B.Sc. (Blended) PHYSICS MAJOR Program

Savitribai Phule Pune University

Revision and Amendment

B. Sc. (Blended) **CHEMISTRY MAJOR**

Four Year undergraduate program

Syllabus for SEM I – IV (**88 Credits**)

In accordance with guidelines of NEP 2020

(To Be Implemented from Academic Year 2023 – 2024)

Semester 1			
	Course Name	Title allocation as per NEP	
CHE 101 MJ (T)	Introductory and Organic Chemistry +Python for chemistry	DSC (Discipline Specific Course)- Major Core	**4**
CHE 101 MJ (P)	Chemistry Practical	DSC (Discipline Specific Course)- Major Core	**2**
CC 101 PHY (T)	Introductory Classical Physics	Curricular course	**2**
SEC 101 PHY (p)	Physics Practical	Skill Enhancement Course (SEC)	**2**
GE 101 MTS (T)	Calculus	GE (General Elective)/OE (Open Elective)	**4**
VEC 101 BIO (T)	The Diversity of Life	VEC (Value Education Course)	**2**
VSC 121 BIO (p)	Biology Practical	VSC (Vocational Skill course)	**2**
AEC 101 ENG	English/Critical Thinking / Communication skill	AEC (Ability Enhancement Course)	**2**
CHE 101 IKS	Indian Knowledge System	IKS (Indian Knowledge System)	**2**
			22

1 Credit = 12+3 hours (12 hrs. teaching and 3 hrs. assessment)

CHE 101 MJ (T)	4 Credits
General Chemistry	**No. of lectures**
The Periodic Table	1
Molecular Structure and Bonding	2
Acids and Bases	3
Stoichiometry	1
Organic Chemistry	
Carbon – the basis of life	1
Structure and Bonding Alkanes (sp3 Hybridisation)	2
Structure and Bonding Alkenes (sp2 Hybridisation)	1
Benzene and its derivatives	1
Structure and Bonding of Alkynes (sp hybridisation)	1
Functional Groups	1
Electrophiles and Nucleophiles	2
Nucleophilic substitution reactions	1
Organic redox reactions	1
ODEs	
Applications of 1st order ODES: ecology models	1
Applications of 1st order ODES: chemical reaction rates, Newton's law of cooling	2
Second-order ODEs: definitions of homogeneous/inhomogeneous, linear/non-linear; solution of homogeneous constant-coefficient linear ODEs	1
Physical Chemistry	
First Law of Thermodynamics; adiabatic processes, constant volume processes, enthalpy, cyclical processes, free expansions	3
Second Law of Thermodynamics, Irreversible processes, entropy, free energy	2
Real world examples - eg solar energy, geothermal, wind power	4
PYTHON I	**No. of lectures**
Introduction to python programming, basic arithmetic and Hello world programs • Variables, Operators and Datatypes; Operations on datatypes; Input and Output • Functions: Modules, Built-in functions, User defined functions, keyword arguments • Conditional statements (if, elif, else) and Loops.	12

CHE 101 MJ (P)	2 Credits
	No. of lectures

1. Analysis of copper oxide and copper dioxide to determine law of multiple proportions	3
2. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.	3
3. Viscosity measurements using Ostwald's viscometer.	3
4. Basic Analytical Terms: Volumetric and Gravimetric analysis, Titration, Types of titration viz. acid base, redox, iodometric, iodimetric and complexometric titrations, Types of indicators, Selection of indicator, Aquametry (Karl-Fisher titration)	3
5. Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.	3
6. Estimation of Fe (II) ions by titrating it with KMnO4.	3
7. Estimation of hardness of water by complexometric titration	3
8. Techniques: Crystallization, Sublimation, Distillation, Steam Distillation, Vacuum Distillation, Column Chromatography, Thin Layer Chromatography. Record melting point & Boiling Point.	3
9. Bromination (any one): a) Acetanilide by conventional methods. b) Acetanilide using green approach (Bromate-bromide method)	3
10. Nitration: (any one): a) Acetanilide/nitrobenzene by conventional method. b) Salicylic acid by green approach (using ceric ammonium nitrate).	3
11. Reduction of p-nitro benzaldehyde by sodium borohydride.	3
12. Hydrolysis of amides and esters.	3

CC 101 PHY (T)	**2 Credits**
Classical Mechanics	**No. of lectures**
Straight line motion	1
Vectors	1
Two-and three-dimensional motion	1
Force and Motion: Newton's Laws	1
Force and Motion: Drag and Friction	1
Kinetic energy, work, power	1
Potential energy, conservation of energy	1
Collisions and momentum	1
Rotational motion	1
Angular momentum-I	1
Angular momentum-II	1
Gravitation	
Newton's law of gravity, superposition	1
Gravity at the earth's surface, far above the earth and within the earth	1
Work and gravitational potential energy	1
Kepler's laws: the planets and satellites	1

Orbital motion and energy	1
Einstein, the equivalence principle, gravity, gravitational lenses, gravitational waves	1
Thermal physics	
Zeroth Law of Thermodynamics	1
Thermal expansion and absorption of heat	1
Heat transfer, conduction, emission, absorption	1
Elasticity, fluids and gases	
Equilibrium and elasticity	1
Density and Pressure, Pascal's and Archimedes' Principles	1
Continuity and Bernoulli's Equation	1
Ideal gases (Kinetic theory of gases)	1
Mean free path, molecular speed distribution	1
Specific heat, adiabatic expansion	1
Real world examples - eg wind power, hydro, blood circulation, water in plants, materials, osmosis, wind and atmosphere	4
ODEs	
Applications of 2nd order ODEs: Springs	2
Applications of 2nd order ODEs: LRC series electrical circuits	2
Real world contextual examples in physics and application of ODEs	1

SEC 101 PHY (P)	**2 Credits**
	No. of lectures
1. Simple Pendulum: To plot a L-T2 graph using a simple pendulum and find the effective length of the simple pendulum for a given time period using the graph. To calculate the acceleration due to gravity at a place.	3
2. Torsional Pendulum: To find the moment of inertia of the disc and the rigidity modulus of the material of the suspension wire subjected to torsional oscillations.	3
3. Young's Modulus: To determine the Young's modulus of elasticity of the material of a given wire using Searle's apparatus.	3
4. Measurement of coefficient of Viscosity.	3
5. Measurements using various instruments and error analysis.	3

