B.Sc. (Blended) EARTH SCIENCE MAJOR Program

Savitribai Phule Pune University

Revision and Amendment

B. Sc. (Blended) **EARTH SCIENCE MAJOR**

Four Year undergraduate program

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

In accordance with guidelines of NEP 2020

(To Be Implemented from Academic Year 2023 – 2024)

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

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

GEO 101 MJ (T)	4 Credits
Introduction to Earth Sciences I	**No. of lectures**
Introduction to Earth Sciences and its various branches	1
Origin of Solar System and Formation of the Sun	**No. of lectures**
Formation of the Universe and of the Sun	6
Solar Nebular hypotheses, Earth and other planetary systems,	
Geology of the Inner planets (e.g. Mars, Venus) and moon. Geology of the Outer planets	
Meteorites-types and origin	
Age of the Earth	
Earths-internal structure	**No. of lectures**
Different layers of the Interior of the Earth	6
Mineralogical and geophysical structure	
Geothermal gradients- oceanic and continental gradients,	
Geochemical differentiation of the Earth	
crust-mantle-core interactions.	
Spheres of the Earth	**No. of lectures**
Process of formation of the different spheres of the Earth.	6
Characteristics of the asthenosphere, lithosphere, hydrosphere, biosphere and atmosphere.	
Biogeochemical cycles	**No. of lectures**
Introduction to the Rocks cycle, water cycle, carbon, nitrogen and oxygen cycles	6
Biomagnification of heavy metals and toxic contaminants, etc.	
Geological time scale	**No. of lectures**

Geological Time scale.	6
Concept of Eon, Era, Period, Epoch,	
Origin and Evolution of life across the Geological time scale	
Index fossils through time.	
Introduction and concept of stratigraphy	**No. of lectures**
Introduction and concept of stratigraphy, paleontology and	6
geochronology. Principles of stratigraphy, Unconformities.	
PYTHON I	
Introduction to python programming, basic arithmetic and Hello world programs • Variables, Operators and Datatypes; Operations on datatypes; Input and Output • Functions: Modules, Built-in functions, User defined functions, keyword arguments • Conditional statements (if, elif, else) and Loops.	12

GEO 101 MJ (P)	**2 Credits**
	No. of practicals
1. Physical properties of different silicate minerals	2
2. Physical properties of different non-silicate minerals	2
3. Physical properties of different ore minerals	2
4. Identification of different types of rocks	2
5. Understanding the Geological Time Scale and various mass-extinction events. Identification of index fossils	2
6. Understanding the concept of stratigraphic relations using geological maps.	2

CC 101 PHY (T)	2 Credits
Classical Mechanics	**No. of lectures**
Straight line motion	10
Vectors	
Two-and three-dimensional motion	
Force and Motion: Newton's Laws	
Force and Motion: Drag and Friction	
Kinetic energy, work, power	
Potential energy, conservation of energy	
Collisions and momentum	
Rotational motion	
Angular momentum-I	
Angular momentum-II	
Gravitation	**No. of lectures**
Newton's law of gravity, superposition	5
Gravity at the earth's surface, far above the earth and within the earth	
Work and gravitational potential energy	
Kepler's laws: the planets and satellites	
Orbital motion and energy	
Thermal physics	
Zeroth Law of Thermodynamics	10
Thermal expansion and absorption of heat First Law of Thermodynamics; adiabatic processes, constant volume processes, enthalpy, cyclical processes, free expansions	
Heat transfer, conduction, emission, absorption. Second Law of Thermodynamics, Irreversible processes, entropy, free energy	
Elasticity, fluids and gases	
Equilibrium and elasticity	5
Density and Pressure, Pascal's and Archimedes' Principles	
Continuity and Bernoulli's Equation	
Ideal gases (Kinetic theory of gases)	

Mean free path, molecular speed distribution	
Specific heat, adiabatic expansion	
Real world examples - eg wind power, hydro, blood circulation, water in plants, materials, osmosis, wind and atmosphere	
ODEs	
Applications of 2nd order ODEs: Springs	6
Applications of 2nd order ODEs: LRC series electrical circuits	
Real world contextual examples in physics and application of ODEs	

