Savitribai Phule Pune University

Revision and Amendment

Three Year B. Sc. (Blended) Course

Course Syllabus for SEM I – IV (98 Credits)

(To Be Implemented from Academic Year 2020 – 2021)

Introduction

B. Sc. (Blended) Course

The SPPU instituted the innovative Bachelor Degree known as **B. Sc. (Blended)** in collaboration with the University of Melbourne (UoM), Australia and the Indian Institute of Science Education and Research to strengthen science education at the undergraduate level.

The SPPU is among the top universities in the country and has been in the forefront for initiating innovative programs. The UoM is ranked #1 in Australia and it has been among the top 50 in the world. IISER was established by the Government of India to strengthen science education and research in the country has attained national and international recognition in a short span of a decade. It offers a holistic BS – MS program in Science covering the basic science disciplines.

The **B. Sc. (Blended) course** is a joint initiative of SPPU-UoM-IISER offering a transparent and internationally recognized bachelor's degree underlining clearly the teaching objectives and learning outcome. In the first two years of the degree program all four basic sciences (Biology, Chemistry, Mathematics and Physics) along with Environmental Science and Earth Science will be taught providing basic knowledge. The students can opt for **specialization either in Physics or Chemistry or Environmental Science or Earth Science in the third year**. The UoM and IISERP will provide with support in terms of special lectures, workshops, and quality assurance.

Objectives

- To introduce the fundamentals of science education.
- To enrich students' knowledge in all basic sciences.
- To help the students to build interdisciplinary approach.
- To inculcate sense of scientific responsibilities, social and environment awareness.
- To help the students build-up a progressive and successful career in academics and industry.

Highlights of the Program

- The course will be run in collaboration with UoM and IISER
- Special lectures by expert faculty from UoM, IISER and other institutes.
- The UoM will provide online teaching of some topics from the syllabus.
- The course will be quality assured by the UoM.
- The degree will be considered at par with that of UoM and the students will be eligible to pursue higher studies at UoM and other Universities in Australia.

- The students will be imparted solid training to enable them to pursue Masters and Integrated Ph. D. degrees in reputed institutes such as IITs, IISERs and Central Universities

Eligibility

First Year B. Sc. (Blended)
Higher Secondary School Certificate (10+2) or its equivalent Examination in Science stream with either PCM group (Physics, Chemistry & Mathematics) or PCMB group (Physics Chemistry, Mathematics & Biology)

Second Year B. Sc.
Students are not directly admitted to second year of B. Sc. (Blended) course. Those who pass 13 subjects (practical courses are mandatory to pass) out 17 the subjects (Semester I & Semester II combined) will be promoted to second year.

All the students shall opt for UGC mandatory course in Environmental Studies during second year. They shall pass this course in order to achieve eligibility for the 3rd year.

Third Year B. Sc.
Students are not directly admitted to third year of B. Sc. (Blended) course. Those who complete first year in totality and pass 14 subjects (practical courses are mandatory to pass) out 18 the subjects (Semester III & Semester IV combined) will be promoted to Third year B. Sc. (Blended) course.

ATKT rules in B. Sc. (Blended) course will be as per university guidelines.

Reservation and relaxation will be as per the Government rules.

Course Structure

Duration: The duration of **B. Sc. (Blended)** Degree Program shall be of three years.

Medium of Instruction: The medium of instruction for the course shall be English.

The course is a semester and credit system based course and is divided into six semesters of 14 weeks each. The total number of credits for Sem I, II, III & IV (combined) are98 credits during the first two years with instruction in basic sciences *viz.*Biology, Chemistry, Mathematics and Physics along with Environmental Science or Earth Science. In the third year, the student specializes **either in Physics or Chemistry or Environmental Science or Earth Science**. The

Third year will comprise of two semesters having minimum of 44 and maximum of 50 Credits depending upon subject requirements.

At **first year of under-graduation**, students will be given the basic information that includes – all basic science subjects as mentioned above. The topics include general and organic chemistry, calculus, introductory classical physics, waves, gravitation, unifying themes in biology, diversity of life, ecology, environment, earth science, etc. Relevant experimentation on these topics is included in practical courses. They will also be introduced to scientific writing and communication skills. During semester II, in addition to basic sciences and Computation course, the students will have to opt for either Earth Science or Environmental Science. This will introduce students to fundamentals of either Earth Science or Environmental Science which will help students who wish to specialise in either Earth Science or Environmental Science during their third year.

At the **second year under-graduation** level, students will be introduced to linear algebra, vectors, complex numbers, computing, electricity, magnetism, special relativity, physical chemistry, inorganic chemistry, reactions and synthesis, cell biology, genetic control principles of physiology, both animal and plant physiology, mechanism of evolution, and population biology, environment, earth science, etc. The relevant practical experiments are included to enrich the student's knowledge. During Semester III & IV, in addition to basic sciences, the students will have to opt for either Earth Science or Environmental Science. This will prepare students to application aspects of either Earth Science or Environmental Science to be taught during third year of specialisation in either Earth Science or Environmental Science.

In addition to core subjects, all the students shall opt for UGC mandatory course in Environmental Studies during second year. This course will be in addition to core subjects. They shall pass this course in order to achieve eligibility for the 3rd year.

