Modern College of Arts, Science and Commerce,

Ganeshkhind, Pune-411016, India

(Autonomous)

(Affiliated to Savitribai Phule Pune University)

B. Sc. Blended

A

Three Year Degree Program

In collaboration with

University of Melbourne, Australia

and

Savitribai Phule Pune University, Pune-411007, India

Program structure

Choice Based Credit System (CBCS)

Board of Studies B. Sc. Blended

Meeting for the syllabus approval

Proposed credit framework for the S.Y. B. Sc. Blended Autonomous (Semesters III - IV)

Semester III

Course Code	Course Name	Credits
MTH 301	Vector Calculus and Differential Equations	4
PHY 302	Quantum mechanics and Thermodynamics	3
CHM 303	Reactions and Synthesis	3
BIO 304	Functional Biology	3
EVS 310	Environmental Science I	3
LAB 305	Physics Practical-III	2
LAB 306	Chemistry Practical-III	2
LAB 307	Biology Practical-III	2
LAB 311	Environmental Science I - Practical	2
EVS 312	Environmental Studies - I (UGC Mandatory Course)	2
	Total Credits	**26**

Semester IV

Subject Code	Title of the Subject	Credits
MTH 401	Probability and Statistics	4
PHY 402	Electricity, magnetism and Optics	3
CHM 403	Structure and Properties	3
BIO 404	Genetics Evolution and Ecology	3
EVS 410	Environmental Science II	3
LAB 405	Physics Practical-IV	2
LAB 406	Chemistry Practical-IV	2
LAB 407	Biology Practical-IV	2

LAB 411	Environmental Science II Practical	2
EVS 412	Environmental Studies - II (UGC Mandatory Course)	2
	Total Credits	**26**

Curriculum for S.Y. B. Sc. (Blended) Degree Program (Semester III - IV)

Semester III

MTH 301 Vector Calculus and Differential Equations	
Credits : 4	**Number of lectures: 48 +12**
Topic	**No. of Lectures**
Linear Algebra (13 lectures)	
Characteristic and minimal polynomial, Cayley-Hamilton Theorem	1
Applications of eigenvectors/diagonalisation eg Markov chains	2
Inner product axioms; examples/non-examples of inner products	1
Length, angle, Cauchy-Schwarz inequality in terms of inner product	2
Orthogonality, projections in terms of inner product	1
Change of basis and linear transformations	1
Definition of eigenvectors and eigenvalues	1
Calculating eigenvalues and eigenvectors	1
Diagonalisation of matrices; matrix powers	1
Orthogonal matrices, real symmetric matrices	1
Gram-Schmidt algorithm	1
Vector Calculus (28 lectures)	
Functions of several variables; level curves and cross sections of surfaces	2
Common surfaces including paraboloid, ellipsoid, hyperboloid	2

Domains and ranges of functions of several variables	1
Limits and continuity of functions of several variables; Definition of C^N	1
Partial derivatives, tangent plane	1
Differentiability of functions of several variables	1
Directional derivative, gradient	1
Chain rule and total derivative	1
Stationary points of surfaces, classification of stationary points using second derivatives	1
Optimisation applications	1
Constrained extrema using Lagrange multiplier method	1
Double integrals, changing order of integration	1
Polar co-ordinates, change of variables for double integrals	1
Triple integrals	1
Change of variables for triple integrals; cylindrical co-ordinates	1
Spherical co-ordinates	1
Vector fields, div and curl operators	1
Parameterisation of paths	1
Line integrals of scalar functions	1
Line integrals of vector functions	1
Integrals of scalar functions over surfaces, applications of surface integrals eg surface area, mass	1
Integrals of vector functions over surfaces, flux	1
Green's Theorem	1
Gauss Divergence Theorem	1

Stokes' Theorem	1
Applications of integral theorems eg Maxwell's equations	1
Polynomial Differential Equations (PDEs) 7 lectures	
Fourier Series	1
Fourier series: Dirichlet, discontinuities and differentiation	1
Fourier series: Weak convergence and series summation	1
Linearity and Superposition	1
Laplace equation and harmonic functions	1
Fourier transform	1
Fourier transform: properties	1
Student work/evaluation	**12**
Total	**60**