SEC 101 CHE (T)	**2 Credits**
General Chemistry	**No. of lectures**
The Periodic Table	4
Molecular Structure and Bonding	
Acids and Bases	
Stoichiometry	
Organic Chemistry	
Carbon – the basis of life	10
Structure and Bonding Alkanes (sp^3Hybridisation)	
Structure and Bonding Alkenes (sp^2Hybridisation)	
Benzene and its derivatives	
Structure and Bonding of Alkynes (sphybridisation)	
Functional Groups	
Electrophiles and Nucleophiles	
Nucleophilic substitution reactions	
Elimination reactions	
Addition reactions	
Electrophilic aromatic substitution reactions	
Nucleophilic addition reactions	
Organic redox reactions	
ODEs	
Applications of 1st order ODES: ecology models	4
Applications of 1st order ODES: chemical reaction rates, Newton's law of cooling	

Second-order ODEs: definitions of homogeneous/inhomogeneous, linear/non-linear; solution of homogeneous constant-coefficient linear ODEs	
Physical Chemistry	
First Law of Thermodynamics; adiabatic processes, constant volume processes, enthalpy, cyclical processes, free expansions	6
Second Law of Thermodynamics, Irreversible processes, entropy, free energy	
Real world examples - eg solar energy, geothermal, wind power	

GE 101 MTS (T)	**4 Credits**
Logic and Proof	**No. of lectures**
Basic set theory (review)	12
Logical connectives (conjunction, disjunction, negation, conditional, bi-conditional) and truth tables	
Propositional logic, logical equivalence, logical laws	
Real numbers and their properties; completeness property	
Proof methods: direct proof, contrapositive	
Proof methods: contradiction, proof by cases	
Proof methods: induction	
Natural numbers, integers, rational numbers	
Real numbers	
Complex Numbers	
Review of complex numbers including algebra, Argand plane, cartesian and polar form	6
Complex exponential	
de Moivre's theorem; roots of complex numbers	
Differential calculus	
Review of differential calculus: limits, derivative, differentiation rules incl. polynomials, trigonometric, exponential, log functions; product, quotient, chain rules	6
Review of inverse trigonometric functions and their derivatives, implicit differentiation	6

Integral calculus	
Riemann integration	18
Fundamental Theorem of Calculus; review of standard anti-derivatives	
Techniques of integration (review): derivative present substitution, linear substitution	
Techniques of integration (review): integration of trigonometric functions using identities	
Techniques of integration (review): integration of rational functions including partial fractions, integration yielding inverse trig functions	
Techniques of integration (review): trigonometric substitutions; integration by parts	
Improper integrals	
Applications of integration: areas between curves	
Applications of integration: volumes of surfaces of revolution	
Ordinary differential equations: definition of ODE, order, general solution, initial conditions; separable ODEs	
Solving linear ODE using integrating factor	
Particular solutions of inhomogeneous constant coefficient linear ODEs using method of undetermined coefficients; principle of superposition	

VEC 101 BIO (T)	**2 Credits**
Evolution and the Diversity of Life	**No. of lectures**
Theory of evolution: understanding life's diversity	12
Evolutionary relationships (phylogenies) are summarized in classifications	
Chemical evolution of life – Molecules to cells	
Cell theory and the origin of life	
Prokaryotic Cells: Bacteria and Archaea	
Evolution of the eukaryotic cell	
Endosymbiosis	
Protists 1 - Red and Green algae	
Protists 2 – Chromists	

Protists 3 - Dinoflagellates and apicomplexans, flagellates, ciliates, amoebae	
Evolution of sex, life cycles	
Origins of multi multicellularity	
Slime molds and fungi	12
Fungi	
Introduction to Land Plants	
Bryophytes	
Evolution of vascular tissue, Lycophytes, fern allies, early fossil land plants	
Ferns	
Seed plants, the seed and secondary growth, Cycads and Ginkgo	
Conifer diversity and biology	
Angiosperm structure, biology and diversity, the flower, double fertilization.	
Angiosperm phylogeny and evolution	
Introduction to animals (Metazoa)	
Simple animals	
Protostomes-Flatworms and annelids	
Molluscs	
Arthropods	
Deuterostomes, Echinoderms-Chordates	
Fishes –sharks/rays, teleosts, coelacanth, lungfish	
Amphibians	
Reptiles	
Birds	
Mammals	
The Primate story	