The third year under graduation level will be detailed out at later stage.

Examination and Grading

The course is based on credit system and the examination process consists of two parts: continuous assessment (internal 50%) and end semester examination (50%). The internal assessment will consist of Class Room Examinations (subjective/objective), Field Work, Viva-Voce, Assignments, Lab Work, tutorials, group discussions, etc. The grading will be as per the university norms applicable to credit system.

University Terms

Dates for commencement and conclusion for the first and second terms will be declared by the University authorities. Terms can be kept by only duly admitted students. The term shall be granted only on minimum 75 percent attendance at theory and practical course and satisfactory performance during the term.

Intake capacity of student: B. Sc. Blended course: 64

Proposed Curriculum Structure for the B. Sc. (Blended) Course (Semesters I - IV)

Nomenclature: BIO: Biology. CHM: Chemistry. MTH: Mathematics. PHY: Physics. ENG: English; COMP – Computing; GEO – Earth Science; EVSB – Environmental Science

1 Credit = 1 Contact hour per week both for theory and lab courses

Semester I

Semester I				
Subject Code	**Title of the Subject**	**Credits**		**Total Lectures**
MTH 101	Maths 1: Calculus	4	15 Lectures per Credit	60
PHY 102	Physics 1: I Introductory Physics	3		45
CHM 103	Chemistry 1: General Chemistry – Chemistry of life	3		45
BIO 104	Biology 1: Diversity of Life	3		45
PHY LAB 105	Physics Practical	2		30
CHM LAB 106	Chemistry Practical	2		30
BIO LAB 107	Biology Practical	2		30
ENG 108	English: Critical Reading, Writing, Communication	3		45
Total Credits		**22**		**330**

Semester II

Semester II				
Subject Code	**Title of the Subject**	**Credits**		**Total Lectures**
MTH 201	Maths 2: Algebra	4	15 Lectures per Credit	60
PHY 202	Physics 2: Electromagnetism, Optics and Modern Physics	3		45
CHM 203	Chemistry 2: Physical and Inorganic	3		45
BIO 204	Biology 2: Cell Biology	3		45
FLEXI	Flexi Course 1	3		45
PHY LAB 205	Physics Practical	2		30
CHM LAB 206	Chemistry Practical	2		30
BIO LAB 207	Biology Practical	2		30
COMP208	Computing	2		30
Total Credits		**24**		**360**
Flexi Course 1- for SPPU Campus students will chose from either Earth Sciences I (GEO 209) or Environmental Science I (EVSB 210). For other affiliated colleges under SPPU, Flexi Course -1 will be finalised based on individual requirements of the respective colleges.				

Semester III

Semester III				
Subject Code	**Title of the Subject**	**Credits**		**Total Lectures**
MTH 301	Maths 3: Vector Calculus, and Probability and Statistics I	4	15 Lectures per Credit	60
PHY 302	Physics 3: Quantum mechanics and Thermodynamics	3		45
CHM 303	Chemistry 3: Reactions and Synthesis	3		45
BIO 304	Biology 3: Functional Biology	3		45
FLEXI	Flexi Course 2	3		45
PHY LAB 305	Physics Practical	2		30
CHM LAB 306	Chemistry Practical	2		30
BIO LAB 307	Biology Practical	2		30
FLEXI	Practical for Flexi Course 2	2		30
Total Credits		**24**		**360**
EVSB 312 (UGC mandatory course)	Environmental Studies - I (Theory & practical)	2		30
Flexi Course 2 - for SPPU Campus students will chose from either Earth Sciences II (GEO 308) or Environmental Science II (EVSB 310). For other affiliated colleges under SPPU, Flexi Course - 2 will be finalised based on individual requirements of the respective colleges.				

Semester IV

Semester IV				
Subject Code	**Title of the Subject**	**Credits**		**Total Lectures**
MTH 401	Maths 4: Differential Equations, and Probability and Statistics II	4	15 Lectures per Credit	60
PHY 402	Physics 4: Electricity& magnetism, Special Relativity and Fourier Optics	3		45
CHM 403	Chemistry 4: Structure and properties	3		45
BIO 404	Biology 4: Genetics Evolution and Ecology	3		45
FLEXI	Flexi Course 3	3		45
PHY LAB 405	Physics Practical	2		30
CHM LAB 406	Chemistry Practical	2		30
BIO LAB 407	Biology Practical	2		30
FLEXI	Practical for Flexi Course 3	2		30
Total Credits		**24**		**360**
EVSB 412 (UGC Mandatory course)	Environmental Studies - II (Theory & practical)	2		30

Flexi Course 3 - for SPPU Campus students will chose from either Earth Sciences III (GEO 408) or Environmental Science III (EVSB 410). For other affiliated colleges under SPPU, Flexi Course -3 will be finalised based on individual requirements of the respective colleges.

