DEPARTMENT OF PHYSICS

COURSE STRUCTURE

for

M.Sc. (PHYSICS)

Four Semesters (Two Years)

Programme

Based on

Choice Based Credit System (CBCS)

(As per ordinance-14)

I & II Semester 2020-21

III & IV Semester 2021-22

AWADHESH PRATAP SINGH UNIVERSITY, REWA (M.P.)

Semester Course of M.Sc. Physics Based on CBCS

Vision of the University:

To be the premier institution that offers teaching and learning programmes of the best quality, graduate students who excel and become leaders in the chosen profession contributing to the community, the nation and the world, and prepares individuals of the highest moral fibre. The vision of university is:

To create an ideal society and an intellectual environment that initiates, nourishes and perpetuates values of co-existence and to fulfil and achieve excellence.

The university, under the dynamic leadership of our honorable Vice-chancellor is working on quite a few ambitious plans. The idea is to develop the university as a knowledge city.

About the Department:

The department came into existence in 1982 with its initial name physics. The foundation stone of the building where the department came intoexistence was laid by the. Initially Prof. S.P. Agrawal.

The Department runs M.Sc., M.Phil. and Ph.D. programs in Physics. Currently around one hundred fifty students are studying in the department. The department has made notable research contributions in the areas of space physics and materials science. Researchers of the department have been visiting and interacting with various research institutions of the country. More than 200 research papers and articles have been published by the faculty of the department in National/International journals. The research papers of the faculty members are also cited in reference books and journals of high impact factor. Since the inception of the department, more than 50 students have been awarded Ph. D. degree and over 250 students have obtained M. Phil. degree.

The Department has organized Invited Talks, Workshops, Seminar and tutorials to improve theknowledge of students regarding the latest developments in the field of Space physics and materials science.

Faculty:

1. Prof. A.K. Saxena — Professor and Head
2. Dr. C.M. Tiwari — Full Time Faculty
3. Dr. B.K. Tiwari — Full Time Faculty

Aims:

1. Developing the Physics Skills among the students and preparing them to take up a career in research.
2. Create more interest in the subject and motivate students for self-learning.
3. Strengthening the logical reasoning which is the main ingredient to understand Physical concepts.

Objectives:

1. To develop deep understanding of the fundamental scientific /concepts in Physics and capability of developing ideas based on them.
2. To encourage students for research studies in Physics and related fields.
3. To enable the students in being life-long learner and enable them to independently expand theirphysics expertise when needed.

Programme: **M.Sc. Physics**

Programme Code: **016**

Duration: **4 Semesters (Two Year)**

Number of Seats: **72**

Eligibility:

B.Sc. with Physics as a subject.

Age Limit: No age limit.

Admission Procedure:

The admission is done as per merit of qualifying examinations.

PROGRAMME OUTCOMES (POs)

PO #	PROGRAMME OUTCOME
PO 1	**Critical Thinking**: Take informed actions after identifying the assumptions that frame our thinking and actions, check out the degree to which these assumptions are accurate and valid, and look at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
PO 2	**Effective Communication**: Speak, read, write and listen clearly in personand through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.
PO 3	**Social Interaction**: Elicit views of others, mediate disagreements and help reach conclusions in group settings.
PO 4	**Effective Citizenship**: Demonstrate empathetic social concern and equity-centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.
PO 5	**Ethics**: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.
PO 6	**Environment and Sustainability**: Understand the issues of environmental contexts and sustainable development.
PO 7	**Self-directed and Life-long Learning**: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PROGRAMME SPECIFIC OUT COMES (PSOs) (M.Sc. Physics)

PSO #	PROGRAMME SPECIFIC OUTCOME
PSO 1	To gain a functional knowledge of theoretical concepts and experimental aspects of Physics and their applications in the day-to-day life.
PSO 2	To integrate the gained knowledge with various contemporary and evolving areas in physical sciences like physical, analytical, synthetic, instrumental etc.
PSO 3	To understand, analyze, plan and implement qualitative as well as quantitative analytical synthetic and phenomenon-based problems in physical sciences.
PSO 4	Provide opportunities to excel in academics, research or Industry.

COURSE STRUCTURE FOR M.Sc. PHYSICS AT A GLANCE

Semester-I

Semester-I

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-1;Classical Mechanics	Core	60	40	100	04
C-2;Quantum Mechanics-I	Core	60	40	100	04
C-3;Electronic Devices	Core	60	40	100	04
*GE-1; Mathematical Physics	Generic Elective	60	40	100	04
CV-1;Comprehensive Viva Voce				100	04
PL-1;Practicals-General				100	02
PL-2;Practicals-Electronics				100	02
Semester Total				700	24

Semester-II

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-4; Quantum Mechanics-II	Core	60	40	100	04
C-5;Statistical Mechanics	Core	60	40	100	04
C-6; Electrodynamics & Plasma Physics	Core	60	40	100	04
*GE-2;Atomic & Molecular Physics	Generic Elective	60	40	100	04
CV-2 ; Comprehensive Viva Voce				100	04
PL-3;Practicals-General				100	02
PL-4;Practicals-Electronics				100	02
Semester Total				700	24

Semester-III

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-7; Nuclear & Particle Physics	Core	60	40	100	04
C-8;Condensed Matter Physics	Core	60	40	100	04
^DCE-1; Digital Electronics or ^DCE-2;Energy Physics or ^DCE-3;Space Technology Or ^DCE-4;Remote Sensing & Applications	Discipline Centric Elective	60	40	100	04
*GE-3; Informatics	Generic Elective	60	40	100	04
CV-3; Comprehensive Viva Voce				100	04
PL-5;Practicals-General				100	02
PL-6;Practicals-Electronics				100	02
Semester Total				700	24

Semester-IV

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-9; Laser Physics	Core	60	40	100	04
C-10;Modern Experimental Techniques	Core	60	40	100	04
^DCE-5; Advance Electronics or ^DCE-6;Astrophysics or ^DCE-7;Environmental Physics Or ^DCE-8;Physics of Nanomaterials	Discipline Centric Elective	60	40	100	04
*GE-4; Atmospheric Science	Generic Elective	60	40	100	04
CV-4; Comprehensive Viva Voce				100	04
PL-7;Practicals-General				100	02
PL-8;Practicals-Electronics				100	02
Semester Total				700	24
Total Semester (I+II+III+IV)				2800	

Programme Administration

Evaluation:

1. Each course will be assessed for 100 marks, out of which 60 marks will be for end-semester examination and 40 marks will be for Continuous Evaluation. The duration of end-semester examination for each course shall be of three hours.
2. The question paper of end-semester examination of each course will consist of two sectionsA & B. Section A will consist of short answer type questions each carrying 6 marks and section B of long answer type questions each carrying 10 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.
3. During the semester, a teacher offering the course will do the continuous evaluation of the student at three points of time by conducting three tests of 20 marks each. Of these, two must be written tests and third may be written test/Quiz/Seminar/Assignment. Marks obtained in two best tests out of three will be awarded to the student.
4. Total of Marks obtained in end-semester examination and best two tests under continuous evaluation will decide the grade in the course.

