocessor unit and its Functional block diagram.(2+2=4)
UNIT-V	Assembly Language Programming of 8085: Instruction set of 8085: Data transfer operations, Arithmetic operations, Logic operations, Branch operations, Addressing modes of 8085, Assembly language programs involving data transfer, branch, arithmetic and logic operations. (8+4=12)
Tutorials	Review of basic electronics: Biasing of Diodes and Transistors, Currents in a transistor, Design of CE and CC Amplifier, Design of two stage amplifier. In addition to the above, problems from the reference books can be given as assignments to the students.
Text Books	1. OP-AMP and Linear Integrated Circuits by Ramakanth, A. Gayakwad, PHI, New Delhi. 2. Digital Logic and Computer design by Morris Mano, PHI, New Delhi. 3. Microprocessors Architecture, Programming and Applications with 8085/8086 by Ramesh S Gaonkar, Wiley - Eastern Ltd.
Reference Books	1. Integrated Electronics, by J. Millman and C.C. Halkias, TMH, New Delhi. 2. Electronic Devices and Circuit Theory by Robert Boylestead and Louis Nashelsky, PHI, New Delhi. 3. Digital Principle and Applications by A.P. Malvino and Donald P. Leach, TMH, New Delhi.
Suggested E-resources	1. https://www.electronics-tutorials.ws 2. https://myethiolectures.files.wordpress.com/2015/06/programming-8085. 3. https://www.electronics-notes.com/articles/basic_concepts 4. https://www.javatpoint.com/digital-electronics

M.Sc. (Two Year Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY8004P
Title of the Course	General Physics Lab
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Practicum 80+40=120. The 80 hrs for the hands on experiments, observations and record of the data, 20 hours for the experiment, instruments demonstration, lab practices and 20 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*Objectives are to enable the students to understand the purpose of their experiments; properly carry out the experiments; troubleshoot experiments; appropriately record and analyze the results; understand what constitutes "reasonable" data; estimate the error bounds on their measurements. The deduction and presentation of experimental results using graphs and tables.*
Learning outcomes	The students would be able to: • Collect data and update the experimental process iteratively and reflectively • Assess the procedure and outcomes of an experiment quantitatively and qualitatively • Extend the scope of an experiment if or not results are as per expectation • 4.Communicate the process and outcomes of an experiment • Perform an experiment collaboratively and ethically • Understand the meaning of a good or rich data • Get an idea of the magnitude of the measured property and compare that with other similar objects and its relation to the applied/pure science.

Syllabus	
	Students are required to complete at least seven experiments. Students are expected carry out the practical after understanding theoretical principle behind each experiment, design of experiments, working principle of the equipment/instruments, sources of errors in experiments etc. Experimental errors must be estimated in all experiments. The results of the experiments carried out by the students will reported to the teacher in regular manner in a specified format written in the Practical records book. 1. To find wavelength of Sodium light using Michelson interferometer and to determine the difference in wavelengths of D_1 and D_2 lines of atomic spectra of Sodium. 2. To plot the polar curve of a filament lamp and to determine its mean spherical intensity. 3. To find refractive index of air and verify the Dale–Gladstone equation using Jamin's interferometer. 4. To find elastic constants of glass by Cornu's optical method. 5. To verify the Fresnel's law of refraction and reflection. 6. To study beam characteristics of a He-Ne laser beam. 7. (a) Measurement of wavelength of a given laser light using ruler. (b) Measurements of thickness of thin wire using laser. 8. To determine the wavelength of a given laser beam using Michelson interferometer. 9. Determination of wavelength of given laser and verify the law governing interference from a Young's double slit experiment. 10. Determination of wavelength of given laser and verify the law governing interference from a circular pin hole aperture. 11. Determination of wavelength of given laser and verify the law governing Interference from a Young's single slit experiment. 12. To determine the Verdet constant of a given optically active rod using the method of Faraday rotation. 13. To study variation in internal resistance of a material with temperature. 14. To study the Hall effect using a given semiconductor probe to find the Hall Voltage and Hall Coefficient, Charge Carriers, Hall angle and mobility of material. 15. To determine the coefficient of thermal conductivity of given material by Angstrom's method. 16. To study arc spectra by constant deviation spectrometer. 17. To demonstrate the discrete excited states of Argon atom and find the ionization potential using Frank-Hertz experiment. 18. To study the dissociation limit of iodine. 19. To determine e/m of electron using Millikan's oil drop method. Any other experiment can be designed to demonstrate the concepts and phenomenon demonstrating the concepts of General physics broadly related to the experiments given in the above list.
Text Books	1. Advanced Practical Physics for Students, B.L. Worsnop and H.T. Flint Methuen & Co. Ltd., 36 Essex Street W.C., London (UK) (1931). 2. Advanced Practical Physics VOL. I by S.P. Singh, Pragati Prakashan, Meerut (2017). 3. Advanced Practical Physics VOL. II by S.P. Singh, Pragati Prakashan, Meerut (2014).

Reference Books	1. E-book downloadable from https://www.scribd.com/document/72270640/Advanced-Practical-Physics-Worsnop-and-Flint
Suggested E-resources	1. https://ocw.mit.edu/courses/8-13-14-experimental-physics-i-ii-junior-lab-fall-2016-spring-2017/afdfff9f8bbe067239af19c8b178a764_MIT8_13-14F16-S17exp7.pdf 2. https://www.youtube.com/watch?v=kgBLF6yJGK4 3. Implications of real-gas behavior on refractive index calculations for optical diagnostics of fuel–air mixing at high pressures by C. T. Wanstall, A. K. Agrawal and J. A. Bittle, Combustion and Flame, **214** 47-56 (2020). 4. https://doi.org/10.1016/j.combustflame.2019.12.023
EoSE	The duration of the examination shall be Five hours wherein the student has to perform any one experiment. The marks distribution shall be the following: 1. One experiment: 50 (Formula(e)-8, Figure(s)- 7, Observations-15, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 10

M.Sc. (Two Year Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY8005P
Title of the Course	Electronics Lab
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Practicum: 80+40=120. The 80 hrs for the hands on experiments, observations and record of the data, 20 hrs for enhancing the experiment skills, instruments demonstration, lab practices and 20 hrs on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*Objectives are to enable the students to understand the purpose of basic analog and digital electronics based experiments. Proper conduction and execution of experiments; troubleshoot experiments; appropriately recording of data and their analysis; understand what constitutes "reasonable" data; estimate the error bounds on their measurements. The deduction and presentation of experimental results using graphs and tables.*
Learning outcomes	The students would be able to: • Collect data and update the experimental process iteratively and reflectively • Assess the procedure and outcomes of an experiment quantitatively and qualitatively • Extend the scope of an experiment if or not results are as per expectation • Communicate the process and outcomes of an experiment • Perform an experiment collaboratively and ethically • Understand the meaning of a good or rich data, precision and accuracy.