VSC 121 BIO (P)	**2 Credits**
	No. of lectures
1. Observation of zooplankton from pond samples under microscope	2

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

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

GEO 101 IKS	**2 Credits**
Indian Rhetoric	**No. of lectures**
Rhetoric as Everyday Experience: Persuasion & Convincing: Advt. & Campaigns Arguments and Debates: Courtrooms to Politics Historical context of Classical Rhetoric in Greece Democracy, Public Opinion and Rhetoric	6

Rhetoric: Elements & Versions Context and Intent Appeals & Arrangement Instruments & Ornamentation Culture, History and Versions of Rhetoric	6
1Nyay Shastra- Indian Framework of Debate Brief background and premise Basic elements, of Nyay Shastra Logic and arrangement Good & Bad forms of Debate	6
Natya Shastra Brief background and premise Basic elements of Natya Shastra Sahahridaya & Sadharanikarn Rasa & Bhaav	6

OR

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

Semester 2			
Course Code	Course Name	Title allocation as per NEP	After
GEO 151 MJ (T)	Earth Sciences II: Mineralogy, Crystallography	DSC (Discipline Specific Course)- Major Core	4
GEO151 MJ (P)	Earth Science Practical	DSC (Discipline Specific Course)- Major Core	2
CC 151 PHY (T)	Modern Physics	Curricular Course	2
SEC 151 CHE (T)	Inorganic and Physical Chemistry	Skill Enhancement Course (SEC)	2
GE 151 MTS (T)	Algebra	GE (General Elective)/OE (Open Elective)	4
VEC 151 BIO (T)	Biology of Cells	VEC (Value Education Course)	2
VSC 171 BIO (p)	Biology Practical	VSC (Vocational Skill course)	2
AEC 151 ENG	English, /Critical Thinking / Communication skill	AEC (Ability Enhancement Course)	2
GEO 191 MN	Interdisciplinary elective	Minor	2
Total			**22**

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

GEO 151 MJ (T)	4 Credits
	No. of lectures
Introduction to Mineralogy	
Minerals: Definition, types of minerals, minerals versus crystals, branched and scope	10
Classification of Minerals (Dana's Classification)	
Properties of Minerals, Physical properties and their identification	
Silicate minerals and their structure, carbonate minerals, ore minerals	
Introduction to Petrological microscope, optical properties of minerals, Refractive Index, Birefringence, Pleochroism, Extinction angle, 2V, Conoscopic interference figures, Becke line test etc.	
Processes of mineral formation	
Rock Forming Minerals: Silicate and non-silicate minerals	
Crystallography	**No. of lectures**
Introduction, Crystal Morphology, Symmetry, Crystallography Notation (Miller, Weiss)	10
Crystal Systems: Orthorhombic, Tetragonal, Isometric (cubic), Monoclinic, Triclinic, Hexagonal	
Crystal Chemistry: Introduction, Structure of Atom,	
Bonding forces in crystal (Ionic, Covalent, van der Waal's, Metallic bond), Atomic patterns in minerals (packing),	
Geometrical and electrical stability of minerals (co-ordination no, radius ratio, relative size of atoms),	
Concept of isomorphism, polymorphism, pseudomorphism.	
Introduction to Petrology	**No. of lectures**
Definition, branches and scope	4
Characteristics of igneous, sedimentary and metamorphic rocks, Rock cycle,	

Introduction, Branches of paleontology, types of fossils,	4
conditions necessary for fossilization, Modes of preservation of fossils	
Uses of fossils, Collection and preparation of fossils.	
PYTHON -II	
• Lists, Strings, Tuples and Dicts • Introduction to numpy • Introduction to matplotlib for basic plotting	12

