VISVA-BHARATI

SIKSHA BHAVANA
(INSTITUTE OF SCIENCE)

INTEGRATED SCIENCE EDUCATION AND RESEARCH CENTRE
(ISERC)

Five-Year Integrated M. Sc.

STRUCTURE OF SYLLABUS APPROVED BY BOS OF ISERC ON 9TH FEBRUARY 2016
(With revisions regarding foundation courses approved by BOS of ISERC on 20TH January 2019)

FIRST YEAR

FIRST SEMESTER

Subject	Credit Points	Marks	Classes/week	Tutorials/week	Practical/week	Total classes/week
Chemistry	5	75 + 50 *	3	1	3	7
English	2	50	2	-	-	2
Life Science	5	75 + 50 *	3	1	3	7
Mathematics	5	75 + 50 *	3	1	3	7
Physics	5	75 + 50 *	3	1	3	7
Tagore Studies	4	50	4	-	-	4
Total	**26**	**600**	**18**	**4**	**12**	**34**

SECOND SEMESTER

Subject	Credit Points	Marks	Classes/week	Tutorials/week	Practical/week	Total classes/week
Chemistry	5	75 + 50 *	3	1	3	7
Life Science	5	75 + 50 *	3	1	3	7
Mathematics	5	125	3	1	3	7
Physics	5	75 + 50 *	3	1	3	7
Social Science	2	50	2	-	-	2
Tagore Studies	4	50	4	-	-	4
Environmental Studies	2	25	2	-	-	2
Total	**28**	**625**	**20**	**4**	**12**	**36**

*Theory 75 marks and Practical 50 marks

SECOND YEAR

THIRD SEMESTER

Subject	Credit Points	Marks	Classes/week	Tutorials/week	Practical/week	Total classes/week
Chemistry	5	75 + 50 *	3	1	3	7
Life Science	5	75 + 50 *	3	1	3	7
Mathematics	5	75 + 50 *	3	1	3	7
Philosophy & History of Science-I	2	50	2	-	-	2
Physics	5	75 + 50 *	3	1	3	7
Total	**22**	**550**	**14**	**4**	**12**	**30**

FOURTH SEMESTER

Subject	Credit Points	Marks	Classes/week	Tutorials/week	Practical/week	Total classes/week
Chemistry	5	75 + 50 *	3	1	3	7
Life Science	5	75 + 50 *	3	1	3	7
Mathematics	5	125	3	1	3	7
Philosophy & History of Science-II	2	50	2	-	-	2
Physics	5	75 + 50 *	3	1	3	7
Total	**22**	**550**	**14**	**4**	**12**	**30**

*Theory 75 marks and Practical 50 marks

THIRD YEAR

FIFTH SEMESTER

Subject	Credit Points	Marks	Classes/ week	Tutorials/ week	Practical/ week	Total classes/week
Chemistry(Major)	14	200+150 *	8	2	3+3+3	19
Earth and Environmental Science (Major)	14	200+150 *	8	2	3+3+3	19
Life Science (Major)	14	200+150 *	8	2	3+3+3	19
Mathematics (Major)	14	350	8	2	3+3+3	19
Physics (Major)	14	200+150 *	8	2	3+3+3	19
*Additional Compulsory***	6	50+50+50	6	2	-	8
Advanced Computing	4	100			3+3	6
Total	**24**	**600**	**14**	**4**	**15**	**33**

*Theory 200 marks and Practical 150 marks.

** One from Major and two from the other subjects to be chosen. Choice bucket: (i) Analytical Chemistry-I, (ii) Principles of Soil Science, (iii) Developmental Biology, (iv) Mathematical Theory of Probability & Statistics, (v) Statistical Mechanics

SIXTH SEMESTER

Subject	Credit Points	Marks	Classes/ week	Tutorials/ week	Practical/ week	Total classes/week
Chemistry(Major)	14	200+150 *	8	2	3+3+3	19
Earth and Environmental Science (Major)	14	200+150 *	8	2	3+3+3	19
Life Science (Major)	14	200+150 *	8	2	3+3+3	19
Mathematics (Major)	14	300+50[#]	8	2	3+3+3	19
Physics (Major)	14	200+150 *	8	2	3+3+3	19
*Additional Compulsory***	6	50+50+50	6	2	-	8
Advanced Computing	4	100			3+3	6
Total	**24**	**600**	**14**	**4**	**15**	**33**

*Theory 200 marks and Practical 150 marks, [#]Theory 300 marks and Practical 50 marks

**One from Major and two from the other subjects to be chosen. Choice bucket: (i) Analytical Chemistry-II, (ii) Environmental Earth Science, (iii) Diversity of Life Forms, (iv) Mathematical Modeling, (v) Spectroscopy-I

FOURTH YEAR

SEVENTH SEMESTER

Subject	Credit Points	Marks	Classes/ week	Tutorials/ week	Practical/ week	Total classes/week
Chemistry(Major)	14	200+150 *	8	2	3+3+3	19
Earth and Environmental Science (Major)	14	200+150 *	8	2	3+3+3	19
Life Science (Major)	14	200+150 *	8	2	3+3+3	19
Mathematics (Major)	14	300+50[#]	8	2	3+3+3	19
Physics (Major)	14	200+150 *	8	2	3+3+3	19
*Additional Compulsory***	6	50+50+50	6	2	-	8
Advanced Computing	4	100			3+3	6
Total	**24**	**600**	**14**	**4**	**15**	**33**

*Theory 200 marks and Practical 150 marks, [#]Theory 300 marks and Practical 50 marks

**One from Major and two from the other subjects to be chosen. Choice bucket: (i) Polymer Science, (ii) Ecology, (iii)

Evolution, (iv) Integral Equations & Calculus of Variations, (v) Spectroscopy-II

EIGHTH SEMESTER

Subject	Credit Points	Marks	Classes/ week	Tutorials/ week	Practical/ week	Total classes/week
Chemistry(Major)	14	200+150 *	8	2	3+3+3	19
Earth and Environmental Science (Major)	14	200+150 *	8	2	3+3+3	19
Life Science (Major)	14	200+150 *	8	2	3+3+3	19
Mathematics (Major)	14	300+50#	8	2	3+3+3	19
Physics (Major)	14	200+150 *	8	2	3+3+3	19
*Additional Compulsory***	6	50+50+50	6	2	-	8
Advanced Computing	4	100			3+3	6
Total	**24**	**600**	**14**	**4**	**15**	**33**

*Theory 200 marks and Practical 150 marks, #Theory 300 marks and Practical 50 marks

**One from Major and two from the other subjects to be chosen. Choice bucket: (i) Renewable Energy, (ii) Hydrology and Water Management, (iii) Statistical Methods for Biology, (iv) Mathematical Ecology, (v) Fundamentals of Laser

FIFTH YEAR

NINTH SEMESTER

Subject	Credit Points	Marks	Classes/ week	Tutorials/ week	Practical/ week	Total classes/week
Chemistry (Major)	24	600	Dissertation			
Earth and Environmental Science (Major)	24	600	Dissertation			
Life Science (Major)	24	600	Dissertation			
Mathematics (Major)	24	600	Dissertation			
Physics (Major)	24	600	Dissertation			
Total	**24** (In each subject)	**600**				

TENTH SEMESTER

Subject	Credit Points	Marks	Classes/ week	Tutorials/ week	Practical/ week	Total classes/week
Chemistry (Major)	24	600	Dissertation			
Earth and Environmental Science (Major)	24	600	Dissertation			
Life Science (Major)	24	600	Dissertation			
Mathematics (Major)	24	600	Dissertation			
Physics (Major)	24	600	Dissertation			
Total	**24** (In each subject)	**600**				

DETAILS OF SYLLABI

ADVANCED COMPUTING

THIRD YEAR: SEMESTER-V
Paper AC-3-5-1: Advanced Computing Laboratory-I (Practical, Credits: 4)

THIRD YEAR: SEMESTER-VI
Paper AC-3-6-1: Advanced Computing Laboratory-II (Practical, Credits: 4)

FOURTH YEAR: SEMESTER-VII
Paper AC-4-7-1: Advanced Computing Laboratory-III (Practical, Credits: 4)

FOURTH YEAR: SEMESTER-VIII
Paper AC-4-8-1: Advanced Computing Laboratory-IV (Practical, Credits: 4)

THIRD YEAR: SEMESTER-V

Paper AC-3-5-1: Advanced Computing Laboratory-I (Credits: 4)

Fundamentals to Matlab, Introduction to Matlab Environment, Defining Matrices, Matrix Manipulation
Data Structures, 2D Graphics, 3D Graphics, Flow Control, Editor/Debugger window, Creating Matlab functions, Improving code performance, Programming in Matlab as suggested by the course Instructor.

REFERENCES:

1. P. Niyogi, Numerical Analysis and Algorithms, Tata McGraw-Hill Publishing Company Limited, 2003.
2. V. Rajaraman, Cmputer Fundamentals
3. E. Balaguruswamy-Programming in ANSI C., Tata –McGraw Hill (1992)
4. B.S. Gottfried- Theory and Problems of Programming in C, Tata McGraw Hill (1998).
5. V. Rajaraman, Programming in C, Prentice Hall (1994)
6. Magrab, Azarm, Balachandran, Duncan, Herold, Walsh, An Engineer's Guide to MATLAB

THIRD YEAR: SEMESTER-VI

Paper AC-3-6-1: Advanced Computing Laboratory-II (Credits: 4)

Programming with MATHEMATICA: The interactive use of Mathematica commands to manipulate algebraic expressions, work with arrays, perform operations from calculus and linear algebra, solve differential and difference equations, graph functions and visualize data. Functions, assignment statements and rules
Mathematica program, as suggested by the Course Instructor.

REFERENCES:

1. Daniel Dubin, "Numerical and Analytical Methods for Scientists and Engineers Using Mathematica", Wiley-Interscience, 2003.
2. “Mathematica Reference Guide “, Addison-Wesley Publishing Company,1992.
3. “The Mathematica Book”, Fifth Edition Wolfram Media, 2003.
4. B.S. Gottfried- Theory and Problems of Programming in C, Tata McGraw Hill (1998).
5. V. Rajaraman, Programming in C, Prentice Hall (1994).
6. P. Glasserman, Monte Carlo Methods in Financial Engineering, Springer, 2004.
7. R. U. Seydel, Tools for Computational Finance, 4th Ed., Springer, 2009.

FOURTH YEAR: SEMESTER-VII

Paper AC-4-7-1: Advanced Computing Laboratory-III (Credits: 4)

Fast Fourier Transform, Monte Carlo Simulation, Programming in Java

FOURTH YEAR: SEMESTER-VIII

Paper AC-4-8-1: Advanced Computing Laboratory-IV (Credits: 4)

Python language, Overview of Linux as operating system. Installation, configuration, system utilities. Kernel Internals: Processes, memory management, Interrupts and exceptions, system calls, file systems, Device drivers, Networking, Real time Linux, Embedded Linux systems.
Further problems, as suggested by the Course Instructor

REFERENCES:

1. Bovet, P. B., and Cesati, M., Understanding the Linux Kernel, O'Reilly, Shroff Publishers and Distributors,.
2. Beck, M., *et. al.*, Linux Kernel Programming, Third Edition, Pearson Education Asia.

CHEMISTRY

FIRST YEAR: SEMESTER-I

Paper CH-1-1-1	(Theory, Credits: 3)
Paper CH-1-1-2	(Practical, Credits: 2)

FIRST YEAR: SEMESTER-II

Paper CH-1-2-1	(Theory, Credits: 3)
Paper CH-1-2-2	(Practical, Credits: 2)

SECOND YEAR: SEMESTER-III

Paper CH-2-3-1	(Theory, Credits: 3)
Paper CH-2-3-2	(Practical, Credits: 2)

SECOND YEAR: SEMESTER-IV

Paper CH-2-4-1	(Theory, Credits: 3)
Paper CH-2-4-2	(Practical, Credits: 2)

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper CH-3-5-1	(Theory, Credits: 4)
Paper CH-3-5-2	(Theory, Credits: 4)
Paper CH-3-5-3	(Practical, Credits: 4)
Paper CH-3-5-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper CH-3-5-5, Analytical Chemistry-I	(Theory, Credits: 2)

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper CH-3-6-1	(Theory, Credits: 4)
Paper CH-3-6-2	(Theory, Credits: 4)
Paper CH-3-6-3	(Practical, Credits: 4)
Paper CH-3-6-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper CH-3-6-5, Analytical Chemistry-II	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper CH-4-7-1	(Theory, Credits: 4)
Paper CH-4-7-2	(Theory, Credits: 4)
Paper CH-4-7-3	(Practical, Credits: 4)
Paper CH-4-7-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper CH-4-7-5, Polymer Science	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper CH-4-8-1 (Theory, Credits: 4)
Paper CH-4-8-2 (Theory, Credits: 4)
Paper CH-4-8-3 (Practical, Credits: 4)
Paper CH-4-8-4 (Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:
Paper CH-4-8-5, Renewable Energy (Theory, Credits: 2)

FIFTH YEAR: SEMESTER-IX
DISSERTATION PAPERS:
Paper CH-5-9-1 (Credits: 24)

FIFTH YEAR: SEMESTER-X
DISSERTATION PAPERS:
Paper CH-5-10-1 (Credits: 24)

FIRST YEAR: SEMESTER-I

Paper CH-1-1-1 (Theory, Credits: 3)

1. Atomic Structure, Radioactivity and Periodic Properties

Bohr's theory of atomic structure, Sommerfeld's modifications.de Broglie relation, Heisenberg's uncertainty principle; Vector model. Quantum mechanical model of atom, spectroscopic term symbols; concept of atomic orbitals, shapes of *s*, *p* and *d* orbitals, radial and angular probability diagrams of *s*, *p* and *d* orbitals. Pauli's exclusion principle, Hund's rule, exchange energy, *Aufbau* principle; Electronic configurations of the elements.

Radioactivity: Natural and artificial; Units of radioactivity, radioactive equilibrium, isotopes, isobars and isotones. Soddy-Fajan's rule, Nuclear dimension, Nucleons, Stability of the nucleus and nuclear binding energy.

Periodic classification of elements, Modern periodic table, General characteristics of *s*-, *p*-, *d*- and *f*- block elements.Effective nuclear charge, Slater's rule. Atomic radii, Ionic radii, Covalent radii. Ionisation potentials.Electron affinity; Electronegativity and its periodic trend, Inert pair effect. Diagonal relationships.

2. Structure & Reactivity and Stereochemistry of Carbon Compounds

Hybridization; Inductive and field effects; bond energy, bond polarity, bond polarizability, conjugation (resonance), resonance energy, hyperconjugation, bond moments, dipole moment. Aromaticity, Huckel's (4n+2) rule, anti-aromaticity, application of Huckel's rule to benzenoid and non-benzenoid systems. Intermolecular and intramolecular forces, weak chemical forces, hydrogen bond, dipolar interaction, van der Waals' forces.

Static stereochemistry: Representation of molecules in Fischer, flying wedge, sawhorse and Newman formulae and their inter-translation, chirality, elements of symmetry.

Stereoisomerism: Enantiomerism and diastereomerism; Nomenclature. Resolution of racemic mixture.Conformational nomenclature; Conformational analysis of ethane, propane and n-butane.

3. Kinetic Theory of Gases, Modification of Equation of States and Concept of Intermolecular Forces and their Temperature Dependence

Postulates of kinetic theory, concepts of pressure and temperature; Distribution of velocities in one dimension, extension to two and three dimension, Maxwell's distribution of speed, feature of kinetic distribution, mean speed, root mean square speed, most probable speed; Equipartition of energy, specific heats of gases.

Collision of gas molecules; Inter-molecular forces, short description of Keesom, Debye and London forces, dipole moment, bond moment, vander Waals' equation of state, Virial equation of state.

Deviation from ideal behavior, existence of critical state, critical constants in terms of van der Waals' equation, law of corresponding states and its validity.

Paper CH-1-1-2 (Practical, Credits: 2)

Organic Qualitative Analysis: Detection of special elements (N, Cl, Br, I and S) by chemical tests; determination of melting point of the given compound: solubility test and solubility classification, detection of functional groups by systematic chemical tests.

Addition or changes in the laboratory experiments may be made by the department as and when required.

FIRST YEAR: SEMESTER-II

Paper CH-1-2-1 (Theory, Credits: 3)

1. Chemistry of Main Group Elements, Their Reactions and Chemical Bonding-I

Electron deficient compound, electron rich molecules; Halogens and Noble gas compounds, interhalogen compounds, pseudo halogens, polyhalides, phosphonitrillic compounds, sulphur nitrogen compounds, silicates, aluminosilicates.

Chemical Bonding: Ionic Bonding: Size effects, radius ratio rules. Packing of ions in crystals, Lattice energy, Born-Lande equation, Born-Haber cycle, Fajan's Rules; defects in solids.

Covalent Bonding: Valence Bond theory, hybridization, Bent's rule, Valence shell electron pair repulsion (VSEPR) model and molecular structure, ionic-covalent bond. Molecular orbital (MO) theory, multiple bonding, MO

diagrams of homonuclear and heteronuclear diatomic molecules.

Metallic bonding: Band theory, Band splitting (diamond and graphite structures), conduction, semiconduction and insulation, p-n junctions.

2. Organic Reaction Mechanisms

Bond cleavage and bond formation; Structure stability, formation and fates of electrophiles, nucleophiles, radical concept of onium and enium ions, carbocations, carbanions, carbenes, benzynes.Classification of reactions. ΔH, ΔS, ΔG; dependence of ΔH on bond energy, strain energy, solvation energy etc. of reactants and products, equilibrium controlled changes, intermolecular vs intramolecular reactions. Prototropic shifts, ring-chain tautomerism, valence tautomerism, relative stability of tautomers with reference to bond energy. Kinetic studies, study of intermediates, cross-over experiment, stereochemical proof, isotope labeling-kinetic and non-kinetic, primary and secondary kinetic isotope effect.

3. First Law of Thermodynamics and Thermochemistry

Introduction and scope of thermodynamics, definition of systems and surroundings, types of systems, extensive properties, intensive properties, concepts of thermal equilibrium, concept of temperature, concept of heat and work, reversible work, irreversible work and maximum work. First law of thermodynamics, internal energy as a state function, properties of a state function, definition of isothermal and adiabatic processes, Joule's experiment and its consequence. Joule-Thompson's experiment and enthalpy as a state function; calculation of work done, heat changes for isothermal and adiabatic changes involving ideal gas. Liquification of gases: adiabatic cooling.
Laws of thermochemistry, Hess's law and their applications, Born-Haber cycle, standard enthalpy changes in various transformations, Kirchoff's relation. Principle for determination of heat capacity experimentally.

Paper CH-1-2-2 (Practical, Credits: 2)
Inorganic Qualitative Analysis: Qualitative analysis of inorganic mixture containing not more than three radicals, by systematic tests and/or semimicro tests.
Addition or changes in the laboratory experiments may be made by the department as and when required.

SECOND YEAR: SEMESTER-III
Paper CH-2-3-1 (Theory, Credits: 3)
1. The Chemistry of Transition Elements-General Features and Acid-Base

Comparative study of the metals of first transition series with reference to electronic configuration, atomic and ionic radii, ionization potentials, oxidation states, etc; metallic nature and catalytic properties. General trends in passing from 3d through 4d to 5d block elements.