	• Get an idea of the magnitude of the measured property and compare that with other similar objects and its relation to the applied/pure science.
Syllabus	
	Students are required to complete at all experiments allotted to them from Section-A and section-B. Students are expected to carry out the practical work after understanding circuitry and theoretical principle behind each experiment, design of experiments, working principle of the equipments/instruments, sources of errors in experiments etc. Experimental errors must be estimated in all experiments. The results of the experiments carried out by the students will reported to the teacher in regular manner in a specified format written in the Practical records book. **LIST OF EXPERIMENTS** **SECTION-A: Analog Electronics** 1. Measurement of operational amplifier parameters. 2. Study of low pass, high pass and band pass active filter circuits. 3. Study of an active integrator circuit. 4. Study of an active differentiator circuit. 5. Study of Wien Bridge Oscillator circuit. 6. Study of Square wave generator circuit. 7. Study of triangular wave generator circuit. 8. Study of comparator and Schmitt Trigger circuits. 9. Study of UJT parameters and relaxation oscillator circuit. 10. Study of series voltage regulated power supply. **SECTION-B: Digital Electronics** 1. Study of Combinational Systems: (i) Two bit and four bit adders (ii) 4-bit Subtractor (iii) Decoder and 7- segment display device (iv) Multiplexer and (v) Decoder/De-multiplexer circuits. 2. Study of Flip-Flop circuits : RS, JK, JKMS, D &T Flip-Flops 3. Study of Shift Registers. 4. Study of Binary Counters: (i) 4-bit Ripple counter (ii) 4-bit synchronous counter and (iii) BCD counter. **Note:** Any other experiments based on the subject: suggested, designed and fabricated by the concern expert.
Text Books	1. Lab and component manuals 2. OP-AMP and Linear Integrated Circuits by Ramakanth, A. Gayakwad, PHI, New Delhi. 3. Digital Logic and Computer design by Morris Mano, PHI, New Delhi.
Reference Books	1. Integrated Electronics, by J. Millman and C.C. Halkias, TMH, New Delhi. 2. Electronic Devices and Circuit Theory by Robert Boylestead and Louis Nashelsky, PHI, New Delhi. 3. Digital Principle and Applications by A.P. Malvino and Donald P. Leach, TMH, New Delhi.

Suggested E-resources	1. https://www.electronics-notes.com/articles/basic_concepts 2. https://www.javatpoint.com/digital-electronics 3. https://www.electronics-tutorials.ws
EoSE	The duration of the examination shall be Five hours wherein the student has to perform allotted: one experiment of section A and one experiment from section B. The distribution marks is as follows: 1 One experiment of Section A: 30 (Circuit diagram- 7, Formula(e)-3, Observations-10, Calculations-5, Result(s)-3, Precautions-2). 2. One experiment of Section B: 20. (Circuit diagram- 5, Observations & demonstrations-10, Result(s)-3, Precautions-2). 3. Viva Voce : 20 4. Evaluation of the record book of experiments performed in the semester: 10

M.Sc. II Sem. (Physics)

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8006T
Title of the Course	Computational Methods in Physics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*The aim of this course is to train the students to solve physics problems through different numerical techniques and use computer programming for simulation and data analysis, to understand numerical techniques to find the roots of equations and solution of system of linear equations, numerical differentiation, integration and numerical solutions of ordinary and partial differential equations.*
Learning outcomes	The students would be able to understand: • Different numerical methods to solve problems using computer programs. • Simulate physical systems using Monte Carlo Method. • The use of modern mathematical techniques in performing numerical computations. • Recognize the various interpolation formulae, best fit curve, nature of a specific numerical problem and would develop the acumen for choosing an appropriate numerical technique to find its solution. • To solve the roots of linear equation using an appropriate numerical method. • To estimate errors while solving equations and effectively use methods like matrix inversion, Gauss elimination and Gauss Seidel methods to solve linear equations. • To interpret and apply the basic methodology of numerical differentiation and numerical integration to a broad range of physics problems.