GE 101 MTS (T)	**4 Credits**
Logic and Proof	No. of lectures
Basic set theory (review)	12
Logical connectives (conjunction, disjunction, negation, conditional, bi-conditional) and truth tables	
Propositional logic, logical equivalence, logical laws	

Real numbers and their properties; completeness property	
Proof methods: direct proof, contrapositive	
Proof methods: contradiction, proof by cases	
Proof methods: induction	
Natural numbers, integers, rational numbers	
Real numbers	
Complex Numbers	No. of lectures
Review of complex numbers including algebra, Argand plane, cartesian and polar form	6
Complex exponential	
de Moivre's theorem; roots of complex numbers	
Differential calculus	No. of lectures
Review of differential calculus: limits, derivative, differentiation rules incl. polynomials, trigonometric, exponential, log functions; product, quotient, chain rules	6
Review of inverse trigonometric functions and their derivatives, implicit differentiation	6
Integral calculus	No. of lectures
Riemann integration	18
Fundamental Theorem of Calculus; review of standard anti-derivatives	
Techniques of integration (review): derivative present substitution, linear substitution	
Techniques of integration (review): integration of trigonometric functions using identities	
Techniques of integration (review): integration of rational functions including partial fractions, integration yielding inverse trig functions	
Techniques of integration (review): trigonometric substitutions; integration by parts	
Improper integrals	
Applications of integration: areas between curves	
Applications of integration: volumes of surfaces of revolution	
Ordinary differential equations: definition of ODE, order, general solution, initial conditions; separable ODEs	
Solving linear ODE using integrating factor	
Particular solutions of inhomogeneous constant coefficient linear ODEs using method of undetermined coefficients; principle of superposition	

VEC 101 BIO (T)	**2 Credits**
Evolution and the Diversity of Life	No. of lectures

Theory of evolution: understanding life's diversity	12
Evolutionary relationships (phylogenies) are summarized in classifications	
Chemical evolution of life – Molecules to cells	
Cell theory and the origin of life	
Prokaryotic Cells: Bacteria and Archaea	
Evolution of the eukaryotic cell	
Endosymbiosis	
Protists 1 - Red and Green algae	
Protists 2 – Chromists	
Protists 3 - Dinoflagellates and apicomplexans, flagellates, ciliates, amoebae	
Evolution of sex, life cycles	
Origins of multi multicellularity	No. of lectures
Slime molds and fungi	12
Fungi	
Introduction to Land Plants	
Bryophytes	
Evolution of vascular tissue, Lycophytes, fern allies, early fossil land plants	
Ferns	
Seed plants, the seed and secondary growth, Cycads and Ginkgo	
Conifer diversity and biology	
Angiosperm structure, biology and diversity, the flower, double fertilization.	
Angiosperm phylogeny and evolution	
Introduction to animals (Metazoa)	
Simple animals	
Protostomes-Flatworms and annelids	
Molluscs	
Arthropods	
Deuterostomes, Echinoderms-Chordates	
Fishes –sharks/rays, teleosts, coelacanth, lungfish	
Amphibians	
Reptiles	
Birds	
Mammals	
The Primate story	

VSC 121 BIO (P)	**2 Credits**
	No. of lectures
1. Observation of zooplankton from pond samples under microscope	3
2. Determination of dissolved oxygen in water sample using Winkler titration	3

3. Collection and identification of invertebrate samples from pond by using different types of nets.	3
4. Visit to the museum at zoology department at Pune University and observe the collected specimens.	3
5. Using a taxonomic browser to identify the taxonomic lineage and explain key characteristics of the species.	3
6. Observe the characteristics of prokaryotic and eukaryotic cells.	3

AEC 101 ENG			**2 Credits**
Sr. no	Theory	Practical	No. of lectures
1	Listening - Overview, Question Types, Listening Tips, Completing the blanks, Making Assumptions, understanding numbers Understanding the alphabet, Distinguishing similar sounds	Listening for - Description, Time, Frequency, Similar meanings, Emotions, Explanation, Classification, Comparison and contrasts, Negative meaning, Chronology	12
2	Reading- Overview, Question Types, Reading Tips	Using first paragraph to make predictions, Using the topic sentence to make predictions, looking for specific details Analyzing Questions and Answers, Identifying the tasks	12

CHE 101 IKS	**2 Credits**
Indian Rhetoric	No. of lectures
Rhetoric as Everyday Experience: Persuasion & Convincing: Advt. & Campaigns Arguments and Debates: Courtrooms to Politics Historical context of Classical Rhetoric in Greece Democracy, Public Opinion and Rhetoric	6
Rhetoric: Elements & Versions Context and Intent Appeals & Arrangement Instruments & Ornamentation Culture, History and Versions of Rhetoric	6
1Nyay Shastra- Indian Framework of Debate Brief background and premise Basic elements, of Nyay Shastra Logic and arrangement Good & Bad forms of Debate	6
Natya Shastra Brief background and premise Basic elements of Natya Shastra Sahahridaya & Sadharanikarn Rasa & Bhaav	6

OR

CHE 101 IKS	2 Credits
Vedic Mathematics	**No. of lectures**
Vedic Mathematics: Brief History Mathematics in Ancient India. Relevance & Utility of Vedic Mathematics Contributions by Aryabhata & Brahmagupta Contributions by Mahaveer Acharya & Bharti Krishna Tirtha	5
Application of Vedic Mathematics Multiplication of two numbers of two digits Multiplication of two numbers of three digits multiplication of two numbers of three digits Nikhilam Navtashchramam Dashtaha	5
Division and Divisibility Two digits divisor Three digits divisor Divisibility- Two digits divisor	5
Power and Root Power: Square (two-digit numbers) Cube (two-digit numbers). Square root (four-digit number) Cube root (six-digit numbers)	5
LCM and HCF	4