Standard redox potentials, Nernst equation, formal or conditional potential, influence of complex formation, precipitation and change of pH on redox potentials. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagrams.

van der Waals' forces; Ion-dipole and dipole-dipole interactions, London forces, hydrogen bonding. Effects of weak chemical forces on physical properties.

2. Aliphatic Compounds: Synthesis, General Properties and Reactions
Synthesis, properties and reactions of alkanes, alkenes and alkynes.
Alcohols and ethers: Relative reactivity 1°, 2° and 3° alcohols; synthesis and reactions of alcohols. Reactions of epoxides and ether via C-O cleavage.
Aldehydes and Ketones: Reactivity; Grignard reaction, $LiAlH_4$ and $NaBH_4$ reactions, electrolytic reaction, reductive coupling, M.P.V. reduction, Cannizaro reaction, etc.; nucleophilic addition to α,β-unsaturated carbonyls. Condensation reaction via addition-elimination, reaction with derivatives of NH_3, Wolff-Kishner reduction, aldol condensation.Claisen condensation, Wittig reaction, Mannich reaction, E-Clarke reaction, Reformatsky reaction, Tischenko reaction, etc.

Carboxylic acid and their derivatives: Nucleophilic substitution at acyl carbon of acyl halide, anhydride, ester, carboxylic acid, etc.; Esterification; Ester hydrolysis; HVZ reaction, Claisen ester condensation, acyloin condensation, Bouveault Blanc reduction, decarboxylation, Hunsdieker reaction, etc.

3. Second Law of Thermodynamics and its Relevance in Physical and Chemical Processes and Third Law of Thermodynamics and Liquid State

Second law of thermodynamics, Carnot's cycle and Carnot's theorem, absolute scale of temperature, entropy as a state function, entropy changes in various physical processes.
Clausius inequality, reversibility and irreversibility of a process, Auxiliary state functions- Helmholtz free energy and Gibbs free energy, Gibbs-Helmholtz equation, open system: Partial molar quantities, chemical potentials, Nerst distribution law, thermodynamics of homogeneous and heterogeneous equilibria, and thermodynamics of dilute solutions. Third law of thermodynamics.Approach to absolute zero by adiabatic demagnetization.
Nature of liquid state, surface tension, surface energy, excess pressure, capillary rise, Work of cohesion and adhesion, spreading of liquid over other surface, temperature dependence of surface tension, viscosity of liquids, origin, temperature dependence of viscosity of liquids.

Paper CH-2-3-2 (Practical, Credits: 2)
Quantitative Inorganic Analysis: Titrimetric estimations based on acidimetry and alkalimetry, Redox titrimetric estimations based on permanganometry and dichromatometry, Titrimetric estimations based on complexometry.
Addition or changes in the laboratory experiments may be made by the department as and when required.

SECOND YEAR: SEMESTER-IV
Paper CH-2-4-1 (Theory, Credits: 3)

1. Co-ordination Chemistry-I, Oxidation-Reduction and Weak Chemical Forces

Lewis acid base adducts. Double salts and complex salts, Werner's Theory, ambidentate and polydentate ligands, chelate complexes. Naming of coordination compounds.Coordination number; Stereochemistry.Constitutional, geometrical, optical isomerism; Substitution reactions on square planar and octahedral complexes. Stability constants of coordination complexes. Valence bond description; Crystal field theory; Splitting of d^n configurations in octahedral and tetrahedral fields, crystal field stabilization energy, pairing energy; Jahn Teller distortion.

Acid-Base: Arrhenius's concepts; Solvent system, Brönsted and Lowry's concept, relative strengths of acids, hydracids and oxyacids, Pauling's rules, Lewis concept and Usanovich's concept. Super acids, HSAB principle.Acid-Base equilibria; pH, buffer solutions, acid-base neutralization curves, acid-base indicators, choice of indicators, Salt hydrolysis.

Solubility product principle and common ion effect: their applications in the separation and identification of common cations and anions, precipitation of metal hydroxides and sulphides.

2. Aromatic Compounds, Organonitrogen Compounds and Organometallic Compounds

Aromatic electrophilic substitution: π- and σ-complex, ipso substitution, activating and deactivating groups, orienting influence; Activated aromatic nucleophilic substitutions.
Aldehydes and ketones: Synthesis and general properties.
Phenols: Synthesis; Ring substitution vs o-substitution, Reaction of phenols: Reimer-Tiemann reaction, Kolbe's reaction, Manasse reaction, Fries rearrangement, Claisen rearrangement, nitration, sulphonation, halogenation, oxidation, oxidative coupling by Fe^{3+}, etc.
Organonitrogen compounds: Acidity of α-H of nitroalkanes, substitution of α-H of nitroalkanes, alkyl cyanides and isocyanamides: their hydrolysis, von Richter reaction, 1°, 2° and 3° amines, Hofman's exhaustive methylation, carbylamine reaction, etc. Ring substitution vs N-substitution in aromatic amines, diazotization and coupling reactions, aromatic diazonium compounds.
Preparation and synthetic application of Grignard reagents and organolithium compounds, Boron reagents.

3. Chemical Kinetics and Catalytic Reactions

Chemical Kinetics: Concepts of rate, rate constant order and molecularity of a reaction, integrated forms of rate expressions, half-life period, order of reactions, multiple reactions, steady state concept, consecutive, opposing and parallel reactions, temperature dependence of rate constant, chain and polymerization reactions.

Theories of reaction rates, collision theory and absolute reaction rate theory.
Homogeneous catalysis: acid-base catalysis, primary salt effect, autocatalysis, Heterogeneous catalysis (surface reaction), Enzyme catalysis; Michaelis-Menten equation, Michaelis constant, influence of temperature and pH.

Paper CH-2-4-2 (Practical, Credits: 2)

Physical Chemistry–I: Partition co-efficient of I_2 between organic solvent and water, Partition co-efficient of benzoic acid between benzene and water, Viscosity by Ostwald's Viscometer, Acid catalyst ester hydrolysis, Decomposition of H_2O_2 in presence of $FeCl_3$, Solubility product of a sparingly soluble salt in presence of common ions, Solubility product of a sparingly soluble salt in presence of non-common ions, etc.
Addition or changes in the laboratory experiments may be made by the department as and when required.

THIRD YEAR: SEMESTER-V
MAJOR PAPERS:

Paper CH-3-5-1 (Theory, Credits: 4)

1. Chemical Bonding-II
Emperical MO- Huckel theory-examples, Symmetry adapted MO-Symmetry methods for qualitative MO diagrams. Analogous MO treatment for transition metal complexes, MO energetics model (Walsh's model). Study of variation of energy of MOs with the change of bond angle, Construction of Walsh correlation diagram.MO diagram of polyatomic molecules, hypervalence, 3c-2e and 3c-4e bonding.Valence bond-VSEPR model, hybrid AO, sets of geometry, theoretical idea about bond angles; qualitative assessment of the effects of mutual repulsion of the bonded and non-bonded electron pairs on angular distortions, Symmetry methods for construction of hybrid atomic orbitals.

2. Coordination Chemistry-II
Magnetic properties and spectral properties of 3d ions, orbital and spin magnetic moment; quenching of magnetic moment; super-exchange; antiferromagnetism; d-d spectra: weak field splitting schemes, Orgel and Tanabe Sugano diagrams and spectroscopic ground states, selection rules for electronic spectral transitions, Charge transfer spectra; Spectrochemical series; Labile and inert complex; Trans effect. Spinel, inverse spinel, OSSE.

3. Reaction Mechanism: Substitution and Free-radical Reactions
Substitution reactions: Aliphatic nucleophilic substitution-S_N1, S_N2, mixed S_N1 and S_N2, SET mechanisms, neighboring group mechanism, neighboring group participation by pi and sigma bonds, anchimetric assistance; S_Ni mechanism; nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon; reactivity effects on substrate structure, attacking nucleophile, leaving group and reaction medium; phase transfer catalysis and ultra sound; ambident nucleophile; regioselectivity, Aromatic nucleophilic substitution- S_NAr, benzyne and $S_{RN}1$ mechanisms; reactivity effects of substrate structure, leaving group and attacking nucleophile, Aliphatic electrophilic substitution- S_E1, S_E2 and S_E^i mechanisms; electrophilic substitution accompanied by double bond shifts; effects of substrates, leaving group and solvent polarity on the reactivity; energy profile diagrams; the ortho/para ratio; orientation in other ring systems; *ipso* attack.
Free radical reactions: Types of free radical reactions, free radical substitution mechanism; mechanism at an aromatic substrate; neighboring group assistance; reactivity for aliphatic and aromatic substrates at a bridgehead; reactivity in the attacking radicals; effects of solvents on reactivity; allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids; auto-oxidation; free radical rearrangements.

Paper CH-3-5-2 (Theory, Credits: 4)

1. Nuclear Properties and Structure

Nuclear stability; Fermi gas model, Liquid drop model, Nuclear shell model, Magic number, Nuclear spin, Nuclear configuration and parity. Nuclear isomerization and non-optical transitions.Nuclear temperature and entropy.Models of disintegration. Theory of radioactivity decay- Golden rule and selection rule.
Types of nuclear reactions, conservation law. Q-value, cross-section and mechanism of nuclear reaction.Resonance and non-resonance reaction.Nuclear fission and fusion.

2. Reaction Mechanism: Elimination, Addition and Rearrangement Reactions
Elimination reactions: E1, E2 and E1cB mechanisms; product stereochemistry; effects of substrate structures, attacking base, leaving group and the medium on reactivity; mechanism and orientation in pyrolytic elimination.
Addition reactions: Addition to carbon-carbon multiple bonds- mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free-radicals; regio- and chemoselectivity; orientation and reactivity; Addition to carbon-hetero multiple bonds- mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles; addition to Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds; Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Perkin and Stobbe reactions.
Rearrangement reactions: Formation and stability of carbonium ions, carbanion, carbenes, nitrenes, radicals and arynes. Rearrangement involving carbocation (Wagner-Meerwin, Pinacol-Pinacolone rearrangement), reaction involving acyl cation, PPA cyclization and Fries rearrangement, rearrangement of carbenes (Wolff & Arndst-Eistert synthesis), rearrangement of nitrenes (Hoffmann, Curtius, Schmidt, Lossen, Beckmann rearrangement); sigmatropic rearrangements.

3. Electrolytic Conductance: Basic principle of measuring the resistance of an electrolytic solution, specific, equivalent and molar conductance, ionic mobility, transport number and its method of measurements, variation of conductance with concentration and temperature, equivalent conductance at infinite dilution, application of conductometric titration, dissociation of weak electrolyte, basic idea of ion atmosphere, electrophoretic effect, relaxation effect, Onsager equation.

Paper CH-3-5-3 (Practical, Credits: 4)

Physical Chemistry-II: Determination of the Cell Constant of a conductometer and find the equivalent conductance at infinite dilution of a strong electrolyte, Conductometric titration of a strong acid and weak acid by a strong base, Determination of formal potential of Fe^{2+}/Fe^{3+} system potentiometrically, Determination of formal potential of quinone-hydroquinone system pH metrically, Verification of Lambert-Beer's law, etc
Syntheses of some inorganic complexes based on cobalt, nickel, manganese, copper and vanadium, etc.
Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper CH-3-5-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER:
(Compulsory for students having major in Chemistry and optional for students having major in other subjects)
Paper CH-3-5-5: Analytical Chemistry-I (Theory, Credits: 2)
Principles and typical examples of Acid Base titration; Oxidation-reduction (permanganometry, dichromatometry, iodometry and iodimetry), precipitation and complexometric (metal indicators, masking and demasking agents) titrations.
Gravimetric analysis; Theory, practice and applications of chromatography-GLC, GSC, LLC, LSC, HPLC, HPTLC, *etc*. Gas chromatography, ion-chromatography.
Errors and evaluation, mean, median; Precision, standard deviation, relative standard deviation, absolute and relative error, types of error, source of error, confidence interval, confidence limit, methods of reporting analytical data; statistical evaluation of data.

THIRD YEAR: SEMESTER-VI
MAJOR PAPERS:

Paper CH-3-6-1 (Theory, Credits: 4)

1. Bio-inorganic Chemistry-I

Essential and trace elements of life, roles of metal ions (Na^+, K^+, Mg^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, Zn^{2+}). Metal ion transport-Na^+ ion pump. Ionophores.Hemoglobin and myoglobin; cytochromes; ferrodoxin; Biological nitrogen fixation, photosynthesis, carbonate/bicarbonate buffer, toxic metal ions, chelation therapy, Pt and Au complexes as drugs, metal dependent diseases.

2. Bio-organic Chemistry and Carbohydrates

Amino acids: synthesis, isoelectric point, ninhydrin reaction, resolution of amino acids. Peptides: Geometry of the peptide linkage, synthesis, structural determination, C- and N- terminal unit determination; amino-acid sequence. Protein: classification, structure. Enzymes: chemical and biological catalysis, properties of enzymes, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification. Mechanism of enzyme action, transition state theory, enzyme mechanism for chymotrypsin and ribonuclease, Coenzymes.

Nucleic acids: Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding, Structure of nucleosides and nucleotides, Structure of DNA and RNA, double helix model of DNA (Watson-Crick model) and forces responsible for holding it.

Monosaccharides, classification; Osazone formation; Stepping up and stepping down of aldoses; interconversion of aldoses to ketoses and vice versa; Epimerisation; D-glucose and D-fructose; Anomeric effect, mutarotation; Disaccharides: Elementary idea.

3. Symmetry and Group Theory

Introduction to symmetry, symmetry element and operations, Point groups, Abelian groups, symmetry operators and their matrix representation, reducible and irreducible representation, characters of representation, Great orthogonality theorem (without derivation); Character table and its construction with special emphasis on C_{2v}, C_{2h}, C_{3v}, C_{4v} notation of irreducible representation. Symmetry adopted linear combination, Projection operator, Mulliken symbols; Direct product representation, molecular vibrations, symmetry species of the vibration mode, selection rules for IR and Raman spectra. Splitting of Terms in octahedral field: elementary idea on the construction of Tanabe-Sugano diagram.

Paper CH-3-6-2 (Theory, Credits: 4)

1. Organometallic Chemistry, Metal Clusters, Inorganic Ring and Cage Compounds

Organometallic compounds: definition, classification and nomenclature. Application of 18e rule to carbonyls, nitrosyls, cyanides and metal carbon sigma and pi bonded organometallic complexes of transition metals. Metal-olefin complexes: Zeise's salt and Ferrocene. Catalysis: examples of some industrially important catalytic systems.

Cluster classification, skeletal electron counting, bonding in metal clusters, polyhedral skeleton electron pair theory (PSEPT), higher boron hydrides- structure and reactivity, styx numbers, closo, nido and arachno boranes, Lipscomb topological diagrams, Wades rule, Jemmis' unifying electron counting rule, Zintl ions

2. Heterocyclic Chemistry

Synthesis (including retrosynthesis), reactivity, orientation and important reactions of heterocyclic compounds (furan, pyrrole, thiophene, pyridine, indole, quinoline, isoquinoline).

3. Colligative Properties and Electrochemical Processes

Colligative properties: Lowering of vapour pressure (Raoult's law); derivation of colligative properties of solution and their inter-relationships. Abnormal behavior, non-ideal solution and vant Hoff factor. Concept of activity and activity coefficients; Debye-Huckel limiting law.

Nernst equation, EMF of chemical cells; reference electrodes; transference cells; liquid junction potential, primary and secondary cells.

Paper CH-3-6-3 (Practical, Credits: 4)

Inorganic Quantitative Estimation-I: Quantitative separation and estimation of a mixture of iron-copper, iron-manganese, calcium-magnesium, iron-calcium, iron-chromium, etc.

Organic syntheses

Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper CH-3-6-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Chemistry and optional for students having major in other subjects)

Paper CH-3-6-5: Analytical Chemistry-II (Theory, Credits 2)

Atomic spectroscopy: basic principle, instrumentation and applications of AAS, AES, AFS, flame emission spectroscopy, ICP-MS, Fluorometry. Separation technique: solvent extraction. Craig extraction and counter current distribution.

Radiochemical technique: Working principle. Role of carrier, isotopic exchange reaction; Neutron activation analysis, radioactive reagents; radiometric titration; Radiation chemistry: interaction of radiation with nucleic acid; Radiation dosimetry: physical, chemical, *etc*.

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper CH-4-7-1 (Theory, Credits: 4)

1. Molecular Magnetism

Basic concepts of magnetism, magnetization and magnetic susceptibility, Types of magnetic behavior (dia-, para-, ferro-, ferric- and antiferro-) and their temperatures dependence, Curie and curie-Weiss laws, temperature independent paramagnetism, Pascal's constants and its utilities, Determination of χ_M in solution, Usefulness of μ_s and μ_j equation respectively for transitiona dn inner-transition series, Van Vleck equation and its applications, spin-orbit coupling, zero-field splitting, quenching of orbital angular momentum, High-spin/low-spin equilibrium, types of exchange interactions.

Magnetic properties of substances, orbital and spin angular momentum of electrons, paramagnetic moment and magnetic susceptibility. Determination of magnetic susceptibility: Gouy, Faraday and SQUID. Curie and Curie-Weiss law. Quantum theory of paramagnetic susceptibility- Van Vleck equation (smaller, comparable and larger than kT energy level gaps), Temperature independent paramagnetism. Free ions (Zeeman effect), spin orbit coupling (Sm^{3+} and Eu^{3+}). Magnetic properties of metal complexes. Antiferromagnetic interactions: direct, superexchange interactions.

2. Dynamic Stereochemistry and Organic Name Reactions

Conformation and reactivity, Curtin-Hammett principle and Wenstein-Elliel equations.

Acyclic and cyclic system (nucleophilic substitution reaction, formation and cleavage of epoxide ring, addition reaction to double bonds, elimination reactions, pyrolytic syn elimination, oxidation of cyclohexanols, neighbouring group participation reactions, etc.), stereoelectronic effects,

Aldol condensation, Witig reaction, Prevost reaction, Simmons Smith reaction, Nef reaction, Favorskii reaction, Baeyer-Villiger oxidation. Heck reaction, Suzuki coupling, Arndst-Eistert synthesis; Knoevenagel, Perkin, Stobbe and Wagner-Meerwein reaction. Pinacol-Pinacolone, Fries, Hoffman, Curtius, Schmidt, Lossen, Beckmann, rearrangement.Mannich reaction, Michael addition, Stork enamine reaction, Robinson annulation, Sharples asymmetric epoxidation, Birch reduction.

3. Interface and Colloidal Stability and Ion-Solvent Interaction

Electrical double layer and theories of electrical double layer, Helmholtz-Perrin model, Gouy-Chapman model, Stern model, Zeta potential, Streaming potential, sedimentation potential. DLVO theory.

Ion association, symmetric and asymmetric ion-pair formation, Bjerrum theory. Solvation of ions, salvation

number, Frank-Wien model of ionic salvation, Born model, thermodynamics of ionic salvation, enthalpy and free energy of salvation of ions, experimental determination of salvation of ions.