Curriculum for B.Sc. (Blended) Program (Semesters I - VI)

Nomenclature: BIO: Biology. CHM: Chemistry. MTH: Mathematics. PHY: Physics. ENG: English; COMP – Computing; GEO – Earth Science; EVSB – Environmental Science

Semester I

MTH 101	
Logic and Proof	**No. of lectures**
Basic set theory (review)	1
Logical connectives (conjunction, disjunction, negation, conditional, bi-conditional) and truth tables	2
Propositional logic, logical equivalence, logical laws	1
Real numbers and their properties; completeness property	1
Proof methods: direct proof, contrapositive	1
Proof methods: contradiction, proof by cases	1
Proof methods: induction	1
Natural numbers, integers, rational numbers	1
Real numbers	1
Complex Numbers	**No. of lectures**
Review of complex numbers including algebra, Argand plane, cartesian and polar form	1
Complex exponential	1
de Moivre's theorem; roots of complex numbers	2
Differential calculus	**No. of lectures**
Review of differential calculus: limits, derivative, differentiation rules incl. polynomials, trigonometric, exponential, log functions; product, quotient, chain rules	5
Review of inverse trigonometric functions and their derivatives, implicit differentiation	4
Integral calculus	**No. of lectures**
Riemann integration	1

Fundamental Theorem of Calculus; review of standard anti-derivatives	1
Techniques of integration (review): derivative present substitution, linear substitution	1
Techniques of integration (review): integration of trigonometric functions using identities	1
Techniques of integration (review): integration of rational functions including partial fractions, integration yielding inverse trig functions	1
Techniques of integration (review): trigonometric substitutions; integration by parts	1
Improper integrals	1
Applications of integration: areas between curves	1
Applications of integration: volumes of surfaces of revolution	1
Ordinary differential equations: definition of ODE, order, general solution, initial conditions; separable ODEs	1
Solving linear ODE using integrating factor	1
Particular solutions of inhomogeneous constant coefficient linear ODEs using method of undetermined coefficients; principle of superposition	1

PHY 102	
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	**No. of lectures**
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
Thermal physics	**No. of lectures**
ZerothLaw of Thermodynamics	1
Thermal expansion and absorption of heat First Law of Thermodynamics; adiabatic processes, constant volume processes, enthalpy, cyclical processes, free expansions	2
Heat transfer, conduction, emission, absorption. Second Law of Thermodynamics, Irreversible processes, entropy, free energy	2
Elasticity, fluids and gases	**No. of lectures**
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	2
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

CHM 103	
General Chemistry	**No. of lectures**
The Periodic Table	1
Molecular Structure and Bonding	2
Acids and Bases	3
Stoichiometry	1
Organic Chemistry	**No. of lectures**
Carbon – the basis of life	4
Structure and Bonding Alkanes (sp^3Hybridisation)	
Structure and Bonding Alkenes (sp^2Hybridisation)	2
Benzene and its derivatives	1

Structure and Bonding of Alkynes (sphybridisation)	1
Functional Groups	1
Electrophiles and Nucleophiles	2
Nucleophilic substitution reactions	1
Elimination reactions	1
Addition reactions	1
Electrophilic aromatic substitution reactions	1
Nucleophilic addition 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

BIO 104	
Evolution and the Diversity of Life	**No. of lectures**
Theory of evolution: understanding life's diversity	1
Evolutionary relationships (phylogenies) are summarized in classifications	1
Chemical evolution of life – Molecules to cells	1
Cell theory and the origin of life	1
Prokaryotic Cells: Bacteria and Archaea	2
Evolution of the eukaryotic cell	1
Endosymbiosis	1
Protists 1 - Red and Green algae	1
Protists 2 – Chromists	1

Protists 3 - Dinoflagellates and apicomplexans, flagellates, ciliates, amoebae	1
Evolution of sex, life cycles	1
Origins of multiculticellularity	1
Slime moulds and fungi	1
Fungi	1
Introduction to Land Plants	1
Bryophytes	1
Evolution of vascular tissue, Lycophytes, fern allies, early fossil land plants	1
Ferns	1
Seed plants, the seed and secondary growth, Cycads and Ginkgo	1
Conifer diversity and biology	1
Angiosperm structure, biology and diversity, the flower, double fertilization.	1
Angiosperm phylogeny and evolution	1
Introduction to animals (Metazoa)	1
Simple animals	1
Protostomes-Flatworms and annelids	1
Molluscs	1
Arthropods	1
Deuterostomes, Echinoderms-Chordates	1
Fishes –sharks/rays, teleosts, coelacanth, lungfish	1
Amphibians	1
Reptiles	1
Birds	1
Mammals	2
The Primate story	1

ENG 108 (Theory and Practical) – Syllabus

Sr. no	Theory	Practical
1	**Listening -** Overview, Question Types, Listening Tips, Completing the blanks, Making Assumptions, Understanding	Listening for - Description, Time, Frequency, Similar meanings, Emotions, Explanation, Classification, Comparison and

	numbers Understanding the alphabet, Distinguishing similar sounds	contrasts, Negative meaning, Chronology
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
3	**Writing-** Overview, Question types, Writing tips	Responding to task, Coherence and cohesion, Lexical resource, Generalizing and Qualifying, Grammatical range and accuracy
4	**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

PHY LAB- 105

List of experiments

1. Simple Pendulum: To plot a L-T^2 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.

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.Young's Modulus:To determine the Young's modulus of elasticity of the material of a given wire using Searle's apparatus.