Semester 2			
Course Code	Course Name	Title allocation as per NEP	After
CHE 151 MJ (T)	Inorganic and Physical Chemistry	DSC (Discipline Specific Course)- Major Core	4
CHE151 MJ (P)	Chemistry Practical	DSC (Discipline Specific Course)- Major Core	2
CC 151 PHY (T)	Modern Physics	Curricular Course	2
SEC 151 PHY (p)	Physics Practical	Skill Enhancement Course (SEC)	2
GE 151 MTS (T)	Algebra	GE (General Elective)/OE (Open Elective)	4
VEC 151 BIO (T)	Biology of Cells	VEC (Value Education Course)	2
VSC 171 BIO (p)	Biology Practical	VSC (Vocational Skill course)	2
AEC 151 ENG	English, /Critical Thinking / Communication skill	AEC (Ability Enhancement Course)	2
CHE 191 MN	interdisciplinary elective	Minor	2
Total			**22**

1 Credit = 12+3 hours (12 hrs. teaching and 3 hrs. assessment)

CHE 151 MJ (T)	4 Credits
Chemistry of Life	
The chemical basis of life	1
Bioenergetics	1
Enzymes and catalyzed reactions	2
Metabolism: Catabolism and anabolism	2
Concatenation and Biopolymers	1
Stereochemistry and Biomolecular chirality	1
Small inorganic molecules of biological importance	2
Inorganic Chemistry	**No. of lectures**
Ionic Compounds and their Solutions	2
Structures of Solids	3
Main Group Chemistry	4
Redox reactions and electrochemistry	4
The transition metals: a survey	1
Coordination Chemistry	4
Bonding in complex ions	2
Quantum Chemistry	
Schrödinger's equation and Heisenberg's Uncertainty Principle	1
Bohr and Schrodinger models of the hydrogen atom	1
Complex atoms; Pauli Exclusion Principle, Periodic Table of Elements, selection rules and spectra	1
Nuclear fission and fusion	1
PYTHON -II	**No. of lectures**
Lists, Strings, Tuples and Dicts • Introduction to numpy • Introduction to matplotlib for basic plotting	12

CHE 151 MJ (P)	2 Credits
	No. of lectures
1. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloride acid with sodium hydroxide	3
2. Glass electrode- Buffer solutions: To titrate a weak base (Na2CO3) with a strong acid (HCl) using an (a)acid-base indicator, and (b) a glass electrode	3
3. To determine the rate of chemical reaction by using hydrolysis of tert-Butyl chloride.	3

4. Synthesis of hexamminenickel (II) [Ni(NH3)6]I2	3
5. Synthesis of potash alum from aluminum metal (scrap Aluminum metal)	3
6. To synthesize a typical coordination complex, hexaamminecobalt (III) chloride, [Co(NH3)6]Cl3.	3
7. Estimation of Cu(II) and K2Cr2O7 using sodium thiosulphate solution (Iodimetrically).	3
8. Use of Computer - Chem Draw-Sketch, ISI – Draw, Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name.	3
9. Preparation of Derivatives: Oxime, 2, 4-DNP, Acetyl, Benzoyl, Semi carbazone.	3
10. Preparation of ⍺-phenyl Cinnamic acid from Benzaldehyde.	3
11. The preparation of paracetamol	3
12. Diels alder reaction using Anthracene and maleic anhydride	3

CC 151 PHY (T)	**2 Credits**
Electricity and Magnetism	No. of lectures
Electric charge, conductors and insulators	1
Coulomb's Law, superposition principle	1
Electric field, superposition principle	1
Electric flux	1
Gauss's law, applications	1
Energy and electric field; electric potential	1
Calculating potential from the field, electric potential, potential energy surfaces.	1
Electric dipoles	1
Capacitance; parallel plate capacitors	1
Energy storage in capacitors, dielectrics, series and parallel circuits	1
Conductors, electric current, electric power, Ohm's law	1
Kirchoff's rules, resistors in series and parallel circuits	1
Magnetic field, magnetic force, Lorentz force, cyclotrons	1
Lorentz force, ion velocity filter, Hall effect, Biot-Savart Law	1
Bio-Savart Law, Ampere's Law, solenoids, earth's magnetic field	1
Magnetic field due to a current, forces on current-carrying wires, Electromagnetic induction, magnetic flux	1
Lenz' Law, Faraday's law, Maxwell's equations, applications	1
Magnetic materials	1
Oscillations and Waves	No. of lectures
Damped harmonic motion, resonance - electronic circuits, evolution of	2

populations	
One dimensional waves , Interference and standing waves, Sound waves and the speed of sound, Intensity, sound level and the physics of music	2
Doppler effect and supersonic motion, shock waves	1
Optics	No. of lectures
Images and mirrors	1
Thin lenses and optical instruments	1
Young's experiment, interference	1
Thin films and the Michaelson interferometer	1
Diffraction by slits and apertures	1
Diffraction by gratings and X-ray diffraction	1
Optical Microscopy	1
Spectroscopy	1
Modern Physics	No. of lectures
Challenges to classical physics; special relativity	1
Lorentz transformation, transformation of velocities, Doppler effect	1
Relativistic momentum and energy	1
Photons and the photoelectric effect	1
Quantum physics, blackbody radiator, matter waves	1
Trapped particles and the tunneling particles	1
Nuclear physics, nuclear properties, nuclear decay	1
Quarks, Leptons, The Big Bang	1

SEC 151 PHY (P)	**2 Credits**
1. To find the specific charge density of an electron particle in a CRT by Thomson method.	3
2. Determination of the radius of a current carrying coil 2-Determination of magnetic field with the variation of distance along the axis of current carrying coil.	3
3. To determine the Wavelength of main spectral line of mercury light using plane transmission grating.	3
4. To determine the Refracting Angle, Refractive Index and Dispersive power of prism using spectrometer.	3
5. To determine the coefficient of thermal Conductivity of bad conductor by Lee's Disc.	3
6. Charging and Discharging of Capacitor.	3
7. Verification of Kirchhoff's law.	3