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PHY 302 Quantum Mechanics and Thermodynamics	
Credits : 3	**Number of lectures: 36 + 9**
Topic	**No. of Lectures**
Quantum Mechanics (20 lectures)	
The Breakdown of Classical Physics	3
Matter Waves and Quantum Interpretation	3
Quantum Mechanics in One Dimension	2
Expectation Values, Observables and Operators	3
Tunneling Phenomena	2

Quantum Mechanics in 3-dimensions	2
Hydrogen atom, hydrogenic ions, helium atom	3
Hydrogen molecule ion, hydrogen molecule	2
Thermodynamics (9 lectures)	
Temperature and the Zeroth Law of Thermodynamics. Thermal equilibrium.	2
Transport, conduction, conductivity, diffusion in gases.	2
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.	3
Applications of PDEs in thermodynamics (2 lectures)	
Wave equation	1
Heat and Diffusion equation	1
Application Linear Algebra in quantum mechanics (5 lectures)	
Change of basis and linear transformations	1
Definition of eigenvectors and eigenvalues	1
Calculating eigenvalues and eigenvectors	1
Diagonalisation of matrices; matrix powers	1
Orthogonal matrices, real symmetric matrices	1
Student work/evaluation	**9**
Total	**45**

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CHM 303 Reactions and Synthesis	
Credits : 3	**Number of lectures: 36 + 9**
Topic	**No. of Lectures**
Reactions and Synthesis 1 (12 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 Retrosynthesis.	1

Michael addition Chemistry, reaction of enolates with various Michael electrophiles	1
Kinetic and Thermodynamic enolates, Enamines and silylenol ethers	1

Reactions and Synthesis 2 (12 lectures)	**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 (12 lectures)	
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 relations	2
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
Student work/Evaluation	**9**
Total	**45**

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BIO 304 Functional Biology	
Credits : 3	**Number of lectures: 36 + 9**
Topic	**No. of Lectures**
Functional Biology of Organisms	
Introduction to Functional Biology	1
Animal biology (Humans as an example)	
Anatomy and Function 1: Tissues, Organs and Viscera	1

Anatomy and Function 2: Skeletal & Muscular system	1
Nervous system 1: The central nervous system (CNS) and nervous tissues	1
Nervous system 2: Autonomic nervous system and motor responses	1
Endocrine system 1: Endocrine and Exocrine glands	1
Endocrine system 2: HPA axis introduction	1
Respiration and Metabolism 1: Breathing in air and water	1
Respiration and Metabolism 2: Regulation of metabolism	1
Cardiovascular and circulatory system 1: Regulation of the circulatory system	1
Cardiovascular and circulatory system 2: Peripheral circulation	1
Digestive system	1
Urinary and Excretion systems 1: Anatomy and function	1
Urinary and Excretion systems 2: Osmoregulation in terrestrial & aquatic environments	1
Thermal dynamics	1
Immunology 1: Innate immune system	1
Immunology 2: Adaptive/Humoral immune system	1
Reproduction and Development 1: Gonads and the Reproductive tract	1
Reproduction and Development 2: Gametes, Fertilization and conception	1
Plant biology	
Growth and Development	2
Photosynthesis	2
Water Balance	2

Phloem and translocation	1
Mineral nutrition and nutrient assimilation	2

Respiration and lipid metabolism	2
Reproduction	1
Signaling; hormones, light responses, control of flowering	1
Abiotic stress	1
Secondary metabolism and defense	1
Microbial physiology	2

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EVS 310 - Environmental Science I	
Credits : 3	**Number of lectures: 36 + 9**
Topic	**No. of Lectures**
Fundamentals of Ecology (15 lectures)	
Ecology Definition, Concept, and Scope, Interdisciplinary science	2
Ecosystems – nature, structure and function, autecology and synecology, branches of ecology	2
Ecological Concepts - ecological succession, ecotone, edge effect, niche concept, homeostasis, ecological indicator plants and animals, concept of carrying capacity & limiting factors	3
Bio-geographical regions of India and its characters, principals of classification, key species of each region	2
Agro-ecological zones of India: basis of classification and characteristics in brief	1