Paper CH-4-7-2 (Theory, Credits: 4)

1. Solid State Science

Crystals, Bravais lattice, Crystal planes and Miller indices, Common crystal structures, Diffraction of X-rays, Bragg law and Laue equation, Reciprocal lattice, Brillouin zones.

Bonding of solids, Elastic properties, Phonons, Lattice specific heat, Free electron theory and electronic specific heat, Response and relaxation phenomena, Drude model of electrical and thermal conductivity, Hall effect and thermoelectric power, Electron motion in a periodic potential, Band theory of solids: metals, insulators and semiconductors.

Diamagnetism, Paramagnetism, Ferromagnetism, Larmor's theorem, Langevin's theory, Curie-Weiss law, Hysteresis and energy loss in ferromagnetic materials.

2. Nanoscience

Hydrophobic hydration and interaction, micelle formation, colloidal aggregates and nanoparticles, Stability in solution, Surface charge of colloidal particles, Zero dimensional nanostructure, Homogeneous and heterogeneous nucleation, Metallic nanoparticles- synthesis and applications, Nanowires and nanorods: one dimensional nanostructures, Spontaneous growth, VLS, Electrospinning, Lithography; Thin film: two dimensional nanostructure, Langmuir-Blodgett (LB) film, Photolithography, Characterization of nanostructures, properties of colloids and nanoparticles; their applications.

Paper CH-4-7-3 (Practical, Credits: 4)

Inorganic Quantitative Estimation-II: Analysis of some ores and alloys: Quantitative estimation of the important metal constituents.

Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper CH-4-7-4 (Practical, Credits: 2)

Project based work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Chemistry and optional for students having major in other subjects)

Paper CH-4-7-5: Polymer Chemistry (Theory, Credits: 2)

Importance of polymers: monomers, repeat units, degree of polymerization; linear, branched and network polymers; kinetics of free radical and condensation polymerization; Classification: Polymerization-condensation, addition, radical chain-ionic and coordination, copolymerization. Polymer characterization: number, weight and viscosity average molecular weight; practical significance of molecular weight and its measurement by viscosity and light scattering methods. Structure and property: glass transition temperature, relationship between T_g and T_m, factors controlling T_g; Functional polymer-fire retarding polymers and electrically conducting polymers; Biomedical polymers.

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper CH-4-8-1 (Theory, Credits: 4)

1. Supramolecular Chemistry and Rare Earth Elements

Molecular recognition and host-guest interactions; Chelate and macrocyclic effects; Preorganization, Thermodynamic and kinetic selectivity, Cation, Anion and Neutral molecule binding: Crown ethers, lariat ethers, spherands, podand, podate, cryptand, cryptate, coronand, coronate. Organometallic receptors and their host-guest complexes, spherical recognition, molecular devices and supramolecular assemblies. Complexation of organic cations, calixarenes, cation host to anion host, shape selectivity, Guanidinium receptors, coordination interactions, cavitands: cyclodextrins and molecular tweezers. Molecular switches.

General characteristics of rare earth elements, magnetic and spectral properties; comparison between lanthanide

and actinide; lanthanide contraction. Separation of lanthanides (ion-exchange and solvent extraction). lanthanides as NMR shift reagent and low temperature superconductors.

2. Asymmetric Synthesis and Green Chemistry

Introduction, Kinetic and thermodynamic principles; diastereoselective and enantioselective synthesis; Methods of asymmetric synthesis: Resolution, use of chiral pool, chiral auxiliaries, use of stoichiometric chiral reagents, asymmetric catalysis.

The need of green chemistry, Principles of green chemistry, Concept of atom economy, Tools of green chemistry-microwave, ultrasound, ionic liquids. Supercritical H_2O and CO_2 as solvents, etc.Green chemistry in real world cases and planning green synthesis in chemical laboratory.

3. **Electro-analytical Methods**

Decomposition and discharge potential, current voltage diagram, linear sweep voltametry (LSV), reversible and irreversible systems, Cottrell equation (qualitative), excitation and switching potential, cyclic voltametry and its application; Coulometry and amperometry-analytical applications.

Electrode-solution interface layer, electrolytic process, three electrode systems, supporting electrolyte, DME, Ilkovic equation, Ilkovic-Heyrolsky equation, test of reversibility, current-voltage diagram, DC and AC polarography, stripping voltametry.

Paper CH-4-8-2 (Theory, Credits: 4)

1. Inorganic Reaction Mechanism of Complexes in Aqueous Solution and Bio-inorganic Chemistry-II

Energy profile of a reaction, application of different reaction parameters in understanding reaction mechanism, effect of leaving group, non-leaving group, entering group, steric hindrance and acceleration; solvent exchange reaction-importance in suggesting reaction mechanism, derivation of some important rate laws, classification of ligand substitution reaction mechanism-associative, dissociative, interchange, etc.

ATP hydrolysis, hemerythrin, hemocyanine, rubredoxin, blue copper proteins. vitamin B12 coenzyme. ascorbate oxidase, superoxide dismutase, cytochrome C oxidase, nitrogenase, carboxypeptidase, carbonic anhydrase, DNA polymerase.

2. Organic Photochemistry and Pericyclic Reactions

Basic principles, Jablonski diagram, excited state of some organic molecules, *cis-trans* mechanism; reactions of carbonyl, olefin and conjugated carbonyl compounds, photoinduced functionalization involving Norrish type I and II; Paternobuchi reaction, Di-pi methane rearrangement,

Phase and symmetry of orbitals; Introduction to Pericyclic reaction and its classification; Cycloaddition reactions, Electrocyclic reactions and Sigmatropic reactions : FMO approach, co-relation diagram.

3. Electrode Kinetics and Theory of Semiconductor

Butler-Volmer equation; Tafel equation from Volmer equation. Equilibrium exchange current density; Current potential reaction for reversible electrode. Doss rectification. Electrokinetics of corrosion reaction. Pourbaix diagrams. Corrosion current and potential. Evans diagrams.

Structure of semiconductor-electrolyte interface. Analogies between semiconductors and electrolytic solutions. Garrett-Brattain space charge. Differential capacity. Mott-Schottky equation. Flat band potential. Semiconductor electrode in photoelectric device.

Paper CH-4-8-3 (Practical, Credits: 4)

Physical Chemistry-III: Determination of pK values of phosphoric acid by potentiometric titration with sodium hydroxide using a glass electrode. Determination of the concentration of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate. Determination of hydrolysis constant of a salt of strong acid and weak base e.g.; aniline hydrochloride conductometrically. Determine the indicator constant of an indicator (phenolphthalein) spectroscopically. Determination of composition and stability constant of a complex formed between iron (III) ions and salicylic acid by Job's method.

Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper CH-4-8-4 (Practical, Credits: 2)
Project based work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Chemistry and optional for students having major in other subjects)

Paper CH-4-8-5: Renewable Energy: Solar, Hydrogen and Biomass Energy (Theory, Credits: 2)

Basics of photovoltaic energy conversion, Optical properties of solids, Direct and indirect transition semiconductors, Interrelationship between absorption coefficients and band gap recombination of carriers. P-N junction inorganic solar cell, Transport equation, Current density, Open circuit voltage and short circuit current, Single crystal silicon and amorphous silicon solar cells, Tandem solar cell, Solid liquid junction solar cell, Principles of photoelectrochemical solar cell, Organic solar cell: bilayer heterojunction solar cell, bulk heterojunction solar cell, molecular heterojunction solar cell and dye sensitized solar cell.

Relevance in relation to depletion of fossil fuels and environmental considerations, Solar hydrogen through photoelectrolysis, Solid state hydrogen storage materials, Various factors relevant to safety, Use of hydrogen as fuel in vehicular transport and electricity generation and hydrogen fuel cell.

Biomass sources, Fuel cells, Methanol and ethanol fuel cells, Biofuel cells, Prospects of fuel cell research in India, Bottlenecks of commercialization of alcohol fuel cells and biofuel cells.

REFERENCES:

INORGANIC CHEMISTRY

1.	Fundamental Concepts of Inorganic Chemistry, Asim K. Das, Part I and II
2.	Concise Inorganic Chemistry, J.D. Lee
3.	Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, P.L. Gaus
4.	Advanced Inorganic Chemistry, F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann
5.	Inorganic Chemistry, J.E. Huheey, E.A. Keiter, E.L. Keiter, O.K. Medhi
6.	General and Inorganic Chemistry, R.P. Sarkar, Part I and II
7.	Inorganic Chemistry, R.L. Dutta, Part I and II
8.	Chemistry of the Elements, N.N. Greenwood, A. Earnshaw
9.	Concepts and Models of Inorganic Chemistry, B. Douglas, McDaniel, Alexander G. Wulfsberg
10.	Inorganic Chemistry, Gary Wulfsberg
11.	Inorganic Chemistry- A Unified Approach, William Poerterfield
12.	Inorganic Chemistry, A.G. Sharpe
13.	Inorganic Chemistry, T. Moeller
14.	Fundamentals of Inorganic Chemistry, D. Banerjea
15.	Bioinorganic Chemistry, Asim K. Das
16.	Principles of Bioinorganic Chemistry, S.J. Lippard
17.	Supramolecular Chemistry- Concepts and Perspectives- J.M. Lehn

ORGANIC CHEMISTRY

1.	Organic Chemistry, I.L. Finar, Volume I and II
2.	Advanced Organic Chemistry, Jerry March
3.	Advanced General Organic Chemistry, Sachin K. Ghosh
4.	A Guidebook to Mechanism in Organic Chemistry, Peter Sykes
5.	Basic Stereochemistry of Organic Molecules, Subrata Sengupta
6.	Stereochemistry of Organic Compounds, E.L. Elliel, S.H. Wilen
7.	Stereochemistry of Organic Compounds, D. Nasipuri
8.	Organic Spectroscopy, William Kemp
9.	Spectrometric Identification of Organic Compounds, R.M. Silverstein, F.X. Webster
10.	Organic Reactions, Stereochemistry and Mechanism, P.S. Kalsi
11.	Organic Chemistry, Clayden, Greeves, Warren and Wothers
12.	Advanced Organic Chemistry, F.A. Carey and R.J. Sundburg
13.	Modern Methods of Organic Synthesis, W. Caruthers and I. Coldam
14.	Organic Name Reactions, Gautam Brahmachari
15.	Organic Chemistry, R.T. Morrison and R.N. Boyd
16.	Organic Chemistry, T.W.G. Solomons

PHYSICAL CHEMISTRY

1.	Physical Chemistry, P.C. Rakshit
2.	Physical Chemistry, G.W. Castellan
3.	Atkins' Physical Chemistry, P. Atkins, J De Paula
4.	A Text Book of Physical Chemistry, Volume 1-5, K.L. Kapoor
5.	Chemical Kinetics, Keith J. Laidler
6.	Physical Chemistry, I.N. Levine
7.	Spectroscopy, C. Banwell
8.	Text Book of Physical Chemistry, S. Glassstone
9.	Physical Chemistry, W.J. Moore
10.	Quantum Chemistry, I.N. Levine
11.	Quantum Chemistry, D.A. Mcquarrie

12.	Physical Chemistry, R. S. Berry, S. A. Rice and J. Ross
13.	Symmetry Through the Eyes of a Chemist, I. Hargittai and M. Hargittai

ANALYTICAL CHEMISTRY

1.	Quantitative Inorganic Analysis, A.I. Vogel
2.	Fundamentals of Analytical Chemistry, Skoog, West, Holler and Crouch
3.	Analytical Chemistry- Problems and Solutions, S.M. Khopkar

MATERIAL SCIENCE AND RENEWABLE ENERGY

1.	Introduction to Solid State Physics, C. Kittle
2.	Fundamental of Solid State Physics, J. R. Christman
3.	Solid State Physics, Ascroftand Mermin
4.	A Textbook of Nanoscience and Nanotechnology, T. Pradeep
5.	Nanostructures and Nanomaterials: Synthesis, Properties and Application, G. Cao and Y. Wang
6.	Solar Cell Devices- Physics, S. J. Fonash.
7.	Fundamentals of Solar Cells, Photovoltaic Solar Energy, A. L. Fahrenbruch and R. H. Bube
8.	Principles and Applications of Semiconductor Photochemistry, M. X. Tan, P. E. Laibinis, S. T. Nguyen, J. M. Kesselman, C. E. Stanton and N. S. Lewis
9.	Photoelectrochemical solar cells, D. S. Campbell

PRACTICAL

1.	Practical Chemistry, Nad, Ghoshal and Mahapatra
2.	Advanced Practical Chemistry, S.C. Das
3.	Qualitative micro and semimicro analysis, G.N. Mukherjee, Cal. Univ. Press
4.	Vogel's Qualitative Inorganic Analysis, G. Svehla
5.	Text Book of Practical Organic Chemistry, A.I. Vogel
6.	Experimental Physical Chemistry, V. D. Athawale, P. Mathur

EARTH AND ENVIRONMENTAL SCIENCE

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper EES-3-5-1: Climatology and Climate Change	(Theory, Credits: 4)
Paper EES-3-5-2: Water Pollution	(Theory, Credits: 4)
Paper EES-3-5-3	(Practical, Credits: 4)
Paper EES-3-5-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper EES-3-5-5: Principles of Soil Science	(Theory, Credits: 2)

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper EES-3-6-1: Energy and Environment	(Theory, Credits: 4)
Paper EES-3-6-2: Soil Pollution and Solid Waste Management	(Theory, Credits: 4)
Paper EES-3-6-3	(Practical, Credits: 4)
Paper EES-3-6-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper EES-3-6-5: Environmental Earth Science	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper EES-4-7-1: Remote Sensing and GIS	(Theory, Credits: 4)
Paper EES-4-7-2: Environmental Toxicology	(Theory, Credits: 4)
Paper EES-4-7-3	(Practical, Credits: 4)
Paper EES-4-7-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper EES-4-7-5: Ecology	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper EES-4-8-1: Environmental Laws, Policies and Sustainable Development	(Theory, Credits: 4)
Paper EES-4-8-2: Environmental Management	(Theory, Credits: 4)
Paper EES-4-8-3	(Practical, Credits: 4)
Paper EES-4-8-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper EES-4-8-5: Hydrology and Water Management	(Theory, Credits: 2)

FIFTH YEAR: SEMESTER-IX

DISSERTATION PAPERS:

Paper EES-5-9-1	(Credits: 24)

FIFTH YEAR: SEMESTER-X

DISSERTATION PAPERS:

Paper EES-5-10-1	(Credits: 24)

THIRD YEAR: SEMESTER-V
MAJOR PAPERS:

Paper EES-3-5-1: Climatology and Climate Change (Theory, Credits: 4)

Elementary ideas about weather and climate system, scale of meteorology, heat budget of the earth, weather parameters (temperature, pressure, precipitation, humidity, cloudiness, visibility, wind) and their records, latitudinal and seasonal variation of insolation, earth's thermal Environment and seasons, atmospheric stability, inversions and mixing height, windrose, boundary layer meteorology, laminar flow, wind structure and turbulence near the surface mixing length theory, secondary circulation and frictional convergence, turbulent transfer of momentum, theories of turbulence, planetary scale motions in the atmosphere and oceans; monsoon, enso, extreme weather events, tropical cyclones and western disturbances, classification of climates – koppen's and thornthwaite's scheme of classification, greenhouse effect, global warming & climate change, consequences of climate change, climate forcing and feedbacks, past climate record, possible causes of recent climate change, model strategies for predicting climate change, international treaties and protocol on climate change.

REFERENCES:

1. Barry RG & RJ Chorley, Atmosphere, Weather & Climate, 7th Ed., Routledge
2. D. Lal, Climatology
3. S. Singh, Text book of Physical geography
4. Siddhartha, The earth's dynamic surface.
5. Dessler Andrew, Introduction to modern climate change

Paper EES-3-5-2: Water Pollution (Theory, Credits: 4)

Chemistry of water & water pollutants; Importance of water to life forms, types, sources and consequences of water pollution, types and characteristics of domestic, industrial and agricultural wastes – their effects on water bodies, elemental pollution, heavy metals, metalloids, organic pollutants, persistent organic pollutants, pesticides in water, radioactive and thermal pollution water quality parameters and its standards (DO, BOD, COD, acidity, alkalinity, hardness, residual chlorine and chlorine demand, coliform), criteria and standards, waste water treatment and water use, municipal water treatment, treatment of water for industrial use, sewage treatment, eutrophication, ground water pollution with special reference to West Bengal (Arsenic and Fluoride),river action plan; source of marine pollution and control.

REFERENCES:

1. Environmental Chemistry, (1994) Stanley. E. Manahan, Lewis Publication
2. Chemistry of the Environment, Spiro, 2nd Ed., EEE
3. Biology of Freshwater Pollution Mason, C.F.,, 3rd Ed, Longman
4. Environmental Problems & Solutions, Asthana & Asthana, S. Chand
5. Environmental Chemistry, De, AK.,

Paper EES-3-5-3 (Practical, Credits: 4)

Study of physicochemical parameters (temperature, pH, DO, dissolved CO_2, conductivity, turbidity, Chlorine, total hardness, BOD, COD), Bacteriological analyses of water, Study of pond biota (phytoplanktons, zooplanktons), Plotting and interpretation of weather parameters

Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper EES-3-5-4 (Practical, Credits: 2)

Project work and presentation

REFERENCES:

1. Maiti, S.K., Handbook of methods in Environmental Studies, Vol. I & II, ABD Publ.
2. American Public Health Association, 12th Ed.
3. Trivedy, R.K., & Goel, P.K., Chemical & Biological Methods for Water Pollution Studies, Environmental Publ.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Earth and Environmental Science and optional for students having major in other subjects)

Paper EES-3-5-5: Principles of Soil Science (Theory, Credits: 2)

Genesis, Nature and classification of Soil; Inorganic constituents of Soil -Soil composition; Primary minerals- weathering of primary minerals; Secondary Minerals; Organic constituents - Soil Organic matter; Humus; Soil Biomass; Biochemical reactions of soil microorganism; Nonhumified organic matter; humified organic matter; Physical properties of soil - Soil texture; soil structure; soil density and porosity; soil consistence; soil air- soil water- soil temperature. Chemical properties of soil - electrical charges, clay – colloidal properties; CEC, AEC, Soil reaction- acidity and alkalinity

REFERENCES:

1. Arora, Environmental Management of toxic & hazardous chemicals, IVY Publ.
2. McBride - Environmental Chemistry of Soils
3. N.C Brady -The Nature and Properties of Soil
4. Dutta -Principles and Practice of Soil Science

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper EES-3-6-1: Energy and Environment (Theory, Credits: 4)

Basic concepts and forms of energy; Principles of energy conversion; Global energy use and supply; Energy use pattern in different parts of the world, Electrical energy- generation, transmission and storage; energy in transportation ;Conventional energy sources: Fossil fuels – classification, composition, physio-chemical characteristics and energy content of coal, petroleum and natural gas; Fossil fueled power plants and their Environmental impact, Hydro-power and their Environmental impacts, Radioactivity and nuclear fueled power plants, Nuclear fuel cycle and radioactive waste, nuclear-fission and fusion; Sun as source of energy, Passive Solar energy, Solar thermal energy, solar collectors, solar ponds; Solar photovoltaic cells, Wind energy Energy from ocean wave and tides, geothermal energy; Biomass as source of energy; biomass composition and types; biomass conversion; gasification etc; energy plantation; Petro crops, bio-energy (algae, aquatic weeds etc.), biogas

REFERENCES:

1. Elliot, Energy, Society & Environment, Routledge Publ.
2. Clare Smith, Environmental Physics
3. J.A. Fay and D.S. Golomb, Energy and Environment

Paper EES-3-6-2: Soil Pollution and Solid Waste Management (Theory, Credits: 4)

Sources, behavior and fate of soil pollutants, effects of soil pollutants on biota, crops, vegetation, interaction of fertilizers, pesticides, industrial waste effluents and heavy metals with different components of soil, soil micro-organisms and their functions, role of microorganisms in the biochemical cycles, N fixation & P- solubilization, degradation of different types of pesticides insecticides, fungicides and weedicides in soil, residual toxicity, losses of these substances due to volatilization, leaching and microbial immobilization, their toxicity and pollution, sources and generation of solid wastes, different methods of dispersal and management of solid wastes, recycling of waste materials, waste disposal, recycling and power generation, fly ash utilization, methods of waste disposal & recycling, vermi-composting, management of solid wastes, hospital wastes, hazardous and toxic wastes, nuclear waste.