4. To determine the angular acceleration α and torque τ of flywheel.

5. To determine moment of inertia of Flywheel

6. To Study Newton's Second Law of Motion.

CHM LAB- 106

List of Physical chemistry experiments **(Any 3)**

1. To determine the rate constant of the hydrolysis of Ethyl acetate using an acid catalyst.

2.. Molar mass determination of some base metals, gases.

3. Determination of dissociation constant of a weak acid.
4. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known substance.
5. Calculation of the enthalpy of ionization of ethanoic acid.

List of Inorganic chemistry experiments **(Any 3)**

1. Basic Analytical Terms: Volumetric and Gravimetric analysis, Titration, Types of titration viz. acid base, redox, iodometric, iodometric and complexometric titrations, Types of indicators, Selection of indicator, Aquametry (Karl-Fisher titration)
2. Oxalate Complexes of Aluminum and Chromium.
3. Estimation of Fe (II) with $K_2Cr_2O_7$ using internal external (diphenylamine, anthranilic acid) and external indicator.
4. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
5. Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$ solution.

List of Organic chemistry experiments **(Any 3)**

1. Techniques:

Crystallization, Sublimation, Distillation, Steam Distillation, Vacuum Distillation, Column Chromatography, Thin Layer Chromatography. Record melting point & Boiling Point.

2. Functional group tests following functional groups

Alcohols, Alkenes, Aldehydes and Ketones, Acids, Phenols, Amines, Amides, Esters, Aromatic compounds.

3. Preparations: (Any 3)

a. Preparation of 4, 4'-Dimethoxy-dibenzylideneacetone

b. Preparation of 4-tert-Butylphenol

c. Reduction of p-nitro benzaldehyde by sodium borohydride

d. Nitration of Salicylic acid by green approach (using ceric ammonium nitrate).

e. Bromination of cinnamic acid.

BIO LAB 107

1. Observation of zooplankton from pond samples under microscope
2. Determination of dissolved oxygen in water sample using Winkler titration
3. Collection and identification of invertebrate samples from pond by using different types of nets.
4. Visit to the museum at zoology department at Pune University and observe the collected specimens.
5. Using a taxonomic browser to identify the taxonomic lineage and explain key characteristics of the species.
6. Observe the characteristics of prokaryotic and eukaryotic cells.

Semester II

MATHS 201	
Analysis	**No. of lectures**
Limits of real-valued functions	1
Proving limits using the definition	1
Continuity & differentiability	1
Examples of differentiable and non-differentiable functions; continuity and differentiability of standard functions including polynomials, trigonometric, exponential, log functions and their inverses	1
Techniques for evaluating limits including L'Hopital's rule, sandwich theorem	1
Mean Value Theorem and applications	1
Applications of differential calculus eg related rates	1
Sequence and series	**No. of lectures**
Sequences, limits, convergence and divergence	**1**
Proving limits using definition	**1**
Methods for evaluating limits: standard limits, limit theorems, continuity rule, sandwich theorem	**1**
Series, convergence and divergence of series, geometric series, harmonic p-series	**1**
Series convergence tests: divergence test, comparison test	**1**
Series convergence tests: ratio test, integral test, alternating series test	1

Power series, Taylor polynomials	1
Taylor series	1
Taylor's theorem, error in Taylor polynomial estimates	1
Vectors	**No. of lectures**
Vector arithmetic, dot product, vector projections (review)	1
Vector cross product; scalar triple product; parametric curves specified by vector equations	1
Lines and planes in R^3	1
Lines and planes in R^3	1
Linear Algebra 1	**No. of lectures**
Solving systems of linear equations with Gaussian elimination	1
Solutions of systems of linear equations - consistency, uniqueness	1
Geometric interpretation of solutions	1
Matrices, matrix addition, multiplication, transpose and properties (review)	1
Matrix inverse	1
Determinant	1
R^n as a vector space, linear independence of vectors in R^n	1
Span of a set of vectors, subspaces of R^n	1
Basis and dimension in R^n	1
Abstract vector space axioms; examples and non-examples of vector spaces	1
Bases, dimension and co-ordinates in (finite dimensonal) abstract vector spaces	1
Definition of linear transformation and examples/non-examples	1
Linear transformations of the plane	1
Matrix representation of a linear transformation	1
Image and kernel of a linear transformation	1
Rank and nullity	1

PHYSICS 202	
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**
Simple harmonic motion, pendulum, diatomic molecules,Damped harmonic motion, resonance - electronic circuits, evolution of populations	2
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

CHEMISTRY 203	
Chemistry of Life	**No. of lectures**
The chemical basis of life	1
Bioenergetics	1
Enzymes and catalysed reactions	2
Metabolism: Catabolism and anabolism	2
Concatenation and Biopolymers	1
Stereochemistry and Biomolecular chirality	1
Biochemistry and Biomolecular structure	2
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
Transition metals in biological systems	1
Simple harmonic motion, pendulum, diatomic molecules	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