Types of Ecosystems - Terrestrial (Forest Ecosystems, Grassland Ecosystems, Tundra Ecosystems, Desert Ecosystem), Aquatic (Freshwater Ecosystem, Marine Ecosystem)	2
Applied ecology - solutions for biodiversity conservation & climate related issues: restoration ecology, plants and microbes in conservation soils, restoration of land and degraded water bodies, carbon sequestration, Concept of ecological foot print	3
Fundamentals of Biodiversity (21 lectures)	
Biodiversity Definition, Concept, Scope	2
Genetic Diversity: Introduction, Nature and Origin of Genetic Variations	2
Species Diversity: Definition, History and Origin of Species Diversity, Diversity Indices Based on Species: Species Richness, Species Abundance, Taxic Diversity	3
Nature and importance of Urban Biodiversity, Hotspots in India – concept and basis of 'hotspot' identification	2
Endangered, Endemic and Extinct Species of India: Threatened species categories of IUCN, threatened species of plants and animals in India and their reasons, Red data books.	3
Biodiversity loss: Introduction, factors causing loss of diversity, founder effects, demographic bottlenecks, genetic drift, inbreeding depression, process responsible for species extinction, migratory corridors – concept and importance	3
Biodiversity conservation: *In-Situ* and *Ex-Situ* conservation, social approach of conservation, Convention related to biodiversity conservation such as - RAMSAR sites, CBD, CITES. Biodiversity Act.	3
Biodiversity Management: Organizations Associated with Biodiversity Management, Organizations Involved in Financing Biodiversity Management.	3
Student work /evaluation - Assignments / Tutorials	9

- Reviews of various research papers, reports, books - Presentations	

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LAB 305 Physics Practical-III

Credits :2

1) Michealson's interferometer: To find the wavelength of given laser beam.
2) Specific charge of the electron (e/m): To find the specific charge of the electron from the path of an electron beam in crossed electric and magnetic fields of variable strength.
3) Rydberg's constant: To find Rydberg's constant using diffraction grating.
4) Photoelectric effect: To estimate Planck's constant and work function of the photoelectrons by measuring the variation of stopping potential with the frequency of light. To see the graph of current Vs voltage for different intensity and frequency of light.
5) Electron diffraction: To measure diameter of smallest diffraction rings at different anode voltages.
6) Millikans oil drop experiment: To measure to charge of the electron.

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LAB 306 Chemistry Practical-III

Credits :2

1) Determination of EMF of a given cell and determination of its thermodynamic parameters (free energy and equilibrium constant)
2) Determination of time of flow and comment on the trend in the viscosity of the given liquid. OR Determination of molecular weight of a polymer using viscometer.
3) Measurement of pH of soil samples and suggestions about the remedy in soil health (if any) and the suitable crops to be taken.
4) Determination of pH of given water samples, suggestions to make it drinkable (if any).
5) Determination of molecular weight using steam distillation.
6) Benzyldehyde to benzyl acetophone
7) Hydroquinone to quinone

8) Separation of binary mixtures (Any three)

(i)Acid-Base, (ii) Acid-Neutral, (iii) Base-Neutral, (iv) Base-Phenol, (v) Phenol-Neutral

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LAB 307 Biology Practical-IV

Credits :2

1) Preparation of media, autoclaving and culturing of bacteria using different plating techniques, dilution and colony counting
2) Bacterial Growth curve
3) Grams staining (gram positive, gram negative and yoghurt samples)
4) Enzyme kinetics (effect of pH, temperature, substrate and enzyme concentration)
5) Estimation of glucose
6) Antibiotic sensitivity test: zone of inhibition

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LAB 311 - Environmental Science I Practical

Credits :2

1) Assessment of abiotic components in an ecosystem as physicochemical properties in – Atmosphere, Hydrosphere, Lithosphere
2) Assessment of biotic components in an ecosystem primarily pattern of organisms and habitat exposure
3) Assessment of biodiversity in a given geographical area – Floral & Faunal diversity (citing categories of different life forms based on morphological features only)
4) Quadrat study for Herbacious Species or plants, involving random sampling to measure the abundance, density and frequency of various species in an ecosystem
5) Quadrat / Transact study for Faunal species, involving random sampling to measure the abundance, density and frequency of various species in an ecosystem
6) Field visit and reporting: Forest/desert/aquatic ecosystem – record biotic and abiotic components and interactions