GE 151 MTS (T)	4 Credits
Analysis	No. of lectures
Limits of real-valued functions	12
Proving limits using the definition	
Continuity & differentiability	
Examples of differentiable and non-differentiable functions; continuity and differentiability of standard functions including polynomials, trigonometric, exponential, log functions and their inverses	
Techniques for evaluating limits including L'Hopital's rule, sandwich theorem	
Mean Value Theorem and applications	
Applications of differential calculus eg related rates	
Sequence and series	No. of lectures
Sequences, limits, convergence and divergence	12
Proving limits using definition	
Methods for evaluating limits: standard limits, limit theorems, continuity rule, sandwich theorem	
Series, convergence and divergence of series, geometric series, harmonic p-series	
Series convergence tests: divergence test, comparison test	
Series convergence tests: ratio test, integral test, alternating series test	
Power series, Taylor polynomials	
Taylor series	
Taylor's theorem, error in Taylor polynomial estimates	
Vectors	No. of lectures
Vector arithmetic, dot product, vector projections (review)	6
Vector cross product; scalar triple product; parametric curves specified by vector equations	
Lines and planes in R^3	
Lines and planes in R^3	
Linear Algebra 1	No. of lectures
Solving systems of linear equations with Gaussian elimination	18
Solutions of systems of linear equations - consistency, uniqueness	
Geometric interpretation of solutions	
Matrices, matrix addition, multiplication, transpose and properties (review)	
Matrix inverse	
Determinant	
R^n as a vector space, linear independence of vectors in R^n	
Span of a set of vectors, subspaces of R^n	

Basis and dimension in R^n	
Abstract vector space axioms; examples and non-examples of vector spaces	
Bases, dimension and co-ordinates in (finite dimensonal) abstract vector spaces	
Definition of linear transformation and examples/non-examples	
Linear transformations of the plane	
Matrix representation of a linear transformation	
Image and kernel of a linear transformation	
Rank and nullity	

VEC 151 BIO (T)	**2 Credits**
The Biology of Cells	No. of lectures
Introduction to Cell Biology	2
Theme: The cell contained	No. of lectures
The plasma membrane	6
Cell walls, extracellular matrix, cellulose synthesis, other cell wall components	
Cytoplasm: content, chemistry and properties	
Cytoskeleton, actin filaments, microtubules	
Theme: Information flow in the cell	No. of lectures
Nucleus, chromosomes, DNA	4
Genes and the genetic code	
Control of gene expression	
Theme: Endomembrane system and intracellular trafficking	No. of lectures
ER and ribosome, proteins and enzymes	6
Golgi apparatus	
Vesicles, transport and secretion, Lysosomes	
Theme: Harvesting energy	
Mitochondria, ATP, energetic reactions, electron transport pathways, cellular respiration	
Chloroplasts, photosynthesis, historical experiments, pigments, photosystems	
Theme: Multicellularity and the Dividing Cell	No. of lectures
Cell division, cell cycle, mitosis, cytokinesis, division and distribution of organelles	6
Meiosis, formation of haploid cells	
Communication and signaling, recognizing and responding	
Cell differentiation and multicellularity	

VSC 171 BIO (P)_	2 Credits
	No. of lectures
1. Microscopy and observation recording of representative organelle readymade specimens	2
2. Staining of cell for observations of- Flagella, cell wall, endospores, etc. a. Plant call, bacterial, fungi samples b. malachite green, safranin, Leifson flagella stain/RYU flagella stain, nitric acid, crystals of potassium chlorate	2
3. Introduction and visualization DNA-Proteins in silico	2
4. A one day visit to IISER Pune for electron/ fluorescence microscopy observations	2
5. Observation of budding in yeast & different kinds of cells	2
6. Observation of live/dead cells using Trypan blue staining	2
7. Isolation of DNA	2
8. Mitosis in onion root tips	2

AEC 151 ENG			2 Credits
Sr. no	Theory	Practical	No. of lectures
1	Writing- Overview, Question types, Writing tips	Responding to task, Coherence and cohesion, Lexical resource, Generalizing and Qualifying, Grammatical range and accuracy	12
2	Speaking- Overview, Question type, Speaking tips	Introduction and Overview, Giving Information, Organizing and discussing a topic, Sequence, Comparing and contrasting Respond to follow up questions, ask for clarification, Avoid short answers, Transition and intonation	12

CHE 191MN	2 Credits
Chemistry of Cosmetics and Perfumes	No. of lectures
Introduction, History of Cosmetics and Natural Products, Pharmaceutical Affairs Law in Japan and Its Relevance to Natural Products, Skin-Whitening Cosmetics, Antiaging Cosmetics, Hair Growth Promoters, Plant Cell/Tissue Culture Technology for Natural Products in Cosmetics	12
	12

OR

CHE 191MN	2 Credits
Analysis of Drugs/Narcotics	No. of lectures
Amphetamine and Related Compounds, The Analysis of LSD, Cannabis sativa and Products, Diamorphine and Heroin, Cocaine, Analysis Barbiturates	12

Semester 3			
Course Code	Course Name	Title allocation as per NEP	credit
CHE 201 MJ (T)	Chemistry: Reactions and Synthesis	DSC(Discipline Specific Course)- Major Core	**6**
CHE 201 MJ (P)	Chemistry Practical	DSC(Discipline Specific Course)- Major Core	**2**
CC 201PHY (T)	Quantum Mechanics and Thermodynamics	Curricular Course	**2**
MN 241MTS (T)	Vector Calculus and Differential Equations	Minor	**4**
GE 201BIO (T)	Functional Biology of Organisms	GE (General Elective)/OE (Open Elective)	**2**
VSC 221BIO (p)	Biology Practical	VSC (Vocational Skill course)	**2**
AEC 201ENG	English/Critical Thinking / Communication skill	AEC (Ability Enhancement Course)	**2**
CHE 231 FP	Field Project	FP (Field Project)/OJT (On job training)/CEP	**2**
Total			**22**