Syllabus	
UNIT-I	Computers and Numerical Analysis: IEEE 64 bit Floating point number representation, arithmetic operations, consequences of floating Point representation, computing errors, Error propagation, Introduction to parallel and distributed computing, Measuring efficiencies of Numerical procedures. (4+2=6) System of Linear Equations: Solving a system of Linear equations using Gauss Elimination, Gauss Jordan methods, Inverse of a matrix, Iterative methods to solve Equations: Gauss Seidel iterations, comparison of Iterative and Direct Methods.(4+2=6)
UNIT -II	Non-linear equations: Bisection and Newton Raphson method, Solution of Polynomial Equations, Newton methods for a system of nonlinear equation. (3+2=5) Interpolation: Lagrange Interpolation, Difference tables, Truncation error, Spline Interpolation. (3+1=4) Curve fitting: Straight line fit, fitting using polynomial function of higher degree, Exponential Curve Fit, cubic spline fitting. (2+1=3)
UNIT-III	Fourier Transform: Fourier analysis and orthogonal functions, Discrete Fourier Transform, Power Spectrum of driven pendulum. (3+2=5) Numerical Integration: Simpson and Guass quadrature method.(4+2=6) Numerical Differentiation: Difference approximation of first derivative. (1+0=1)
UNIT-IV	Differential equations: Euler and Taylor Series methods, Runge-Kutta Methods, Predictor-corrector Method, Comparison of different methods. (5+4=9) Elementary ideas of solutions of Partial Differential Equations. (1+0=1) Monte-Carlo simulations: Sampling and Integration, Metropolis Algorithm, Applications in Statistical physics. (2+0=2)
UNIT-V	Matrices and Eigen values: Eigen values and Eigen vectors, Similarity transformation and Diagonalization, power method to find eigen values, physical meaning of Eigen values and eigen vectors. (8+4=12)
Text Books	1. Computer Oriented Numerical methods, V. Rajaraman, 3rd Edition, PHI (2013). 2. Applied Numerical Analysis, C.F. Gerald and P. Wheatley, Seventh Edition, Pearson Education Inc. (2004). 3. Applied Numerical Methods Using MATLAB, W. Y. Yang, W. Cao, and T.-S. Chung and J. Morris, Wiley (2005). 4. An Introduction to Computational Physics, T. Pang, 2nd Edition, Cambridge University Press (2006). 5. Computational Physics: Problem Solving with Computers, R.H. Landau and M.J. Paez, 2nd Edition, John Wiley & Sons (2007). 6. An Introduction to Computer Simulation Methods: Applications to Physical Systems, H. Gould, J. Tobochnik & W. Christian, 3rd Edition, Addison Wesley (2006). 7. Numerical methods for scientific and engineering computations, M.K. Jain and S.R.K. Iyengar, New Age International (2003).
Reference Books	1. A Guide to Monte Carlo Simulation in Statistical Physics, D.P. Landau and K. Binder, Cambridge (2000) 2. Introductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall (2005). 3. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canale, McGraw Hill International editions, 2nd edition (1990). 4. An Introduction to Numerical Analysis, K.E. Atkinson, 2nd Edition, John Wiley & Sons (1989). 5. Computational Physics: An Introduction, Franz J. Vesely, 2nd Edition, Springer (2001). 6. Numerical Methods for Physics, A.L. Garcia, 2nd Edition, Prentice - Hall (2015). 7. Computational Methods in Physics and Engineering, S.S.M. Wong. World Scientific Publishing Co., Singapore (1997). 8. Computational Physics, J.M. Thijssen, 2nd Edition, Cambridge University Press (2007).
Suggested E-resources	1. https://www.iist.ac.in/sites/default/files/people/compmeth.pdf 2. https://www.cambridge.org/core/books/computational-methods-for-physics/47BC9EA18B56E877F80CB18B87D53904 3. https://farside.ph.utexas.edu/teaching/329/329.pdf

	4. https://www.ap.smu.ca/~thacker/teaching/3437/lectures.html 5. https://webs.um.es/jmz/IntroFisiCompu/CalcuNume/troyer/rgp.pdf 6. https://courses.physics.ucsd.edu/2017/Spring/physics142/Lectures/Lecture18/Hjorth-JensenLectures2010.pdf 7. https://www.asc.ohio-state.edu/physics/ntg/6810/readings/Hjorth-Jensen_lectures2015.pdf

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8007T
Title of the Course	Electrodynamics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*The emphasis of the course is to develop concepts and formulations of the electrodynamics and introduce basic mathematical concepts related to electromagnetic vector fields. This course imparts knowledge on the concepts of basic principles of electrostatics, magnetic fields of steady currents, motional e.m.f. and electromagnetic induction, Maxwell's equations, propagation and radiation of electromagnetic waves and plasma physics*
Learning outcomes	Students will be able to: • Understand the basic mathematical concepts related to electromagnetic vector fields. • Apply the principles of electrostatics to the solutions of problems relating to electric field and electric potential, boundary conditions. • Apply the principles of magnetostatics to the solutions of problems relating to magnetic field and magnetic potential. • Understand the concepts related to Faraday's law, induced emf and Maxwell's equations. • Understand the concept of propagation of electromagnetic waves in free space, dielectric and conductors. • Apply Maxwell's equations to solutions of problems relating to transmission lines and waveguides. • Gain basic knowledge about the plasma physics

Syllabus	
UNIT-I	Coulomb law and electrostatics, Field lines, flux and Gauss law and applications , Laplace and Poisson equations, uniqueness theorem, boundary-value problems, method of images, dielectrics. (4+2=6) Magnetostatics: Biot-Savart law, Ampere's theorem, electromagnetic induction. Magnetic fields in matter, magnetization (4+2=6)
UNIT -II	Maxwell's equations in free space and linear isotropic media, boundary conditions on fields at interfaces. (2+1=3) Scalar and vector potentials, Gauge invariance. (2+1=3) Electromagnetic waves in free space, dielectrics and conductors, reflection and refraction, polarization, Fresnel's law, Dispersion relations in plasma. (4+2=6)
UNIT-III	Transmission lines: lossless line, terminated transmission line and general lossy line. (2+1=3) Rectangular wave guide, classification of waves (TEM, TE, TM), Electromagnetic cavities: time average electric and magnetic energies, damping constant, quality factor (no derivation). (2+1=3) Relativistic formulation of electrodynamics, Maxwell equations in covariant form, gauge invariance and four-potential, the action principle and electromagnetic energy momentum tensor. (4+2=6)
UNIT-IV	Radiating Systems and Multipole fields: retarded potential, field and radiation of a localized oscillating source, electric dipole fields and radiation. (2+1=3) Lienard-Wiechert potential, dynamics of charged particle in static and electromagnetic field, electric and magnetic fields due to a uniformly moving charge and an accelerated charge. (4+2=6) Radiation from moving charges, Qualitative discussion of Bremsstrahlung, synchrotron radiation (no derivations), Radiation reaction: The Abraham-Lorentz formula, radiation damping (2+1=3)
UNIT-V	Basic properties and occurrence: definition of plasma, natural occurrence of plasma, Astrophysical plasmas. Criteria for plasma behaviour, plasma oscillation, quasineutrality and Debye shielding, plasma parameter and plasma production, thermal ionization, Saha equation (No derivation). Brief discussion of methods of laboratory plasma production, steady stage glow discharge, microwave breakdown and induction discharge. (8+4=12)
Text Books	1. Introduction to Electrodynamics by David J. Griffiths, 2nd Edition, Prentice Hall (1989). 2. Classical Electrodynamics by J.D. Jackson, 3rd Edition, Wiley (1999). 3. Elements of Electromagnetics by M. Sadiku, 3rd Edition, Oxford University Press (2000). 4. Plasma Physics by Chen, 2nd Edition, Plenum Press (1984). 5. Principles and applications of electromagnetic fields by P & C – Robert Plonsey and R.E Collins, McGraw Hill (1961). 6. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Balmain, 2^{nd} Edition, Pearson (1968).
Reference Books	1. Classical Electricity and Magnetism by W.K.H. Panofsky and M. Phillips, 2^{nd} Edition, Dover Publications (2005). 2. Electrodynamics by H J W Muller Kirsten, 2 nd Edition, World Scientific (2011). 3. Classical Electrodynamics by W. Greiner, Springer (1998). 4. Electrodynamics of Continuous Media: Volume 8 by L. D. Landau, L. P. Pitaveskii and E. M. Lifshitz, Butterworth-Heinemann (1984). 5. Principles of plasma physics by N. A. Krall, A. W. Trivelpiece, San Francisco Pr. (1986).
Suggested E-resources	1. https://ocw.mit.edu/courses/8-311-electromagnetic-theory-spring-2004/