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EVS 312: Environmental Studies - I (UGC Mandatory Course)	
Credits : 2	**Number of lectures: 24+6**
Topic Details	**Lectures**

Unit 1 : Multidisciplinary nature of environmental studies Definition, scope and importance Need for public awareness.	4
Unit 2 : Natural Resources : Renewable and non-renewable resources : 1. Natural resources and associated problems. 2. Forest resources : Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. 3. Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. 4. Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies. 5. Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. 6. Energy resources : Growing energy needs, renewable and nonrenewable energy sources, use of alternate energy sources. Case studies. 7. Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification. • Role of an individual in conservation of natural resources. • Equitable use of resources for sustainable lifestyles.	6
Unit 3 : Ecosystems 1. Concept of an ecosystem. 2. Structure and function of an ecosystem. 3. Producers, consumers and decomposers. 4. Energy flow in the ecosystem. 5. Ecological succession. 6. Food chains, food webs and ecological pyramids. 7. Introduction, types, characteristic features, structure and function of the following ecosystem:- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	7

Unit 4 : Biodiversity and its conservation • Introduction – Definition : genetic, species and ecosystem diversity. • Biogeographical classification of India • Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values • Biodiversity at global, National and local levels. • Inida as a mega-diversity nation • Hot-sports of biodiversity. • Threats to biodiversity : habitat loss, poaching of wildlife, man wildlife conflicts. • Endangered and endemic species of India • Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity.	7
Student Work • Case Studies • Review - Books , Scientific Journals • Group Discussions, etc • Field Visit	6
Total	**30**

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Semester IV

MTHS 401 Probability and Statistics

Credits : 4	**Number of lectures: 48 +12**
Probability (20 lectures)	**No. of Lectures**
Review of probability, events, laws of probability	2
Conditional probability, independent events	1
Random variables; discrete random variables and distributions; mean, variance and standard deviation of discrete random variable	2
Bernoulli trials, binomial distribution	1
Poisson distribution and Poisson process	1
Continuous random variables and distributions, probability density functions, cumulative distribution function	1
Mean, variance, standard deviation, median and percentiles of a continuous distribution	1
Normal distribution	1
Uniform and exponential distribution	1
Distributions of functions of a random variable	1
Sums/differences/scalar multiples of random variables, independent random variables, distributions of sums/differences of independent random variables	2
Central Limit Theorem	1
Normal approximation to the binomial distribution, distribution of the sample mean	2
Distribution of sample proportion	1
Stochastic processes, Markov chains	1
Limiting behaviour of Markov chains	1
Statistics (28 lectures)	
Study design: bias, confounding, precision, comparison, control	2

Study design: observational studies vs designed experiments	1
Exploratory data analysis: describing and displaying categorical data (tables, frequencies, bar chart)	2
Exploratory data analysis: describing and displaying univariate numeric data (dotplots, boxplots, histograms, mean, median, quartiles/percentiles, standard deviation, variance, IQR)	1
Exploratory data analysis: describing and displaying bivariate numeric data (scatterplot, correlation)	2
Statistical modeling (single mean model, multiple means model, regression model)	2
Sampling distributions: population vs sample, parameter vs statistic; distribution of sample mean, proportion; standard error	2
Estimation: Confidence intervals, confidence interval for mean (using z), confidence interval for mean using t	1
Estimation: confidence interval for difference in mean, confidence intervals for proportion	1
Estimation: required sample size, confidence interval vs prediction interval	1
Estimation: required sample size, confidence interval vs prediction interval	1
Theory of estimation: unbiasaed estimators, maximum likelihood estimators	1
Theory of estimation: unbiasaed estimators, maximum likelihood estimators	1
Hypothesis testing: concepts and terminology, testing a single mean (z and t)	1
Hypothesis testing: errors, power, 2-sample test, paired test, testing proportion	1
Hypothesis testing: Non-parametric tests for 2 samples	1