COURSE STRUCTURE

Under CBCS

M.Sc. PHYSICS

SEMESTER-I

Semester-I

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-1;Classical Mechanics	Core	60	40	100	04
C-2;Quantum Mechanics-I	Core	60	40	100	04
C-3;Electronic Devices	Core	60	40	100	04
*GE-1; Mathematical Physics	Generic Elective	60	40	100	04
CV-1;Comprehensive Viva Voce				100	04
PL-1;Practicals-General				100	02
PL-2;Practicals-Electronics				100	02
Semester Total				700	24

Semester-II

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-4; Quantum Mechanics-II	Core	60	40	100	04
C-5;Statistical Mechanics	Core	60	40	100	04
C-6; Electrodynamics & Plasma Physics	Core	60	40	100	04
*GE-2;Atomic & Molecular Physics	Generic Elective	60	40	100	04
CV-2 ; Comprehensive Viva Voce				100	04
PL-3;Practicals-General				100	02
PL-4;Practicals-Electronics				100	02
Semester Total				700	24

Semester-III

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-7; Nuclear & Particle Physics	Core	60	40	100	04
C-8;Condensed Matter Physics	Core	60	40	100	04
^DCE-1; Digital Electronics or ^DCE-2;Energy Physics or ^DCE-3;Space Technology Or ^DCE-4;Remote Sensing & Applications	Discipline Centric Elective	60	40	100	04
*GE-3; Informatics	Generic Elective	60	40	100	04
CV-3; Comprehensive Viva Voce				100	04
PL-5;Practicals-General				100	02
PL-6;Practicals-Electronics				100	02
Semester Total				700	24

Semester-IV

Course code & Name of Paper	Course Type	Theory paper	Internal Assessment	Maximum Marks	Credits
C-9; Laser Physics	Core	60	40	100	04
C-10;Modern Experimental Techniques	Core	60	40	100	04
^DCE-5; Advance Electronics or ^DCE-6;Astrophysics or ^DCE-7;Environmental Physics Or ^DCE-8;Physics of Nanomaterials	Discipline Centric Elective	60	40	100	04
*GE-4; Atmospheric Science	Generic Elective	60	40	100	04
CV-4; Comprehensive Viva Voce				100	04
PL-7;Practicals-General				100	02
PL-8;Practicals-Electronics				100	02
Semester Total				700	24
Total Semester (I+II+III+IV)				2800	

M.Sc.(Physics) Semester-I

Choice Based Credit System

Core Paper C-1 : **CLASSICAL MECHANICS**

Paper - I

Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Newtonian mechanics of one and many particle system: Conservation laws, Constraints and their classification, Principle of virtual work: D'Almbert's principle in generalized coordinates, Lagrange's equation from D'Almbert's principle. Configuration space, Hamilton's principle deduction from D'Almberts principle, Generalized momenta and Lagrangian formulation of the conservation theorems, Reduction to the equivalent one body problem: Equation of motion and first integrals, differential equation for the orbit.

Unit II

The equations of canonical transformation and generating functions; The Hamilton Jacobi Action and Angel variables. Poisson's brackets; simple algebraic properties of Poisson's brackets. The equation of motion in Poisson's Brackets notation. Poisson theorem; principle of least action. The Kepler problem, Inverse central force field, Rutherford scattering.

Unit III

Theory of small oscillations, Equations of motion, Eigen frequencies and general equation of motion, normal modes and coordinates, Applications to coupled pendulum and linear bistable molecule. Rotating co-ordinate systems. Acceleration in rotating frames. Coriolis force and its terrestrial astronomical applications, Elementary treatment of Eulerian co-ordinates and transformation matrices. Angular momentum inertia tensor. Eular equations of motion for a rigid body. Torque free motion for a rigid body.

Unit IV

Symmetries of space and time. Invariance under galilion transformation, Covariant four dimensional formulation, 4-Vectors and 4-scalers. Relativistic generalization of Newton's laws, 4-

momentum and 4-force, variance under Lorentz transformation relativistic mechanics. Covariant Lagrangian, covariant Hamiltonian, equations.

Unit V

The principle of equivalence, Relativistic theory of gravitation. Einstein's elevator, principle of general covariance, nature of the gravitational field. Energy momentum tensor. Einstein's field equations. The Schwarchild exterior solution of field equations, the experimental tests of the general theory relativity: The advance of the perihelion of Mercury, the deflection of light in a Schawarz child field, the gravitational shift of spectral lines.

Books Recommended:

1.	H.Goldstein (Addison Wesley)	Classical Mechanics
2.	N.C.Rana & P.S.Jog	Classical Mechanics
3.	Landau & Lifshitz (Pergamon Press)	Classical Mechanics
4.	A.Sommarfield (Academic Press)	Classical Mechanics
5.	R.G.Takwale & P.S.Puranik	Introduction to Classical Mechanics

Classical Mechanics

Course outcome:

Co1: This course will enable students to understand the concepts of classical theory with references to Newtonian mechanics.

Co2: Ability achieved to apply canonical transformation and Hamilton Jacobi problems.

Co3: It shall developed the ability to use different classical mechanics concepts related to astronomical and scattering applications.

Co4: In depth knowledge in pseudo forces and coriolis forces etc and their existence due to rotation of earth and related phenomena observed on earth would be understood by students.

M.Sc.(Physics) Semester-I

Choice Based Credit System

Core Paper C-2 :**QUANTUM MECHANICS-I**
Paper -II

Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Basic Postulates of quantum Mechanics, equation of continuity, Normality, orthogonality and closure properties of eigen functions, expectation values and Ethrentest theorems, solution of Schrodinger equation for one dimensional (a) Potential well (b) Potential step and (c) Potential barrier.

Unit II

Linear vector space, concept of Hibert space, bra and ket notation for state vector, representation of state vectors and dynamical variables by matrices and unitary transformation (Translation and rotation), creation and annihilation operators, matrices for x and p. Heisenberg uncertainty relation through operator (Schwartz Inequality).

Unit III

Solution of Schrodinger equation for (a) linear harmonic oscillator (b) hydrogen - line atom (c) square well potential and their respective application to atomic spectra, molecular spectra and low energy nuclear states (deutorn).

Unit IV

Angular momentum in quantum mechanics, Eigen values and Eigen function of L2 and L in term of spherical harmonics, commutation relation. Time independent perturbation theory. Non-degenerate and degenerate cases.

Unit V

Space time symmetries : Displacement in space, conservation of Linear momentum, Displacement in time : Conservation of energy, Rotation in space : conservation of angular momentum, space inversion parity, Time reversal Invariance, change of wave function under a gauge transformation, wave function in a field free region.

Books Recommended:

1. L.I.Schiff — Quantum Mechanics
2. S.Gasiorovvicz — Quantum Physics
3. B.Craseman and J.D. Powell — Quantum Mechanics
4. A.P.Messiah — Quantum Mechanics
5. J.J. Sakurai — Modern Quantum Mechanics
6. Mathews and Venkatesan — Quantum Mechanics

Quantum Mechanics – I

Course outcome:

CO1: Create ability to develop one and three dimensional harmonic oscillator differential equations by power series method in understanding hydrogen spectrum.

CO2: Ability to derive angular momentum operators and spherical harmonics with polar diagrams.

CO3: Ability to derive the time independent and time dependent perturbation equations and apply to explain different phenomenon.

CO4: Ability to apply approximation methods to understand various phenomenon, estimate ground state energy, etc.

M.Sc.(Physics) Semester-I
Choice Based Credit System

Core Paper C-3 : **ELECTRONIC DEVICES**
Paper -III

Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Unipolar Transistors : JFET,MOSFET and MESFET; structure derivations of the equations for I-V characteristics under different conditions. Charge Transfer Devices;CCD-structure,performance and applications. Unijunction Transistors & Programmable Unijunction Transistors(PUT)-Operation and IV characteristics. pnpn diodes,Silicon Controlled Rectifier(SCR),DIAC,TRIAC-structure, operation and characteristics.

Unit II

Photonic devices: radiative and non-radiative transitions, optical absorption, bulk and thin film photo conductive device (LDR), diode Photo detectors, Solar cell (open circuit voltage and short circuit current, fill actor), LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), semi-conductors; diode lasers (conditions for population inversion in active region, light confinement factor, optical gain and threshold current for lasing.