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8008T
Title of the Course	Quantum Mechanics-II
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*This course introduces the advanced quantum mechanical tools. It introduces the formulation and applications of two additional approximation methods namely variational and WKB methods to solve simple problems. It aims to equip the students with quantum mechanical tools to study the scattering process and appreciate the consequences of quantum mechanical effects on scattering cross section. Moreover, it introduces the quantum mechanical formalism of the time dependent perturbation theory and allied applications. To introduce the students about need and development of the relativistic quantum mechanics and realize how Quantum mechanics can unfold mysteries in understanding the nature.*
Learning outcomes	At the end of this course learners will be able to: • Grasp the basic formalism of the WKB and Variational methods and to apply these to solve simple problems. • Use the mathematical apparatus of time dependent perturbation theory which is mandatory to study the theory of beta decay, gamma decay, alpha decay as well as basic concepts underlying nuclear techniques to explore the physics and chemistry of materials which are covered in the forthcoming courses as well in advanced courses. • Learn the basic concepts of scattering such as cross section, scattering amplitude, scattering length, partial wave etc. • Learn the methods of partial waves analysis, effective range theory, Born approximations etc. to study the scattering processes of classical and quantum mechanical particles and resulting physics.

	• Appreciate the evolution of relativistic quantum mechanics, its fundamental equations and mysterious results unravelling strength of the quantum mechanical methods. Students will learn how the Dirac, KG and Pauli equations unfold interesting properties of particles following relativistic dynamics.
Syllabus	
UNIT-I	Approximation methods: WKB approximation: Introduction of the method, The Classical region, Tunneling, The WKB wavefunction and connection formulae, Criterion for validity of approximation, Applications to potential well with a vertical wall and no vertical walls, Energy of one dimensional bound system. (4+2=6)
	The Variational method: Basic formulation and principle of the method, bound state (Ritz method), Applications to linear harmonic oscillator, Ground state energy under delta potential, Helium atom (Screening effect). (4+2=6)
UNIT -II	Theory of scattering: The scattering experiment, Classical and quantum mechanical scattering, Relationship of scattering cross-section to the wavefunction, Scattering amplitude, Method of partial waves, Expansion of a plane wave into partial waves. (5+3=8)
	Scattering by a central potential V(r): Dependence of phase shift on V(r), angular momentum and energy, Zero energy scattering, Scattering length, Scattering by a square well potential, effective range theory. (3+1=4)
UNIT-III	Born approximation and Integral equation of scattering: Born approximation, Green Function, The integral equation for scattering, The Born series, Criterion for the validity of the Born approximation, Low energy soft-sphere scattering, Yukawa Scattering, Scattering of electrons by atoms, Rutherford scattering. (5+3=8)
	Identical particles:The identity of particles, the indistinguishability principle, symmetry of wave functions, spin and statistics, Pauli exclusion principle, Illustrative example: scattering of identical particles, case of spin half and spin zero particles. (3+1=4)
UNIT-IV	Time dependent perturbation theory: Basic principle and formulation of time dependent perturbation theory, constant perturbation, Continuum, Transition to continuum, Fermi's golden rule, scattering cross section in the Born approximation, Harmonic perturbation. (5+3=8)
	Radiative transitions in atoms: Theory of radiative transitions in atoms, The dipole transitions, Selection rules involving m and ℓ. Forbidden transitions. (3+1=4)
UNIT-V	Relativistic wave equations: The Klein Gordan equation: Introduction, The Klein-Gordan equation, Interpretation of probability and the equation of continuity. (2+1=3)
	Dirac equation: The first order wave equation- The Weyl and Dirac equation, Properties of Dirac matrices, Covariant form of Dirac equation, Existence of intrinsic angular momentum of Dirac particle, Solutions of Dirac equation-spinors,Non-relativistic limit of Dirac equation-Pauli equation,spin-orbit coupling, Hole theory and supporting experimental evidences. (6+3=9)
Text Books	1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern Ltd. (1986). 2. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson Education Inc. (2005).
Reference Books	1. Principles of Quantum Mechanics, R. Shankar, Plenum Press, New York (1994). 2. Modern Quantum Mechanics, J.J. Sakurai, Addison and Wesley (1994).
Suggested E-resources	1. https://www.youtube.be /7Y5me3mwXpA, https://www.youtube.be /4BM58741VOg ,https://www.youtube.be /loVNly0Gyw

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8009P
Title of the Course	Electronics Project and Microprocessor Lab
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Practicum: 80+40=120. The 80 hrs for design and fabrication of analog/digital electronic circuits and for algorithm, programme writing and execution of ALP and 20 hrs for testing electronic circuits and debugging tools. 20 hrs for diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or Electronics
Co-requisites	None
Objectives of the course	*Objectives are to enable the students to understand the design and fabrication of electronic circuits; Writing and execution of assembly language programs on 8085 microprocessor kit. Proper conduction and execution of experiments; troubleshoot experiments; appropriately recording of data and their analysis; understand what constitutes "reasonable" data; estimate the error bounds on their measurements. The deduction and presentation of experimental results using graphs and tables.*
Learning outcomes	The students would be able to: • Hand on experience on the testing and operation of electronic components, multimeter, CRO, power supply, function generator etc. • Design and fabrication of electronic modules for lab experiments. • Collect data and update the experimental process iteratively and reflectively • Assess the procedure and outcomes of an experiment quantitatively and qualitatively • Extend the scope of an experiment if or not results are as per expectation • Communicate the process and outcomes of an experiment • Perform an experiment collaboratively and ethically • Understand the meaning of a good or rich data, precision and accuracy.