1 Credit = 12+3 hours (12 hrs. teaching and 3 hrs. assessment)

CHE 201 MJ (T)	6 Credit
Reactions and Synthesis 1	No. of Lectures
Organic Synthesis C-C bond Forming Reactions: Grignard Reagents and Organolithiums. Formation and reaction with Carbonyl compounds.	1
Organometallic Reagents in Synthesis: Applications of Organocerium and Organocuprate reagents.	1
Carbonyl Compounds and Reactions: Carbonyl compounds, tautomerism as a general phenomen, keto-enol tautomerism of carbonyl compounds, mechanism of keto-enol tautomerism	1
Generating enolate anions, suitable base catalysts for enolising aldehydes, ketones ester and β-dicarbonyl compounds, general α-substitution reaction	1
Reactions of enols and enolates, α-substitution with H/D+ Stereochemical consequences and deuterium incorporation. Halogenation of carbonyl compounds, The haloform reaction	1
Halogenation of carbonyls, Hell-Volhard-Zelinsky reaction. Synthetic applications of a-halo carbonyl compounds	1
Alkylation of enolates, LDA, scope and limitations	1
Aldol reaction, mechanism and retrosynthesis, inter-and- intra-molecular variants, mixed Aldol reaction	1
Claisen reaction, mechanism and retrosynthesis, mixed Claisen and Deickman reaction.	1
Malonate Diester Chemistry, Acetoacetate chemistry, Synthesis of substituted acetic acid and acetone derivatives. Scope, Mechanism and	1
Retrosynthesis.	
Michael addition Chemistry, reaction of enolates with various Michael electrophiles	1
Kinetic and Thermodynamic enolates, Enamines and silylenol ethers	1
Retrosynthesis.	
Reactions and Synthesis 2	No. of Lectures
Redox (and important acid-base) Reactions: Oxidation of elements by halogens and dioxygen. Metal and main group halides and oxides. Discussion of selected syntheses, chemistry and structures of halides and oxides including amphoteric behaviour and hydroxide/aqua ion formation. Thermodynamic vs kinetic control of reactions.	1
Thermodynamic aspects of halide and oxide formation. Thermodynamic parameters, their estimation and uses of tabulations. Born-Haber cycle and construction and uses of Ellingham diagrams for these systems. (Electrides and sodides?)	1
Oxidation of metals by protons etc. and generation of aqua ions. Comparison of TM and main group systems and hydrolysis in TM aqua ions (acid-base chemistry of	

coordinated water-hydroxide-oxo ligands). Connection between electrochemical and thermodynamic parameters. Construction and uses of Latimer and Frost diagrams.	1
Interpretations of Frost diagrams exemplified by the more complex chemistry of main group elements, such as nitrogen. Thermodynamic content of plots (free energy of formation vs oxidation state) and predictive power.	1
Nernst equation revisited and construction and uses of Poubaix diagrams combining redox and acid base reactions. Comparison of chemistry of representative elements as reflected in Pourbaix diagrams.	1
Exchange reactions: Solid/gas phase systems exemplified by transport reactions and preparation of solid-state materials, in vulcanology, halogen lamps etc. Solution examples of double decomposition (metathesis). Solubility trends. Common ion effect.	1
Hard/soft acid/base theory. Thermodynamic basis for HSAB theory. Usefulness in predicting direction of equilibrium and solubility.	1
Substitution Reactions: Typical reactions and synthetic applications and examples. Inert and labile complexes. Stability (K, b) and factors affecting stability (metals, ligands). Irving-Williams series, Chelate effect. Applications of chelate effect. Siderophores. antioxidants, garden products, chelation therapy in medicine.	1
Mechanism of substitution reactions. Square planar Pt complexes and applications. Trans effect. Pt chemistry. Applications in synthesis of action of chemotherapeutic agents.	1
Dissociative, interchange and associative mechanisms in substitution, racemization etc in octahedral complexes.	1
Combination of substitution and redox chemistry in TM systems. Co(III) syntheses, Cr(II) catalysed substitution. Electron transfer, inner- and outer-sphere reactions.	1
Metal centred reactions: Template reactions and reactions of coordinated ligands. Atom transfer reactions (redox reactions). Metal directed ligand syntheses	1
Thermodynamics	
Ideal gases, the kinetic theory of gases, equipartition theory, Boltzmann distribution	2
Heat, work, internal energy. First law of thermodynamics. Heat capacity and enthalpy. Compression of an ideal gas under various conditions. Latent heats	2
Multiplicity and ideal gases. Entropy, spontaneous change and the Second Law of Thermodynamics. Interacting ideal gases and the entropy of mixing.	2
Gibbs Free energy and spontaneity, Helmholtz Free energy, standard free energies, free energy as a function of pressure and temperature The Fundamental equation, properties of internal energy and Maxwell's	2

relations	
Thermodynamics criteria for chemical and phase equilibria, chemical potential and partial molar quantities, the Gibbs Free Energy minimum and equilibrium, extent of reaction and equilibrium constant, molecular description of equilibrium, response of equilibria to temperature	2
Thermodynamics of liquids and liquid mixtures, chemical potentials of liquids, ideal liquid mixtures and Raoult's Law, Henry's Law, vapor pressure diagrams, liquid-liquid phase diagrams Free energy and entropy of mixing, excess functions and real solutions, solute and solvent activity, activity coefficient, osmotic pressure	2
PYTHON III	No. of Lectures
Object Oriented Programming: Classes, Inheritance • Exception handling • Basic File Handling Introduction to pandas: extraction of data from CSV, XLSX and TXT files. • Basics of GUI Programming using tkinter	12

CHE 201 MJ (P)	**2 Credit**
	No. of lectures
1. Dissociation constant of an acid- base indicator by spectrophotometry	
2. The reaction between potassium persulphate and potassium iodide by colorimetry	
3. Determination of concentration of sulfuric acid, acetic acid and copper sulphate by conductometric titration with sodium hydroxide.	
4. Pyrolusite ore - Estimation of silica gravimetrically and Manganese volumetrically.	
5. Solder alloy – Estimation of Tin gravimetrically and Lead volumetrically	
6. Ion exchange capacity of resin by Co and Ni.	
7. To determine the amount of Titanium as TiO2 in given pigment sample	
8. Estimation of saponification value from the given oil sample.	
9. Chalcone from P-chloro Benzaldehyde.	
10. Azo dye from Anthranilic acid	
11. 4,6 dimethyl coumarin from p-cresol.	
12. Cannizzaro reaction of aromatic aldehyde.	