Unit III

Microwave Devices,Tunnel Diodes-operation mechanism and I-V characteristics.Transferred Electron Devices: Gunn diodes-Structure ,formation and drift of space charge domains,operation and I-V characteristics. Avalanche transits time devices :READ, IMPATT and TRAPATT diodes-operation and characteristics.

Unit IV

Memory Devices: Read Only Memory (ROM) and Random Access Memory (RAM). Types of ROM: PROM, EPROM, EEPROM and EAPROM, Static and dynamic RAMs (SRAM & DRAM), characteristics of SRAM and DRAM. Hybrid Memories : CMOS and NMOS memories, Nonvolatile RAM, ferro-electric memories, charge coupled devices (CCD), storage devices : Geometry and organization of magnetic (FDD & HDD) and Optical (CD-ROM, CD-R, CD-R/W, DVD) Storage devices.

Unit V

Electro-optics, Magneto-optic and Acousto-optic effects, materials properties related to get these effect, important ferro electric, liquid crystal and polymeric materials for these devices, piezoelectric, electrostrictive and magnetostrictive effects. Important materials for these properties and their applicat6ions in sensors and actuator devices, acoustic delay lines, piezoelectric resonators and filters, high frequency piezoelectric devices-surface, acoustic wave devices.

Books Recommended:

1. SM Sze Wiley (1985) Semiconductors devices-physics technology
2. M.S.Tyagi Introduction to semiconductors devices
3. M Sayer and A Mani Singh Measurement instrumentation and experimental design in physics and engineering
4. Ajoy Ghatak and Thyagrajam Optical Electronics
5. R P Jain Modern Digital Design

Electronic Devices

Course outcome:

CO1: Detailed information regarding various electronic devices and their applications shall enable students develop Electronic circuits for electronic applications.

CO2: Develop ability to understand different photonic and Microwave devices for photonic and microwave applications.

CO3: Shall provide concepts of memory devices and electro- optics devices and their Applications and thus enable students to understand electronic devices and computer system.

M.Sc.(Physics) Semester-I
Choice Based Credit System

Generic Elective Paper GE-1 : **MATHEMATICAL PHYSICS**

Paper IV Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Differential equations : Recurrence relation, generating functions and orthogonality of Bessel functions of first and second kind, Hermite, Legendre, Associate Legendre and Laguerre Polynomials. Curvilinear co-ordinate system with specific cases of Cartesian, Cylinderical and Spherical coordinate systems.

Unit II

Integral transforms. Fourier integral. Fourier transform and inverse Fourier transforms. Fourier transform of derivatives. Convolution theorem. Elementary Laplace transforms. Laplace transform of derivatives. Application to a damped harmonic oscillator.

Unit III

Green's functions : Non-homogenous boundary value problems, Green's function for one dimensional problems, eigen function expansion of Green's function, Fourier transform method of constructing Green's function, Green's function for electrostatic boundary value problems and quantum-mechanical scattering problem.

Unit IV

Complex variables: Analyticity of complex functions. Cauchy Riemann equations. Cauchy theorem. Cauchy integral formula. Taylors, Maclaurin, Laurent series & mapping. Theorem of residues. Simple cases of contour integration. Jordan's lemma Integrals involving multiple valued unctions (Branch points).

Unit V

Introduction to Tensors: n-dimensional space, coordinate transformations, Indicial and summation conventions, Kronecker delta symbol, tensors of higher rank. Algebric operations on tensors, Quotient law; symmetric and anti-symmetric tensors, line element, metric tensor, covariant, contravariant and mixed, fundamental tensor. Christoffel symbols and their transformation laws, geodesics and its equation, Riemann-Christoffel's tensor its properties, covariant curvature tensor and its properties, contraction of Riemann Chrostoffel tensor, Bianchi identities

Books Recommended:

1.	L.A.Pipes	Mathematics of Engineers and Physicists
2.	Arfken	Mathematical Methods for Physicists
3.	P.K.Chattopadhyay	Mathematical Physics
4.	H.K.Das	Mathematical Physics
5.	Ghatak, Goyal & Guha	Mathematical Physics
6.	M.R.Spiegel (Schaum Series)	Complex variable & Laplace Transform

Mathematical Physics

Course outcome:

CO1: Shall provide detailed information about various mathematical functions and thus shall develop ability to understand various basic concepts of Physics.

CO2: Ability developed to solve integral and inverse Fourier and Laplace transforms.

CO3: Develop ability to analysis complex functions and multivalued functions.

CO4: Shall provide concepts of Tensorial quantities.

M.Sc.(Physics) Semester-II
Choice Based Credit System

Core Paper C-4 : **QUANTUM MECHANICS-II**
Paper V

Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners
Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I
Approximation method for bound states : Rayleigh-Schrodinger Perturbation theory of non-degenerate and degenerate levels and their application to perturbation of an oscillator, normal helium atom and first order stark effect in hydrogen. Variation method and its application to ground state helium, W K B Approximation method, connection formulae ideas on potential barrier with applications to theory of alpha decay.

Unit II
Time dependant perturbation theory : Methods of variation of constants and transition probability, adiabatic and sudden approximation, wave equation for a system of charged particles under the influence of external electromagnetic field, absorption and induced emission, Einstein's A and B coefficients and transition probability.

Unit III
Theory of Scattering, Physical concepts, scattering amplitude, scattering cross section. Born Approximation and partial waves, scattering by perfectly rigid sphere, complex potential and absorption, scattering by spherically symmetric potential, identical particles with spin, Pauli's spin matrices.

Unit IV
Schrodinger's relativistic equation (Klein-Gordon equation), Probability and current density, Klein-Gordon equation in presence of electromagnetic field, hydrogen atom, short comings of Klein-Gordon equation, Dirac's relativistic equation for free electron, Dirac's Matrices. Dirac's relativistic equation in electromagnetic field, negative energy states and their interpretation hydrogen atom, hyperfine splitting.

Unit V

Theory of Aharonov-Bohm experiment, variational methods; Variational principle, Helium atom, Hydrogen molecule, Ion Scattering theory : Partial waves, Determination of phase - shifts, Hard sphere scattering, Low energy scattering, Resonances.

Books Recommended:

1. LI Schiff — Quantum Mechanics
2. S. Gasiorowicz — Quantum Physics
3. B.Craseman and J J Powell — Quantum Mechanics (Addison Wessley)
4. A.Messiah — Quantum Mechanics
5. J.J. Sakurai — Modern Quantum Mechanics
6. Mathews and Venkatesan — Quantum Mechanics
7. A.K. Ghatak and Loknathan — Quantum Mechanics

Quantum Mechanics – II

Course outcome:

CO1: Ability to apply Born approximation to different scattering problems, i.e., square well potential and Yukawa Potentials, etc.

CO2: Ability to use variational techniques to solve quantum mechanical problems.

CO3: Ability to understand scattering by Born approximation, Partial Wave analysis and solve problems.

M.Sc.(Physics) Semester-II
Choice Based Credit System

Core Paper C-5 : **STATISTICAL MECHANICS**
Paper VI

Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Foundation of statistical mechanics, specification of states of a system contact between statistics and thermodynamics, classical ideal gas entropy of mixing and Gibb's paradox. Microcanonical ensemble, phase space, trajectories and density of states, Liouville theorem, canonical and grand canonical ensembles, partition function, calculation of statistical quantities, energy and density fluctuations.

Unit II

Statistics of ensembles, statistics of indistinguishable particles, density matrix Maxwell - Boltzmann, Fermi Dirac and Bose - Einstein statistics, properties of ideal Bose gases, Bose - Einstein condensation, properties of ideal Fermi gas, electron gas in metals, Boltzman transport equation.

Unit III

Cluster expansion for a classical gas, virial equation of state, mean field theory of lsing model in 3,2 and 1 dimension. Exact solution in one-dimension.