REFERENCES:

1. G.M. Pierzynski, J. Thomas Sims and George F. Vance - Soils and Environmental Quality-
2. Ibrahim A Mirsal – Soil Pollution: Origin, Monitoring and Remediation
3. Yaron. B, Calvet R, and R. Prost.- Soil Pollution: Process and Dynamics
4. Maier, Pepper & Gerba, - Environmental Microbiology
5. Subba Rao N.S., Soil Microbiology

Paper EES-3-6-3 (Practical, Credits: 4)

Environmental Diary, Organic content in Soil , N, P, K content in Soil, Computational works in Energy resources, Noise pollution, SPM, SO_2, NOx, Ozone, Chlorophyll content, Identification of common rocks and minerals; Interpretation of Toposheet and geological map, Drainage pattern assessment
Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper EES-3-6-4 (Practical, Credits: 2)

Project work and presentation

REFERENCES:

1. Soil analysis: Handbook of reference methods,. Soil and Plant analysis council Inc.
2. Maiti, S.K., Handbook of methods in Environmental Studies, Vol. I & II, ABD Publ.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Earth and Environmental Science and optional for students having major in other subjects)

Paper EES-3-6-5: Environmental Earth Science (Theory, Credits: 2)

Surface features and Internal structure of earth; Weathering and Erosion; Mass wasting; Erosion, transportation and deposition by running water, wind and glaciers; Fluvial processes and landforms; Drainage patterns; Coastal landforms and Processes; Plate tectonics as a unifying theory, Earthquake, volcanism; Mineral Resources and Environment : Types of minerals and their use, Concept of reserve and resources; Genesis and distribution of mineral deposits; Exploration and Extraction (mining) methods for mineral resources, Oceans and new areas for exploration of mineral resources. National Mineral Policy, Best management Practices in mining.

REFERENCES:

1. Botkin & Keller, Environmental Science: Earth as a Living Planet, John Weily
2. Monroe, 1.S., The Changing Earth,
3. Edward, A, Environmental Geology, Prentice Hall
4. Raymond Seiver, Understanding Earth

FOURTH YEAR: SEMESTER-VII
MAJOR PAPERS:

Paper EES-4-7-1: Remote Sensing and GIS (Theory, Credits: 4)

Principles and Basic concepts of Remote Sensing, The Electromagnetic Spectrum; Interaction of Electromagnetic Radiation with atmosphere and earth surface features; Spectral characteristics of rocks, soils, vegetation and water; Indian Scenario of remote sensing, Earth Resource and Meteorological satellites; Orbital characteristics, Characteristic and types of Remote sensors, Remote Sensing Data Products; Spatial, Temporal, Spectral and Radiometric Resolution; Basic concept of Arial Photography and photogrammetry, Visible and NIR Remote Sensing: FCC, Visual image Interpretation . Thermal remote sensing: Basic principles, Thermal sensors, characteristics of image and their use. Microwave remote sensing: Basic definitions and principles, interaction between Microwaves and earth's surface; Interpretation and application of radar images; Fundamentals of Digital Image Processing, Image Rectification, Image enhancement, Image classification; Geographic Information system :- Definitions and terminology, Spatial Data Models (Raster and vector); GIS Data Management; Data Input and editing; Data Analysis and Modelling; Introduction to GIS and IP packages, Basic principles and advantages of Global Positioning System (GPS);Remote sensing applications in pollution monitoring; forest and vegetation mapping; Remote sensing and GIS applications in rural and urban land use mapping; water resource monitoring and geologic hazard zonation mapping; Geospatial technology for sustainable development.

REFERENCES:

1. Lilles & Keifer, Remote Sensing & Image Interpretation, 3rd Ed, John Weily & Sons

2. Jenson, J.R., Remote Sensing of the Environment, Pearson Education, Delhi
3. Heywood, I, Cornelius S. & Carver, S., An Introduction to Geographical Information Systems, Pearson Education, Delhi
4. Guha P.K., Remote Sensing for the Beginners
5. Rampal K.K., Handbook of Aerial Photography and its Interpretation
6. Joseph, Fundamental of Remote Sensing

Paper EES-4-7-2: Environmental Toxicology (Theory, Credits: 4)

Classification of xenobiotics, basic principles in Environmental toxicology, distribution & fate of toxicants in the Environment and organisms, biotransformation and detoxification mechanisms, types of toxicity: acute, chronic immediate and delayed; toxicity bioassays, statistical concepts in Environmental toxicology: LD_{50}, ED_{50}, LC_{50}, toxicity of mixture of toxicants; interaction of toxicants: synergism, antagonism, additive effect, potentiation, biomagnification, bioaccumulation, influence of ecological factors on the effects of toxicity, pollution of the ecosphere by industries, global dispersion of toxic substance, sources and circulating mechanisms of pollutants, degradable and non-degradable toxic substances, toxic chemicals in the Environment, biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone, PAN, pesticides, carcinogens in the Environment, types of Environmental health hazards, water borne disease, air-borne diseases and allergies, applied toxicology, forensic toxicology, clinical toxicology, and occupational toxicology.

REFERENCES:

1. Zakrzewski S, Environmental Toxicology, 3rci Ed., Oxford Univ. Press
2. Wright D.A. & Welbourn, P., Environmental Toxicology, Cambridge Univ. Press
3. Loomis & Hays, Loomi 's Essentials of Toxicology, 4th Ed., Academic Press
4. Klaassen, CD., Amdur, M.D., Doull, J. (ed.), Toxicology, Mac MiJJan Pub. Company.

Paper EES-4-7-3 (Practical, Credits: 4)

Ecology practical, Visual Interpretation of satellite imagery; Digital Image Processing; Bioassay methods in toxicology, Local biodiversity of Santiniketan (Flora and fauna)

Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper EES-4-7-4 (Practical, Credits: 2)

Project work and presentation

REFERENCES:

1. Abbasi & Ramasami, Biotechnological Method of Pollution Control, Univ. Press
2. Sadasivam, S. & :Manikam, A, 1992, Biochemical Methods for Agricultural Sciences, Wiley Eastern Ltd.
3. Maiti, S.K., Handbook of methods in Environmental Studies, Vol. I & II, ABD Publ.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Earth and Environmental Science and optional for students having major in other subjects)

Paper EES-4-7-5: Ecology (Theory, Credits: 2)

Biogeochemcial cycles, Basic types of Biogeochemcial cycles, Hydrological cycle, Carbon cycle , Nitrogen cycle, Sulphur cycle, Phosphorus cycle, Nutrient budget (internal & external), Trophic structure of ecosystems, Energy flow in ecosystem; Pyramids of energy, biomass and number; Population Ecology:, Population growth curves, Population regulation, Interspecific (parasitisim, predation, concept of niche, competition) and intraspecific relationships; Community Ecology; Structure and function of communitis, Ecological succession, Major ecosystems of the world, Problems faced by ecosystems and their possible management

REFERENCES:

1. Odum, E.P., Fundamentals of Ecology, Saunders Publ., Philadelphia
2. Odum, H.T., Basic Ecology,

3. Rickfels, RE. & Miller, G.L. Ecology, Freeman & Comp., N.Y
4. Sharma, P.D., Ecology & Environment, Rastogi Pub., Delhi

FOURTH YEAR: SEMESTER-VIII
MAJOR PAPERS:

Paper EES-4-8-1: Environmental Laws, Policies and Sustainable Development (Theory, Credits: 4)

Legislation and Public Policy Strategies in Pollution control, Legal Provisions for Environmental Protection in India (The Acts and the Rules), Sanction and enforcement bodies of Environmental laws (WHO, CPCB, SPCB), Role of Supreme Court in Environmental Matters; Green Benches; International Conventions and Treaties, Eco-mark. Role of tradition and culture in Environmental conservation, Environmental ethics, Gandhi & Tagore as Environmentalists, Western Environmental thoughts, Eco-feminism, Man-Nature-Society, Issue and events in the growth of Environmental Sociology in India and the West; Origin and development of Environmental Impact Assessment (EIA), EIA in project planning and implementation, EIA methodologies, evaluation criteria, Risk assessment and management, mitigation measures, Comparison of alternatives, Review and decision making, EIA Case studies; Environmental education and awareness, Peoples participation and Environmental movements (Silent Valley, Chipko, Appiko, Narmada, Tehri & Garwal Dam movements) Environmental groups and community based planning, Role of NGO in Environmental issues.

REFERENCES:

1. Canter, Environmental Impact Assessment, McGraw-Hill.
2. Saxena, Environmental Management, Rawat Publication
3. Chary & Vyasula, Environmental Management: An Indian Perspective, MacMillan
4. Srivastava, Environmental Impact Assessment, APR Publication.
5. Agrawal, Environmental Laws: Indian Perspective, Nidhi Publication.

Paper EES-4-8-2: Environmental Management (Theory, Credits: 4)

Environmental Management: Definition and scope of Environmental Management (EM) Characteristics and goals of EM; Tools of EM, participants of EM; Environmental management System (EMS); Definition, need of EMS, Core element of EMS, Benefits of EMS; Concept of Adaptive Management (AM), condition that warrant AM, steps in the process of AM; Environmental Management Planning (EMP); Concepts – the need of EMP, the need of Environmental management policy in Indian perspective; Case studies of EMP; Baseline information system, concept, importance in Environmental management, important aspects in building a baseline information system; Tools applied in Environmental management; Environmental assessment, economic assessment, benefit cost analysis, Environmental impact statement (EIS), Environmental audit, waste minimization programme and Environmental management system, life cycle assessment (LCA), Environmental design, ISO 14000 series, concept, basic principles of ISO 14000 series, components of ISO 14001, benefits of implementing ISO 14001 under Indian context, case studies; Joint Forest Management, concept, Genesis of JFM, National resolution on JFM 1990. JFM *vis-a-vis* Village Forest committee (VFC) benefit sharing, Natural Disaster Management (NDM), definition of disaster, types of disaster, manmade and natural, stages of disaster management, role of scientific and local knowledge in NDM.

REFERENCES:

1. David E. Alexander, Natural disasters**.**
2. Keith Smith, Environmental hazards: assessing risk and reducing disaster**.**
3. Graham A. Tobin and Burrell E. Montz, Natural hazards: explanation and integration**.**
4. S. Singh, Text book of Physical geography.
5. V. Subramanian, Environmental hazards in South Asia.
6. Environment Impact Assessment :- A.K. Shrivastava APH Publication

Paper EES-4-8-3 (Practical, Credits: 4)

Field visit for ecosystem study (duration 5-7 days), One field tour for appraisal of common landforms, rocks/mines/mining process; duration 2-4 days, Industrial tour, Epidemiological survey of chronic and acute

disease-arsenicosis/goiter/flurosis
Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper EES-4-8-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Earth and Environmental Science and optional for students having major in other subjects)

Paper EES-4-8-5: Hydrology and Water Management (Theory, Credits: 2)

Water: a global perspective, water as a resource, Surface water, precipitation and run off, Principles of hydro-geomorphology, watershed characteristics, runoff and sediment yield, stream flow, lake and wetland hydrology; Groundwater basics, Principles of ground water flow, Well hydraulics, groundwater quality, ground water modeling, Rain water harvesting, Watershed development, Geospatial technology in water management.

REFERENCES:

1. D.K. Todd, Groundwater Hydrology
2. R. Nagarajan, Water

ENGLISH

FIRST YEAR: SEMESTER-I
Paper ENG-1-1-1: Functional English (Theory, Credits: 2)

FIRST YEAR: SEMESTER-I
Paper ENG-1-1-1: Functional English (Theory, Credits: 2)
Preamble: The course intends to develop the creative and analytical skills of the candidate in order to facilitate better written communication in English. It also prepares for the awareness of basic grammer. The course is divided into 3 modules and each module carries 1 credit.

Module 1:
Formal Written Communication: Letter writing and e-mail, writing a resume.

Module 2:
Creative Skills: Writing a paragraph, drafting a report.

Module 3:
Analytical Skills and Grammar: Comprehension passage, Précis, Change of voice, Changing the tense, Direct and indirect speech, Simple and complex sentences.
Since the course is intended for students of science, relevant comprehension passages may be selected.

REFERENCES:
1. Synergy: Communication in English and Study Skills ed. Board of editors. Orient Longman, 2008.
2. Examine Your English ed. Margaret M. Maison. Orient Longman, 2008.
3. English Grammar Skills ed. David Bolton. Orient Longman, 2008.

LIFE SCIENCE

FIRST YEAR: SEMESTER-I

Paper LS-1-1-1: Molecules and their Interaction Relevant to Biology (Theory, Credits: 3)
Paper LS-1-1-2 (Practical, Credits: 2)

FIRST YEAR: SEMESTER-II

Paper LS-1-2-1: Cellular Organization (Theory, Credits: 3)
Paper LS-1-2-2 (Practical, Credits: 2)

SECOND YEAR: SEMESTER-III

Paper LS-2-3-1: Fundamental Processes (Theory, Credits: 3)
Paper LS-2-3-2 (Practical, Credits: 2)

SECOND YEAR: SEMESTER-IV

Paper LS-2-4-1: Cell Communication and Cell Signaling (Theory, Credits: 3)
Paper LS-2-4-2 (Practical, Credits: 2)

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper LS-3-5-1: System Physiology (Theory, Credits: 4)
Paper LS-3-5-2: Metabolism of Carbohydrates, Proteins, Lipids and Nucleic acids (Theory, Credits: 4)
Paper LS-3-5-3 (Practical, Credits: 4)
Paper LS-3-5-4 (Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper LS-3-5-5: Developmental Biology (Theory, Credits: 2)

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper LS-3-6-1: Inheritance Biology (Theory, Credits: 4)
Paper LS-3-6-2: Ecological Principles (Theory, Credits: 4)
Paper LS-3-6-3 (Practical, Credits: 4)
Paper LS-3-6-4 (Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper LS-3-6-5: Diversity of Life Forms (Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper LS-4-7-1: Immunology and Immunotechniques (Theory, Credits: 4)
Paper LS-4-7-2: Methods in Biology-I (Theory, Credits: 4)
Paper LS-4-7-3 (Practical, Credits: 4)
Paper LS-4-7-4 (Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper LS-4-7-5: Evolution (Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper LS-4-8-1: Applied Biology (Theory, Credits: 4)

Paper LS-4-8-2: Methods in Biology-II (Theory, Credits: 4)
Paper LS-4-8-3 (Practical, Credits: 4)
Paper LS-4-8-4 (Practical, Credits: 2)
ADDITIONAL ELECTIVE PAPER
Paper LS-4-8-5: Statistical Methods for Biology (Theory, Credits: 2)

FIFTH YEAR: SEMESTER-IX
DISSERTATION PAPERS:
Paper LS-5-9-1 (Credits: 24)

FIFTH YEAR: SEMESTER-X
DISSERTATION PAPERS:
Paper LS-5-10-1 (Credits: 24)

FIRST YEAR: SEMESTER-I

Paper LS-1-1-1: Molecules and their Interaction Relevant to Biology (Theory, Credits: 3)

A. Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).

B. Stablizing interactions (electrostatic, hydrophobic interaction, etc.).

C. Essential concepts of bioenergetics: Glycolysis, oxidative phosphorylation, coupled reaction.

D. Principles of catalysis, enzymes and enzyme kinetics of substrates and inhibitors.

E. Structure of proteins (Primary, secondary and tertiary structure, domains, motif and folds).

F. Structure of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA)

Paper LS-1-1-2 (Practical, Credits: 2)

Problems as suggested by the course instructor and largely based on LS-1-1-1

Addition or changes in the laboratory experiments may be made by the department as and when required.

FIRST YEAR: SEMESTER-II

Paper LS-1-2-1: Cellular Organization (Theory, Credits: 3)

A. Membrane structure and function (Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes).

B. Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility).

C. Organization of genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons).

D. Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle).

E. Microbial Physiology (Growth yield and characteristics, strategies of cell division, stress response).

Paper LS-1-2-2 (Practical, Credits: 2)

Problems as suggested by the course instructor and largely based on LS-1-2-1

Addition or changes in the laboratory experiments may be made by the department as and when required.

SECOND YEAR: SEMESTER-III

Paper LS-2-3-1: Fundamental Processes (Theory, Credits: 3)

A. DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).

B. RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport).

C. Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins).

D. Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

Paper LS-2-3-2 (Practical, Credits: 2)

Problems as suggested by the course instructor and largely based on LS-2-3-1

Addition or changes in the laboratory experiments may be made by the department as and when required.

SECOND YEAR: SEMESTER-IV

Paper LS-2-4-1: Cell Communication and Cell Signaling (Theory, Credits: 3)

A. Host parasite interaction Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens.

B. Endocrine system; hormone mechanism of action (including receptors), hormonal signaling and signaling 1,31,31defects and diseases

C. Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

D. Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, apoptosis, therapeutic interventions of uncontrolled cell growth.

Paper LS-2-4-2 (Practical, Credits: 2)

Problems as suggested by the course instructor and largely based on LS-2-4-1

Addition or changes in the laboratory experiments may be made by the department as and when required.