CC 201 PHY(T)	**2 Credit**
Quantum Mechanics	No. of Lectures
The Breakdown of Classical Physics	

Matter Waves and Quantum Interpretation	
Quantum Mechanics in One Dimension	
Hydrogen atom, hydrogenic ions, helium atom	
Hydrogen molecule ion, hydrogen molecule	
Hydrogen atom, hydrogenic ions, helium atom	
Thermodynamics	No. of Lectures
Temperature and the Zeroth Law of Thermodynamics. Thermal equilibrium.	1
Transport, conduction, conductivity, diffusion in gases.	1
The two-state paramagnet and the Einstein model of a solid; quantum deviations from classical equipartition. Partition function. Interacting systems, large systems, Stirling's approximation	2
Heat engines, Carnot Cycle, Otto Cycle, Stirling Cycle.	1
PDEs	No. of Lectures
Wave equation	1
Heat and Diffusion equation	1
Linear Algebra	
Change of basis and linear transformations	1
Definition of eigenvectors and eigenvalues	1
Calculating eigenvalues and eigenvectors	1
Diagonalization of matrices; matrix powers	1
Orthogonal matrices, real symmetric matrices	1

MN 241 MTS (T) **4 Credit**	
Linear Algebra	No. of Lectures
Change of basis and linear transformations	18
Definition of eigenvectors and eigenvalues	
Calculating eigenvalues and eigenvectors	
Diagonalization of matrices; matrix powers	
Orthogonal matrices, real symmetric matrices	
Characteristic and minimal polynomial, Cayley-Hamilton Theorem	
Applications of eigenvectors/diagonalization Markov chains	
Inner product axioms; examples/non-examples of inner products	
Length, angle, Cauchy-Schwarz inequality in terms of inner product	
Orthogonality, projections in terms of inner product	
Gram-Schmidt algorithm	

Vector Calculus	No. of Lectures
Functions of several variables; level curves and cross sections of surfaces	18
Common surfaces including paraboloid, ellipsoid, hyperboloid	
Domains and ranges of functions of several variables	
Limits and continuity of functions of several variables; Definition of C^N	
Partial derivatives, tangent plane	
Differentiability of functions of several variables	
Directional derivative, gradient	
Chain rule and total derivative	
Stationary points of surfaces, classification of stationary points using second derivatives	
Optimization applications	
Constrained extrema using Lagrange multiplier method	
Double integrals, changing order of integration	
Polar co-ordinates, change of variables for double integrals	
Triple integrals	
Change of variables for triple integrals; cylindrical co-ordinates	
Spherical co-ordinates	
Vector fields, div and curl operators	
Parameterization of paths	
Line integrals of scalar functions	
Line integrals of vector functions	
Integrals of scalar functions over surfaces, applications of surface integrals eg surface area, mass	
Integrals of vector functions over surfaces, flux	
Green's Theorem	
Gauss Divergence Theorem	
Stokes' Theorem	
Applications of integral theorems eg Maxwell's equations	
PDEs	No. of Lectures
Fourier Series	12
Fourier series: Dirichlet, discontinuities and differentiation	
Fourier series: Weak convergence and series summation	
Linearity and Superposition	
Laplace equation and harmonic functions	
Wave equation	
Heat and Diffusion equation	
Fourier transform	
Fourier transform: properties	

GE 201BIO (T)	2 Credit
Functional Biology of Organisms	No. of Lectures
Introduction to Functional Biology	2
Animal biology (Humans as an example)	
Anatomy and Function 1: Tissues, Organs and Viscera	12
Anatomy and Function 2: Skeletal & Muscular system	
Nervous system 1: The central nervous system (CNS) and nervous tissues	
Nervous system 2: Autonomic nervous system and motor responses	
Endocrine system 1: Endocrine and Exocrine glands	
Endocrine system 2: HPA axis introduction	
Respiration and Metabolism 1: Breathing in air and water	
Respiration and Metabolism 2: Regulation of metabolism	
Cardiovascular and circulatory system 1: Regulation of the circulatory system	
Cardiovascular and circulatory system 2: Peripheral circulation	
Digestive system	
Urinary and Excretion systems 1: Anatomy and function	
Urinary and Excretion systems 2: Osmoregulation in terrestrial & aquatic environments	
Thermal dynamics	
Immunology 1: Innate immune system	
Immunology 2: Adaptive/Humoral immune system	
Reproduction and Development 1: Gonads and the Reproductive tract	
Reproduction and Development 2: Gametes, Fertilization and conception	
Plant biology	No. of Lectures
Growth and Development	12
Photosynthesis	
Water Balance	
Phloem and translocation	
Mineral nutrition and nutrient assimilation	
Respiration and lipid metabolism	
Reproduction	
Signaling; hormones, light responses, control of flowering	
Abiotic stress	
Secondary metabolism and defense	
Microbial physiology	

VSC 221 BIO (P)	2 Credit
	No. of lectures
1.Bacterial growth: optical density measurement	2
2.Counting of different kind of blood cells using hemocytometer	2
3.Estimation of hemoglobin	2
4.Determination of blood pressure and amount of oxygen in the blood	2
5.Action of salivary amylase in relation to enzyme concentration and temperature	2
6.Demonstration of imbibition	2
7.Demonstration of osmosis in plants	2
8.Demonstration of plasmolysis in onion cells	2
9.Separation of plant pigments by chromatography	2
10.Estimation of chlorophyll in the leaf tissue	2

CHE 251 FP (Any 2)	2 Credit

Semester 4			
Course Code	Course Name	Title allocation as per NEP	**After**
CHE 251 MJ (T)	Chemistry: Structure and Properties	DSC(Discipline Specific Course)- Major Core	**6**
CHE 251 MJ (P)	Chemistry Practical	DSC(Discipline Specific Course)- Major Core	**2**
CC 251 PHY (T)	Electricity, Magnetism, Special Relativity, and Optics	Ability Enhancement Course (AEC)	**2**
SEC 251 PHY (p)	Physics Practical	Skill Enhancement Course (SEC)	**2**
MN 291 MTS (T)	Probability and Statistics	Minor	**4**
GE 251 BIO (T)	Genetics, Evolution and Ecology	GE (General Elective)/OE(Open Elective)	**2**
AEC 251 PS	English, /Critical Thinking / Presentation skill	AEC(Ability Enhancement Course)	**2**
CHE 281 FP	Field Project	FP(Field Project)/OJT(On job training)/CEP	**2**
Total			**22**