Unit IV

Thermodynamics fluctuation spatial correlation Brownian motion, Langevin theory, fluctuation dissipation theorem, the Fokker-Planck equation, Onsager reciprocity relations.

Unit V

Phase transition: phase transition of first and second kind, critical exponent, Yang and Lee theory, Production of low temperature, Approach to absolute zero by adiabatic demagnetization, measurement of low temperature Landau's theory Critical exponents.Order parameter fluctuation in Gaussian approximation.Scale invariance.

Books Recommended
:

1.	F.Reif	Statistical and thermal Physics
2.	K Huang	Statistical Mechanics
3.	R.K.Pathria	Statistical Mechanics
4.	R Kubo	Statistical Mechanics
5.	Tandan	Statistical Physics

Statistical Mechanics

Course outcome:

CO1: Understanding the concepts of various ensembles in classical and quantum statistics and applicability

CO2: Understanding the concepts of various ensembles in classical and quantum statistics and applicability.

C03: Supper fluid nature of liquid helium and understanding of various phenomena.

M.Sc.(Physics) Semester-II
Choice Based Credit System

Core Paper C-6 : **ELECTRODYNAMICS & PLASMA PHYSICS**
Paper-VII

Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Field & potential due to quadrupole, Poisson and Laplace equations, field between two coaxial cylinders, multipole expansion of a charge distribution, uniqueness theorem, method of images, point source in front of infinite conducting plane, point source within two intersecting planes, Inversion in a sphere (grounded sphere, sphere not grounded), Laplace in spherical coordinates, Dielectric polarization, Gauss law in presence of dielectric, Clausius Mossotti equation.

Unit II

Biot-Savart's law, Ampere's circuital law and application to simple problems (circular loop and straight parallel conductors) magnetic vector potential, field from a circular loop using vector potential, concept of guage and gauge transformations, the magnetic dipole, Faradaya law of electromagnetic induction, Maxwell displacement current, Maxwells equations (integral and differential forms). Power/energy flow, plane waves, Helmholtz equation, Poynting vector, wave propagation in free space dielectric and conducting media.

Unit III

Plane waves in a non-conducting medium, linear and circular polarization, reflection and refraction of e.m.waves at the interface of a non-conducting media. Total internal reflection, waves in conducting medium electric dipole field and radiation, magnetic dipole field. retarded potential, Lenard Wiechert potential and field for a moving point charge, Larmor's radiation formula.

Unit IV

Elementary concept of occurrence of plasma. Gaseous and solid state plasma. Production of gaseous and solid state plasma. Plasma parameters. Plasma confinement pinch effect instability in

a pinched-plasma column. Electrical neutrality in a plasma. Debye screening distance. Plasma oscillations: Transverse oscillations and longitudinal oscillations.

Unit V

Domain of Magnetohydrodynamics and plasma Physics : Magneto-nydrodynamic equations, magnetic hydro-static pressure hydrodynamic waves : Magneto-sonic and Alfven waves, particle orbits and drift motion in a plasmas, Experimental study of Plasma, the theory of single and double probes.

Books Recommended:

1. Bitteneerort — Plasma Physics
2. Chen — Plasma Physics
3. Gupta, Kumar, Singh — Electrodynamics
4. Sen — Plasma State and matter
5. Jackson — Classical electrodynamics
6. Pamolsky & Philips — Classical electricity and Magnetism

Electrodynamics and Plasma Physics

Course outcome:

CO1: Electrodynamics and plasma physics belong to basic research disciplines that have many different areas of applications; students will be well acquainted with fundamental and applied aspects

CO2: A student shall be equipped with strong foundations of electrodynamics and plasma physics which will help to understand theories of communication electronics, dielectrics, radio wave propagation and various properties of plasma.

M.Sc.(Physics) Semester-II
Choice Based Credit System

Generic Elective: Paper GE-2 : **ATOMIC & MOLECULAR PHYSICS-I**
Paper-VIII

Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Quantum states of one electron atom. Atomic orbital. Hydrogen spectrum, Paulis principle, Spectra of alkali elements, Spin orbit interaction and line structure of alkali Spectra. Methods of molecular quantum mechanics, Thomas Fermi statistical model, Hartree and Hartree fock method, Two electron system. Interaction energy in L-S and J-J coupling, hyperfine structure (qualitative), line broadening mechanisms (general ideas).

Unit II

Types of molecules. Diatomic linear. Symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules as a rigid rotator, Energy level and Spectra of non-rigid rotator, intensity of rotational lines.

Unit III

Vibrational energy of diatomic molecule, diatomic molecule as a simple harmonic oscillator, Energy levels and spectrum, Morse potential energy curve, Molecules as vibrating rotator, Vibration spectrum of diatomic molecule PQR branches, IR spectrometer (qualitative).

Unit IV

Introduction to ultraviolet, visible and infra-red spectroscopy, Raman spectroscopy; Introduction, pure rotational and vibrational spectra, Techniques and instrumentation, Photo electron spectroscopy, elementary idea about photoacoustic spectroscopy and Mossbauer spectroscopy (principle).

Unit V

Group Theory - concept of group, symmetry groups of square, multiplication table of C_{4v} representation theory of finite groups. Properties of representation of a group, reducibility of a

representation, Theorem on representation. Irreducible representation. Schur's Lemma 1 & 2 and orthogonality theorem, characters of a representation, orthogonality of characters, the character table of C_{2V}, C_{3V}, & C_{4V} Point groups, Application of group theory to molecular vibration.

Books Recommended:

1.	H.E. White	Introduction to atomic spectra
2.	C.B. Banwell	Fundamental of molecular spectroscopy
3.	Walker and Strnghem	Spectroscopy Vol. I, II and III
4.	G.M. Barrow	Introduction to molecular spectroscopy
5.	Herzberg	Spectra of diatomic molecules
6.	Jeanne L and McHale	Molecular Spectroscopy
7.	J.M.Brown	Molecular Spectroscopy
8.	P.F. Bemath	Spectra of atoms and molecules
9.	J.M.Halian	Modern Spectroscopy

Atomic and Molecular Physics

Course outcome:

CO1: To understand the basic mechanism taking place inside the atom and molecule.

CO2: To understand the spectrum of Hydrogen like atoms, molecular structure and Spectroscopy.

CO3: To distribute electrons in elements and to analyze/interpret rotational and vibrational spectra.

CO4: Shall provide concepts of spectroscopy and their applications.

M.Sc.(Physics) Semester-III
Choice Based Credit System

Core Paper C-7 : **NUCLEAR AND PARTICLE PHYSICS**

Paper-IX Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Nuclear Interaction and Nuclear reaction:

Nuclear forces, exchange and tensor forces, meson theory of nuclear forces, Low-energy n-p scattering and spin dependence of n-p forces. Direct and compound nuclear reaction mechanism, reciprocity theorem.

Unit II

Accelerators of charged particles:

Study of cyclotron, phase stability, frequency modulated cyclotron (synchorocyclotron) magnetic induction accelerator (Betatron), Electron synchrotron and linear accelerator (Linac).

Unit III

Nuclear models:

Liquid drop model, Bohr-wheeler's theory of nuclear fission, shell model, spin orbit interaction, magic number, spin and angular momenta of nuclear ground state, nuclear quadrupole moment.

Unit IV

Nuclear decay and elementary particles:

β Decay, general features of β ray spectrum, Fermi theory of β decay, selection rules, parity in β decay, multipole radiation, internal conversion, nuclear isomerism.

Unit V

Elementary particles:

Classification of elementary particles, fundamental interaction, parameters of elementary particles. Symmetry and conservation laws, symmetry schemes of elementary particles SU(3).