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper LS-3-5-1: System Physiology (Theory, Credits: 4)

A. Photosynthesis - Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C3, C4 and CAM pathways.

B. Nitrogen metabolism in plants - Nitrate and ammonium assimilation; amino acid biosynthesis.

C. Plant hormones –physiological effects and mechanisms of action.

D. Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

E. Solute transport and photoassimilate translocation in plants– uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.

F. Human Circulatory and Cardiovascular System: Blood volume, blood volume regulation, blood groups, haemoglobin, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

G. Nervous system - Neurons, action potential, gross neuroanatomy of the brain, central and peripheral nervous system.

H. Sense organs – Vision and hearing

I. Excretory system - Physiology of excretion, regulation of water balance, electrolyte balance, acid-base balance

Paper LS-3-5-2: Metabolism of Carbohydrates, Proteins, Lipids and Nucleic acids (Theory, Credits: 4)

A. Human Digestive system – Digestion and absorption of nutrients.

B. Carbohydrate Metabolism- glycolysis, oxidative phosphorylation, glycogenolysis, glycogen synthesis, gluconeogensis.

C. Protein Metabolism- amino acid degradation, amino acid biosynthesis, urea cycle

D. Lipid Metabolism- lipolysis, fatty acid oxidation, plasma lipoproteins, cholesterol, lipid synthesis

E. Synthesis and catabolism of components of Nucleic acids- purine, pyrimidine, pentose sugars.

Paper LS-3-5-3 (Practical, Credits: 4)

Problems as suggested by the course instructor and largely based on LS-3-5-1, LS-3-5-2 and LS-3-5-5

Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper LS-3-5-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Life Science and optional for students having major in other subjects)

Paper LS-3-5-5: Developmental Biology (Theory, Credits: 2)

A) Basic concepts of development : Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants;

B) Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.

C) Morphogenesis and organogenesis in animals : Axes and pattern formation in Drosophila, and chick; organogenesis –limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development.

D) Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper LS-3-6-1: Inheritance Biology (Theory, Credits: 4)

A. Mendelian principles: Dominance, segregation, independent assortment.

B. Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests

C. Extensions of Mendelian principles : Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

D. Extra chromosomal inheritance : Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

E. Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

F. Human genetics: Pedigree analysis, karyotypes.

G. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.

H. Structural and numerical alterations of chromosomes : Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Paper LS-3-6-2: Ecological Principles (Theory, Credits: 4)

A. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

B. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

C. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

D. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

E. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

F. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

G. Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

H. Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

I. Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

J. Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on

conservation/management strategy (Project Tiger, Biosphere reserves).

Paper LS-3-6-3 (Practical, Credits: 4)

Problems as suggested by the course instructor and largely based on LS-3-6-1, LS-3-6-2 and LS-3-6-5
Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper LS-3-6-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Life Science and optional for students having major in other subjects)

Paper LS-3-6-5: Diversity of Life Forms (Theory, Credits: 2)

A. Principles & methods of taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical & quantititative methods of taxonomy of plants, animals and microorganisms.
B. Levels of structural organization: Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems. Comparative anatomy, adaptive radiation, adaptive modifications.
C. Outline classification of plants, animals & microorganisms: Important criteria used for classification in each taxon. Classification of plants, animals and microorganisms. Evolutionary relationships among taxa.
D. Organisms of health & agricultural importance: Common parasites and pathogens of humans, domestic animals and crops.
E. Organisms of conservation concern: Rare, endangered species. Conservation strategies.

FOURTH YEAR: SEMESTER-VII
MAJOR PAPERS:

Paper LS-4-7-1: Methods in Biology-I (Theory, Credits: 4)

A. Molecular Biology and Recombinant DNA methods:
B. Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods.
C. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels.
D. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.
E. Expression of recombinant proteins using bacterial, animal and plant vectors.
F. Isolation of specific nucleic acid sequences
G. Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors.
H. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.
I. Protein sequencing methods, detection of post translation modification of proteins.
J. DNA sequencing methods, strategies for genome sequencing.
K. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques.
L. Isolation, separation and analysis of carbohydrate and lipid molecules RFLP, RAPD and AFLP techniques.

Paper LS-4-7-2: Immunology and Immunotechniques (Theory, Credits: 4)

Innate and adaptive immune system- Toll-like receptors, Cells and molecules involved in innate and adaptive immunity. Antigens, antigenicity and immunogenicity, B and T cell epitopes, structure and function of antibody molecules, Generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, Humoral and cell-mediated immune responses, primary and secondary immune modulation, Cell-mediated effector functions, inflammation, The complement system, Hypersensitivity and autoimmunity, Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, Congenital and acquired immunodeficiencies, vaccines, Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, fluocytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

Paper LS-4-7-3 (Practical, Credits: 4)

Problems as suggested by the course instructor and largely based on LS-4-7-1, LS-4-7-2 and LS-4-7-5
Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper LS-4-7-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Life Science and optional for students having major in other subjects)

Paper LS-4-7-5: Evolution (Theory, Credits: 2)

A. Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis.

B. Origin of cells and unicellular evolution: Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiement of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes; Anaerobic metabolism, photosynthesis and aerobic metabolism.

C. Paleontology and Evolutionary History: The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo.

D. Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence.

E. Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift.

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper LS-4-8-1: Applied Biology (Theory, Credits: 4)

A. Transgenic animals, Gene therapy, Stem cell biotechnology: Transgenic animals and their advantages, Transfection methods, Knockout animals, Gene correction, Gene editing, Gene replacements/augmentation.
Stem cell biotechnology: Stem cells, Cell cloning, Stem Cell therapy.

B. Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for plants and animals.

C. Genetic manipulation of fruit setting and ripening. Genetic engineering for herbicide resistance.

D. Breeding in plants and animals, including marker – assisted selection

E. Bioremediation and phytoremediation

F. Biosensors

Paper LS-4-8-2: Methods in Biology-II (Theory, Credits: 4)

A. Bioinformatics: General and Structural: Major bioinformatics resources: NCBI, EBI, ExPASy,Sequence and structure databases, Sequence analysis, Sequence-based database searches, Pair wise sequence alignments & Multiple sequence alignments, Taxonomy and phylogeny, Protein secondary structure prediction and classification of protein folds

B. Biophysical Method: UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy; X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.

C. Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

D.Microscopic techniques: Light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission electron microscopy, confocal microscopy.

E. Electrophysiological methods: Single neuron recording, patch-clamp recording, ECG, Brain activity recording, lesion and stimulation of brain, pharmacological testing, PET, MRI, fMRI, CAT.

Paper LS-4-8-3 (Practical, Credits: 4)

Problems as suggested by the course instructor and largely based on LS-4-8-1, LS-4-8-2 and LS-4-8-5
Addition or changes in the laboratory experiments may be made by the department as and when required.

Paper LS-4-8-4 (Practical, Credits: 2)

Project work and presentation

ADDITIONAL ELECTIVE PAPER

(Compulsory for students having major in Life Science and optional for students having major in other subjects)

Paper LS-4-8-5: Statistical Methods for Biology (Theory, Credits: 2)

Measures of central tendency and dispersal; Concept of probability and application in biological sampling and genetics; Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Concept of Regression and Correlation; t-test; Analysis of variance; X2 test;; Basic introduction to Multivariate statistics, *etc*.

REFERENCES:

1.	Campbell, N.A. and Reece, J.B. (2008), Pearson Benjamin Cummings, San Francisco.
2.	Raven, P.H., *et al*, (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi.
3.	S. Stranding (2011) Gray's Anatomy the anatomical Basis of Clinical Practice (40th Edition) Churchill Livingstone.
4.	Berg, J.M. and Stryer L, (2012), Biochemistry (7th Edition), W. H. Freeman.
5.	Murray, Bender., (2012) Harper's Illustrated Biochemistry (29th Ed) , The McGrawHill company
6.	Guyton and Hall. (2011), Text Book of Medical Physiology (12th Ed.,), Elsevier.
7.	Dale, J.W., (2012), From Genes to Genomes (3rd Ed.,), John Wiley and Sons.
8.	Nelson, d. L. and Cox, M. M. (2013). Lehninger: Principles of Biochemistry (6th Ed.,) W. H. Freeman.
9.	Griffiths, A.J. F., et al., (2008), introduction to Genetic Analysis (9th Ed), W. H. Freeman and Co.,
10.	Bruce Alberts, Alexander Johnson, et al (2014). Molecular Biology of the Cell, Garland Science.
11.	Chapman J. L. and Reiss M. J., (1999). Ecology: Principles and Applications. Cambridge University Press.
12.	Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology (7th Ed.,). Cambridge University Press.
13.	Gardner E. J., Simmons M. J., and Snustad D. P. (2006). Principles of Genetics (8th Ed.,). John Wiley and Sons.
14.	Krebs J. E., Kilpatrick S. T., and Goldstein E. S., (2013). Lewins Genes XI. Jones & Bartlett Learning.

MATHEMATICS

FIRST YEAR: SEMESTER-I

MT-1-1-1: Mathematics-I	(Theory, Credits: 3)
MT-1-1-2: Computing Lab-I	(Practical, Credits: 2)

FIRST YEAR: SEMESTER-II

MT-1-2-1: Mathematics-II	(Theory, Credits: 3)
MT-1-2-2: Scientific Computing	(Theory, Credits: 2)

SECOND YEAR: SEMESTER-III

MT-2-3-1: Mathematics-III	(Theory, Credits: 3)
MT-2-3-2: Computing Lab-II	(Practical, Credits: 2)

SECOND YEAR: SEMESTER-IV

MT-2-4-1: Mathematics-IV	(Theory, Credits: 3)
MT-2-4-2: Partial Differential Equations	(Theory, Credits: 2)

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

MT-3-5-1: Discrete Mathematics	(Theory, Credits: 4)
MT-3-5-2: Analysis-I	(Theory, Credits: 4)
MT-3-5-3: Theory of Optimization	(Theory, Credits: 4)
MT-3-5-4: Complex Analysis	(Theory, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

MT-3-5-5: Mathematical Theory of Probability & Statistics	(Theory, Credits: 2)

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

MT-3-6-1: Analysis-II	(Theory, Credits: 4)
MT-3-6-2: Advanced Modern Algebra	(Theory, Credits: 2)
MT-3-6-3A: Numerical Linear Algebra	(Theory, Credits: 2)
MT-3-6-3B: Numerical Linear Algebra	(Practical, Credits: 2)
MT-3-6-4: Differential Geometry	(Theory, Credits: 4)

ADDITIONAL ELECTIVE PAPER:

MT-3-6-5: Mathematical Modeling	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

MT-4-7-1: Analysis-III	(Theory, Credits: 4)
MT-4-7-2: Introduction to Continuum Mechanics	(Theory, Credits: 4)
MT-4-7-3: Galois Theory	(Theory, Credits: 4)
MT-4-6-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

MT-4-7-5: Integral Equations & Calculus of Variations	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

MT-4-8-1: Analysis-IV	(Theory, Credits: 4)
MT-4-8-2: Numerics of Partial Differential Equations	(Theory, Credits: 4)
MT-4-8-3: Dynamical System	(Theory, Credits: 4)

MT-4-8-4 (Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

MT-4-8-5: Mathematical Ecology (Theory, Credits: 2)

FIFTH YEAR: SEMESTER-IX

DISSERTATION PAPERS:

Paper MT-5-9-1 (Credits: 24)

FIFTH YEAR: SEMESTER-X

DISSERTATION PAPERS:

Paper MT-5-10-1 (Credits: 24)

FIRST YEAR: SEMESTER-I

Paper MT-1-1-1: Mathematics-I (Theory, Credits: 3)

Set Theory, Finite, countable and Uncountable sets.

Functions of one variable- Limits, Continuity, and Differentiability of function of one variable.

Real valued functions of several variables: Limit Continuity and Differentiability.

Functions of a Complex Variable- Limits of Functions, Theorems on Limits, Continuous Functions, and Continuity in terms of Real and Imaginary parts.

Differentiability of Functions- Definition and Examples, The Cauchy-Riemann Equations, Sufficient Conditions for Differentiability, Cauchy- Riemann Equations in polar form.

Sequences and Series- Sequences, Limit and Limit Points of a Sequence, Cauchy's General Principle of Convergence, Infinite Series, Absolutely Convergent Series.

Tensor algebra and Tensor calculus.

REFERENCES:

1. Thomas G.B. and R.L. Finny, Calculus and Analytic Geometry Addison Wesley, Pearson-education recent edition.
2. H.L.Royden, Real Analysis, Prentice Hall of India Pvt. Ltd.
3. Tom. M. Apostol, Calculus Vol. I, Vol. II, J. Wiley & Sons.

Paper MT-1-1-2: Computing Lab-I (Practical, Credits: 2)

Introduction to Problem Solving: Algorithm, Flow charts, Tracing flow charts, Problem solving methods, computer languages and compilers

C Language preliminaries: Character set, Identifiers and keywords, Data types, Declarations, Expressions, statements and symbolic constants

Input-Output: getchar, putchar, scanf, printf, gets, puts, functions.

Operators and expressions: Arithmetic, unary, logical, bit-wise, assignment and conditional operators

Control statements: While, do-while, for statements, nested loops, if else, switch, break, Continue, and goto statements, comma operators

Storage types: Automatic, external, register and static variables. Sample Programs written in C

Problems as suggested by the course Instructor.

REFERENCES:

1. Mastering C by Venugopal, Prasad – TMH
2. Complete reference with C Tata McGraw Hill
3. C – programming E.Balagurusamy Tata McGray Hill
4. How to solve it by Computer : Dromey, PHI
5. Schaums outline of Theory and Problems of programming with C : Gottfried
6. The C programming language : Kerninghan and Ritchie
7. Programming in ANSI C : Ramkumar Agarwal
8. Let Us C by kanetkar

FIRST YEAR: SEMESTER-II

Paper MT-1-2-1: Mathematics-II (Theory, Credits: 3)

Application of Derivatives- Mean value theorems and applications, Taylor's theorem and expansion, Critical points, Inflection Points, Concavity and convexity of a curve.

Partial Derivatives, Chain Rule, Gradient & Directional Derivative. Tangent Plane & Normal. Maxima, Minima, saddle points and Lagrange Multipliers.

Integration- Fundamental theorems of integral calculus, Definite integral, Reduction formulae.

Vector algebra and Vector calculus and 3-dimensional geometry.

Fourier transforms: Fourier, sine and cosine transforms.

Laplace and inverse Laplace transforms; properties, convolutions.

REFERENCES:

1. Thomas G.B. and R.L. Finny, Calculus and Analytic Geometry Addison-Wesley, Pearson education recent edition.
2. Spiegel, M. R., Theory and Problems of Vector Analysis and an introduction to Tensor Analysis, Schaum Publishing Co., 1959.
3. Weatherburn, Vector Analysis (vol. 2).
4. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 1990.
5. H. T. H. Piaggio, Differential Equations.
6. Simmons, Differential Equations.
7. S. L. Ross, Differential Equations.
8. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, 1944.
9. A. D. Poularikas, The Transforms and Applications Handbook, CRC Press, 1996.
10. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993

Paper MT-1-2-2: Scientific Computing (Theory, Credits: 2)

Approximate numbers. Significant figures, Round off numbers. Errors, Absolute, Relative and percentage errors.
Difference table, propagation of error in a difference table. Differences of a polynomial. Polynomial interpolation. Error in polynomial interpolation. Newton's forward and backward interpolation formulae. Lagrange's interpolation formula, divided difference, finite difference, Hermite and Spline interpolation, Inverse interpolation. Numerical differentiation.
Numerical integration: Trapezoidal rule, Simpson's one-third rule. Composite rules. Geometrical significance.
Solutions of nonlinear equations. Bisection method, Newton's method and its variants, fixed point iterations, convergence analysis; Geometrical significance.
Numerical solution of a system of linear equations: Gauss Elimination method. Iterative methods: Gauss Jacobi and Gauss Seidel.

REFERENCES:

1. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Ed., AMS, 2002.
2. K. E. Atkinson, An Introduction to Numerical Analysis, Wiley, 1989.
3. S. D. Conte and C. de Boor, Elementary Numerical Analysis - An Algorithmic Approach, McGraw-Hill, 1981.
4. R. Mitchell and S. D. F. Griffiths, The Finite Difference Methods in Partial Differential Equations, Wiley, 1980.

SECOND YEAR: SEMESTER-III

Paper MT-2-3-1: Mathematics-III (Theory, Credits: 3)

Repeated and Multiple Integrals with application to volume, surface area, and moments of inertia.
Line & Surface Integrals. Green's, Gauss and Stokes' theorems and their applications.
First order differential equations: Exact differential equations, integrating factors, Bernoulli equations, Riccati equations, existence and uniqueness theorem, applications.
Higher-order linear Ordinary differential equations – solutions of homogeneous and nonhomogeneous equations, method of variation of parameters, operator method
Series solutions of linear differential equations, Legendre equation and Legendre polynomials, Bessel equation and Bessel functions of first and second kinds;

REFERENCES:

1. Thomas G.B. and R.L. Finny, Calculus and Analytic Geometry Addison- Wesley, Pearson education recent edition.
2. Spiegel, M. R., Theory and Problems of Vector Analysis and an introduction to Tensor Analysis, Schaum Publishing Co., 1959.
3. Weatherburn, Vector Analysis (vol. 2).
4. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 1990.
5. H. T. H. Piaggio, Differential Equations.
6. Simmons, Differential Equations.
7. S. L. Ross, Differential Equations.
8. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, 1944.

9. A. D. Poularikas, The Transforms and Applications Handbook, CRC Press, 1996.
10. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993

Paper MT-2-3-2: Computing Lab-II (Practical, Credits: 2)

Functions:

Arrays: Multi dimensional arrays.

Pointers:

Programming in C

Finding the largest and smallest of a finite set of numbers.
Arranging a given set of numbers in ascending/descending order.
Finding transpose of matrices.
Finding the product of two matrices.
Finding the sum of the digits of a number.
Integration by
(a) Trapezoidal rule
(b) Simpon's 1/3rd rule
Finding real root of an equation by
(a) Fixed point iteration method
(b) Bisection method
(c) Newton-Raphson method

REFERENCES:

1. P. Niyogi, Numerical Analysis and Algorithms, Tata McGraw-Hill Publishing Company Limited, 2003.
2. V. Rajaraman, Cmputer Fundamentals
3. E. Balaguruswamy-Programming in ANSI C., Tata –McGraw Hill (1992)
4. B.S. Gottfried- Theory and Problems of Programming in C, Tata McGraw Hill (1998).
5. V. Rajaraman, Programming in C, Prentice Hall (1994)
6. Magrab, Azarm, Balachandran, Duncan, Herold, Walsh, An Engineer's Guide to MATLAB

SECOND YEAR: SEMESTER-IV

Paper MT-2-4-1: Mathematics-IV (Theory, Credits: 3)

Cartesian product, relations, Equivalence relations. Partial ordering relation. Permutations: Cycle, transposition, Order of a permutation.
Determinant and Matrix theory.
Theory of group: Axioms, properties, subgroup, Cyclic group
Vector Space and examples, Subspace, Sum and intersection of subspaces, Solution space of linear equations, Linear independence of vectors, Basis, Dimension, Coordinates with respect to different basis.
Null Space, Row Space, Column Space.
Linear Transformations (LT) between two vector spaces, Representing LT by a matrix, Rank-Nulity Theorem, Base change and similarity matrices.
Eigen value and eigen vector, Characteristic polynomials, Diagonalisation and triangulation of Matrices, Cayley Hamilton Theorem.
Inner Product space, Chauchy-Schwartz Inequality, Orthogonal basis, Graham-Scmidt orthogonalization process.

REFERENCES:

1. I. N. Herstein, Topics in Algebra, 2nd edition, Wiley Eastern, 1975.
2. C. Musili, Introduction to Rings and Modules, 2nd edition, Narosa,1992.
3. M. Artin, Algebra, Prentice Hall of India, 1994.
4. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall of India, 1996.
5. G. C. Cullen, Linear Algebra with Applications, 2nd edition, Addison Wesley, 1997.
6. S. Axler, Linear Algebra Done Right, 2nd edition, UTM, Springer, 1997.