	• Get an idea of the magnitude of the measured property and compare that with other similar objects and its relation to the applied/pure science.
Syllabus	
	In section A: students are required to submit a detailed project report and working model (designed and fabricated one electronic circuit) of the project for evaluation. In section B students will write and execute one program based on assembly language programming of 8085 microprocessor. External Assessment will involve presentation and viva –voce. The results of the experimental work and programming carried out by the students will reported to the teacher in regular manner in a specified format written in the Practical records book. **Section A** **Design and fabrication of one Experimental Kit** Students will be required to carry out an electronic laboratory project either individually or in groups in the Electronics Laboratory under guidance of a teacher, which involves planning, design & construction of equipments & circuits based on any one of: OP-AMP instrumentation, wave form generators, wave shaping circuits, Power supplies, Combinational and sequential digital systems. It involves about 20 hrs of practical work per student that can be used to demonstrate physical principles or to carry out laboratory experiments. **Section B** **Microprocessor Assembly Language Programming** Assembly Language Programming of 8085 Microprocessor. At least ten exercises of arithmetical and logical operations involving data transfer and branching operations. **List of Programs** 1. Write and execute an assembly language program to count number of 1’s in an 8-bit data and store the results accordingly. 2. Write and execute an assembly language program for addition of number of data bytes and store the results accordingly. 3. Write and execute an assembly language program to calculate the 1’s and 2’s complement of an 8-bit number and store the results accordingly. 4. Write and execute an assembly language program for addition of two decimal numbers with and without carry and store the results accordingly. 5. Write and execute an assembly language program to mask lower nibble/particular bits of data that is stored at memory address 9100 and store results at 9101. The original data must be saved in a register. 6. Write and execute an assembly language program to split a hexadecimal data into two nibbles and store split data in memory. 7. Write and execute an assembly language program for block transfer of data bytes from source address to the destination address. 8. Write and execute an assembly language program to find lowest/largest data byte out of a given set of bytes. 9. Write and execute an assembly language program to multiply two 8-bit data. 10. Write and execute an assembly language program for the addition of two ‘BCD’ numbers of 4-digits each and store the results at the designated address accordingly. 11. Write and execute an assembly language program to arrange numbers in ascending/descending order and store the results accordingly. 12. Write and execute an assembly language program for a delay of at least 10 seconds 13. Write and execute an assembly language program for unmasking of a masked data. **Note**: any other experiments based on the subject: suggested by the concern expert.

Text Books	1. Lab and component manuals 2. OP-AMP and Linear Integrated Circuits by Ramakanth, A. Gayakwad, PHI, New Delhi. 3. Digital Logic and Computer design by Morris Mano, PHI, New Delhi. 4. Microprocessors Architecture, Programming and Applications with 8085/8086 by Ramesh S Gaonkar, Wiley - Eastern Ltd., 1987.
Reference Books	1. Integrated Electronics, by J. Millman and C.C. Halkias, TMH, New Delhi. 2. Electronic Devices and Circuit Theory by Robert Boylestead and Louis Nashelsky, PHI, New Delhi. 3. Digital Principle and Applications by A.P. Malvino and Donald P. Leach, TMH, New Delhi.
Suggested E-resources	1. https://www.electronics-notes.com/articles/basic_concepts 2. https://www.javatpoint.com/digital-electronics 3. https://www.electronics-tutorials.ws
EoSE	The duration of the examination shall be Five hours wherein the student has to perform allotted: one electronic project of section A and one ALP program from section B. The distribution marks is as follows: 1. Electronic project of Section A: 30 2. One ALP program of Section B: 20. 3. Viva Voce : 20 4. Evaluation of the record book of experiments performed in the semester: 10

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8010P
Title of the Course	Computational Physics Lab
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Practicum, 80+40=120. The 80 hrs for algorithm, programme writing and executing and 20 hrs for debugging tools. 20 hrs for diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*The laboratory exercises have been so designed that the students will learn the usage of C/C++ language and Matlab to solve mathematical and various physics problems. The students will be equipped with knowledge of programming in C/C++, determining roots of equations, interpolation, curve fitting, numerical differentiation, numerical integration, solution of ordinary differential equations and random numbers after completing the course on Numerical Methods. Students will learn the use of computers for solving physics based problems.*
Learning outcomes	The students would be able to understand: • The proficiency in effectively using the Windows operating system. • To highlight the use of computational methods to solve physical problems. • Uses of computer languages. • Hands on training on Problem solving on Computers. • Different numerical methods to solve problems using computer programs. • To write basic programs for numerical analysis, matrix manipulation, 2D and 3D plotting using MATLAB.

Syllabus	
SECTION A: PROGRAMMING IN C/C++	1. Gauss elimination Method 2. Gauss Seidel Method 3. Bisection Method 4. False Position Method 5. Secant Method 6. Newton Raphson Method 7. Matrix Transpose 8. Matrix Inverse 9. Fitting of a straight line 10. Trapezoidal Rule 11. Simpson's 1/3 Rule 12. Gauss Quadrature Method 13. First order Numerical Derivative 14. Runge-Kutta Method 15. Predictor-Corrector Method 16. Simpson's 1/3 Rule 17. Euler's Method Note: Students are required to write and execute at least ten programs from above list.
SECTION B: INTRODUCTION TO MATLAB	1. Find minima and maxima of curve 2. Plotting bisection and regula falsi 3. Solving Differential and Integral equation 4. Curve Plotting 5. Fast Fourier transform and Discrete Fourier Transform (DFT) 6. Linear Interpolation 7. Multiple interpolation 8. Sample three different parabolic functions at the points defined in x 9. Vectors and Matrices operation 10. Curve Fitting 11. Interpolation and Extrapolation 12. Least Squares fitting 13. Cubic spline interpolation 14. Spline Interpolation Note: Students are required to write and execute at least ten programs from above list.
Text Books	1. Computer Oriented Numerical methods, V. Rajaraman, 3rd Edition, PHI (2013). 2. Y. Kanetkar, Let Us C, BPB Publications, New Delhi, India (2012). 3. Computer Programming in Fortran 77: With an Introduction to FORTRAN 90, V. Rajaraman, Prentice-Hall of India (2003). 4. Matlab: An Introduction With Applications, Amos Gilat 4th Edition, John Wiley & Sons, Inc (2011).