Books Recommended:

1. Introduction to Nuclear physics : H.A. Enge
2. Nuclear radiation detectors : S.S.Kapoor and V.S.Ramamurthy
3. Atomic and Nuclear Physics : S.N.Ghoshal
4. Nuclear and Particle Physics : D.C. Tayal
5. Nuclear Physics : R.C. Sharma
6. Introduction to Nuclear Physics : Krane
7. Nuclear physics Principles & Application : Lilley

Nuclear and Particle Physics

Course outcome:

CO1: Understand the basic nuclear properties and phenomena.

CO2: Understand the nuclear transformations.

CO3: Understand the nuclear reactions mechanism.

CO4: Understand about the elementary particles and their quantum number.

CO5: Understand accelerator technology applied to high energy physics.

M.Sc.(Physics) Semester-III Paper-IX
Choice Based Credit System

Core Paper C-8 : **CONDENSED MATTER PHYSICS**
Paper-X Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Crystal Structure : Bravais lattice in two and three dimension. Simple crystal structures: Hexagonal close packed structure, Diamond structure, zinc blende structure, chloride structure, cesium chloride structure.

Unit II

Crystal diffraction by X-Ray:
Reciprocal lattice, Reciprocal lattice of bcc and fcc lattice. Relation between crystal lattice axes and crystal reciprocal lattice axes. Bragg diffraction. Condition in term of reciprocal lattice vector. Brillouin zones.

Unit III

Elastic properties of solids:
Stress and strain components, elastic compliance and stiffness constants, elastic energy density, reduction of number of elastic constants, elastic stiffness constants for isotropic body, elastic constant for cubic isotropic bodies, elastic waves, waves in (100) direction, experimental determination of elastic constants.

Unit IV

Lattice vibration and phonons:
Lattice dynamic of a diatomic linear lattice. Lattice vibrational spectrum. The concept of phonons momentum of phonons. Inelastic scattering of photons by phonons. Inelastic scattering of neutrons by phonons. Inelastic scattering of X-Ray.

Unit V

Thermal properties and band theory of solids:

Anharmonicity, thermal expansion, thermal conductivity, equation of state of solids, gruneisen constant. Band theory, classification of solids, concepts of effective mass. Fermi surfaces, anomalous skin effect, De Hass van alphen, cyclotron resonance, magneto resistance.

Books Recommended:

1. Verma and Srivastava : Crystallography for solid State physics.
2. Azaroff: Elementary to Solids.
3. Omar: Introduction Solid State Physics
4. Kittle : Solids State Physics
5. Huang : Theoretical Solids State Physics
6. Weertman and weertman : Elementary Dislocation Theory
7. Buerger : Crystal Structure Physics.
8. Maudelung : Introduction to solid State Physics.

CONDENSED MATTER PHYSICS

Course outcome:

CO1: Knowledge and understanding of solid state materials for their basic properties and possible technological applications.

CO2: Shall enhance the knowledge of students regarding thermal properties and elastic properties.

CO3: The use of fundamental properties and other well developed mechanisms / theories of solid state materials for their better applications in various technological fields.

M.Sc.(Physics) Semester-III
Choice Based Credit System

Discipline Centric
Elective Paper DCE-1 :**DIGITAL ELECTRONICS**
Paper-XI(I) Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Codes : BCD, Gray, ASCII, EBCDIC, Demorgans theorem, Gates:OR, AND, NOT, NOR, OR, NAND, XOR, XNOR, Boolean algebra, Karnaugh map.

Unit II

Logic Family of gates, TTL circuits - TTL AND, OR, NOT, NAND AND NOR gates Totempole, open collector and Tristate Configuration Adder and Subtractor circuit Design. Multiplexers and Demultiplexers Encodes and decoders.

Unit III

Flip-Flops : R-S,D, J-k, J-k Master slave flip flop, race around condition registers, shift registers (left and right shift)

Unit IV

Counters-asynchronous (ripple) counter, synchronous (parallel) counter, MOD-5 counter and MOD-10 counter, BCE counter, Up-Down counter, Shift Register counter (Ring counter)

Unit V

Digital to analog conversion (Binary weighted register method, R-2R ladder network method, single slope, equal slope, successive approximation ADC)

Books Recommended:

1. A.P.Malvino and Donald P.Leach. Digital principles and applications Tata Mcgraw- Hill company, New Delhi, 1993
2. Ramesh S.Gaonkar Microprocessor Architecutre, Programming and Applications with 8085/8086 by, Wiley-Eastern Ltd. 1987.
3. Digital Electronics-S.N.Ali
4. Digital Electronics-Morris Mano
5. Microprocessor and Microcomputers-B.Ram-Dhanpat Rai publication V edition.

Digital electronic

Course Outcome:

CO1. This course shall will the capability the students to words the Hardware design and Software application of computer system.

CO2. Shall give the concepts of logic gates and various combinational logic circuits.

CO3. Ability to understand various sequential logic circuits including register and counter circuits among students.

CO4. It will give an idea of interfacing circuits of basic micro processing circuits.

M.Sc.(Physics) Semester-III
Choice Based Credit System

Discipline Centric
Elective Paper DCE-2 : **Energy Physics**
Paper-XI(II) Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners
Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Fossil fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An over view of developments in offshore wind energy, Tidal energy, Wave energy systems, Ocean Thermal energy conservation, Solar energy, biomass, biochemical conservation, biogas generation, geothermal energy, tidal energy, hydroelectricity.

Unit II

Biomass energy- classification-photosynthesis-biomass conversion process-gobar gas plants-wood gasification-ethanol from wood- advantages and disadvantages of biomass as energy source. **Geothermal energy**, Geothermal sources, Geothermal techniques, wind energy fundamental of wind energy, wind turbines and different electrical machines in wind turbines, Power electric interfaces and grid connection topologies. Ocean thermal energy conversion (OTEC)-energy from waves and tides (basic ideas, nature, applications, merits and demerits of these)., wave energy devices

Unit III

Solar energy: Solar energy ,its importance, storage of Solar energy, solar pond, non convective solar pond, application of solar pond and Solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, working principle and characterization, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems,PV models and equivalent circuits, and sun tracking system.Carbon captured technologies, cell battries, power as consumption, environmental issues and Renewable sources of enegy, sustainability.

Unit IV

Hydro energy: Hydropower resources, Hydropower technologies, environmental impact of Hydropower sources.

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of Piezoelectric effect, materials and mathematical description of Piezoelectricity, Piezoelectric parameter and modeling Piezoelectric generators, Piezoelectric energy harvesting applications, Human Power.

Unit V

Energy Storage and Impact of non-conventional energy: Conversion of energy-pattern of energy consumption in domestic ,industrial, transpotation, agricultural sectors- conservation principles in these sectors-energy crisis and possible solutions-energy options for the developing countries-energy storage and hydrogen as a fuel(basics)-impact due to non -conventional energy sources-global warming.

Books Recommended:

1. Solar energy G.D. Rai ,Ed. V. 1995.
2. Solar energy S.P.Sukhatme, Tata McGraw- Hill publishing company ,Ed.II,1997.
3. Non conventional Energy sources, G.D.rai,4th edition ,1997
4. Energy Technology S. Rao and Dr.B.B.Parulekar 2nd edition,1997
5. Power plant technology A.K.Wahil,1993
6. Renewable energy : Power for a sustainable future Godfery Boyle ,Alden Oess Ltd.,Oxford ,1996
7. Energy Model for 2000 and beyond Jyoti Parikh, , Tata McGraw- Hill publishing company , New Delhi,1997

Energy Physics

Course Outcome:

Co1: Provide knowledge of alternate sources of energy among students and enable their capability in building energy systems using such sources.

Co2: Shall give concepts of biomass and geothermal energy source.