GEO 151 MJ (P)	**2 Credits**
	No. of practicals
1. Mineralogy: Megascopic Minerals and their Physical properties	3
2. Optical: Microscopic Mineralogy	3
3. Crystallography: Crystal System through models	3
4. Petrology: Introduction to different common rocks	3

CC 151 PHY (T)	**2 Credits**
Electricity and Magnetism	**No. of lectures**
Electric charge, conductors and insulators	18
Coulomb's Law, superposition principle	
Electric field, superposition principle	
Electric flux	
Gauss's law, applications	
Energy and electric field; electric potential	
Calculating potential from the field, electric potential, potential energy surfaces.	
Electric dipoles	

Capacitance; parallel plate capacitors	
Energy storage in capacitors, dielectrics, series and parallel circuits	
Conductors, electric current, electric power, Ohm's law	
Kirchoff's rules, resistors in series and parallel circuits	
Magnetic field, magnetic force, Lorentz force, cyclotrons	
Lorentz force, ion velocity filter, Hall effect, Biot-Savart Law	
Bio-Savart Law, Ampere's Law, solenoids, earth's magnetic field	
Magnetic field due to a current, forces on current-carrying wires, Electromagnetic induction, magnetic flux	
Lenz' Law, Faraday's law, Maxwell's equations, applications	
Magnetic materials	
Oscillations and Waves	**No. of lectures**
Simple harmonic motion, pendulum, diatomic molecules, Damped harmonic motion, resonance - electronic circuits, evolution of populations	6
One dimensional waves, Interference and standing waves, Sound waves and the speed of sound, Intensity, sound level and the physics of music	
Doppler effect and supersonic motion, shock waves	
Optics	**No. of lectures**
Images and mirrors	6
Thin lenses and optical instruments	
Young's experiment, interference	
Thin films and the Michaelson interferometer	
Diffraction by slits and apertures	
Diffraction by gratings and X-ray diffraction	
Optical Microscopy	
Spectroscopy	
Modern Physics	**No. of lectures**
Challenges to classical physics; special relativity	6
Lorentz transformation, transformation of velocities, Doppler effect	

Relativistic momentum and energy	
Photons and the photoelectric effect	
Quantum physics, blackbody radiator, matter waves	
Trapped particles and the tunneling particles	
Nuclear physics, nuclear properties, nuclear decay	
Quarks, Leptons, The Big Bang	

SEC 151 CHE (T)	**2 Credits**
Chemistry of Life	**No. of lectures**
The chemical basis of life	6
Bioenergetics	
Enzymes and catalyzed reactions	
Metabolism: Catabolism and anabolism	
Concatenation and Biopolymers	
Stereochemistry and Biomolecular chirality	
Biochemistry and Biomolecular structure	
Small inorganic molecules of biological importance	
Inorganic Chemistry	**No. of lectures**
Ionic Compounds and their Solutions	10
Structures of Solids	
Main Group Chemistry	
Redox reactions and electrochemistry	
The transition metals: a survey	
Coordination Chemistry	
Bonding in complex ions	
Transition metals in biological systems	
Simple harmonic motion, pendulum, diatomic molecules	

Quantum Chemistry	**No. of lectures**
Schrödinger's equation and Heisenberg's Uncertainty Principle	8
Bohr and Schrodinger models of the hydrogen atom	
Complex atoms; Pauli Exclusion Principle, Periodic Table of Elements, selection rules and spectra	
Nuclear fission and fusion	

GE 151 MTS (T)	**4 Credits**
Analysis	**No. of lectures**
Limits of real-valued functions	12
Proving limits using the definition	
Continuity & differentiability	
Examples of differentiable and non-differentiable functions; continuity and differentiability of standard functions including polynomials, trigonometric, exponential, log functions and their inverses	
Techniques for evaluating limits including L'Hopital's rule, sandwich theorem	
Mean Value Theorem and applications	
Applications of differential calculus eg related rates	
Sequence and series	**No. of lectures**
Sequences, limits, convergence and divergence	**12**
Proving limits using definition	
Methods for evaluating limits: standard limits, limit theorems, continuity rule, sandwich theorem	
Series, convergence and divergence of series, geometric series, harmonic p-series	
Series convergence tests: divergence test, comparison test	
Series convergence tests: ratio test, integral test, alternating series test	
Power series, Taylor polynomials	
Taylor series	
Taylor's theorem, error in Taylor polynomial estimates	