Partitioning of variability in regression, significance testing in regression	1
Comparing multiple means: one-way ANOVA	1
Chi-squared test for independence	1
Regresion: least squares method	1
Chi-squared goodness-of-fit	1
Theory of ANOVA	1
Student work/evaluation	12
Total	**60**

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PHY 402 Electricity, Magnetism and Optics

Credits :3 **Number of lectures: 36 + 9**

Topic	No. of Lectures
Electricity and Magnetism (18 lectures)	
Coulomb's Law	2
Gauss's Law	2
Electric Field, Potential	2
Conductors, Insulators	2

Laplace equation	2
Curl and Stoke's theorem	2
Capacitors, capacitance and energy stored in E field	1
Current and continuity equation	1
Magnetic field and Moving Charges	1
Force on Moving charges	1
Magnetic Field and vector potential	1
Special relativity and E and B fields	1
Induction	1
Inductance and energy stored in B field	1
RC circuits	1
CL and RLC circuits	1
Displacement current	1
Complete Maxwell's Equations	1
Electromagnetic Waves	1
Dielectrics and Electric Dipoles	1
Dielectrics	1
Magnetic Dipoles	1
Magnetism in Matter	1
Special relativity (18 lectures)	
Space-time and simultaneity. Einstein axioms for special relativity. The Lorentz transformation.	2
Relativistic kinematics; length contraction, time dilation. Doppler effect. Twin paradox.	2
Relativistic dynamics. Mass-energy equivalence. Conservation of four	2

momentum. Centre of momentum frame. De Broglie waves and photons.	
Nuclear reactions and thermonuclear power.	1
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
Fourier Optics: phase contrast imaging	1
Microscopy applications	4
Student work/evaluation	**9**
Total	**45**

CHM 403 Structure and Properties	
Credits :3	**Number of lectures: 36 + 9**
Structure and Properties	**No. of Lectures**
Molecular shape and simple electronic structure, Isomerism: Orbitals, hybridization and shapes of molecules, stereochemical 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 T_d, O_h, D_{4h})	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
^{13}C NMR, ^{1}H NMR, integration, multiplicity, chemical shift typical ranges	1
Introduction to molecular spectroscopy and spectroscopic transitions, absorbance, transmittance, the Beer-Lambert Law,	1

intensities of spectroscopic transitions	
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. Vibrational spectroscopy: Local mode approximation. Characteristic infrared absorptions (alkyl CH, alcohol, amine RN H_2 and R_2NH, carboxylic acid, amide, ester, ketone, aldehyde, nitrile RCN, alkyne, alkene, aromatic), fingerprint regions, interpretation of IR spectra	1
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
Generalisation of the application of MO approaches to polyatomic molecules	1
Electronic spectroscopy: Chromophores and excited electronic	1

states, electronic transitions, UV-Vis spectroscopy, Franck-Condon Principle, Franck-Condon factors	
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
Student work/evaluation	**9**
Total	**45**

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BIO 404 Genetics, Evolution and Ecology	
Credits :3	**Number of lectures: 36 + 9**
Transmission Genetics	**No. of Lectures**
Genetic variation and behaviour of genes	3
Linkage and recombination; Mapping genes	2
Chromosome maps and genetic markers	1
Sex linkage and sex determination	2
Complementation	2
Chromosomal mutations	2
Non-Mendelian inheritance	1
Extrachromosomal DNA	2
Quantitative genetics	2
Population Genetics	
Genetic variation in populations	2
Mutation and Genetic drift	1
Natural selection	1
Mutation/Selection balance	1
Balanced polymorphism	1
Gene flow & inbreeding	1
Population Biology	
Nature of populations; numbers, mixing (dispersal), structure in age/stage	1
Density independent, density dependent growth (exponential and logistic growth equations)	2
R & K selection, life-histories and links to population growth	1

parameters, (annual vs perennial life-histories, clonality)	
Demography, Life tables, matrix models (requires simple matrix mathematics) and Epidemiology (simple functions)	1
Communities	
Nature of communities; Community structure: how it is described, measured; what drives it; species composition, diversity (alpha, beta, gamma)	1
Intra-community (interspecific) interactions (bi-partite networks); Symbiosis, Predation, Competition, Host-parasite interactions	1
Dynamics of communities (perturbation and succession)	1
Biomes (communities on a global scale)	1
Ecosystems	
Pond ecosystem (or other integrated example)	1
Food chains and webs	1
Pyramids (numbers, biomass, energy), abstraction, defining trophic levels, the problem of omnivory (stable isotope tracers)	1
Biogeochemical cycles (water, C, N, P) pools and fluxes, mass budget models. Rates of processes: productivity, decomposition, trophic transfer, turnover and Mean Residence Time.	1
Student work/evaluation	**9**
Total	**45**