Co3: This course shall make aware the students about solar energy and its application in developments of photo voltaic system.

Co4: Give knowledge about hydro energy and harvesting.

M.Sc.(Physics) Semester-III

Choice Based Credit System

Discipline Centric
Elective Paper DCE-3 : **Space Technology**
Paper-XI(III) Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail witha focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners
Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit 1

Basic Concepts of Earth's Atmosphere Atmospheric nomenclature, Hydrostatic equation scale height, Geopotential height, Exosphere and gaseous escape, Chemical concepts of atmosphere, Thermodynamic considerations, elementary chemical kinetics composition and chemistry of middle atmosphere and thermosphere. Thermal balance in the atmosphere, models of neutral atmosphere (CIRA, US Standard atmosphere)

Unit 2

Solar Radiation and its Effects on the Atmosphere Solar radiation at the top of the atmosphere, Attenuation of solar radiation in the atmosphere, radiative transfer, thermal effect of radiation, photochemical effects of radiation, Airglow Structure and Variability of Earth's Ionosphere Introduction to ionosphere, photochemical processes, Chapman's theory of photo ionization, production of ionospheric layers, loss mechanisms and chemistry of ionospheric regions, morphology of the ionosphere

Unit 3

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

Unit 4

Elements of Solar Physics Structure and composition of the Sun, sun as a source of radiation, sunspots an solar cycles, solar flares, coronal mass ejection Magnetosphere of Earth Solar wind and its characteristics, Interplanetary magnetic field and sector structure, Formation of geomagnetic cavity, magnetopause, magnetosheath and bow shock, polar cusp and magnetotail, Plasmasphere and Van Allen radiation belts

Unit 5

Concepts and Foundations of Remote Sensing Energy sources and Radiation principles, Energy interactions in the atmosphere, energy interactions with earth surface features, Data acquisition and Interpretations, Reference data, The Global Positioning System An ideal remote sensing system, Characteristics of real remote sensing system, Practical applications of remote sensing, Land and Geographic Information System

Books Recommended:

1. Physics of the Space Environment T.I. Gombosi, (CUP)

2. The Solar-Terrestrial Environment: JK. Hargreaves (CUP)

3. Remote Sensing and Image Interpretation: T.M. Lillesand and R.L. Kiefer, (John Wiley & Sons, 4th Edition)

Space Technology

Course Outcome:

CO1: Students will understand the basic laws of Physics governing the satellites in its orbits with their Applications.

CO2: How the power is generated in space? Powers storage devices and deep space requirements will be very interesting for them. Students will also learn about the ground and space based observation techniques.

CO3: Students will understand about the space technology and its application in Earths and space environments.

M.Sc.(Physics) Semester-III
Choice Based Credit System

Discipline Centric

Elective Paper DCE-4 : **Remote Sensing & Applications**

Paper-XI(IV) Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit 1

Elements of Photographic Systems Early history of Aerial photography, Basic negative to positive photographic sequence, Film exposure, Film density and characteristic curves, structure & Spectral sensitivity of black and white, color and color infrared films, film resolution, Aerial cameras, filters, electronic imaging, multiband imaging

Unit 2

Principles of Photogrammetry Basic geometric characteristics of aerial photograph Photographic scale, Area measurement, Relief displacement of vertical features, image parallax, measurement of object height and ground coordinate, Mapping with aerial photographs

Unit 3

Visual Image Interpretation Fundamentals of visual image interpretation, Basic visual image interpretation equipment, Land use/land cover mapping, Geologic and soil mapping, Forestry mapping, water resources and wetland mapping

Unit 4

Multispectral and Thermal Scanning Across tack and along track scanning, Operating principles of multi spectral scanners, Across track thermal scanning, thermal radiation principles, interpreting thermal scanner imagery, Radiometric calibration of thermal scanners. Temperature mapping with thermal scanner data

Unit 5

Digital Image Processing Introduction, Image rectification and restoration, Image enhancement, contrast manipulation, spatial feature manipulation, image classification, different classification schemes, Classification accuracy assessment, Image transmission and compression Earth Resources Satellites Early history of space imaging Landsat 1-4 system, Landsat image interpretation, SPOT satellite program, IRS system, data and applications

Books Recommended:

1. Remote sensing and image interpretation. T.M. Lillesand and R.W. Kiefer (4th ed.) John Wiley and Sons, 2002

2. Fundamentals of Remote Sensing – George Joseph Univ. Press

Remote sensing and Applications

Course Outcome:

CO1: Students will have thorough idea about the various types of camera and sensors used in remote sensing.

CO2: They will also be able to understand the defects and its solutions in the space borne images.

CO3: Students will be able to interpret the remote sensing images for different aspects.

M.Sc.(Physics) Semester-III
Choice Based Credit System

Generic
Elective Paper GE-3 : **Informatics**

Paper-XII Max.Marks. 60
Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners
Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Concept of information and its unit, difference between data and information, features of information. Average Information and Information rate. Data transmission concept-characteristics of data transmission circuits. Concept of analogue and digital signal in data transmission. Coding to increase average information per bit/per word. Shannon's theorem and channel capacity. Coding efficiency, Shannon Fano and Huffman coding procedures. Error detecting and correcting codes-Block and convolution codes.

Unit II

The Sampling theorem, Pulse Code Modulation (PCM)-concept of quantisation, quantisation error, companding, time division multiplexing, PCM system and its band width. Delta Modulation, Phase shift keying, Differential phase shift keying, quadrature phase shift keying, optimum modulation system based on information theory Modems.

Unit III

Organisation of Digital computer, Brief overview of input and output devices, CPU-evolution of microprocessors, Semiconductor memories (RAM and ROM) : organisation and their

characteristics, Cache memory, CDROM, Magnetic disk, Software Concept : types of software and their features. System utility software. Role of software in information technology. Computer language : Features of low level and high level programming languages. Assemblers & compilers, generation of computer languages.

Unit IV

Concept of OS : basic functions and types of OS, Salient features of batch processing, on line processing, single use, multi user, time shared, multi tasking, multi programming and real time systems. Overview of UNIX concept of windows and their basic commands, elements of window NT, concept of booting, batch file, config, sys file, filtering, redirecting and piping.

Unit V

Introduction to communication network and their types, Elements of computer network and advantages. Design features of computer network (Line capacity allocation, routing procedure, flow control procedure). Classification of network-LAN, WAN and MAN. Network topologies-basic features of Bus, Hierarchical, Star Ring and Mesh topologies, Network protocols : seven layers of OSI reference model and its comparison with TCP/IP, History of internet and important features, basic services of internet-www, email, telnet, chat and news.

References

1. Information Technology-Satish Jain (BPB Publication)
2. Information Technology-V.P. Singh & M. Singh (Asian Publication)
3. Principles of Data communication – R.W. Lucky, J. Salz & E.J. Weldon Jr. (McGraw Hill Co.).
4. Principles of Communication Systems – H. Taub & D.L. Schilling (Tata McGraw Hill).
5. Communication Systems : Analog & Digital – R.P. Singh & S.D. Sapre (Tata McGraw Hill).
6. Modern Digital & Analog Communication Systems-B.P. Lathi (Oxford Univ. Press, N. Delhi).
7. Microprocessors and Microcomputers – B. Ram
8. Introduction to Microprocessors – A.P. Mathur
9. Computer Network : Protocol Standards and Interfaces – Uyless Black (PHI)

Informatics

Course Outcome:

Co1: Basic knowledge of various information systems and concepts of information transfer through remote methods will be provided.

Co2: It will provide information about computer anatomy.