1 Credit = 12+3 hours (12 hrs. teaching and 3 hrs. assessment)

CHE 251 MJ (T)	6 Credit
Structure and Properties	No. of Lectures
Molecular shape and simple electronic structure, Isomerism: Orbitals, hybridization and shapes of molecules, sterochemical consequences of tetrahedral carbon (isomers, enantiomers, R/S, D/L, optical rotation)	1
Stereochemistry – optical activity: Molecules with more than one chiral centre (diastereomers, meso compounds, separation of racemic mixtures)	1
Symmetry operations and elements	1
Group theory: Definition of reducible and irreducible representations, Use of group theory to determine the irreducible representation	1
Assignment of point groups	1
Leading to definition of components of character tables (irreducible representations, characters – at least the interpretation of the sign of the character)	
Simple applications, Label molecular shapes, isomers, Identify chiral molecules, Physical properties – e.g. dipole moment, possible optical isomers, Orbital symmetry labels (e.g. s, p & d orbitals in Td, Oh, D4h)	1
Stereochemistry and Reactions: Prochirality, chirality in Nature, Sterochemistry on atoms other than carbon, Retrosynthetic analysis	1
Stereochemistry and Mechanism (nucleophilic substitution, elimination from non-cyclic compounds)	1
Alkene addition reactions – Hydrogenation, halogenation, HX addition. Elimination Reactions epoxide ring forming reactions	1
Zeeman effect: Effect on the energies of a system by application of a magnetic field; Magnetochemistry, spin and orbital contribution to the magnetic moment	1
Magnetic resonance spectroscopies: EPR spectroscopy, hyperfine coupling application to organic radicals and to transition metal complexes	1
Nuclear Magnetic Resonance (NMR), energies of nuclei in magnetic fields	1
Chemical shift and the δ scale, resonance of different nuclei, shielding, spin-orbit coupling and coupling constants, molecular symmetry	1
13C NMR, 1H NMR, integration, multiplicity, chemical shift typical ranges	1
Introduction to molecular spectroscopy and spectroscopic transitions, absorbance, transmittance, the Beer-Lambert Law, intensities of spectroscopic transitions	1
Quantised vibration and simply harmonic oscillator model, wave functions,	1
Molecular vibrational modes, vibrational spectroscopy infrared and Raman spectroscopy 3N-5, 3N-6 vibrational degrees of freedom	1
Vibrational symmetry and IR/Raman activity: Symmetry properties of the vibrational degrees of freedom and to deduce IR, Raman activity. Use of internal coordinates to get symmetry properties of a subset of bands	1

Vibrational spectroscopy: Local mode approximation. Characteristic infrared absorptions (alkyl CH, alcohol, amine RN H2 and R2NH, carboxylic acid, amide, ester, ketone, aldehyde, nitrile RCN, alkyne, alkene, aromatic), fingerprint regions, interpretation of IR spectra	
Molecular orbital theory: Electronic spectroscopy requires understanding of electronic structure leading to Molecular orbital theory – HOMO. LUMO	1
Diatomic molecules, LCAO-MO, Symmetry of MO's	1
Photoelectron spectroscopy	1
Generalisation of the application of MO approaches to polyatomic molecules	1
Hückel Theory	1
Aromatic and Heterocyclic Chemistry of compounds with delocalised p orbitals: Benzene and Aromaticity/Antiaromaticity, Reactions of Aromatic Compounds Electrophilic aromatic substitution. Reactions of Polycyclic and Heteroaromatic Compounds. Reactions via Aromatic Transition States Electrophilic aromatic substitution on naphthalene. Electrophilic aromatic substitution on heteroaromatics (e.g. pyridine and pyrrol). Non C-based aromatic systems	3
Electronic spectroscopy: Chromophores and excited electronic states, electronic transitions, UV-Vis spectroscopy, Franck-Condon Principle, Franck-Condon factors	1
Fates of electronic excited states – fluorescence and phosphorescence, non-radiative transitions, internal conversion and intersystem crossing, fluorescence spectra	1
Applications – light emitting polymers	1
Organometallic chemistry. Types and broad applications of organometallic complexes and catalysts. Ligand types and examples.	1
Group 1 (LiR) and group 2 (Grignard) and p-block chemistries. EPR spectroscopy as a tool to probe electron distribution in carbocyclic and organometallic species	1
Covalent interactions in coordination compounds – rationalisation of spectrochemical series in terms of bonding interactions	1
Binary metal carbonyl complexes Synergistic bonding and the 18-electron rule. IR and NMR spectroscopy	1
Substitution at metal carbonyl. Other organometallic ligand types and complexes thereof. Alkyne and alkene complexes. etc.	1
Redox reaction in organometallic chemistry. Hydrogen complexes and oxidative addition reactions. Reductive elimination reactions. Activation and reactions of organometallic ligands. Insertions, migrations.	1
Catalysis involving transition metals: Catalytic systems. Water gas shift reaction, hydrogenations, acetic acid process etc. Metallocene complexes and their chemistry leading to advanced polymerization catalysts etc.	1
PYTHON IV	No. of Lectures
Non-Linear Equations: Bisection, False-Position, Newton Raphson and Secant Methods	12

• Numerical Integration: Trapezoidal and Simpson's Rules • Linear Regression • Euler's Method and Runge-Kutta Methods	

CHE 251 MJ (P)	**2 Credit**
	No. of lectures
1. Determination of stability constant of Fe3+ -salicylic acid/ Sulfosalicylic acid by JOB's continuous variation method by UV-Visible spectrophotometer.	
2. Dissociation constant of an acid- base indicator by spectrophotometry	
3. Hydrolysis constant of aniline hydrochloride by distribution coefficient method.	
4. Determination of calcium from dairy whitener by Flame photometry.	
5. Determination of chemical oxygen demand (COD)	
6. Preparation and purity determination (Any two) i) Potassium trioxalato chromate (III). ii) Tris (acetylacetanato) Iron (III). iii) Bis(ethylene diamine) copper (II) sulphate.	
7. Estimation of Calcium and Magnesium from Dolomite ore.	
8. Preparation and estimation of drugs: a)Sulfanilamide, b) Methyl Salicylate c) Ibuprofen d) Any other drug molecules	
9. Organic Preparations: Double Stage : 1. Benzoin – Benzil - Benzilic acid 2. Benzophenone – Oxime – Benzanilide 3. Glycine – Hydantoic acid – Hydantoin	
10. Instrument introduction, theory and applications: IR, Mass, NMR, GC, HPLC	
CC 251 PHY (T) **2 Credit**	
Electricity and Magnetism	No. of lectures
Coulomb's Law	18
Gauss's Law	
Electric Field, Potential	
Conductors, Insulators	
Laplace equation	
Curl and Stoke's theorem	
Capacitors, capacitance and energy stored in E field	
Current and continuity equation	
Magnetic field and Moving Charges	
Force on Moving charges	
Magnetic Field and vector potential	
Special relativity and E and B fields	
Induction	
Inductance and energy stored in B field	
RC circuits	