Vectors	**No. of lectures**
Vector arithmetic, dot product, vector projections (review)	6
Vector cross product; scalar triple product; parametric curves specified by vector equations	
Lines and planes in R^3	
Lines and planes in R^3	
Linear Algebra 1	**No. of lectures**
Solving systems of linear equations with Gaussian elimination	18
Solutions of systems of linear equations - consistency, uniqueness	
Geometric interpretation of solutions	
Matrices, matrix addition, multiplication, transpose and properties (review)	
Matrix inverse	
Determinant	
R^n as a vector space, linear independence of vectors in R^n	
Span of a set of vectors, subspaces of R^n	
Basis and dimension in R^n	
Abstract vector space axioms; examples and non-examples of vector spaces	
Bases, dimension and co-ordinates in (finite dimensonal) abstract vector spaces	
Definition of linear transformation and examples/non-examples	
Linear transformations of the plane	
Matrix representation of a linear transformation	
Image and kernel of a linear transformation	
Rank and nullity	

VEC 151 BIO (T)	**2 Credits**
The Biology of Cells	**No. of lectures**
Introduction to Cell Biology	2
Theme: The cell contained	**No. of lectures**

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

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

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

GEO 191MN	2 Credits
Introduction to Gemology	**No. of lectures**
Introduction to Gemology and Gemstones	8
Geological significance and occurrence of various gemstones	4
Gem Identification and properties of Colored stones, Diamonds, Pearls etc.	12

Semester 3			
Course Code	Course Name	Title allocation as per NEP	**credit**
GEO 201 MJ (T)	Earth Science III: Petrology (Igneous, Metamorphic and Sedimentary)	DSC(Discipline Specific Course)-Major Core	**6**
GEO 201 MJ (P)	Earth Science Practical III	DSC(Discipline Specific Course)-Major Core	**2**
CC 201 PHY (T)	Quantum Mechanics and Thermodynamics	Curricular Course	**2**
MN 241 MTS (T)	Vector Calculus and Differential Equations	Minor	**4**
GE 201 EVS (T)	Introductory Environmental Science I	GE (General Elective)/OE (Open Elective)	**2**
VSC 221 EVS (p)	Environmental Science Practical I	VSC (Vocational Skill course)	**2**
AEC 201 ENG	English/Critical Thinking / Communication skill	AEC (Ability Enhancement Course)	**2**
GEO 231 FP	Field Project	FP (Field Project)/OJT (On job training)/CEP	**2**
Total			**22**

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

GEO 201 MJ (T)	6 Credits
	No. of lectures
Introduction to Petrology	
Branches of Petrology, Scope	45
Igneous Petrology	
Magma and its composition, formation of crystals and glass	
Concept of partial melting vs. anatexis, magma differentiation, 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)	
Forms of igneous bodies (Concordant- sill, laccolith and lopolith; Discordant- dyke, vein and batholith), Intrusive and extrusive rocks	
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)	
UHP metamorphism	
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	
PYTHON -III	

Python courses related to Petrology and petrogenesis, plotting and classification related programe.	12

GEO 201 MJ (P)	**2 Credits**
	No. of practicals
1. Igneous Petrology, Types of Igenous Rocks	3
2. Metamorphic Petrology, Types of metamorphic Rocks	3
3. Sedimentary Petrology, Types of sedimentary rocks	3
4. Petrology: Introduction to different common rocks	3

CC 201 PHY (T)	**2 Credit**
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	12

Heat, work, internal energy. First law of thermodynamics. Compression of an ideal gas under various conditions. Transport, conduction, conductivity, diffusion in gases.	
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	
Second Law of Thermodynamics. Heat engines, Carnot Cycle, Otto Cycle, Stirling Cycle.	
PDEs	**No. of Lectures**
Wave equation	2
Heat and Diffusion equation	
Linear Algebra	**No. of Lectures**
Change of basis and linear transformations	4
Definition of eigenvectors and eigenvalues	
Calculating eigenvalues and eigenvectors	
Diagonalization of matrices; matrix powers	
Orthogonal matrices, real symmetric matrices	