Paper MT-2-4-2: Partial Differential Equations (Credits: 2)

First order partial differential equations, Linear and quasi-linear first order equations. Lagrange's Method/Characteristic method of solution and its geometrical interpretation, Charpits method, Special types of first order equations.

Higher order PDE and operator method.

Classification of PDEs, Canonical forms.

One dimensional wave equation and De'Alembert's method.

Fourier series solution of wave equation, Separation of variables method to solve heat equation, Laplace equation, Diffusion equation;

Boundary and initial value problems (Dirichlet and Neumann type) involving wave equation, heat conduction equation, Laplace's equations and solutions by method of separation of variables (Cartesian coordinates); initial boundary value problems in non-rectangular coordinates.

Green's functions for elliptic, parabolic and hyperbolic equations..

Solution of ODE and PDE by Laplace transform;

REFERENCES:

1. Joe D. Hoffman, Numerical methods for Engineers and Scientists, McGrow Hill.
2. G. D. Smith, Numerical solutions to Partial Differential Equations, Brunel

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper MT-3-5-1: Discrete Mathematics (Theory, Credits: 4)

Review of Set Theory: Sets and classes, Relations and functions, Equivalence relations and equivalence classes, Principle of mathematics induction, Recursive definitions, Posets, Chains and well-ordered sets, Axiom of choice, Cardinal and ordinal numbers, Cantor's lemma, Set theoretic paradoxes.

Logic Theory: Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates.

Combinatorics: Principles of addition and multiplication, Arrangements, Permutation and combinations, Multinomial theorem, Partitions and allocations, Pigeonhole principle, Inclusion-exclusion principle, Generating functions, Recurrence relations.

The Basics: graphs, paths and cycles, connectivity, trees and forests, bipartite graphs, contraction and minors, Euler tours, Hamilton Cycle.

REFERENCES:

1. J.P. Tremblay and R.P. Manohar, Discrete Mathematics with Applications to Computer Science, McGraw Hill, 1989.
2. V. K. Balakrishnan, Introductory Discrete Mathematics, Dover, 1996.
3. F. Harary, Graph Theory, Narosa, 1995.
4. Bela Bollobas, Graph Theory: An Introductory Course, GTM, Springer Verlag, 1990.
5. Elliott Mendelson, Introduction to Mathematical Logic.
6. Heinz-Dieter Ebbinghaus, Jörg Flum, Wolfgang Thomas, Mathematical Logic.

Paper MT-3-5-2: Analysis-I (Theory, Credits: 4)

Sequences and Series of Functions- Point wise and Uniform convergence of a sequence of functions, Cauchy's Condition for uniform convergence, Mn-test, Test for uniform convergence of series– Weierstress M test, Abel's test and Dirichlet's test, Uniform convergence and continuity, uniform convergence and integration uniform convergence and differentiation.

Power Series- Radius of convergence, Basic Theorems, Cauchy-Hadamard formula, Uniform convergence, Abel's theorem, Uniqueness of power series, Term by term, differentiation and integration of a Power series.

Riemann integration: Condition of integrability, properties of integrable functions, Darboux theorem, indefinite integral and their properties, functions with infinite number of discontinuities, (countable number of limit points), monotone functions, fundamental theorem on integral calculus, mean value theorems. Improper integrals, convergence at infinity, absolute and conditional convergence.

Metric Spaces-Definition, Example of Metric Spaces. Closed and Open sets- Convergence of a sequence, Spherical Neighbourhood, Closure of a Set, Closed Sets, Open Sets, Interior and Boundary Points. Complete Metric Spaces-Cauchy Sequences, Example of Complete Metric Spaces, Example of Incomplete Metric Spaces, Diameter of a set, Bounded Set, Cantor's Intersection Theorem, Baire's Category theorem , Isometry, Fixed PointTheorem.

REFERENCES:

1. H.L. Royden, Real Analysis, Prentice Hall.
2. B.Z. Vulikh, A Brief course in the Theory of Functions of a Real Variable, Mir Publishers
3. I.P.Natanson, Theory of Functions of a Real variable, Vol. 1, Frederick Ungar Pub. Co.
4. I.K.Rana, An introduction to measure and integration, Narosa Publishing House.
5. W. Rudin, Real and Complex Analysis, McGraw Hill.

Paper MT-3-5-3: Theory of Optimization (Theory, Credits: 4)

Linear Models- Formulation and Examples, Basic Polyhedral Theory- Convexity, Extreme points, Supporting hyperplanes etc, Simplex Algorithm- Algebraic and Geometrical approaches, Artificial variable technique.

Graphical method for solving two and three variable problems, simplex method, Big M method, degenerate LP problem, product form of inverse of a matrix, revised simplex method.

Duality Theory- Fundamental theorem, Dual simplex method, Primal-dual method,

Assignment & Transportation Problems: Models and Algorithms, Network Flows: Shortest path Problem, Max-Flow problem and Min-cost Flow problem.

Theory of games, two-person zero sum games with and without saddle-points, pure and mixed strategies, graphical method of solution of a 2 X n game.

Dynamic Programming, Principle of optimality, discrete and continuous models.

Quadratic programming Problems, Wolfe's method, Beale's method.

Nonlinear Constrained Optimization problems related to Khun Thuker Conditions.

Inventory Theory & Queuing Theory.

REFERENCES:

1. R. Fletcher, Optimization, Academic Press, 1969.
2. N. S. Kambo, Mathematical Programming Techniques, East West Press, 1997.
3. G.F.Hadley; Addison –Wesley Pule, Reading, Mass, Linear Programming.
4. Chakraborty & Ghosh; Moulik Library, Culcutta, Linear Programming and Game theory.
5. M. D. Davis; Basic Books, N.Y., Game Theory: A nontechnical introduction.

6. J.C.C. Mckinsey, Mc-Graw Hill B.C., N.Y., Introduction to the theory of games

Paper MT-3-5-4: Complex Analysis (Theory, Credits: 2)

Analytic Functions- Definition and Examples, Harmonic Functions, Conjugate Harmonic Functions, Construction of an analytic function whose real part is given (Related theorem is to be assumed).

Bilinear Transformations- Definition, Cross Ratio, Fixed Points of a Bilinear Transformation, Normal Form of a Bilinear Transformation, Inverse Points, Circles, Orientation principle.

Complex Integration: Cauchy's integral theorem, Cauchy's integral formula.

Zeros of an analytic functions, Uniqueness of analytic functions, Singularities, Laurent's theorem, Removable singularity, Limit points of zeros and poles, Riemann's theorem on removable singularity, Cauchy's residue theorem.

REFERENCES:

1. J. H. Mathews and R. W. Howell, Complex Analysis for Mathematics and Engineering, 3rd edition, Narosa, 1998.
2. L. V. Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 1979.
3. R.V. Churchill and J.W. Brown, Complex Variables and Applications, 5th edition, McGraw Hill, 1990.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Mathematics and optional for students having major in other subjects)

Paper MT-3-5-5: Mathematical Theory of Probability & Statistics (Theory, Credits: 2)

Probability - Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes's Theorem, and independence.

Random Variables - Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, moment generating function.

Special Distributions - Discrete uniform, Binomial, Geometric, Poisson, Exponential, Gamma, Normal distributions, Function of a Random Variable.

Joint Distributions**:** Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bivariate normal distribution.

Estimation of parameters: Maximum likelihood and method of moments. Properties of best estimates.

Testing of Hypothesis: Neyman-Pearson lemma, standard tests for one and two sample problems.

REFERENCES:

1. Gupta, Amritava, Groundwork of Mathematical Probability, Academic Publishers, Calcutta.
2. A. Papoulis, Probability, Random Variables and Stochastic Processes, McGraw Hill, 1985.
3. H. J. Larson, Introduction to Probability Theory and Statistical Inference, 3rd edition, Wiley, 1969.

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper MT-3-6-1: Analysis-II (Theory, Credits: 2)

Topological spaces, Basis for a topology, The order topology, Subspace topology, Closed sets. Countability axioms, Limit points, Convergence of nets in topological spaces, Continuous functions.

Metric topology, Quotient topology. Separation axioms, Connected spaces, Connected sets in R, Components and path components, Compact spaces, Compactness in metric spaces, Local compactness.

The product topology, Embedding lemma, Uryshon's lemma, Uryshon's metrization theorem, Tietz extension theorem. The Tychonoff theorem, Completely regular spaces.

Differentail Topology, Topological manifolds, Differential manifolds, Submanifolds, Local Immersion theorem, Integration of manifolds.

REFERENCES:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
2. James R. Munkres, Topology, Second Edition, Prentice Hall, 1999.

3. Stephan Willard, General Topology, Dover, 2004.
4. Klaus Janich, Topology, Springer, UTM, 1984.
5. James Dugundji, Topology, McGraw Hill, 1966.

Paper MT-3-6-2: Advanced Modern Algebra (Theory, Credits: 2)

Review on Groups. normal subgroups, cosets, Lagrange's theorem. Homomorphisms, Kernel, Image of a homomorphism, Isomorphism, Direct product of groups. Group action on a set, Semi-direct product, Sylow' theorems, Free groups, Solvable and Nilpotent groups.

Decomposition groups and inertia groups, proof of the law of quadratic reciprocity using number fields, finiteness of class groups, Dirichlet's Unit Theorem, Riemann and Dedekind zeta functions, class number formula, Dirichlet L-functions.

Rings: Fundamentals of rings, Quotient rings, Maximal, Prime and Principal ideals, Euclidean and Polynomial rings, Modules, basics of field theory.

Advanced Graph Theory: Matching and Covers. Konig's Theorem, Independent Set. Cuts and Connectivity: 2-connected Graphs, Menger's theorem; Network Flow: Max-flow Min-cut and the Ford-Fulkerson algorithm. Euler's formula, Kuratowski's theorem, plane duality. Coloring: coloring maps and planar graphs, Cayley graph, Spectrum of a graph.

REFERENCES:

1. I. N. Herstein, Topics in Algebra, 2nd edition, Wiley Eastern, 1975.
2. C. Musili, Introduction to Rings and Modules, 2nd edition, Narosa, 1992.
3. M. Artin, Algebra, Prentice Hall of India, 1994

Paper MT-3-6-3A: Numerical Linear Algebra (Theory, Credits: 2)

Fundamentals of Linear systems, LU decompositions, Gaussian elimination with partial pivoting, Banded systems, Positive definite systems, Cholesky decomposition.

Vector and matrix norms, Perturbation theory of linear systems, Condition numbers, Estimating condition numbers.

Gram-Schmidt orthonormal process, Householder transformation, Givens rotations, QR factorization, Roundoff error analysis of orthogonal matrices, Stability of QR factorization.

Solution of linear least squares problems, Normal equations, Singular Value Decomposition(SVD), Polar decomposition, Moore-Penrose inverse, Rank deficient least squares problems,

Sensitivity analysis of least-squares problems. Review of eigenvalues and canonical forms of matrices, Sensitivity of eigenvalues and eigenvectors, Adjoint operators, normal, unitary, and self-adjoint operators, Schur's theorem, spectral theorem for normal operators. Reduction to Hessenberg and tridiagonal forms, Power and inverse power methods, Rayleigh quotient iteration.

Overview of iterative methods: Jacobi, Gauss-Seidel and successive overrelaxation methods, Krylov subspace method, The Lanczos iterations.

Approximation of Functions: Least squares Polynomial Approximation, Approximation with Orthogonal Polynomials, Chebyshev Polynomials, Mini-Max Error Approximation.

REFERENCES:

1. L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, 1997.
2. D. S. Watkins, Fundamentals of Matrix Computation, Wiley, 1991.
3. G. H. Golub and C.F.Van Loan, Matrix Computation, John Hopkins U. Press, Baltimore, 1996.
4. G. W. Stewart, Introduction to Matrix Computations, Academic Press, 1973.
5. J.W. Demmel, Applied numerical linear algebra, SIAM, Philadelphia, 1997.

Paper MT-3-6-3B: Numerical Linear Algebra (Practical, Credits: 2)

Using Matlab do the numerical computations of the solution of Ax=B for different methods discussed in MT-3-6-3A.

REFERENCES:

1. L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, 1997.
2. D. S. Watkins, Fundamentals of Matrix Computation, Wiley, 1991.
3. G. H. Golub and C.F.Van Loan, Matrix Computation, John Hopkins U. Press, Baltimore, 1996.
4. G. W. Stewart, Introduction to Matrix Computations, Academic Press, 1973.
5. J.W. Demmel, Applied numerical linear algebra, SIAM, Philadelphia, 1997.

Paper MT-3-6-4: Differential Geometry (Theory, Credits: 4)

Curvilinear coordinates in En. Base vectors and reciprocal base vectors. Interpretation of covariant derivatives. Intrinsic derivative, Parallel vector fields. Serret-Frenet formulas. First fundamental quadratic form. Angle between two intersecting curves in a surface. Isometric surfaces, Gaussian curvature, Geodesic. Geodesic coordinates. Bianchi's identity, Ricci tensors, Einstein space. Geodesic curvature of surface curves. The second fundamental form of a surface. Tensor derivative. Formulas of Gauss, The integrability conditions. Formulas of Weingarten, Equations of Gauss and Codazzi. Mean and total curvature of a surface. Meusnier's theorem. Principal directions and principal curvatures.

REFERENCES:

1. T.J. Willmore, An introduction to Differential and Riemannian Geometry, Oxford University Press
2. 4. J.A.Thorpe, Introduction to Differential Geometry, Springer-Verlag.
3. B.O.'Neil, Elementary Differential Geometry, Academic Press
4. 6. S.Sternberg, Lectures on Differential Geometry, Prentice-Hall

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Mathematics and optional for students having major in other subjects)

Paper MT-3-6-5: Mathematical Modeling (Theory, Credits: 2)

Introduction to Mathematical Modeling in the Physical Sciences ; Importance of the usage of mathematical models over physical models ; Classification of mathematical models: Deterministic and Stochastic models and their distinctive features ; Formulation of some mathematical models and their analyses for (i) linear frictionless systems, (ii) linear systems with friction, (iii) nonlinear frictionless systems and (iv) nonlinear systems with friction ; Concepts of equilibrium and stability from linearized stability analysis of
an equilibrium solution.

REFERENCES:

1. Richard Haverman: Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow (Classics in Applied Mathematics), Prentice Hall.
2. J N Kapoor: Mathematical modelling, New Age International, 2001 Reprint
3. Mathematical Modelling - F.R. Giordano, M.D.Weir&William P.Fox, Third edition.

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper MT-4-7-1: Analysis-III (Theory, Credits: 4)

Outer measure of a set. Properties of outer measure. Measurable sets and Lebesgue measure. Properties of measurable sets. Existence of non-measurable sets. Measurable functions and their properties. Equivalent functions. Simple functions

Sequence of functions. Almost everywhere convergence and convergence in measure. Lebegue's theorem, Riesz theorem and Egoroff's theorem. Structure of measurable functions ---Lusin's theorem and Frechet's theorem.

Necessary and sufficient condition for Riemann integrability in terms of measure. Lebesgue integral of bounded function and its properties Comparison of Riemann integral and Lebesgue integral. Passage to the limit under the sign of integration. Bounded convergence theorem.

Summable functions. Integrals of summable functions. Properties of the integrals of summable functions.

Passage to the limit under the integral sign of a sequence of summable functions. Dominated convergence theorem. Levi's theorem and Fatou's theorem.

REFERENCES:

1. H. L. Royden, Real Analysis, Prentice Hall
2. P. R. Halmos, Measure Theory, Prentice Hall
3. P. K. Jain & V. P. Gupta, Lebesgue Measure and Integration, Wiley Eastern Ltd.
4. I. K. Rana, An introduction to measure and integration, Narosa Publishing House.

Paper MT-4-7-2: Introduction to Continuum Mechanics (Theory, Credits: 4)

Stress tensor. Equilibrium equations. Mohr's circle for plane stress. Deformation, Strain tensor, Rate of deformation tensor. Equations of motion. Dynamic similarity. Exact solutions.

Velocity of fluid, Streamlines and path lines, Steady and unsteady flows, Velocity potential, Vorticity vector, Conservation of mass, Equation of continuity. Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid, Euler's equation of motion, Bernoulli's equation.

Singularities of flow, Source, Sink, Doublets, Rectilinear vortices. Complex variable method for two-dimensional problems, Complex potentials for various singularities, Circle theorem, Blasius theorem, Theory of images and its applications to various singularities.

Three dimensional flows, Irrotational motion, Weiss's theorem and its applications. Viscous flow, Vorticity dynamics, Vorticity equation, Reynolds number, Stress and strain analysis, Navier-Stokes equation, Boundary layer Equations.

Viscous fluid flows

REFERENCES:

1. N. Curle and H. Davies, Modern Fluid Dynamics, Van Nostrand Reinhold, 1966.
2. L. M. Milne Thomson, Theoretical Hydrodynamics, Macmillan and Co., 1960.
3. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 1993.
4. F. Chorlton, A Text Book of Fluid Dynamics, Von Nostrand Reinhold/CBS, 1985.
5. A. R. Patterson, A First Course in Fluid Dynamics, Cambridge University Press, 1992.
6. S. Sokolnikoff, Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua, John Wiley & Sons, Inc.
7. Frank M White, Viscous Fluid Flow, McGraw-Hill, 1991.

Paper MT-4-7-3: Galois Theory (Theory, Credits: 4)

Field extension, Finite field extension, Algebraic and transcendental extension, Splitting fields: Existence and uniqueness (upto isomorphism), Algebraically closed fields, Elements of finite fields. Separable extensions. Simple extension, Primitive elements, Normal extensions, Automorphisms of extensions, Galois extensions, Fundamental theorem of Galois theory, Galois group of a polynomial. Solution of polynomial equations by radicals, Insolvability of the general equation of degree 5 by radicals. Geometric constructions by ruler and compass; Three famous impossibilities. A regular n-gon is constructible if and only if n is a Fermat prime. Cyclotomic polynomials and the Wedderburn Theorem on division ring.

REFERENCES:

1. D. S. Malik, J. N. Mordeson and M. K. Sen, Fundamentals of Abstract Algebra, McGrew Hill. 1997.

2. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd. 1975.
3. Joseph Rotman, Galois Theory, Springer.
4. E. Artin, Galois Theory, Notre Dame.
5. I. Stewart, Galois Theory, Chapman and Hall, 1989.
6. J. P. Escofier, Galois Theory, GTM-204, Springer, 2001

Paper MT-4-7-4: Practical-I (Practical, Credits: 2)

Laboratory based project work.
Finding solution of a system of linear equations by
(a) Gauss elimination method
(b) Gauss Jacobi method
(b) Gauss-Seidel iterative method

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Mathematics and optional for students having major in other subjects)

Paper MT-4-7-5: Integral Equations & Calculus of Variations (Theory, Credits: 2)

Integral Equations: Basic concepts, Volterra integral equations, Relationship between linear differential equations and Volterra equations, Resolvent kernel, Method of successive approximations, Convolution type equations, Volterra equation of first kind, Abel's integral equation, Fredholm integral equations, Fredholm equations of the second kind, the method of Fredholm determinants, Iterated kernels, Integral equations with degenerate kernels, Eigen values and Eigen functions of a Fredholm alternative, Construction of Green's function for BVP, Singular integral equations.