CL and RLC circuits	
Displacement current	
Complete Maxwell's Equations	
Electromagnetic Waves	
Dielectrics and Electric Dipoles	
Dielectrics	
Magnetic Dipoles	
Magnetism in Matter	
Special relativity	No. of Lectures
Space-time and simultaneity. Einstein axioms for special relativity. The Lorentz transformation.	1
Relativistic kinematics; length contraction, time dilation. Doppler effect. Twin paradox.	2
Relativistic dynamics. Mass-energy equivalence. Conservation of four- momentum. Centre of momentum frame. De Broglie waves and photons.	2
Optics- Applications and microscopy	No. of Lectures
Classical optics: Fermat's Principle	1
Fourier Optics: Huygens-Fresnel Principle	1
Fourier Optics: Fresnel diffraction integral	1
Fourier Optics: Paraxial approximation	1
Fourier Optics: Fraunhofer diffraction	1
Fourier Optics: Apertures and imaging	1
Microscopy applications	4

SEC 251 PHY (P)	**2 Credit**
1 Study of Charging and discharging of capacitor and calculation of time constant.	3
2 Determination of e/m by Thomson method.	3
3 Determination of the refractive index of a transparent liquid (water) using a hollow prism and spectrometer.	3 3
4 Study of the graph between refractive index and wavelength for different colors of light and to verify Cauchy's Formula.	3 3
5.Study of LCR circuit	

MN 291 MTS (T)	**4 Credit**
Probability	No. of Lectures
Review of probability, events, laws of probability	20
Conditional probability, independent events	

Random variables; discrete random variables and distributions; mean, variance and standard deviation of discrete random variable	
Bernoulli trials, binomial distribution	
Poisson distribution and Poisson process	
Continuous random variables and distributions, probability density functions, cumulative distribution function	
Mean, variance, standard deviation, median and percentiles of a continuous distribution	
Normal distribution	
Uniform and exponential distribution	
Distributions of functions of a random variable	
Sums/differences/scalar multiples of random variables, independent random variables, distributions of sums/differences of independent random variables	
Central Limit Theorem	
Normal approximation to the binomial distribution, distribution of the sample mean	
Distribution of sample proportion	
Stochastic processes, Markov chains	
Limiting behavior of Markov chains	
Statistics	No. of Lectures
Study design: bias, confounding, precision, comparison, control	28
Study design: observational studies vs designed experiments	
Exploratory data analysis: describing and displaying categorical data (tables, frequencies, bar chart)	
Exploratory data analysis: describing and displaying univariate numeric data (dot plots, boxplots, histograms, mean, median, quartiles/percentiles, standard deviation, variance, IQR)	
Exploratory data analysis: describing and displaying bivariate numeric data (scatterplot, correlation)	
Statistical modeling (single mean model, multiple means model, regression model)	
Sampling distributions: population vs sample, parameter vs statistic; distribution of sample mean, proportion; standard error	
Estimation: Confidence intervals, confidence interval for mean (using z), confidence interval for mean using t	
Estimation: confidence interval for difference in mean, confidence intervals for proportion	
Estimation: required sample size, confidence interval vs prediction interval	
Theory of estimation: unbiased estimators, maximum likelihood estimators	
Hypothesis testing: concepts and terminology, testing a single mean (z and t)	
Hypothesis testing: errors, power, 2-sample test, paired test, testing proportion	
Hypothesis testing: Non-parametric tests for 2 samples	
Comparing multiple means: one-way ANOVA	

Theory of ANOVA	
Regression: least squares method	
Partitioning of variability in regression, significance testing in regression	
Chi-squared test for independence	
Chi-squared goodness-of-fit	

GE 251 BIO (T)	**2 Credit**
Transmission Genetics	No. of Lectures
Genetic variation and behaviour of genes	6
Linkage and recombination; Mapping genes	
Chromosome maps and genetic markers	
Sex linkage and sex determination	
Complementation	
Chromosomal mutations	
Non-Mendelian inheritance	
Extrachromosomal DNA	
Quantitative genetics	
Population Genetics	No. of Lectures
Genetic variation in populations	6
Mutation and Genetic drift	
Natural selection	
Mutation/Selection balance	
Balanced polymorphism	
Gene flow & inbreeding	
Population Biology	No. of Lectures
Nature of populations; numbers, mixing (dispersal), structure in age/stage	4
Density independent, density dependent growth (exponential and logistic growth equations)	
R & K selection, life-histories and links to population growth parameters, (annual vs perennial life-histories, clonality)	
Demography, Life tables, matrix models (requires simple matrix mathematics) and Epidemiology (simple functions)	
Communities	No. of Lectures
Nature of communities; Community structure: how it is described, measured; what drives it; species composition, diversity (alpha, beta, gamma)	4
Intra-community (interspecific) interactions (bi-partite networks); Symbiosis, Predation, Competition, Host-parasite interactions	
Dynamics of communities (perturbation and succession)	

Biomes (communities on a global scale)	
Ecosystems	No. of Lectures
Pond ecosystem (or other integrated example)	4
Food chains and webs	
Pyramids (numbers, biomass, energy), abstraction, defining trophic levels, the problem of omnivore (stable isotope tracers)	
Biogeochemical cycles (water, C, N, P) pools and fluxes, mass budget models. Rates of processes: productivity, decomposition, trophic transfer, turnover and Mean Residence Time.	

CHE 281 FP (Any 2)	**2 Credit**
Field Project in Chemistry	No. of Lectures

AEC 251 PS	**2 Credit**
Formal Presentation Skills	No. of Lectures
Presentation Types and Forms Theme based presentations Purpose based presentations- informative, persuasive, demonstrative, entertaining Form based presentation- Collage making.	6
News Presentation Understanding facts, focusing on gestures, controlled pace and pitch. Topic and Illustration Based Presentation Picture and non-verbal presentation	6
Presentation on an Article Presentation on an article for a magazine on trending issues Presentation based on illustration: Poster presentation	6
Presentation- Applications Presentation: based on the current reading material E-Portfolio: developing a self-presentation	6