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

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

Fourier series: Weak convergence and series summation	
Linearity and Superposition	
Laplace equation and harmonic functions	
Wave equation	
Heat and Diffusion equation	
Fourier transform	
Fourier transform: properties	

GE 201 EVS (T) **2 Credit**	
	No. of Lectures
Introduction & Multidisciplinary nature of Environmental Science	2
Fundamentals of Earth System: Formation and characteristics of various Earth Systems (Atmosphere, 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	6
Natural resources – definition and types, renewable and non-renewable resources, resource use and depletion	4
Renewable & Non-renewable Energy Sources	8
Fossil Fuels, Coal, Oil, Natural gas nuclear energy	
Renewable energy sources – Importance and Types	
Solar, wind, geothermal, Biomass, Hydropower, Wind energy etc.	
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	
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	
Environmental concerns – historical development of environmentalism and conservation on Indian perspective	
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)	

VSC 221 EVS (P)	**2 Credit**
	No. of Lectures
Field Visit - Pond / Lake ecosystem, Fresh water ecosystem, biodiversity studies	24
Field visit to geothermal field areas, hydropower plants	
Solar Energy design and harvesting: Design and implement a small-scale solar energy harvesting system. Measure factors such as incident sunlight intensity, efficiency of the solar cells, and the output power generated. This project could involve both theoretical calculations and practical measurements in the field.	

GEO 231 FP (Any 2)	**2 Credit**
Fieldwork in Geology	**No. of Lectures**
Geological fieldwork will be carried out in diverse terrains to train students to identify different rocks of different geological ages, structural aspects as well as stratigraphic relations etc. in the field e.g. Jurassic of Kutch, Gujarat, Aravalli- Delhi belt of Rajasthan, Deccan Basalts of Maharashtra, Dharwar group of rocks in Southern India etc.	45

Semester 4			
Course Code	Course Name	Title allocation as per NEP	**After**
GEO 251 MJ (T)	Geochemistry and Structural Geology	DSC(Discipline Specific Course)- Major Core	**6**
GEO 251 MJ (P)	Earth Science Practical IV	DSC(Discipline Specific Course)- Major Core	**2**
CC 251 PHY (T)	Electricity, Magnetism, Special Relativity, and Optics	Ability Enhancement Course (AEC)	**2**
SEC 251 CHE (T)	Chemistry: Structure and Properties	Skill Enhancement Course (SEC)	**2**
MN 291 MTS (T)	Probability and Statistics	Minor	**4**
GE 251 EVS (T)	Introduction to Environmental Sciences II	GE (General Elective)/OE(Open Elective)	**2**
AEC 251 PS	English, /Critical Thinking / Presentation skill	AEC(Ability Enhancement Course)	**2**
GEO 281 FP	Field Project	FP(Field Project)/OJT(On job training)/CEP	**2**
Total			**22**

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

GEO 251 MJ (T)	4 Credits
Geochemistry	**No. of lectures**
Introduction to the Periodic Table	50
Geochemical classification of elements (Goldschmidt's classification)	
Concept of Partition coefficient and compatible and incompatible elements	
Major oxides, alkali elements, LILE's, HFSEs, REEs and their significance in geology	
Mineral chemistry, concepts, Methods of chemical analyses, Instrumentation (XRD, XRF, EPMA, LA-ICPMS), mineral stoichiometry.	
Major geochemical reservoirs of the earth, co-relation to different tectonic settings	
Introduction to Isotope Geology, Radiogenic and stable isotopes	
Principals of radioactive dating to understand age of the earth	
	No. of lectures
Introduction to Structural Geology	10
Concept of Strike, Dip, Folding and Faulting in rocks	
Types of Folds and Faults	
PYTHON -IV	
Python courses related to geochemical modelling, geochemical classification and geochemical interpretation.	12