BIOLOGY 204	
The Biology of Cells	**No. of lectures**
Introduction to Cell Biology	2
Theme: The cell contained	
The plasma membrane	2
Cell walls, extracellular matrix, cellulose synthesis, other cell wall components	2
Cytoplasm: content, chemistry and properties	1
Cytoskeleton, actin filaments, microtubules	2
Theme: Information flow in the cell	
Nucleus, chromosomes, DNA	2
Genes and the genetic code	2
Control of gene expression	2
Theme: Endomembrane system and intracellular trafficking	
ER and ribosome, proteins and enzymes	3
Golgi apparatus	1
Vesicles, transport and secretion, Lysosomes	2
Theme: Harvesting energy	
Mitochondria, ATP, energetic reactions, electron transport pathways, cellular respiration	2
Chloroplasts, photosynthesis, historical experiments, pigments, photosystems	2
Theme: Multicellularity and the Dividing Cell	
Cell division, cell cycle, mitosis, cytokinesis, division and distribution of organelles	2
Meiosis, formation of haploid cells	1
Communication and signaling, recognizing and responding	2
Cell differentiation and multicellularity	2

GEO 209 - Earth Sciences I (Theory & practical)	
Topic Details	**Lectures**
Fundamentals of Earth System Sciences: Origin of Sun, Earth and other planetary systems, Geology of the Inner planets (e.g. Mars, Venus) and moon. Meteorites-types and origin.	8

Earth-internal structure: Interior of the Earth-Mineralogical and geophysical structure, Geothermal gradients- oceanic and continental, geochemical differentiation, crust-mantle-core interactions.	8
Spheres of the Earth: Process of formation of the different spheres of the Earth, Characteristics of the asthenosphere, lithosphere, hydrosphere, biosphere and atmosphere.	5
Biogeochemical cycles: Introduction to the Rocks cycle, water cycle, carbon, nitrogen and oxygen cycles, Biomagnification of heavy metals and toxic contaminants, etc.	5
Geological time scale: Introduction and concept of stratigraphy, paleontology and geochronology. Principles of stratigraphy, Unconformities. Geological Time scale. Concept of Eon, Era, Period, Epoch, Origin of life, Evolution of life with time, Index fossils though time.	7
Elements of Geological mapping: Geological mapping, Introduction to Topo-maps, concept of scale, types of geographic projections, Representing lithological and structural elements on maps.	5
Geosciences Practical • Geological Time Scale • Identification and morphological descriptions of Index fossils • Identification and description of common rock forming minerals • Reading Topomaps and symbols • Lithological and structural symbols	7

EVSB 210 - Environmental Science I(Theory & practical)	
Topics	**No. of Lectures**
Introduction & Multidisciplinary nature of Environmental Science	2
Fundamentals of Earth System: Formation and characteristics of Earth Systems (Atmosphere, Lithosphere, biosphere and hydrosphere).	4
Ecosystems – concepts and structure, diversity and stability, concepts of biomes, Energy flow in ecosystem, food chain, food web, ecological pyramids, biodiversity	4
Natural resources – definition and types, renewable and non-renewable resources, resource use and depletion	2

The atmosphere – structure and composition, physicochemical role of the atmosphere	2
Rocks and minerals, the rock cycle, biogeochemical cycles, soil-structure and types, land resources, and landforms	2
Renewable & Non renewable Energy Sources	2
The Urban environment and issues – internal migration, waste generation and management, vehicular traffic, air and water pollution, urban heat island, future of cities, urban green space and aesthetics, Concept of smart cities, sustainable cities	3
Environmental issues – local, regional, and global. Concepts of pollution of air, water, and land, urbanization and solid wastes, biodiversity loss, land degradation and desertification, biodiversity loss, Acid rain, ozone layer depletion, Green House gases, climate change	4
Environmental concerns – historical development of environmentalism and conservation on Indian perspective	2
Sustainable development - What is unsustainable development and what is sustainable development? Definition and concept, The Brundtland commission and later developments, Determinants of sustainable development, Indicators of sustainable development, Sustainable society, societal prerequisites of sustainable development, International cooperation, Sustainable development goals (SDG), Millennium Development Goals (MDG)	4
Student work / Practical - Field Visit - Pond / Lake ecosystem, Fresh water ecosystem - Assignments - Geological Time Scale - Identification and description of common rock forming minerals - Reading Topomaps and symbols - Lithological and structural symbols - Presentations	14

COMP 208 (Theory and Practical) - Syllabus	
Topics	**No. of Lectures**

Introduction to computing - What is computing; - Introduction to Electronic data processing; Electronic devices; - Information storage; access and management; - Key terms used in IT; - Introduction to computer networks; - Brief introduction to compilers, interpreters and associated languages - Introduction to Scientific Computing (Definition,Need and design of Scientific Computing processes, Use of different software systems for Scientific Computing, Examples)	7
Introduction to Open Source Software - History and use of Open Source Software - Examples of popular Open Source Software in different domains with special focus on Environmental Science, - Examples	3
Algorithms and System Analysis Design and components of algorithms, flowcharts, steps to design the optimum algorithm, analysis of algorithms, examples; System thinking, steps of system analysis, defining the problem and designing the optimum solution, examples	7
Python Syntax: Variables and Assignments; variable types; input-output; arithmatic; functions and built-in function; If & While; Lists & Tables for loops, Simple Visualisations	18
Numerical Analysis: 1D integrals using Trapezoidal and Simpson's Rule; Euler's Method ; Generating Random numbers	10
Optional	
Mathematical Modelling: Agent Based Modelling; using NET Logo or similar tool, simple Harmonic Oscillator, Random Walks	10