Calculus of Variation: Introduction, Euler-Lagrange equations, Degenerate Euler equations, Natural boundary conditions, Transversality conditions, Simple applications of variational principle, Sufficient condition for extremum.

REFERENCES:

1. A. S. Gupta, Calculus of variation with Applications, Prentice-Hall, India, 1997.
2. G. M. Ewing, Calculus of variation with Applications,Dover, 1985.
3. H. Sagan, Introduction to Calculus of variations, Dover, 1967.
4. S.G. Mikhlin, Linear Integral Equations, Hindustan Book 1960.
5. Petrovsky, Integral Equations.
6. I. M. Gelfand and S.V. Fomin, Calculus of variation (Prentice Hall 1963).
7. F. G. Tricomi, Integral Equations (Inter Science)

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper MT-4-8-1: Analysis-IV (Theory, Credits: 4)

Nonlinear Space, Banach contraction mapping theorem. Banach spaces; bounded linear functionals and bounded linear operators, dual spaces, Hahn-Banach theorem, uniform boundedness principle, open mapping and closed graph theorems, weak convergence.

Hilbert spaces, orthonormal sets, Riesz representation theorem, bounded linear operators on Hilbert spaces.

Adjoint operators, Normal, Unitary, Self-adjoint operators and their spectra. Spectral theorem for compact self-adjoint operators.

Quotient spaces, connectedness, path connectedness. Geometric complexes, polyhedra, orientation

Simplicial homology groups, Structure of homology groups, Euler – Poincare theorem.

Simplicial approximation, induced homomorphisms on the homology groups, Brower fixed point theorem and related results. Fundamental group, Conversing homotopy property for S1, Examples of fundamental groups.

REFERENCES:

1. B. V. Limaye, Functional Analysis, 2nd edition, Wiley Eastern, 1996.
2. E. Kreyszig, Introduction to Functional Analysis with Applications, John Wiley and Sons, 1978.
3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
4. James R. Munkres, Topology, Second Edition, Prentice Hall, 1999.
5. Stephan Willard, General Topology, Dover, 2004.
6. Klaus Janich, Topology, Springer, UTM, 1984.
7. James Dugundji, Topology, McGraw Hill, 1966.

Paper MT-4-8-2: Numerics of Partial Differential Equations (Theory, Credits: 4)

Finite difference schemes for partial differential equations - explicit and implicit schemes; Consistency, stability and convergence - stability analysis by matrix method and von Neumann method, Lax's equivalence theorem; Finite difference schemes for initial and boundary value problems - FTCS, backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme; CFL conditions;

Multigrid methods, Higher Order methods.

Finite element method for ordinary differential equations - variational methods, method of weighted residuals, finite element analysis of one-dimensional problems.

Applications: Fundamental equations of the flow of viscous compressible fluids, Navier-Stokes equations, The energy equation, Fundamental equations in cylindrical and spherical coordinates. Euler's dynamical equations, Bernoulli's theorem. Potential flows. Some exact solutions of Navier-Stokes equations.

REFERENCES:

1. G. D. Smith, Numerical Solutions to Partial Differential Equations, Oxford University Press, 3rd Edn., 1986.
2. J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM, 2004.
3. J. N. Reddy, An Introduction to Finite Element Method, 3rd Edn., McGraw Hill, 2005.
4. L. Lapidus and G. F. Pinder, Numerical Solution of Partial Differential Equations in Science and Engineering, John Wiley, 1982.
5. K. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge University Press, 2nd Edn., 2005.
6. C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.

Paper MT-4-8-3: Dynamical Systems (Theory, Credits: 4)

Discrete and continuous time dynamical systems. Flows and maps. Phase space. Orbits. Fixed points, periodic points and their stability. Attractors and repellors. Logistic map. Tent map. Baker’s map. Graphical analysis of orbits of one-dimensional maps. Hyperbolicity.

General solution of continuous time linear systems. Phase space diagrams. Fixed point analysis. Stable and unstable nodes. Saddle point. Stable and unstable foci. Centre.

Lyapunov and asymptotic stability. Local and global stability. Hartmann-Grobman theorem*, Lyapunov theorem

on stability. Lyapunov functions. Periodic orbits. Limit cycles. Atracting and Invariant set, Poincare-Bendixson theorem. Poincare map.
Sensitive dependence on initial conditions (SDIC). Topological transitivity. Topological mixing. Topologicalconjugacy and semi-conjugacy for maps. Chaos. Chaotic orbits. Lyapunov exponents. Invariant measure. Ergodic maps. Invariant measure for logistic maps.Symbolic dynamics. Shift map. Properties of logistic map for parameter value □□2 + □5. Cantor set. Cantor set structure of logistic map. Topological conjugacy of logistic and shift map. Chaotic behaviour of logistic
map. Bifurcation theory. Saddle-node bifurcation. Pitchfork bifurcation. Period doubling bifurcation. Period doubling route to chaos. Hopf bifurcation.
Sarkovskii's theorem*. Period-3 implies chaos for 1-D maps*. Two-dimensional maps. Toral automorphism.

REFERENCES:

1. M W Hirsch and S Smale - Differential Equations, Dynamical Systems, Academic 1974.
2. R L Devaney - An Introduction to Chaotic Dynamical Systems (Addition-Wesley 1989).
3. D K Arrowsmith et al - Introduction to Dynamical Systems, Cambridge (1990).
4. V I Arnold - Dynamical Systems (Vols. I - IV) Springer-Verlag (1992).
5. PO Drazin - Nonlinear Systems, Cambridge (1993).
6. P Glendinning - Stability, Instability and Chaos, Cambridge (1994)

Paper MT-4-8-4: Practical-II (Practical, Credits: 2)

Laboratory based project work.
Finding solution of Initial and Boundary Value Problem (IVP) for ODE & PDE.
Further problems, as suggested by the Course Instructor

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Mathematics and optional for students having major in other subjects)

Paper MT-4-8-5: Mathematical Ecology (Theory, Credits: 2)

Preliminaries: Introduction to the mathematical ecology, Mathematical tools (algebra and calculus) required for the course. Refreshing of Mathematical tools.
Populations: Homogeneous population exponential, geometric growth and decay, Age-and stage-structured linear models : relaxing the assumption of population homogeneity, Nonlinear models of signal population the continuous time logistic model.
Dynamics: Discrete logistic growth, oscillations, and chaos, Harvesting and the logistic model, Predators and their prey, Competition between two species, mutualism, and species invasions Multispecies community and food web models. Elements of dynamic model; Static variable, control variable, forcing function, parameters (rates), constant. Procedure of dynamic model; Conceptualization of the model, transformation into mathematical model, calibration, Sensitivity analysis, validation & verification.
Integrated ecosystem theories: Exergy, Emergy, Ascendancy & Ecosystem health.
Static model: Network analysis and Ecopath, Through flow, developmental capacity, contribution and dependency co-efficient, Ascendancy & redundancy.

REFERENCES:

1. Differential Equations with Applications and Historical Notes by G.F. Simmons (Tata McGraw Hill Edition, 2003).
2. Mathematical Biology Volumes 1 and 2 by J.D. Murry (Springer, 3/e, 2002).
3. Mathematical Ecology by John Pastor (Wiley-Blackwell, 2008).
4. Fundamentals of Ecological Modelling- Jorgensen & Fath.
5. Modelling for Scale-H. T. Odum
6. Integration of ecosystem theories: A Pattern- S. E. Jorgensen
7. Network analysis in marine ecology-Wuff, Mann & Field
8. Ecology-Krebs
9. Fundamentals of ecology-E. P. Odum
10. Ecology-Ricklefs & Miller

PHILOSOPHY AND HISTORY OF SCIENCE

SECOND YEAR: SEMESTER-III
Paper PHS-2-3-1: History of Science (Theory, Credits: 2)

SECOND YEAR: SEMESTER-IV
Paper PHS-2-4-1: Philosophy of Science (Theory, Credits: 2)

SECOND YEAR: SEMESTER-III

Paper PHS-2-3-1: History of Science (Theory, Credits: 2)

A. Aristotle's scheme of natural science; Zeno's Paradox: Particle vis-à-vis Plenum scheme
B. Medieval Physics of the Heavens, Copernican Revolution and Discovery of Galilean Relativity
C. Cartesian Revolution – Modern Idea of Mathematising the Nature
D. Newtonian Revolution – Discovery of Action-at-a-distance; Galileo's New Method

REFERENCES:

1. Aristotle: Physica
2. Richard Fitzpatrick: A Modern Almagest (Introduction)
3. Galileo: Dialogue Concerning Two Chief World Systems
4. Descartes: Discourse on Method
5. Newton: Principia Mathematica

SECOND YEAR: SEMESTER-IV

Paper PHS-2-4-1: Philosophy of Science (Western, Contemporary) (Theory, Credits: 2)

A. The Aristotelian Heritage of Western Science
B. Hempelian Picture of Scientific Explanation and its Developments
C. Popper: Logic of Scientific Discovery; Falsifiability and verisimilitude
D. Kuhn: Paradigm and Scientific Change
E. How the Laws of Physics Lie

REFERENCES:

1. Hempel: Aspects of Scientific Explanation and other Essays in the Philosophy of Science
2. Popper: Logic of Scientific Discovery
3. Kuhn: Structure of Scientific Revolution
4. Hacking: Representing and Intervening

PHYSICS

FIRST YEAR: SEMESTER-I

Paper PH-1-1-1: Mechanics, Waves and Oscillations	(Theory, Credits: 3)
Paper PH-1-1-2	(Practical, Credits: 2)

FIRST YEAR: SEMESTER-II

Paper PH-1-2-1: Physical Optics	(Theory, Credits: 3)
Paper PH-1-2-2	(Practical, Credits: 2)

SECOND YEAR: SEMESTER-III

Paper PH-2-3-1: Electricity and Magnetism	(Theory, Credits: 3)
Paper PH-2-3-2	(Practical, Credits: 2)

SECOND YEAR: SEMESTER-IV

Paper PH-2-4-1: Quantum Mechanics and Relativity	(Theory, Credits: 3)
Paper PH-2-4-2	(Practical, Credits: 2)

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper PH-3-5-1: Classical Mechanics	(Theory, Credits: 4)
Paper PH-3-5-2: Electronics	(Theory, Credits: 4)
Paper PH-3-5-3	(Practical, Credits: 4)
Paper PH-3-5-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper PH-3-5-5: Statistical Mechanics	(Theory, Credits: 2)

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper PH-3-6-1: Advanced Quantum Mechanics – I	(Theory, Credits: 4)
Paper PH-3-6-2: Electromagnetic Theory	(Theory, Credits: 4)
Paper PH-3-6-3	(Practical, Credits: 4)
Paper PH-3-6-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper PH-3-6-5: Spectroscopy-I	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper PH-4-7-1: Advanced Statistical Mechanics	(Theory, Credits: 4)
Paper PH-4-7-2: Material Science	(Theory, Credits: 4)
Paper PH-4-7-3	(Practical, Credits: 4)
Paper PH-4-7-4	(Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER:

Paper PH-4-7-5: Spectroscopy-II	(Theory, Credits: 2)

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper PH-4-8-1: Nuclear and Particle Physics	(Theory, Credits: 4)
Paper PH-4-8-2: Advanced Quantum Mechanics – II	(Theory, Credits: 4)
Paper PH-4-8-3	(Practical, Credits: 4)

Paper PH-4-8-4 (Practical, Credits: 2)

ADDITIONAL ELECTIVE PAPER

Paper PH-4-8-5: Fundamentals of Laser (Theory, Credits: 2)

FIFTH YEAR: SEMESTER-IX

DISSERTATION PAPERS:

Paper PH-5-9-1 (Credits: 24)

FIFTH YEAR: SEMESTER-X

DISSERTATION PAPERS:

Paper PH-5-10-1 (Credits: 24)

FIRST YEAR: SEMESTER-I

Paper PH-1-1-1: Mechanics, Waves and Oscillations (Theory, Credits: 3)

Effect of centrifugal and Coriolis forces due to the rotation of earth.

Moduli of elasticity, Poisson's ratio, Relations between elastic constants, Shear and longitudinal strain, Twisting couple of a cylinder (solid and hollow), Bending of a beam, Internal bending moment, Cantilever (neglecting mass).

Fluid pressure, Equation of continuity, Reynold's number, Bernoulli's theorem, Toricelli's theorem.

Simple harmonic motion, Superposition principle, Lissajous figures.

Free vibrations with damping, Forced oscillator with one degree of freedom, Resonance.

Free oscillations of systems with two degrees of freedom, Normal modes and normal coordinates.

Fourier analysis of non-sinusoidal waves.

Progressive and standing waves, Phase and group velocity.

REFERENCES:

1. Physics, Vol. I, Robert Resanick and David Halliday.
2. Berkeley Physics, Vol. I.
3. The Feynman Lectures on Physics.
4. Geometrical and Physical Optics, R. S. Longhurst.
5. Optics, A. Ghatak.
6. Modern Optics, A. B. Gupta.
7. A Treatise on General Properties of Matter, Chatterjee and Sengupta.

Paper PH-1-1-2 (Practical, Credits: 2)

1. Determination of the coefficient of thermal conductivity of a bad conductor by Lee's method.
2. Measurement of an unknown resistance by using P.O. box.
3. To study the waveforms, frequency and phase (Lissajous figure method) by using a CRO.
4. To determine the angle of a prism by using a spectrometer.
5. To draw the I-V characteristics of a zener diode.

Addition or changes of experiments may be made by the Centre as and when required.

FIRST YEAR: SEMESTER-II

Paper PH-1-2-1: Physical Optics (Theory, Credits: 3)

Young's experiment, Theory of interference, Lloyd's mirror, Interference in parallel and wedge shaped films, Newton's rings, Michelson interferometer, Multiple beam interference in parallel film and Fabry-Perot interferometer.

Fresnel's diffraction, Zone plate, Diffraction at a straight edge, Fraunhoffer diffraction due to single and double slits, Plane transmission grating.

Production of polarized light by reflection and refraction, Brewster's law, Polarization by double refraction and Huygen's theory, Nicol prism, Retardation plates, Production and analysis of circularly and elliptically polarized light, Optical activity and Fresnel's theory, Biquartz polarimeter.

Laser: Characteristics and main components, population inversion (qualitative idea), Ruby laser, Applications of laser.

REFERENCES:

1. Geometrical and Physical Optics, R. S. Longhurst.
2. Optics, A. Ghatak.
3. Physical Optics, B. K. Mathur and T. P. Pandya.
4. Fundamentals of Optics, Jenkins and White.
5. Modern Optics, A. B. Gupta.
6. Introduction to Modern Optics, G. R. Fowels.

Paper PH-1-2-2 (Practical, Credits: 2)

1. Determination of 'g' using compound pendulum.
2. To determine the internal resistance of a cell by a potentiometer.

3. To determine the horizontal component of earth's magnetic field by a Helmholtz galvanometer and to find its reduction factor.
4. To draw δ-λ curve for a given prism and hence to determine the wavelength of an unknown radiation by using a spectrometer.
5. Design of Zener regulated power supply and to draw the waveforms at each stage.
Addition or changes of experiments may be made by the Centre as and when required.

SECOND YEAR: SEMESTER-III

Paper PH-2-3-1: Electricity and Magnetism (Theory, Credits: 3)

Electrostatics, Coulomb's law, Gauss's law, Magnetostatics, Electric fields in matter, Dielectrics, Polarisation, Magnetic fields in matter, Magnetic materials, Biot-Savart's law, Ampere's law, Faraday's law, Lenz's law, Lorentz force law, Dead-beat and ballistic galvanometers.
Displacement current and equation of continuity, Maxwell equations, Vector and scalar potentials, Gauge transformation, Poynting's theorem.
L-R, C-R and L-C-R circuits and their mechanical analogues, Resonance, Q-value, Power factor, Transformers.
EM wave equation and their solutions, Propagation of plane EM waves in different media, e.g., free space, dielectrics and conductors, Laws of reflection and transmission in normal and oblique incidence in linear and conducting media.

REFERENCES:

1. Introduction to Electrodynamics, D. J. Griffiths.
2. Electricity and Magnetism, H. E. Duckworth.
3. Electricity and Magnetism, Vol. I, Fewkes and Yarwood.
4. The Feynman Lectures on Physics.
5. Physics, Vol. II, Robert Resanick and David Halliday.
6. Fundamentals of Electricity and Magnetism, Basudev Ghosh.

Paper PH-2-3-2 (Practical, Credits: 2)

1. Determination of 'g' by Kater's reversible pendulum.
2. Conversion of galvanometer into ammeter and voltmeter.
3. To determine the temperature coefficient of resistance of the material of a given coil.
4. Determination of dispersive power of the material of a prism by using a spectrometer.
5. To draw static output characteristic curves of a transistor in common-emitter configuration for different base currents.

Addition or changes of experiments may be made by the Centre as and when required.

SECOND YEAR: SEMESTER-IV

Paper PH-2-4-1: Quantum Mechanics and Relativity (Theory, Credits: 3)

Black body radiation, Compton Effect. Bohr's model of hydrogen atom, The correspondence principle, Stern-Gerlach experiment, The concept of spin, de Broglie hypothesis, Wave-particle duality, Davisson-Germer experiment, Uncertainty principle.
Schrödinger equation, Free particle wave function, Schrödinger equation in the presence of a potential, Linear operators, Hermitian operators, Observables, Eigenvalues and Eigenfunctions, Expectation values, Commutation relations.
Particle in one dimensional box, square well, rectangular potential and tunneling, Linear harmonic oscillator, Angular momentum operators and their eigenfunctions.
Special Theory of Relativity: Michelson-Morley experiment, Postulates of special theory of relativity, Galilean transformation, Lorentz transformation, Length contraction and time dilation, Concept of simultaneity, Relativistic velocity transformation relations, Mass energy relation, Relativistic relation between energy and momentum.

REFERENCES:

1. Introduction to Quantum Mechanics, D. J. Griffiths.
2. Quantum Mechanics, B. H. Bransden and C. J. Joachain.
3. Quantum Physics, S. Gasiorowicz.
4. Perspectives of Modern Physics, Arthur Beiser.
5. Special theory of relativity, R. Resnick.
6. Introduction to Electrodynamics, D. J. Griffiths.

Paper PH-2-4-2 (Practical, Credits: 2)

1. Determination of average resistance per unit length of the meter bridge wire by Carey-Foster's method and hence to determine an unknown resistance.
2. To measure phase shift between the current and applied voltage in CR, LR and LCR circuits.
3. Determination of the radius of curvature of the convex surface of a plano-convex lens by Newton's ring method.
4. Determination of specific rotation of cane sugar solution by polarimeter.
5. To draw static output characteristic curves of a transistor in common base configuration for different emitter currents and hence to determine the current gain.

Addition or changes of experiments may be made by the Centre as and when required.