Co3: Students shall learn concepts of O.S. and network technology

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Core Paper C-9: **LASER PHYSICS**

Paper-XIII Max.Marks. 60

Time Duration External Examination - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Basic principles of laser :

Introduction to laser, spontaneous and stimulated emission, Einstein coefficients. Idea of light amplification. Population invertion, laser pumping schemes for two and three level system with threshold condition for laser oscillation.

Unit II

Properties of Laser Beams and Resonators :

Properties of Laser Temporal coherence, spatial coherence, directionality and monochromatic of laser beam, resonators, vibrational mode of resonators, laser amplification, open resonator.

Unit III

Types of lasers :

Solid state lasers i.e.Ruby Laser, Nd-Yag Laser, Semiconductor laser, Gas laser i.e. Carbon dioxide Laser, He-Ne Laser, Basic idea about liquid laser, Dye laser and chemical laser i.e. HCL and HF lasers.

Unit IV

Application of Lasers :

Holography and its principle, theory of holograms, reconstruction of image, characteristics of Holographs, Application of lasers in chemistry and optics laser in Industry i.e.laser belding, Hole drilling, laser cutting, application of lasers in medicine.

Unit V

Basic idea about non-linear optics :

Harmonic generation, second and third harmonic generation, phase matching, optical mixing, parametric generation of light, self-focusing of light.

Books Recommended:

1. Laser-swelto
2. Optical electronics-Yarive
3. Laser spectra scopy-demtroder
4. Laser spectroscopy and Instrumentation Demotroder
5. Molecular spectra scopy - King
6. Non linear optics by B.B.Laud

LASER PHYSICS
Course Outcome:

Co1: Students shall understand through this course shall learn about concepts of lasers and its application in development of lasing system.

Co2: Students shall learn about basic concepts of non-linear optics for laser technology.

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Core Paper C-10: Modern Experimental Techniques
Paper-XIV Max.Marks. 60
Time Duration External Examination - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit 1

Radiation sources, Radiation interactions, Radiation detectors – gas filled detectors – scintillation detectors – semiconductor detectors

Unit 2

Introduction to production of X-ray & X-ray spectra, Instrumentation, X-ray generation, collimators, filters, detectors, X-ray absorption methods, X-ray fluorescence methods, XF – Spectrometer (XFS), Electron spectroscopy for chemical analysis (ESCA)

Unit 3

Nuclear Magnetic Resonance (NMR) spectroscopy, basic principles, nuclear magnetic energy levels, magnetic resonance, NMR Spectrometer Electron Spin Resonance spectroscopy, ESR spectrometer, ESR spectra, Hyperfine interactions

Unit 4

Mass spectroscopy – principle, spectrometer, and its operation, resolution, Mass spectrum, applications Infrared Spectroscopy, correlation of IR spectra with molecular structure, Instrumentation

Unit 5

Mossbauer Spectroscopy – Mossbauer effect, spectrometer, 57 Fe Mossbauer spectroscopy, nuclear hyperfine interactions Neutron diffraction, neutron diffractometer (position sensitive diffractometer)

Books Recommended:

1. Instrumentation Methods of analysis: VIIth Edition, Willard Meritt, Dean, Settle, CBS publishers & distributors

2. Mossbauer Spectroscopy : Leopold May, Plenum Press, N.Y.

3. Neutron Diffraction: G.C. Becon

4. X-Ray diffraction: B.D. Culity, Edison Weisley

5. Radiation Detection & Measurement: Glenn F. Knoll, McGraw Hill

Modern Experimental Techniques

Course Outcome:

Co1: Capability of students in experiments as tools for research activities shall be developed.

Co2: Various types of analylitical techniques would be learned in the students like, nuclear techniques, Condensed matter techniques and spectroscopic techniques.

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Discipline Centric

Elective Paper DCE-5 : **Advanced Electronics**

Paper-XV(I) Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

OP-AMP :

Differential amplifier circuit configurations : dual input balanced output dual input, single input unbalanced output (ac analysis) only, block diagram of a typical op amp analysis, schematic symbol of an op-amp.

Unit II

OP-AMP Parameters : Ideal op-amp.; Op-amp parameters; input offset voltage, input offset current, input bias current, CMRR, SVRR, large signal voltage gain, Slew rate, Gain band width product, output resistance supply currents power consumption, inverting and non-inverting inputs.

Unit III

Application of OP-AMP :

Inverting and non-inverting amplifier, summing, scaling and averaging amplifier, integrator and differentiator. Oscillator Principles: oscillator types, frequency, stability response, the phase shift oscillator, Wein-bridge oscillator, L-C tunable oscillator, square wave generator.

Unit IV

Microprocessors and Micro Computers :

Microprocessor and Architecture : Intel 8086, Microprocessor architecture modes of memory addressing, 8086/8088 Hardware specification : Pin-outs and pin functions, clock generator (8284A) Bus buffering and latching, Bus timing, Ready and wait state, Minimum mode versus maximum mode.

Unit V

Programming the Microprocessors :

Addressing modes : Data addressing modes, program memory addressing modes, stack memory-addressing modes. Instruction set; data movement Instruction, Arithmetic and login instructions, program control instruction.

Books Recommended:

1. Digital Principles and Application : A.P.Malvino & D.P.Leech
2. Op-Amps & Linear Integrated circuits : R.A. Gayakwad
3. Electronics : D.S. Mathur
4. Digital Principles & Applications : Malvino & Leech
5. Microprocessor Architecture, Programming & Applications with 8085/8086 : R.S.Gaonker
6. Microprocessor & Digital Systems : D.V.Hall
7. Fundamental of Electronics : Borker

Advanced Electronics

Course Outcome:

Co1: Students shall gain knowledge about linear integrated circuits with emphasis to operational capabilities and their applications.

Co2: Micro processors concepts would be build among students.

Co3: Detailed H/W knowledge of 8086 ups and assembly language programming shall lead students to design dedicated / general purpose circuits

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Discipline Centric

Elective Paper DCE-6 : **Astrophysics**

Paper-XV(II) Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Observational data : Astronomical coordinates, determination of mass, rating, luminosity, temperature and distance of a star, steller classification and its interpretation, H.R. diagram of clusters, empirical mass luminosity relation.

Unit II

Physical characteristics of the sun, basic data, solar relation and solar magnetic field. Quiet Sun : Photosphere, hydrogen convection zone and granulatin, chromosphere, spicules, corona. Active sun : development of centre of activity, sunspots, prominences and lares. Theory of the general solar magnetic field, sunspot and solar flares, solar wind, solar radiations, solar X – radiation.

Unit III

Stellar interior, Energy generation in stars, contraction hypothesis. Nuclear Processes, P-P and C-N Cycles, reaction rates. Evolution of stars premain sequence, main sequence and post-main sequence stages.

Unit IV

Dense stars, white dwarfs, internal structure, mass-radius relation, mass limit, sources of energy, neutron stars. Variable stars, Pulsating stars, velocity and light curves, classification, dynamics of steller pulsation, Novae and Super-Novae, Crab Nabula, optical, radio and X-ray emission.

Unit V

Galaxies, classification, Milky way, Rotation, Galactic cluster, Peculiar galaxies, Models of the Universe, Radio astronomy, Pulsars, Quasars, Microwave background radiation, X-ray sources.

Books Recommended:

1. Source Book of Space Physics - Glasstone
2. Space Science & Earth Environment – S.S. Degaonkar
3. Star and Planet – Abbeti
4. The Sun – Abbeti
5. Solar Terrestrial Physics-Akasofu and Chapman
6. Astronomy-D.H. Menzel
7. The State of Universe-Ed. By G. Bath
8. Astronomy-Baker
9. Articles from Journals, Space Science Reviews.

Astrophysics

Course Outcome:

Co1: To develop ideas about the evolution of with special emphasis on the sun & various associated phenomena.