GEO 251 MJ (P)	2 Credits
	No. of practicals
Practicals related to Geochemistry and geochemical modelling	12
CIPW norm calculations, determination of major oxides by wet chemical procedures	6
Sample preparation for XRF, ICPMS analyses	6
Practicals related to Structural Geology	6

CC 251 PHY (T)	2 Credit
Electricity and Magnetism	**No. of Lectures**
Coulomb's Law	18
Gauss's Law	
Electric Field, Potential	
Conductors, Insulators	
Laplace equation	
Curl and Stoke's theorem	
Capacitors, capacitance and energy stored in E field	
Current and continuity equation	
Magnetic field and Moving Charges	
Force on Moving charges	
Magnetic Field and vector potential	
Special relativity and E and B fields	
Induction	
Inductance and energy stored in B field	
RC circuits	
CL and RLC circuits	
Displacement current	
Complete Maxwell's Equations	
Electromagnetic Waves	
Dielectrics and Electric Dipoles	

Dielectrics	
Magnetic Dipoles	
Magnetism in Matter	
Special relativity	**No. of Lectures**
Space-time and simultaneity. Einstein axioms for special relativity. The Lorentz transformation.	9
Relativistic kinematics; length contraction, time dilation. Doppler effect. Twin paradox.	
Relativistic dynamics. Mass-energy equivalence. Conservation of four-momentum. Centre of momentum frame. De Broglie waves and photons.	
Einstein, the equivalence principle, gravity, gravitational lenses, gravitational waves (qualitative)	
Nuclear reactions and thermonuclear power.	
Optics- Applications and microscopy	**No. of Lectures**
Classical optics: Fermat's Principle	9
Fourier Optics: Huygens-Fresnel Principle	
Fourier Optics: Fresnel diffraction integral	
Fourier Optics: Paraxial approximation	
Fourier Optics: Fraunhofer diffraction	
Fourier Optics: Apertures and imaging	
Fourier Optics: phase contrast imaging	
Microscopy applications	

SEC 251 CHE (T)	**2 Credit**
	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)	24

Stereochemistry – optical activity: Molecules with more than one chiral centre (diastereomers, meso compounds, separation of racemic mixtures)	
Symmetry operations and elements	
Group theory: Definition of reducible and irreducible representations, Use of group theory to determine the irreducible representation	
Assignment of point groups	
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})	
Stereochemistry and Reactions: Prochirality, chirality in Nature, Sterochemistry on atoms other than carbon, Retrosynthetic analysis	
Stereochemistry and Mechanism (nucleophilic substitution, elimination from non-cyclic compounds)	
Alkene addition reactions – Hydrogenation, halogenation, HX addition. Elimination Reactions epoxide ring forming reactions	
Zeeman effect: Effect on the energies of a system by application of a magnetic field; Magnetochemistry, spin and orbital contribution to the magnetic moment	
Magnetic resonance spectroscopies: EPR spectroscopy, hyperfine coupling application to organic radicals and to transition metal complexes	
Nuclear Magnetic Resonance (NMR), energies of nuclei in magnetic fields	
Chemical shift and the δ scale, resonance of different nuclei, shielding, spin-orbit coupling and coupling constants, molecular symmetry	
^{13}C NMR, ^{1}H NMR, integration, multiplicity, chemical shift typical ranges	
Introduction to molecular spectroscopy and spectroscopic transitions, absorbance, transmittance, the Beer-Lambert Law, intensities of spectroscopic transitions	

Quantised vibration and simply harmonic oscillator model, wave functions,	
Molecular vibrational modes, vibrational spectroscopy infrared and Raman spectroscopy 3N-5, 3N-6 vibrational degrees of freedom	
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	
Molecular orbital theory: Electronic spectroscopy requires understanding of electronic structure leading to Molecular orbital theory – HOMO. LUMO	
Diatomic molecules, LCAO-MO, Symmetry of MO's	
Photoelectron spectroscopy	
Generalisation of the application of MO approaches to polyatomic molecules	
Hückel Theory	
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	
Electronic spectroscopy: Chromophores and excited electronic 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	