	5. Matlab: A Practical Introduction to Programming and Problem Solving, Stormy Attaway, Elsevier (2017). 6. Applied Numerical Methods Using MATLAB, W. Y. Yang, W. Cao, and T.-S. Chung and J. Morris, Wiley (2005). 7. Computational Physics: Problem Solving with Computers, Landau and Paez, 2nd Edition, John Wiley & Sons (2007).
Reference Books	1. Computational Physics: An Introduction, Franz J. Vesely, 2nd Edition, Springer (2001). 2. Computational Methods in Physics and Engineering - S.S.M. Wong. World Scientific Publishing Co., Singapore (1997). 3. Computational Physics - J.M. Thijssen, 2nd Edition, Cambridge University Press (2007). 4. , Computational Physics, R. C. Verma, P. K. Ahluwalia & K. C. Sharma, New Age, 1st Edition (1999).
Suggested E-resources	1. https://www.mimuw.edu.pl/~mrp/cpp/SecretCPP/O%27Reilly%20-%20Practical%20C++%20Programming.pdf 2. https://www.eidos.ic.i.u-tokyo.ac.jp/~tau/lecture/computational_physics/docs/computational_physics.pdf 3. file:///C:/Users/Gunjan/Downloads/MATLAB_AnIntroductionwithAp-AmosGilat.pdf 4. http://cms.dm.uba.ar/academico/materias/2docuat2018/elementos_calculo_numerico_M/Stormy%20Attaway-MATLAB%20%20A%20Practical%20Introduction%20to%20Programming%20and%20Problem%20Solving-Butterwonh-Heinemann%20(2017).pdf 5. https://farside.ph.utexas.edu/teaching/329/329.pdf
EoSE	The duration of the examination shall be Five hours wherein the student has to perform allotted: one programme from section A and one programme from section B. The distribution marks is as follows: 1. One programme from Section A: 25. 2. One programme of Section B: 25. 3. Viva Voce : 20 4. Evaluation of the record book of experiments performed in the semester: 10

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8100T
Title of the Course	Statistical Physics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*Students will learn to find macroscopic thermal properties like specific heat, magnetic susceptibility from microscopic dynamics. The course starts from the classical dynamics and then using quantum dynamics as the microscopic principles. The notion of an ensemble and theory of phase transition is introduced.*
Learning outcomes	The students would be able to understand • Connection between statistics and thermodynamics. • Different ensemble theories to explain the behaviour of the systems using classical statistics. • Difference between classical statistics and quantum statistics. • The density matrix and ensembles theory following the quantum statistics. • Partition functions and to find thermodynamic quantities. Classical and quantum cluster methods. • Statistical behaviour of ideal Bose and Fermi systems. • Bose-Einstein condensation, Liquid He, Ising model for application of statistics methods to a magnetic system. • Landau theory of phase transition, order parameter, statistical correlation and fluctuations.

Syllabus	
UNIT-I	Classical Statistical Mechanics: The Postulate of Classical Statistical Mechanics, Microcanonical Ensemble, Derivation of Thermodynamics, Equipartition theorem, classical ideal gas, Gibbs Paradox. (3+1=4)
	Canonical Ensemble and Grand canonical Ensemble: Canonical Ensemble, Energy fluctuations, Grand Canonical ensemble, Density fluctuations in the Grand Canonical Ensemble, The Chemical potential, Equivalence of the canonical ensemble and grand canonical ensemble. (5+3=8)
UNIT -II	Quantum Statistical Mechanics: The postulates of Quantum Statistical mechanics, Density Matrix, Ensembles, Third law of Thermodynamics, The Ideal Gases: Micro canonical and Grand Canonical Ensemble, Foundations of Statistical Mechanics. (8+4=12)
UNIT-III	The General Properties of Partition function, Classical Limit of Partition functions, Singularities and Phase transitions. (3+1=4)
	Identical particles and symmetry requirement, difficulties with Maxwell-Boltzmann statistics, quantum distribution functions, Bose Einstein and Fermi-Dirac statistics and Planck's formula. (5+3=8)
UNIT-IV	Classical cluster expansion, quantum cluster expansion, Virial coefficient, variational Principles, imperfect gases at low temperatures. (4+2=6)
	Bose Einstein condensation, liquid He4 as a Boson system, quantization of harmonic oscillator and creation and annihilation of phonon operators, quantization of fermion operators.(4+2=6)
UNIT-V	The Ising Model: Definition of Ising model, Spontaneous Magnetization, The Bragg-Williams Approximation, The One dimensional Ising Model. (4+2=6)
	Landau theory of Phase transition, critical indices, scale transformation and dimensional analysis, Thermodynamic fluctuation. (4+2=6)
Text Books	1. Statistical Mechanics. K. Huang. John Wiley & Sons, 2nd edition. 2. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press. 3. Statistical Mechanics: L.D. Landau and E. M. Lifshitz, Pergamon
Reference Books	1. Fundamentals of Statistical and Thermal Physics: F. Reif (McGraw-Hill, New York NY) 2. Statistical Mechanics, R. Kubo, North Holland Publishing, Amsterdam 3. Introduction to Statistical Mechanics by S.K. Sinha, Narosa Publication 4. Statistical Mechanics by B.K. Agarwal & Melvin Eisner, Wiley Eastern
Suggested E-resources	1. https://ocw.mit.edu/courses/8-08-statistical-physics-ii-spring-2005/ 2. https://www.damtp.cam.ac.uk/user/tong/statphys.html