THIRD YEAR: SEMESTER-V

MAJOR PAPERS:

Paper PH-3-5-1: Classical Mechanics (Theory, Credits: 4)

Generalized coordinates, D'Alemberts principle, Lagrange's equation, Hamilton's principle, Lagrangian for simple systems, Cyclic coordinates, Virial theorem, Hamilton's equations of motion, Cyclic coordinates and conservation laws, Gauge invariance, Lorentz forces, Conservative systems, Dissipative systems, Equivalent and inequivalent Lagrangians, Applications of Hamilton's formulation to simple cases.

Motion in a central force field: Equivalent one-body problem, General features of the motion, Classification of orbits, Kepler problem.

Decay and scattering processes: Kinematics of decay of a particle, Elastic and inelastic scattering, Transformations between C- and L- frames, Scattering cross-sections.

Dynamics of rigid body motion: Fixed and moving coordinate systems of a rigid body, Eulerian angles, Angular momentum and kinetic energy of a rigid body, Inertia tensor, Euler's equations of motion, Motion of a heavy symmetric top, Accelerated coordinate systems, Coriolis force.

Theory of small oscillations: General case of coupled oscillations, Eigen-modes and eigen-frequencies, Normal coordinates.

Canonical transformations and Hamilton-Jacobi theory: Canonical transformations, Condition for the transformations to be canonical, Illustration of canonical transformations, Poisson brackets and canonical transformations, Hamilton-Jacobi equation, Method of separation of variables, Action-angle variables, Integrable systems.

REFERENCES:

1. Classical Mechanics, H. Goldstein.
2. Mechanics, L. D. Landau and E. M. Lifshitz.
3. Classical Mechanics, Rana and Jaog.

Paper PH-3-5-2: Electronics (Theory, Credits: 4)

Intrinsic and extrinsic semiconductors, Mobility, Carrier concentration, Position of Fermi surface, P-N junction diode, Depletion width and potential barrier, Junction capacitance, Zener diode, Opto-electronic devices (solar cells, photodiodes, LEDs, etc.).

Bipolar junction transistor, Biasing of transistors in CB, CE and CC configurations, α, β and γ parameters, h-parameters and their conversion, Hybrid model, Equivalent circuits, CB, CC and CE amplifiers, Two stage amplifier.

FET, MOSFET, Heterojunction devices.

Principle of feedback, Negative and positive feedback, Voltage and current feedback, Advantages and

disadvantages of feedback, Positive feedback and Barkhausen criterion for sustained oscillation.
Operational amplifiers and their applications.
Half-adder and full-adder, Universal gates.
Comparators, Schmitt trigger, Flip-Flops, Registers, Counters, A/D and D/A converters.

REFERENCES:

1. Integrated Electronics, J. Millman and C. C. Halkias.
2. Solid State Electronic Devices, B. J. Streetman.
3. Principle of Digital Electronics, A. P. Malvino and D. P. Leach.
4. Electronics Fundamental and Application, D. Chattopadhyay and P. C. Rakshit.

Paper PH-3-5-3: Practical-I (Practical, Credits: 4)

1. To do Fourier analysis of certain complex waveforms by using a parallel resonant circuit.
2. To verify Thevenin's, Norton's and maximum power transfer theorems by using a resistive Wheatstone-bridge network.
3. Determination of the resistance of a suspended coil galvanometer by half deflection method and hence to calculate the figure of merit of the galvanometer.
4. Determination of wavelength of an unknown radiation by plane diffraction grating.
5. To measure the wavelength of laser radiation by studying its diffraction through a single slit.
6. To construct OR, AND and NOT gates using discrete circuit components and to verify their truth tables.
7. To design half and full-adder circuits using basic gates and to verify the respective truth tables.

Addition or changes of experiments may be made by the Centre as and when required.

Paper PH-3-5-4: Practical-II (Practical, Credits: 2)

Laboratory based project work.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Physics and optional for students having major in other subjects)

Paper PH-3-5-5: Statistical Mechanics (Theory, Credits: 2)

Basics of statistical mechanics: Probability distribution, Random walk problem, Calculation of mean and dispersion, State of a system (microscopic and macroscopic), Phase space, Density of states and Liouville's theorem, Postulates of statistical mechanics, Relation between statistical and thermodynamic parameters.
Classical statistical mechanics: Ensemble theory (micro-canonical, canonical and grand-canonical), Applications to classical ideal gas, Gibbs paradox, Statistical equivalence of three ensembles, Fluctuation of energy/number of particles in canonical/grand-canonical ensembles.
Quamtum statistical mechanics: Bose-Einstein and Fermi-Dirac statistics, Maxwell-Boltzmann statistics as a classical limit, Comparison of the three statistics.

REFERENCES:

1. Fundamentals of Statistical and Thermal Physics, Frederick Reif.
2. Statistical Mechanics, R. K. Pathria.
3. Statistical Mechanics, Kerson Huang.
4. Statistical Physics of Particles, Mehran Kardar.

THIRD YEAR: SEMESTER-VI

MAJOR PAPERS:

Paper PH-3-6-1: Advanced Quantum Mechanics – I (Theory, Credits: 4)

Linear vector and representation theory: Linear vector space, Bra and Ket notations, Matrix representation of observables and states, Determination of eigenvalues and eigenstates for observables using matrix representations, Change of representation and unitary transformations, Coordinate and momentum representations, Equations of motion in Schrödinger and Heisenberg pictures.
Commutation relations between angular momentum operators, Raising and lowering operators, Expressions in

terms of spherical coordinates, Commutator between kinetic energy operator and L operator, Application to rigid rotator, Linear harmonic oscillator problem in operator formalism.
Hydrogen atom problem: complete solution in terms of spherical harmonics and Leguerre polynomials.
Approximation methods: Variational method, Time-independent perturbation theory and WKB approximation.

REFERENCES:

1. Introduction to Quantum Mechanics, D. J. Griffiths.
2. Quantum Mechanics, Ashok Das.
3. Quantum Mechanics, R. Shankar.
4. Quantum Mechanics (Vol. 1), Cohen-Tannoudji.

Paper PH-3-6-2: Electromagnetic Theory (Theory, Credits: 4)

Boundary value problems in electrostatics, Green's function, Multipole radiation.
Tensor: Introduction to tensor, Cartesian, covariant and contravariant tensors, Contractions and direct products.
Minkowski space and four vectors, Concept of four-velocity, four acceleration and higher rank tensors, Transformation properties of four-momentum and four-force, Electromagnetic field tensor in four dimensions, Maxwell equations in covariant form, Gauge invariance and four-potential, Action principle and electromagnetic energy momentum tensor. Liénard-Weichert potential, Radiation from an accelerated charge, Larmor formula, Bremsstrahlung and synchrotron radiation, Reaction force of radiation.

REFERENCES:

1. Introduction to Electrodynamics, D.J. Griffiths
2. Classical Electrodynamics, J. D. Jackson.
3. Classical Theory of Fields, Volume 2 (Course of Theoretical Physics Series), L.D. Landau & E.M. Lifshitzs.
4. Classical Electricity and Magnetism, W. K. H. Panofsky and M. Phillips.

Paper PH-3-6-3: Practical-I (Practical, Credits: 4)

1. To draw the resonance curve of a series L-C-R circuit and hence to determine the Q-factor of the circuit. Also, study the variation of impedance of L with frequency.
2. Determination of self inductance of a coil by Anderson's bridge.
3. Determination of the boiling point of a liquid by platinum resistance thermometer.
4. To study the temperature dependence of reverse saturation current in a junction diode and hence to determine the band gap energy.
5. To determine the band gap by measuring the resistance of a thermistor as a function of temperature.
6. To study the use of OP-AMP as an inverting amplifier, a non-inverting amplifier, a unity gain buffer, an adder and a differential amplifier.
7. To design and verify the operations of SR, D and JK flip-flops using basic logic gates.

Addition or changes of experiments may be made by the Centre as and when required.

Paper PH-3-6-4: Practical-II (Practical, Credits: 2)

Laboratory based project work.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Physics and optional for students having major in other subjects)

Paper PH-3-6-5: Spectroscopy – I (Theory, Credits: 2)

Rotational spectra of diatomic molecules (rigid and non-rigid), Vibrational spectra of diatomic molecule (harmonic and anharmonic), Rotational-vibrational spectra of diatomic molecules, Vibrations of polyatomic molecules, Classical and quantum theory of Raman effect, Pure rotational Raman spectra, Vibrational Raman spectra, Electronic spectra of diatomic molecules, Born-Oppenheimer approximation, Franck-Condon principle, Dissociation energy and dissociation products.
Jablonski diagram, Radiative and non-radiative transitions in molecules, Kasha's rule, Quantum yield and lifetime, Conjugate effect, Steric effect, Solvent effect, Effect of pH.

REFERENCES:

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash.
2. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain.
3. Molecular spectra and Molecular Structure, G. Herzberg.
4. High Resolution Spectroscopy, J. M. Hollas.
5. Introduction to Molecular Spectroscopy, G. M. Barrow.

FOURTH YEAR: SEMESTER-VII

MAJOR PAPERS:

Paper PH-4-7-1: Advanced Statistical Mechanics (Theory, Credits: 4)

Ideal Bose system: Thermodynamic behaviour of an ideal Bose gas, Black body radiation, Bose-Einstein condensation, Liquid helium, Bose condensation in gases, Phonons.

Ideal Fermi system: Degenerate electron gas, Chandrasekhar limit, Specific heat of degenerate electron gas, Magnetism of an electron gas.

Phase transition and critical phenomena: Phase transitions, Ising model and lattice gas, Critical exponents, Order parameter, Correlation function and fluctuation dissipation theorem, Scaling hypothesis and scale invariance (qualitative discussions).

REFERENCES:

1. Fundamentals of Statistical and Thermal Physics, Frederick Reif.
2. Statistical Mechanics, R. K. Pathria.
3. Statistical Mechanics, Kerson Huang.
4. Statistical Physics (Part 1), L. D. Landau and E. M. Lifshitz.
5. Statistical Physics of Particles, Mehran Kardar.

Paper PH-4-7-2: Material Science (Theory, Credits: 4)

Solid state science: Crystals, Bravais lattice, Crystal planes and Miller indices, Common crystal structures, Diffraction of X-rays, Bragg law and Laue equation, Reciprocal lattice, Brillouin zones.

Bonding of solids, Elastic properties, Phonons, Lattice specific heat, Free electron theory and electronic specific heat, Response and relaxation phenomena, Drude model of electrical and thermal conductivity, Hall effect and thermoelectric power, Electron motion in a periodic potential, Band theory of solids: metals, insulators and semiconductors.

Diamagnetism, Paramagnetism, Ferromagnetism, Larmor's theorem, Langevin's theory, Curie-Weiss law, Hysteresis and energy loss in ferromagnetic materials.

Nanoscience: Hydrophobic hydration and interaction, Micelle formation, Colloidal aggregates and nanoparticles, Stability in solution, Surface charge of colloidal particles, Zero dimensional nanostructure, Homogeneous and heterogeneous nucleation, Metallic nanoparticles- synthesis and applications, Nanowires and nanorods: one dimensional nanostructures, Spontaneous growth, VLS, Electrospinning, Lithography; Thin film: two dimensional nanostructure, Langmuir-Blodgett (LB) film, Photolithography, Characterization of nanostructures, Properties and applications of colloids and nanoparticles.

REFERENCES:

1. Introduction to Solid State Physics, C. Kittle.
2. Fundamental of Solid State Physics, J. R. Christman.
3. Solid State Physics, Ascroft and Mermin.
4. S. M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2010.
5. A. A. Balandin & K. L. Wong, Eds., Handbook of Semiconductor nanostructures and Nanodevices.
6. H. S. Nalwa; Handbook of Nanostructured Biomaterials and Their Application in Nanobiotechnology.

Paper PH-4-7-3: Practical-I (Practical, Credits: 4)

1. UV-visible electronic absorption spectroscopy of organic molecules in liquid media.
2. UV-visible electronic absorption spectroscopy of organic molecules in thin films.

3. Determination of mutual inductance of a pair of coils.
4. To determine the value of Planck's constant by using Photo-electric effect.
5. Franck-Hertz experiment.
6. Experiment on fibre optics.
7. To determine wavelength of a monochromatic source by Michelson's interferometer.

Addition or changes of experiments may be made by the Centre as and when required

Paper PH-4-7-4: Practical-II (Practical, Credits: 2)

Laboratory based project work.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Physics and optional for students having major in other subjects)

Paper PH-4-7-5: Spectroscopy – II (Theory, Credits: 2)

Spin-orbit interaction and fine structure of hydrogen atom, Lamb shift, Lamb-Rutherford experiment, Hyperfine structure and isotope shifts, Nuclear size effects, Alkali spectra, Rydberg and exotic atoms.

Para and ortho states, Role of spin in two-electron atoms and Pauli's exclusion principle, Doubly excited states of two-electron atoms, Autoionization, Auger effect, Photoelectron spectroscopy.

Selection rules, Line intensity, Lifetime of excited state, Line shape and width, Pressure and Doppler broadening, Zeeman effect, Paschen-Bach effect, Stark effect.

Electron spin resonance (ESR), Nuclear magnetic resonance (NMR), Chemical shift, Coupling.

Mossbauer effect, Nuclear recoil, Doppler effect, Chemical shift, Quadruple effect, Effect of magnetic field and simultaneous electric and magnetic fields.

REFERENCES:

1. Introduction to Atomic Spectra, H. E. White.
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash.
3. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain.

FOURTH YEAR: SEMESTER-VIII

MAJOR PAPERS:

Paper PH-4-8-1: Nuclear and Particle Physics (Theory, Credits: 4)

Basic nuclear properties: Size, shape and charge distribution, Spin and parity. Binding energy, Semi-empirical mass formula, Liquid drop model. Nature of the nuclear force, Form of nucleon-nucleon potential, Charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, Single-particle shell model: its validity and limitations, Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, Reaction mechanism, Compound nuclei and direct reactions.
Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), Hadron classification by isospin and hypercharge, Gellmann-Nishijima formula, Quark model, Baryons and mesons, C, P and T invariance, SU(2) and SU(3): Groups, algebras and generators, Young tableaux rules for SU(2) and SU(3), Elementary ideas of electroweak interactions and standard model, Cosmic rays and cosmic ray shower.

REFERENCES:

1. Nuclear Physics, R. R. Roy and B.P. Nigam (New Age International).
2. Introductory Nuclear Physics, Kenneth S. Krane (Wiley).
3. Atomic and Nuclear Physics (Vol.-2), S. N. Ghoshal (S. Chand group).
4. Elementary Nuclear Theory, H. A. Bethe and P. Morrison (Dover Publications).
5. Nuclear Physics, E. Fermi (University of Chicago press).
6. Nuclei and Particles, E. Segre (W. A. Benjamin).
7. Nuclear Physics, Preston and Bhaduri.
8. Introduction to Particle Physics, D. J. Griffiths (Wiley).
9. Introduction to High Energy Physics, Perkins (Addison-Wesley).

Paper PH-4-8-2: Advanced Quantum Mechanics – II (Theory, Credits: 4)

Interaction picture, Time dependent perturbation theory and Fermi's golden rule.
Symmetries in quantum mechanics: Conservation laws and degeneracy associated with symmetries, Continuous symmetries space and time translations, Rotations, Rotation group, Explicit matrix representation of generators for $j = 1/2$ and $j = 1$, Rotation matrices.
Identical particles: Principle of indistinguishability, Symmetric and antisymmetric wavefunctions, Slater determinant, Ortho and para states, Generalization of Schrödinger equation to N-particle system in one and higher dimensions.
Scattering theory, Partial wave analysis, Born approximation.
Relativistic quantum mechanics: Klein-Gordon equation, Dirac equation, Free particle solution.

REFERENCES:

1. Introduction to Quantum Mechanics, D. J. Griffiths.
2. Quantum Mechanics, Ashok Das.
3. Quantum Mechanics, R. Shankar.
4. Quantum Mechanics (Vol. 1 & 2), Cohen-Tannoudji.
5. Quantum Mechanics, Symmetries, W. Greiner & Muller.
6. Advanced Quantum Mechanics, F. Schwabl.

Paper PH-4-8-3: Practical-I (Practical, Credits: 4)

1. UV-visible electronic emission spectroscopy of organic molecules in liquid media.
2. UV-visible electronic emission spectroscopy of organic molecules in thin films.

3. Experiment on solar cell.
4. Experiment on Hall Effect.
5. Experiment on Four probe method.
6. Experiment on electron spin resonance.
7. To determine thickness of a thin wire by diffraction method.

Addition or changes of experiments may be made by the Centre as and when required.

Paper PH-4-8-4: Practical-II (Practical, Credits: 2)

Laboratory based project work.

ADDITIONAL ELECTIVE PAPER:

(Compulsory for students having major in Physics and optional for students having major in other subjects)

Paper PH-4-8-5: Fundamentals of Laser (Theory, Credits: 2)

Absorption and emission of radiation by matter, Einstein's theory: A and B coefficients, Spatial and temporal coherence, Population inversion, Saturation intensity, Basic laser system, Optical resonator, Threshold condition for laser action, Resonant modes, Rate equations for three and four level laser systems, Typical lasers: Ruby laser, He-Ne laser, Argon ion laser, Semiconductor laser, Nd:YAG laser, Titanium Sapphire laser, Excimer laser, etc.

REFERENCES:

1. Laser Fundamentals, W. T. Silfvast.
2. Solid State Electronic Devices, B. J. Streetman.
3. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain.
4. High Resolution Spectroscopy, J. M. Hollas.
5. Laser Spectroscopy and Instrumentation, W. Demtroder.
6. Principles of Lasers, O. Svelto.

SOCIAL SCIENCE

FIRST YEAR: SEMESTER-II

Paper SS-1-2-1: Social Science (Theory, Credits: 2)

FIRST YEAR: SEMESTER-II

Paper SS-1-2-1: Social Science (Credits: 2)

A. India and its landscape, ecology and environment.

B. India and its economy- industrialisation in India- the impact of colonisation on the Indian economy.

C. Freedom movement in India- the foundation of the Indian National Congress- the growth of communalism, separate electorates and partition.

D. The Women's question in India- beginnings of female education- social reform movements like banning of widow-burning, child marriage and legal sanction for widow remarriage.

E. Peasant movements in India- Santhal rebellion, Indigo rebellion, Pabna uprising, Moplah uprising, Tebhaga movement.

F. The Indian Constitution- quasi-federal type of government- universal adult suffrage- the powers and functions of the President- the Cabinet of Mnisters and the Prime Minister- the responsibility of the ministry to the Parliament- the process of law-making- the powers and functions of the judiciary.

REFERENCES:

1. M. Gadgil and R. Guha, This Fissured Land: an ecological history of India.
2. Rajat Kanta Ray, Industrialisation in India.
3. Bipan Chandra, Mridula Mukherjee, Aditya Mukherjee, K. N. Panikkar, Sucheta Mahajan, India's Struggle for Independence.
4. Partha Chatterjee, The Nation and its Fragments.
5. A. R. Desai, Peasant Struggles in India.
6. Francis Robinson, Separatism among Indian Muslims.
7. The Constitution of India.