PHY LAB- 205

List of experiments

1. To find the specific charge density of an electron in a CRT by Thomson method.

2. Determination of magnetic field with the variation of distance along the axis of current carrying coil.

3. Verification of Kirchhoff's Law.

4. Study of RC circuit.

5. To determine the Refracting Angle, Refractive Index of prism using spectrometer.

6. To determine the Resolving power of prism using spectrometer

CHM LAB-206

List of Physical chemistry experiments (Any 3)

1. To determine the rate of chemical reaction by using hydrolysis of *tert*-Butyl chloride.
2. Effects of catalase enzyme obtained from potato in cleaving H_2O_2 into H_2O and O_2.
3. To measure the vapour pressure of n- Pantane by using high vacuum line.
4. Heat of solution of KNO_3/ NH_4Cl.
5. Glass electrode- Buffer solutions: To titrate a weak base (Na2CO3) with a strong acid a) an acid-base indicator, (b) a glass electrode

List of Inorganic chemistry experiments (Any 3)

1. Synthesis of hexamminenickel (II) $[Ni(NH_3)_6]I_2$
2. Cuprous Chloride, Cu_2Cl_2
3. The transition metals: a survey (Transition metals in biological systems and Bonding in complex ions).
4. Estimation of Cu(II) and K2Cr2O7 using sodium thiosulphate solution (Iodimetrically).
5. Estimation of available chlorine in bleaching powder iodometrically.

List of Organic chemistry experiments (Any 3)

1. Preparation of Derivatives:

Oxime, 2, 4-DNP, Acetyl, Benzoyl, Semicarbazone, Anilide, Amide, Aryloxyacetic acid.

2. Organic single stage preparation: (Any 3)

1. The preparation of paracetamol.
2. The synthesis of meso-1,2-Dihydroxy-1,2-Diphenylethane.
3. Preparation of α-phenyl Cinnamic acid from Benzaldehyde.
4. Preparation of benzyl alcohol from Benzaldehyde
5. Preparation Glucose pentaacetate from Glucose.
6. Preparation of 2-iodobenzoic acid from Anthranilic acid.

3. **Use of Computer (Chemistry Software)** –

Chem Draw-Sketch, ISI – Draw, Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name.

BIO LAB 207 (Any 6)

1. Microscopy and observation recording of representative organelle readymade specimens
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

3. Introduction and visualization DNA-Proteins in silico
4. A one day visit to IISER Pune for electron/ fluorescence microscopy observations
5. Observation of budding in yeast & different kinds of cells
6. Observation of live/dead cells using Trypan blue staining
7. Isolation of DNA
8. Mitosis in onion root tips

Semester III

MATHS 301	
Linear Algebra	**No. of 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**
Characteristic and minimal polynomial, Cayley-Hamilton Theorem	1
Applications of eigenvectors/diagonalisationeg Markov chains	1
Inner product axioms; examples/non-examples of inner products	1
Length, angle, Cauchy-Schwarz inequality in terms of inner product	1
Orthogonality, projections in terms of inner product	1

Gram-Schmidt algorithm	1
Vector Calculus	**No. of Lectures**
Functions of several variables; level curves and cross sections of surfaces	1
Common surfaces including paraboloid, ellipsoid, hyperboloid	1
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
PDEs	
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
Wave equation	1
Heat and Diffusion equation	1
Fourier transform	1
Fourier transform: properties	1

PHYSICS 302	
Quantum Mechanics	**No. of Lectures**
The Breakdown of Classical Physics	**18**
Matter Waves and Quantum Interpretation	
Quantum Mechanics in One Dimension	
Expectation Values, Observables and Operators	
Tunneling Phenomena	
Quantum Mechanics in 3-dimensions	
Hydrogen atom, hydrogenic ions, helium atom	
Hydrogen molecule ion, hydrogen molecule	
Thermodynamics	**No. of Lectures**
Temperature and the Zeroth Law of Thermodynamics. Thermal equilibrium. Ideal gases, the kinetic theory of gases, equipartition theory, Boltzmann distribution	3
Heat, work, internal energy. First law of thermodynamics.Compression of an ideal gas under various conditions. Transport, conduction, conductivity, diffusion in gases.	3
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	3
Second Law of Thermodynamics. Heat engines, Carnot Cycle, Otto Cycle, Stirling Cycle.	2
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

CHEMISTRY 303	
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 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	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	
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	2
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

BIOLOGY 304	
Functional Biology of Organisms	**No. of Lectures**
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

GEO 308 - Earth Sciences II

Topic Details	Lectures
Elementary mineralogy: Definition and concept of mineral, Introduction to common rock forming minerals and distinguishing characteristics. Dana/Strunz classification, Concept of polymorphism, twinning and zoning. Processes of mineral formation. Silicate structure.	15
Mineral Optics: Introduction to Polarising microscope, Optical properties of minerals, Refractive index, Birefringence, Michel-Lévy Interference colour chart, Pleochroism, Extinction angle, Conoscopic interference figures, Becke line test	10
Mineral chemistry: Concept of mineral chemistry, Methods of chemical analyses, Instrumentation (XRD, XRF, EPMA, LA-ICPMS), mineral stoichiometry.	10
Student Work • Case Studies • Review - Books , Scientific Journals • Group Discussions, etc	10