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EVS 410 - Environmental Science II	
Credits :3	**Number of lectures: 36 + 9**
Topics	**No. of Lectures**

Definition, Types and major sources of air pollutants, effects of air pollutants on physico-chemical and biological properties surrounding atmosphere, air borne diseases and their effects on health	4
Types and major sources of water pollutants, effects of water pollutants on physico-chemical and biological properties of water bodies, water borne diseases with special reference to water pollution.	4
Types and major sources of soil pollutants, effects of soil pollutants on physico-chemical and biological properties of soil	4
Air, drinking water and waste water quality standard.	4
Major sources of noise pollution, effects of noise pollution on health, noise level standard in industrial, commercial, residential and silence zones.	4
Radioactive and thermal pollution sources and their effects on surrounding environment.	4
Pollution case studies.	12
Student work - Assignments / Tutorials - Reviews of various research papers, reports, books - Presentations	9
Total	**45**

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LAB 405 Physics Practical-IV
Credit: 2

1. Verification of Stefan's Law by Electrical method and Study the temperature dependence of total radiation and hence verify the Stefan's Law.
2. Determine of the wavelength of sodium light by measuring the diameters of Newton's rings and Determine of the Reflection Index of a Liquid transparent medium such as water using Newton's ring apparatus.
3. Measurement of wavelength of Laser by Diffraction Grating.
4. Measurement of Resistivity & Band gap of Germanium Crystal(N-type) by Four Probe Method.
5. To determine the coefficient of Linear Expansion of a given Sample. 6. Study of

LR circuit.

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LAB 406 Chemistry Practical-IV

Credit: 2

I] **Instrumental method of Analysis (Any 3)**

1) A photometric titration of Cu with EDTA (-745nm)
2) Dissociation constant of an acid- base indicator by spectrophotometry
3) The reaction between potassium persulphate and potassium iodide by colorimetry.
4) Hydrolysis constant of aniline hydrochloride by pH metry
5) Photometric analysis-Job's method e.g. To study complex formation between Fe (III) and salicylic acid and find the formula and stability constant of the complex.

II] **Preparation and purity determination (Any 1)**

1) Potassium trioxalato chromate (III).

2) Tris (acetylacetanato) Iron (III).

3) Bis (ethylene diamine) copper (II) sulphate.

III] Drug Analysis: Determination of iron from given drug sample.

IV] Preparations: Double Stage (Any 2)

a. Glycine – Hydantoic acid – Hydantoin

b. Benzoin – Benzil - Benzilic acid

c. Acetanilide – p-Bromoacetanilide – p-Bromoaniline

d. Hydroquinone – Quinoline – 1,2,4 – Triacetoxybenzene.

e. Cyclohexanone – oxime - ε-Caprolactum

f. Napthalene – Nirtonapthelene – p-amino benzoic acid

g. P-cresol – 4,6-Dimethylcoumarin – 3-Bromo-4,6 Dimethyl Coumarin

h. Benzophenone – Oxime – Benzanilide

i. Pthalic anhydride – O-Benzoyl benzoic acid – Anthraquinone.

j. Acetanilide – p-Nitroacetanilide – p-nitro aniline.

V] Interpretation of UV, FT-IR & ^{1}H-NMR spectrum of above synthesized compounds.

1 : U.V. spectroscopy: Calculation of λ max of the compounds.

2: Combined problems on U.V., I.R. and NMR **Aliphatic Compounds**

3: Combined problems on U.V., I.R. and NMR **Aromatic Compounds**

4: Fluorescence Spectroscopy

VI] Use of Computer for literature search- Scifinder, Reaxys and other search engine.