Co2: To develop basic concepts of astronomical observations & idea about Galaxies, Universe & associated process.

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Discipline Centric

Elective Paper DCE-7 : **Environmental Physics**

Paper-XV(III) Max.Marks. 60

Time Duration - 3 Hours Min. Marks. 21

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I - **Essential of Environmental Physics**

Structures and thermodynamics of atmosphere. Composition of air. Green house effect. Transport of matter, energy and momentum in nature. Stratification and stability of atmosphere. Laws of motion, hydrostatic equilibrium .General circulation of Tropics. Elements of weather and climate of India.

Unit II **Solar and Terrestrial Radiation**

Physics of radiation. Interaction of light with matter .Rayleigh and Mie scattering. Laws of Radiation (Kirchhoff's law, Plank's law, Wien's displacement law, etc.)

Solar and Terrestrial spectra. UV radiation. Ozone depletion problem. IR absorption energy balance of the earth atmospheric system

Unit III - **Environmental Pollution and Degradation**

Elementary Fluid Dynamics .diffusion, Turbulence and turbulent diffusion. Factors governing air, water and noise pollution. Air water quality standards. Waste disposal .heat and Island effect .Land sea Breeze. Puffs and plumes. Gaseous and particulate matters .wet and dry deposition.

Unit IV – **Environmental changes Remote sensing**

Energy sources and combustion processes .Renewable sources of energy. Solar energy, wind energy, bio-energy, hydropower, fuel cells, nuclear energy. Forestry and bioenergy.

Unit V **Global and Regional Climate**

Elements of weather and climate .Stability and vertical motion of air. Horizontal motion of air and water .Pressure gradient forces .viscous forces .Reynold number .Enhance green house effect. Energy balance -a -zero- dimensional Green house model .Global climate models.

Books Recommended:

1.Egbert Booeker &Rienk van Groundelle, Envionmental Physics (John Wiley).
2.J.T.Houghton :The Physics of Atmosphere (Cambridge University Press ,1977).
3. J Twidell and J.weir : Renewable energy sources (ELBS 1988).
4. Sol wieder : An Introduction of Solar energy for Scientists and engineers(John iley 1982)
5. R,N,Keshav murthy and M. Shankar Rao: The Physics of Monsoons (Allied Publishers, 1992)
6. G.J.Haltiner R.T. Williams: Numerical Weather Prediction (John Wiley 1980)

Environmental Physics

Course Outcome:

Co1: To create awareness about the solar & terrestrial radiation & associated environmental changes

Co2: To develop the concepts of weather & climate in relation to near earth & space weather concept.

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Discipline Centric
Elective Paper DCE-8 : **Physics of Nano Materials**
Paper-XV(IV) Max.Marks. 60
Time Duration - 3 Hours
Min. Marks. 21

Course Objectives: Tensors have their applications to Riemannian Geometry, Mechanics, Elasticity,Theory of Relativity, Electromagnetic Theory and many other disciplines of Science and Engineering. Theaim of this course is to study fundamental concepts of tensor and tensor analysis.

Instruction to Examiners
Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

Length scales in Physics, Nanostructures: 1D, 2D and 3D nanostructure (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation – Infinite potential well, potential step potential box, quantum confinement of carries in 3D, 2D, 1D nanostructures and its consequences.

Unit II

Top-down & bottom-up approaches; Formation of nanostructure by ball milling, Chemical Vapor Deposition, Physical Vapor Deposition, Pulsed Laser Ablation technique, Chemical Route of Synthesis: Chemical Precipitation and Co-precipitation, Chemical Bath Depostion, Sol-Gel Synthesis, Micro Emulsion, Solvothermal Synthesis, Spray Pyrolysis and Combustion Technique.

Unit III

X Ray Powder & Single Crystal Diffraction (XRD), X-Ray Fluorescence (XRF), X-Ray Photoelectron Spectroscopy (XPS), Energy Dispersive X-Ray Analysis (EDAX), Nuclear Magnetic Resonance (NMR) & Raman Spectroscopy, Auger Electron Spectroscopy (AES),

Differential Scanning Calorimetry (DSC)-Principle of operation, Instrumentation and application of each.

Unit IV

Scanning Tunneling Microscopy (STM), Contact & Non-Contact Atomic Force Microscopy (AFM), Magnetic Force Microscopy (MFM), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier Transform Infrared (FTIR), Spectrophotometer, Photo Luminescence (PL), UV-visible Spectrophotometer, Electron Energy Loss Spectroscopy (EELS), Electron Probe Micro Analyzer (EPMA) – Principle of operation, Instrumentation and application of each.

Unit V

Quantum wells, Wires & Dots, Organic Semiconductors, Molecular Switches, Motor Molecules & Biometric Components, nano Robots and NEMS, Sensors & Actuators, Biomotors, Gas Sensors, Pollution Sensors, Biosensors, CNT based Fluid Velocity Sensors, Nanomaterials in Drug Deliver: Targeting Ligands, Cancer Treatment, nanonephrology, Nanosurgery.

References

1. Nanomaterials: Synthesis, properties, characterization and applications: A.S. Edelstein and R.C. Cammaratra
2. Nanoelectronics and Nanosystems: Karl Goser, Peter Glosekotter, Jan Diensthuhl, Springer, 2004
3. Handbook of Analytical Instruments, R.S. Khandpur
4. Elements of X-ray Diffraction, B.D. Cullity
5. Thermal Methods of Analysis: W.W. Wendlandt
6. Encyclopedia of nanotechnology, H.S. Nalwa
7. Nanomaterial System: Properties & Applications: A.S. Edelstein and R.S. Cammaratra

Course Outcome:

CO1: A student will have clear basic concepts of nano-structured materials.

CO2: It is expected to train the students for synthesis of various nano-materials and various characterization methods.

CO3: Students shall appreciate the importance of nano-materials in various technological application like medical technology in treatment of various diseases.

M.Sc.(Physics) Semester-IV
Choice Based Credit System

Generic
Elective Paper GE-4: **ATMOSPHERIC SCIENCE**
Paper-XVI Max.Marks. 60
Time Duration 3 Hours Min. Marks. 21

Course Objectives: Tensors have their applications to Riemannian Geometry, Mechanics, Elasticity, Theory of Relativity, Electromagnetic Theory and many other disciplines of Science and Engineering. The aim of this course is to study fundamental concepts of tensor and tensor analysis

Instruction to Examiners

Paper shall consist of Two sections A & B. Paper Setter is required to set **ONE** short answer type question from each unit having internal choice in section A. Section B will consist of **FIVE** long answer type questions with **ONE** from each unit and student will answer any **THREE** questions. Each short answer questions shall be of 6 marks and long answer type question shall be of 10 marks.

Unit I

General features of Earth's atmosphere :

Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric. Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms.

Unit II

Atmospheric Dynamics :

Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

Unit III

Atmospheric Waves :

Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in shared flow, wave absorption, non-linear consideration.

Unit IV

Atmospheric Radar and Lidar :

Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

Unit V

Atmospheric Aerosols :

Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Bambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

Books Recommended:

1. Fundamental Atmospheric Physics : Murray L Salby; Academic Press, Vol. 61, 1996
2. The Physics of Atmosphere - John T. Houghton; Cambridge University Press. 3rd edition 2002.
3. An Introduction to dynamic meteorology-James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations - S Fukao and K Hamazu, Springer Japan, 2014

ATMOSPHERIC SCIENCE

Course outcome:

Co1: Students will be able to explain principle, characteristics and applications of different types of Cyclones and anticyclones and thunderstorms.

Co2: Students will be able to explain the instrumentation of Atmospheric Dynamics, waves and applications

Co3: Students will be able to explain different types of Atmospheric Radar and Lidar and Atmospheric Aerosols with their applications