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8101T
Title of the Course	Ionospheric Physics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*The student is introduced to properties of the ionosphere both from the fundamental Physics and applications point of views.*
Learning outcomes	Students will be able to understand: • Ionosphere propagation and measurement techniques- Effect of Ionosphere on radiowave propagation, Refraction, Dispersion and polarization, Magnetoionic theory, critical frequency and virtual height, Oblique propagation and maximum usable frequency, Ground based techniques: ionosondes, radars, scintillation and TEC, ionospheric absorption, rocket and satellite borne techniques: Langmuir probe, electric field probe mass spectrometer. • Ionospheric Plasma Dynamics: Basic Fluid equations, steady state ionospheric Plasma motions due to applied forces, generation of Electric field mapping, collision frequencies, Electrical conductivities, Plasma diffusion, Ionospheric dynamo, Equatorial Electrojet& EIA. • Airglow and its measurement: Night glow, Dayglow, Twilight glow, Aurora, Photometers, Spectrometers and imagers for airglow measurement, applications of Airglow measurement for ionospheric dynamics and composition. • Ionospheric Plasma irregularities: E-region irregularities associated with electrojet, Sporadic-E, Auroralelectrojet and associated irregularities, F-region irregularities, Equatorial Spread F and its various manifestations. Airglow depletions and plasma bubbles, Ground based, rocket borne and satellite based measurement techniques for these irregularities. Theories of ESF.

	• Ionospheric modeling and models: IRI, SUPIM, TIGCM, PIM. Brief introduction to ionospheres of Mars, Venus and Jupiter
Syllabus	
UNIT-I	Ionosphere propagation and measurement techniques: Effect of Ionosphere on radiowave propagation, Refraction, Dispersion and polarization, Magnetoi-onic theory, critical frequency and virtual height, Oblique propagation and maximum usable frequency, Ground based techniques: ionosondes, radars, scintillation and TEC, ionospheric absorption, rocket and satellite borne techniques: Langmuir probe, electric field probe mass spectrometer. (8+4=12)
UNIT -II	Ionospheric Plasma Dynamics: Basic Fluid equations, steady state ionospheric Plasma motions due to applied forces, generation of Electric field mapping, collision frequencies, Electrical conductivities, Plasma diffusion, Ionospheric dynamo, Sq current system, Equatorial Electrojet & EIA. (8+4=12)
UNIT-III	Airglow and its measurement: Night glow, Dayglow, Twilight glow, Aurora, Photometers, Spectrometers and imagers for airglow measureent, applications of Airglow measurement for ionospheric dynamics and composition. (8+4=12)
UNIT-IV	Ionospheric Plasma irregularities: E-region irregularities associated with electrojet, Sporadic-E, Auroral electrojet and associated irregularities, F-region irregularities, Equatorial Spread F and its various manifestations. Airglow depletions and plasma bubbles, Ground based, rocket borne and satellite based measurement techniques for these irregularities. Theories of ESF. (8+4=12)
UNIT-V	Ionospheric modeling and models: IRI, SUPIM, TIGCM, PIM. Brief introduction to ionospheres of Mars, Venus and Jupiter. (8+4=12)
Text Books	1. Introduction of Ionospheric Physics, Risbeth and Garriot. 2. Aeronomy of the Middle Atmosphere, Guy Brasseur and Susan Solomon. 3. Electromagnetic waves and Radiating System , Jordan 4. Electronics Communication, Kennedy.
Reference Books	1. Antennas and Radio Wave Propagation, R.E. Collin. 2. Electronics Communication Systems, B.P.Lathi.
Suggested E-resources	1. www.physics.usyd.edu.au 2. www.ufa.cas.cz 3. www.uib.no/en/course/phy8352

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8102T
Title of the Course	Astronomy and Astrophysics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*The emphasis of the course is to develop concepts and formulations of the astronomy and astrophysics. This course gives introduction to the physics of the solar system, stars, interstellar medium. galaxy, and the universe, as determined from a variety of astronomical observations and models. This course also describes the details of dark matter and black holes.*
Learning outcomes	Students will be able: • To understand important concepts and methods in astronomy and astrophysics, with the aim to build their background for future research work in this area. • To recognize and explain the movements of the Sun, Moon and planets, as viewed from Earth, over the course of time. • To identify, classify and compare the objects in the Universe, including, but not limited to; atoms, nebulae, stars, stellar clusters, galaxies, clusters of galaxies, quasars.
Syllabus	