VII] Instrument introduction, theory and applications: IR, Mass, NMR, GC, HPLC & XRD

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LAB 407 Biology Practical-IV

Credit: 2

1. Study of the pond ecosystem: physical, chemical factors; biota; primary productivity estimation; role as carbon sink; community structure (over time)
2. Visit the pond, collect samples in three seasons – monsoon (already collected in July/Aug), post-monsoon (January) and summer (March). (field visits)
   i) measure physico-chemical parameters, depth, turbidity, DO, primary productivity (field+lab sessions)
   ii). identify vegetation types, succession in vegetation
3. Introductory population dynamics (Daily monitoring required)
4. i. Establish a simple culture of cladoceran species (isolated from pond sample) in lab. Study dynamics of population (growth curves).
   ii. Density dependant growth – same culture, initiate the experiment with different starting densities.
   iii. Create an artificial mesocosm (tub/tank of defined area), and inoculate with Lemna. / Azolla sp. (brought from nearby habitats). Monitor growth, density and biomass over time.
5. Introduction to Habitat & Community ecology
   i. Visit different types of water bodies (one river/stream and one quarry/pond/lake) and conduct
6. iSampling. Study habitat ecology and community composition. (field session)
   ii. Identify, quantify zooplankton taxa in collected samples. Calculate diversity indices. (lab session)
   iii. Introduction to various sampling methods (point count/line transect/quadrat) in field.
7. Learn methods for estimating plant biomass (using GBH). (field session)
8. Potential sites for field visits: Tamhini Ghat/ Devkund waterfall (major field trip; one day long) + Pashan lake/MIT quarry (short field trip, 1-2 hrs.)
9. Functional ecology (**Optional**)
   i. Using established plankton cultures perform grazing experiments using range of food

densities. (Lab session).

10. Population genetics: solving problems
    i. Use of ABO blood group data to calculate allele frequencies. Data can be gathered both by interviews and by actual blood group determination).
    ii. use of PTC (phenylthiocarbamide) tasting trait to calculate allele frequencies.

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LAB 411 Environmental Science II Practical

Credit:2

1. Sampling and analysis techniques for Water & Waste water studies.(Estimation of pH, DO, BoD, CoD & Hardness)
2. Sampling and analysis techniques for contaminated soil studies.
3. Sampling and analysis techniques for air pollution studies
4. Understanding of Noise Level Meter / DB meter

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EVS 412 Environmental Studies- II (UGC Mandatory Course)	
Credits :2	**Number of lectures: 24 +6**
Topic Details	**Lectures**
Unit 1 : Environmental Pollution Definition • Cause, effects and control measures of:- a. Air pollution b. Water pollution c. Soil pollution d. Marine pollution e. Noise pollution f. Thermal pollution g. Nuclear hazards • Solid waste Management : Causes, effects and control measures of urban and industrial wastes. • Role of an individual in prevention of pollution. • Pollution case studies. • Disaster management : floods, earthquake, cyclone and landslides.	5

Unit 2 : Social Issues and the Environment • From Unsustainable to Sustainable development • Urban problems related to energy • Water conservation, rain water harvesting, watershed management • Resettlement and rehabilitation of people; its problems and concerns. Case Studies • Environmental ethics: Issues and possible solutions. • Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. • Wasteland reclamation. • Consumerism and waste products. • Environment Protection Act. • Air (Prevention and Control of Pollution) Act. • Water (Prevention and control of Pollution) Act • Wildlife Protection Act • Forest Conservation Act • Issues involved in enforcement of environmental legislation. • Public awareness.	4
Unit 3: Human Population and the Environment • Population growth, variation among nations. • Population explosion – Family Welfare Programme. • Environment and human health. • Human Rights. • Value Education. • HIV/AIDS. • Women and Child Welfare. • Role of Information Technology in Environment and human health. • Case Studies.	5
Unit 4 : Field work • Visit to a local area to document environmental assets - river / forest /grassland/hill/mountain • Visit to a local polluted site-Urban/Rural/Industrial/Agricultural • Study of common plants, insects, birds. • Study of simple ecosystems-pond, river, hill slopes, etc.	10
Student work/evaluation	**6**
Total	**30**