EVSB 310 - Environmental Science II	
Topic Details	**No. of Lectures**
Fundamentals of Ecology	
Ecology Definition, Concept, and Scope, Interdisciplinary science	1
Ecosystems – nature, structure and function, autecology and synecology, branches of ecology	1
Ecological Concepts - ecological succession, ecotone, edge effect, niche concept, homeostasis, ecological indicator plants and animals, concept of carrying capacity & limiting factors	2
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	2
Types of Ecosystems - Terrestrial (Forest Ecosystems, Grassland Ecosystems, Tundra Ecosystems, Desert Ecosystem), Aquatic (Freshwater Ecosystem, Marine Ecosystem)	3
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	
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 - Assignments / Tutorials - Reviews of various research papers, reports, books - Presentations	10

UGC Mandatory course

EVSB 312: Environmental Studies - I (Theory & practical)	
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)	6

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.	6
Student Work • Case Studies • Review - Books , Scientific Journals • Group Discussions, etc • Field Visit	12

PHY LAB- 305

List of experiments

1. To study the emission spectra of Hydrogen, Neon and mercury vapours.
2. Rydberg's constant: To find Rydberg's constant using diffraction grating.
3. Determination of Stefan- Boltzmann constant σ .(Black body radiation)
4. Determine of the wavelength of sodium light by measuring the diameters of Newton's ring.
5. To determine coefficient of Linear Expansion.
6. To determine the coefficient of thermal Conductivity of bad conductor by Lee's Disc.

CHM LAB-306

List of Physical chemistry experiments (Any 3)

1. Thermodynamic data of electrochemical cell by e.m.f.measurements.
2. Determination of the equilibrium constant of tri-iodide ion formation
3. Determination of dipole moment of liquid at various temperatures
4. Dissociation constant of an acid- base indicator by spectrophotometry
5. A photometric titration of a mixture of Bi and Cu with EDTA (-745nm)

List of Inorganic chemistry experiments **(Any 3)**

1. Pyrolusite ore - Estimation of silica gravimetrically and Manganese volumetrically.

2. Solder alloy - Estimation of Tin gravimetrically and Lead volumetrically.

3. Paper chromatographic separation of Fe3+, Al3+, and Cr3+.

4. Ion exchange capacity of resine by Co and Ni.

5. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

List of Organic chemistry experiments

1. Seperation of Binary Mixture (4-5 Samples).

2. Preparations: Single Stage (any 3)

1. Ethyl benzene from acetophenone.
2. Hippuric acid from Glycine.
3. Azo dye from Anthranilic acid.
4. Osazone from Glycose.
5. Cannizzaro reaction of aromatic aldehyde.
6. Adipic acid from Cyclohexanone.

BIO LAB 307 **(Any 6)**

1. Bacterial growth : optical density measurement
2. Counting of different kind of blood cells using hemocytometer
3. Estimation of hemoglobin
4. Determination of blood pressure and amount of oxygen in the blood
5. Action of salivary amylase in relation to enzyme concentration and temperature
6. Demonstration of imbibition
7. Demonstration of osmosis in plants
8. Demonstration of plasmolysis in onion cells
9. Separation of plant pigments by chromatography
10. Estimation of chlorophyll in the leaf tissue

Semester IV

MATHS 401	
Probability	**No. of Lectures**
Review of probability, events, laws of probability	1
Conditional probability, independent events	1
Random variables; discrete random variables and distributions; mean, variance and standard deviation of discrete random variable	1
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	1
Central Limit Theorem	1
Normal approximation to the binomial distribution, distribution of the sample mean	1
Distribution of sample proportion	1
Stochastic processes, Markov chains	1
Limiting behaviour of Markov chains	1
Statistics	**No. of Lectures**
Study design: bias, confounding, precision, comparison, control	1
Study design: observational studies vs designed experiments	1
Exploratory data analysis: describing and displaying categorical data (tables, frequencies, bar chart)	1
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)	1
Statistical modeling (single mean model, multiple means model, regression model)	1

Sampling distributions: population vs sample, parameter vs statistic; distribution of sample mean, proportion; standard error	1
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
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
Comparing multiple means: one-way ANOVA	1
Theory of ANOVA	1
Regresion: least squares method	1
Partitioning of variability in regression, significance testing in regression	1
Chi-squared test for independence	1
Chi-squared goodness-of-fit	1

PHYSICS 402	
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.	2
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
Einstein, the equivalence principle, gravity, gravitational lenses, gravitational waves (qualitative)	1
Nuclear reactions and thermonuclear power.	1
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
Fourier Optics: phase contrast imaging	1
Microscopy applications	4

CHEMISTRY 403	
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 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, 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 H_2 and R_2NH, 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

BIOLOGY 404	
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	**No. of Lectures**
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	**No. of Lectures**
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 parameters, (annual vs perennial life-histories, clonality)	1
Demography, Life tables, matrix models (requires simple matrix mathematics) and Epidemiology (simple functions)	1
Communities	**No. of Lectures**
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	**No. of Lectures**
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