UNIT-I	Introductory Concepts: Basic parameters in Astronomical observations (Magnitude scales, Coordinate system), Stellar classification -H.R. Diagram , Saha's equation , Jean's criteria for stellar formation, Galaxy classification. (2+1=3) Cosmology: Cosmological models, observations, cosmic violence (in nucleus of the Galaxy). (2+1=3) Cosmic back-ground radiation, Elementary particles and cosmos, Big-Bang. Model of inflationary Universe (flatness and horizontal problem), Relativistic and Cosmic geometry of space – time and universe. (4+2=6)
UNIT -II	Optical and near IR studies of Stars and Galaxies: Optical Telescopes with CCD's -High angular Resolution Techniques (Speckle, Lunar Occultation adaptive optics). Interferometry with Telescopes. (2+1=3) Spectral Energy Distribution (in optical Bands) in Stars, Rotation of stars, Study of Binary Stars, Gaseous Nebulae. (3+1=4) Extinction curve of interstellar matter, dust-Rotation, Curve of galaxies, Spectral Energy Distribution, Colour studies (Imaging of galaxies in Different bands). (3+2=5)
UNIT-III	High Energy astronomy: Atmospheric transmission, Detection Techniques for X-rays and Gamma-rays, X-ray-Telescopes with imaging and Spectroscopy -Radiation Processes in Accretion Disks around Black Holes and X-rays Binaries -Active Galactic Nuclei. (8+4=12)
UNIT-IV	Dark Matter: Evidences of dark matter – Dark matter components in our galaxy, in Halos of the spiral galaxy, in clusters of candidates in dark matter. Baryonic and non-Baryonic candidates in dark matter. (4+2=6) Radio Telescopes: Radio Interferometry. Very long Base Interferometry (VLBI) of Radio Pulsars. (2+1=3) Radio galaxies: Distribution of HI gas in Galaxies, Radiation mechanism. (2+1=3)
UNIT-V	Black hole Observation, Gravitational lens, Schwarzschild radius, Singularity, X-rays and Gamma rays bursts through cosmic flux detection using photo-multiplier tubes. (4+2=6) Hubble's law and Hubble's constant (Red shift, distance, age of the Universe Measurements). (2+1=3) Galactic Structure: Rotation and spiral (Optical, radio, X-rays, Gamma radiation observation). (2+1=3)
Text Books	1. Solar Astrophysics by Peter V. Foukal, Wiley VCH (1990). 2. Galaxy Formation by Malcolm S. Longair, 2 nd Edition, Springer (2008). 3. Fundamentals of solar Astronomy by Arvind Bhattnagar and William Livingston, World Scientific (2005). 4. The Fundamentals of Stellar Astrophysics by George W. Collins,II, W. H. Freeman and Co. Ltd. (1991). 5. Stellar Astrophysics by R.Q. Haung, K. N. yu, Springer (1998). 6. Advanced Stellar Astrophysics by William Kenneth Rose, Cambridge University Press (1998). 7. Introduction to Stellar Astrophysics by Erika Bohm- Vitense, 1st Edition, Cambridge University Press (1989). 8. Quasars and Active Galactic Nuclei by Ajit K. Kembhavi and Jayant Vishnu Narlikar, Cambridge University Press (1999).
Reference Books	1. Universe by Roger Freedman, Robert Geller, William J. Kaufmann, 11th Edition, W. H. Freman (2019). 2. Physical Universe: An introduction to astronomy by F. Shu, University Science Books (1981). 3. Astrophysics Stars and Galaxies by K.D. Abhyankar, Universities Press (2001). 4. The Sun: An Introduction by Michael Stix, Springer (2012).
Suggested E-resources	1. https://ocw.mit.edu/courses/8-901-astrophysics-i-spring-2006/ 2. https://ocw.mit.edu/courses/8-282j-introduction-to-astronomy-spring-2006/

M.Sc. (Two Year Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY8103T
Title of the Course	Atmospheric Physics
Qualification Level of the Course	NHEQF Level 6.0
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lecture and tutorial, 40+20=60. The 40 lectures for content delivery, 10 hours for the tutorial, and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.
Prerequisites	Intermediate or advanced level courses of Physics or mathematics
Co-requisites	None
Objectives of the course	*This course will provide a basic introduction to various topics in atmospheric physics such as passage of solar radiation through atmosphere, an overview about Atmospheric thermodynamics and dynamics including equations of motions, a concise introduction to cloud microphysics and about Atmospheric Circulation. This course is even suited for a physics student who is not having a previous background in Astrophysics.*
Learning outcomes	The students would be able to understand: • To describe the basic structure and dynamics of atmosphere and the climate system. • To use fundamental thermodynamics to derive expressions for the variation of temperature, pressure, and air density with height. • To learn the basic equations for modeling dynamics of atmosphere, and their basic applications. • The physics of clouds and rain formation. • The scale approximations to the equations of motion (e.g. hydrostatic and geostrophic approximations). • The atmospheric circulation theorems and applications, Barotropic and baroclinic fluids and dynamic instabilities.
Syllabus	

UNIT-I	Radiative transfer in the atmosphere: Temperature of the sun and spectral distribution of solar radiation, blackbody radiation budget of radiation energy, Passage of solar radiation through the atmosphere, atmospheric windows, emissivity, absorption spectra of atmospheric gases, optically thick and thin approximation, aerosol, scattering, calculation of radiative heating and cooling, terrestrial radiation and its passage through the atmosphere. (8+4=12)
UNIT -II	Atmospheric thermodynamics: Laws of thermodynamics, Lapse rate, thermodynamic equations entropy change water-air mixture, moisture variables, potential temperature, virtual temperature, thermodynamic diagram, dry and moist static energy, static stability, convective instability. (8+4=12)
UNIT-III	Basic equations of atmospheric dynamics: Equations of motion in spherical coordinates, rotating frame, coriolis force, quasistatic approximation, scale analysis, Rossby number, balanced flow, natural coordinate system, equations of continuity in spherical and Cartesian coordinates. Thermodynamic energy equations, pressure as vertical coordinate. (8+4=12)
UNIT-IV	Cloud microphysics: Cloud forms and characteristics, formation and growth of precipitation particles, terminal velocity, thunderstorms, artificial rain making. (8+4=12)
UNIT-V	Atmospheric Circulation: Circulation, Vorticity, divergence and deformation Circulation theorems and applications, Barotropic and baroclinic fluids, dynamic instabilities. (8+4=12)
Text Books	1. Physical meteorology, H.G. Houghton, 1985 2. Atmospheric Science-An Introductory Survey, J.M. Vallace and P.V. Hobbs, Academic Press, Elsevier, 2006. 3. A short course on cloud Physics, R.R. Rogers, 1979. 4. An introduction to dynamic meteorology, J.R. Holton, Acad. Press, 1979.
Reference Books	1. Basics of Atmospheric Science, A. Chandrasekar, PHI Publications, 2010. 2. Introduction to Theoretical Meteorology, S.L. Hess, 1959. 3. Atmospheric Waves, T. Beer, Wiley, 1974. 4. Atmospheric Tides, Chapman and Lindzen, Riedel, 1969. 5. A course in Dynamic meteorology, N. Pandarinath, B S Publications, 2006. 6. The Physics of Monsoons, R.N. Keshvamurthy and M.S. Rao, Allied Publishers.1992.
Suggested E-resources	1. https://ocw.mit.edu/courses/10-571j-atmospheric-physics-and-chemistry-spring-2006/pages/lecture-notes/ 2. https://dl.icdst.org/pdfs/files1/4a12b8f80ceb22105a190e71d78bed02.pdf 3. https://uomustansiriyah.edu.iq/media/lectures/6/6_2021_04_17!03_59_20_PM.pdf