Applications – light emitting polymers	
Organometallic chemistry. Types and broad applications of organometallic complexes and catalysts. Ligand types and examples.	
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	
Covalent interactions in coordination compounds – rationalisation of spectrochemical series in terms of bonding interactions	
Binary metal carbonyl complexes Synergistic bonding and the 18-electron rule. IR and NMR spectroscopy	
Substitution at metal carbonyl. Other organometallic ligand types and complexes thereof. Alkyne and alkene complexes. *etc.*	
Redox reaction in organometallic chemistry. Hydrogen complexes and oxidative addition reactions. Reductive elimination reactions. Activation and reactions of organometallic ligands. Insertions, migrations.	
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.	

MN 291 MTS (T)	**4 Credit**
Probability	**No. of Lectures**
Review of probability, events, laws of probability	20
Conditional probability, independent events	
Random variables; discrete random variables and distributions; mean, variance and standard deviation of discrete random variable	
Bernoulli trials, binomial distribution	
Poisson distribution and Poisson process	
Continuous random variables and distributions, probability density functions, cumulative distribution function	
Mean, variance, standard deviation, median and percentiles of a continuous distribution	

Normal distribution	
Uniform and exponential distribution	
Distributions of functions of a random variable	
Sums/differences/scalar multiples of random variables, independent random variables, distributions of sums/differences of independent random variables	
Central Limit Theorem	
Normal approximation to the binomial distribution, distribution of the sample mean	
Distribution of sample proportion	
Stochastic processes, Markov chains	
Limiting behavior of Markov chains	
Statistics	**No. of Lectures**
Study design: bias, confounding, precision, comparison, control	28
Study design: observational studies vs designed experiments	
Exploratory data analysis: describing and displaying categorical data (tables, frequencies, bar chart)	
Exploratory data analysis: describing and displaying univariate numeric data (dot plots, boxplots, histograms, mean, median, quartiles/percentiles, standard deviation, variance, IQR)	
Exploratory data analysis: describing and displaying bivariate numeric data (scatterplot, correlation)	
Statistical modeling (single mean model, multiple means model, regression model)	
Sampling distributions: population vs sample, parameter vs statistic; distribution of sample mean, proportion; standard error	
Estimation: Confidence intervals, confidence interval for mean (using z), confidence interval for mean using t	
Estimation: confidence interval for difference in mean, confidence intervals for proportion	
Estimation: required sample size, confidence interval vs prediction interval	
Theory of estimation: unbiased estimators, maximum likelihood estimators	

Hypothesis testing: concepts and terminology, testing a single mean (z and t)	
Hypothesis testing: errors, power, 2-sample test, paired test, testing proportion	
Hypothesis testing: Non-parametric tests for 2 samples	
Comparing multiple means: one-way ANOVA	
Theory of ANOVA	
Regression: least squares method	
Partitioning of variability in regression, significance testing in regression	
Chi-squared test for independence	
Chi-squared goodness-of-fit	

GE 251 EVS (T)	**2 Credit**
	No. of Lectures
Definition, Types and major sources of air pollutants,	6
effects of air pollutants on physico-chemical and biological properties surrounding atmosphere,	
Air borne diseases and their effects on health	
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.	
Types and major sources of soil pollutants,	
Effects of soil pollutants on physico-chemical and biological properties of soil	
Air, drinking water and waste water quality standard.	
Major sources of noise pollution,	
Effects of noise pollution on health,	
Noise level standard in industrial, commercial, residential and silence zones.	
Radioactive and thermal pollution sources and their effects on surrounding environment.	
Pollution case studies.	

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

GEO 281 FP	2 Credit
Field Project in Earth Science	**No. of Lectures**
Geological fieldwork will be carried out in diverse terrains to train students to identify different rocks of different geological ages, structural aspects as well as stratigraphic relations etc. in the field e.g. Jurassic of Kutch, Gujarat, Aravalli- Delhi belt of Rajasthan, Deccan Basalts of Maharashtra, Dharwar group of rocks in Southern India etc.	45
Mine Visits will be planned to different mines in India	