GEO 408 - Earth Sciences III	
Topic Details	**Lectures**
Fundamentals of Petrology: Concept of lithology vs. petrology, branches of petrology, paragenesis vs. petrogenesis	2
Igneous Petrology Concept of partial melting vs. anatexis, fractional crystallisation, Bowen's reaction series, Diversity of volcanism (MORB, IA, OIB, CFBP), Phase diagrams (univariant, bivariant), IUGS igneous classification (peridotite-pyroxenite-gabbro, TAS, QAPF)	12

Metamorphic Petrology Types of metamorphism, factors controlling metamorphism, Mineralogical Phase Rule, Phase transformation and Metamorphic reactions (net-net transfer, continuous type), Metamorphic facies (burial, regional and contact)	12
Sedimentary Petrology Concept of sedimentation, agents of depositions, primary sedimentary structures, grain size (Krumbein phi scale International scale- ISO 14688-1:2002), granulometry and sorting, sedimentary textures (clastic, wacke, arenite), siliciclastic (conglomerate, sandstones, mudstones), volcaniclastic, biogenic carbonate and phosporites, chemogenic (evaporate, hydrothermal, carbonate), environment of deposition	12
Student Work • Case Studies • Review - Books , Scientific Journals • Group Discussions, etc	7

EVSB 410 - Environmental Science III	
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.	2
Major sources of noise pollution, effects of noise pollution on health, noise level standard in industrial, commercial, residential and silence zones.	2
Radioactive and thermal pollution sources and their effects on surrounding environment.	2
Pollution case studies.	7
Student work - Assignments / Tutorials - Reviews of various research papers, reports, books - Presentations	20

UGC Mandatory course

EVSB 412 - Environmental Studies - II (Theory & practical)	
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.	5

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.	20

PHY LAB-405

List of experiments

1. Verification of Stefan's Law by Electrical method.

2. Study of LR circuit.

3. Study of LCR circuit

4. To determine the self-inductance of the coil using Anderson's bridge and calculate the value of inductive reactance (X_L) of the coil at a particular frequency.

5. Measurement of wavelength of Laser by Diffraction Grating.

6. To determine the Wavelength of main spectral line of mercury light using plane transmission grating.

CHM LAB-406

List of Physical chemistry experiments (Any 3)

1. Determination of the stability constant of a complex by spectrophotometry.
2. The reaction between potassium persulphate and potassium iodide by colorimetry.
3. Determine the formula and stability constant of a metal ion complex (Lead Oxalate) by polarography.
4. Analysis of copper oxide and copper dioxide to determine law of multiple proportions.
5. Behaviour of water at different temperatures

List of Inorganic chemistry experiments **(Any 3)**

1. Photometric Analysis - To study complex formation between Fe (III) and salicylic acid and find the formula and stability constant of the complex.
2. Simultaneous determination of Cr+2 and Cu+2
3. To determine the strength of given mixture of carbonate and bicarbonate in the given mixture by pH metric method.
4. Determination of chemical oxygen demand (COD)
5. Determination of Biological oxygen demand (COD)

List of Organic chemistry experiments **(Any 3)**

1. Organic Preparations: Double Stage

1. Glycine – Hydantoic acid – Hydantoin
2. Benzoin – Benzil - Benzilic acid
3. P-cresol – 4,6-Dimethylcoumarin – 3-Bromo-4,6 Dimethyl Coumarin
4. Benzophenone – Oxime – Benzanilide
5. Acetanilide – p-Bromoacetanilide – p-Bromoaniline
6. Hydroquinone – Quinoline – 1,2,4 – Triacetoxybenzene.

BIO LAB 407 (Any 6)

1. Study of the pond ecosystem: physical, chemical factors; biota; primary productivity estimation; role as carbon sink; community structure (over time)

a) visit the pond, collect samples in three seasons – monsoon (already collected in July/Aug 2019), post-monsoon (Jan 2020) and summer (Mar 2020). (field visits)
b) measure physico-chemical parameters, depth, turbidity, DO, primary productivity
c) (field+lab sessions)
d) identify vegetation types, succession in vegetation

2. Introductory population dynamics (Daily monitoring required)

a) Establish a simple culture of cladoceran species (isolated from pond sample) in lab. Study dynamics of population (growth curves).

b) Density dependant growth – same culture, initiate the experiment with different starting densities.

c) 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.

3. Introduction to Habitat & Community ecology

a) Visit different types of water bodies (one river/stream and one quarry/pond/lake) and conduct sampling. Study habitat ecology and community composition. (field session)

b) Identify, quantify zooplankton taxa in collected samples. Calculate diversity indices. (lab session)

c) Introduction to various sampling methods (point count/line transect/quadrat) in field. Learn methods for estimating plant biomass (using GBH). (field session)

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.)

4. Functional ecology

Using established plankton cultures perform grazing experiments using range of food densities. (Lab session).

5. Solving Genetic problems which obey Mendelian laws
6. Analyze the Human karyotype chart for different genetic disorders
7. Use of ABO blood group data to calculate allele frequencies. (Data can be gathered both by interviews and by actual blood group determination).
8. Use of PTC (phenylthiocarbamide) tasting trait to calculate allele frequencies**.**