Savitribai Phule Pune University

Three Year BSc (Blended) Degree Course

Environmental Science Syllabus

(2018 – 2019)

Curriculum for BSc (Blended) Program (Semesters 1-4)

Nomenclature: BO: Biology. CHM: Chemistry. MTH: Mathematics. PHY: Physics.

Semester 1

MATHS 101	PHYSICS 101	CHEMISTRY 101	BIOLOGY 101
Differential Calculus: Graphs of functions of one-variable, trigonometric functions and their inverses, derivatives of inverse trigonometric functions, implicit differentiation, related rates. Partial derivatives, Limits, Partial Derivatives, Higher Order Partial Derivatives, Chain rule for partial derivatives, Directional derivatives, Application of Partial Derivatives- tangent planes, Normal Line, Extrema for functions of several variables and double integrals, Optimization, Gradient. **Integral Calculus**: Fundamental theorem of calculus, integration by trigonometric and algebraic substitutions, use of partial	**Classical mechanics:** Newton's laws of motion. Momentum and impulse. Translational, vibrational and rotational energy. Simple harmonic motion. Rigid body rotations **Waves and oscillations:** **r**eflection, refraction, superposition, resonance, energy transport, absorption, Doppler effect. Applications to water waves, acoustics, seismology **Gravitation:** Newton's law of gravity, Kepler's Laws. Applications to astrophysics including orbital motion, escape velocity, apparent weightlessness **Fluids:** Pressure, buoyancy, fluid flow, viscosity, surface tension. Applications to	**General Chemistry:** Stoichiometry, equilibrium chemistry, acids and bases, valency, electrostatics, states of matter, The Periodic Table **Organic Chemistry:** Alkanes, alkenes, alkynes, benzene, acids, aldehydes, ketones, functional groups, elimination reactions, addition and substitution reactions (nucleophilic and electrophilic). **The Chemistry of Life**: Stereochemistry and biomolecular chirality. Biopolymers The atmosphere of Earth; 2. Contaminant behavior in the environment; Greenhouse effect - Global temperature-Acid rain and - Ozone layer depletion.	**Unifying themes in biology:** Origin of life, Origin of cell, Cell theory, Chemical composition of cell , RNA and DNA as the basis for life, **Complexity and Evolution:** Structural organization in organisms-unicellular to multicellular organisms, structural complexity in life**-** symmetrical and asymmetrical **Domains of life:** Prokaryotes and Eukaryotes, Five kingdom classification system, Tree of life –Protists,Fungi, Plants, Animals, Viruses and Prions, Evolutionary relationships **Diversity of Life:** Basic principles of classification. Classification of Organisms, Taxonomy, Linneus' System-Binomial System, Concept of species, Phylogeny, Systematics and cladistics

fractions with application to areas and volumes. Integrals Involving Roots, Integrals Involving Quadratics, Integration Strategy, Riemann integration, further techniques of integration and applications - Arc Length, Surface Area, Center of Mass/Centroid, Hydrostatic Pressure and Force, Probability, Improper integrals; Comparison Test for Improper Integrals, and Approximating Definite Integrals.	hydraulics, biology, biophysics, atmospheric physics, aerodynamics **Optics:** Geometrical optics including dispersion, lenses, mirrors, interference, diffraction, polarisation. Applications to microscopy, imaging, vision, crystallography **Introduction To Energy:** Importance of energy in science and society. Types of energy (mechanical, heat, chemical, nuclear, electrical). Law of conservation of energy. Energy transformations. Mechanical energy: force, work, kinetic and potential energy, PE diagrams, conservation of mechanical energy, bound systems. Electricity Basics.	Carbon Cycle; Nitrogen Cycle; Sulphur Cycle; CO formation in atmosphere; Organic Pollutants; Pollution from Combustion Systems; Coal Combustion; Photochemical Smog; Indoor Air Pollution, Dioxins, Furans, PCBs, Radon.	Major evolutionary features and characteristics of body plans of domains of life, mode of nutrition and examples of different domains with examples.
Differential Equations: First order differential equations- Linear Equations, Separable Equations, Exact Equations, Equilibrium Solutions, Second Order Differential Equations - Homogeneous and Nonhomogeneous, Second			**Prokaryotes**: Bacteria and Archaea **Eukaryotes:** **Protists** (Protozoan and Algae: Slime moulds, amoebae, primary plastids – red and green algae, secondary plastids

order linear differential equations with constant coefficients.			– brown algae lineage, dinoflagellates and apicomplexans, euglenoids) **Fungi** -(Zygomycetes, Basidomycetes, Ascomycetes, Deuteromycetes, Yeast and Yeast like fungi, common molds, dimorphic fungi) **Plants** (Cryptogams: Thallophytes, Bryophytes, Pteridophytes, Phanerogams: Gymnosperms, Angiosperms, Dicots and monocots; Alternation of generations and the land plant life cycle-, structure of the flower, double fertilization and seeds, Lichens) **Animals** non- chordates and chordates (Porifera, Cnidaria, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Annelida, Hemichordata, Chordata, Class Pisces, Amphibia, Reptilia, Aves, Mammalia) Viruses and Prions (Viral structures (capsid and genetic material), Different viral hosts, Animal and Plant viruses,

			Bacteriophages, Prions)

Semester 2

MATHS 102	PHYSICS 102	CHEMISTRY 102	BIOLOGY 102
Analysis: Limits of real-valued functions, continuity and differentiability; Mean Value Theorem and applications; sequences and infinite series; Convergence/Divergence of Series, Absolute Series, Integral Test, Comparison Test, Limit Comparison Test, Alternating Series Test, Ratio Test, Root Test, Estimating the Value of a Series, Power Series, Taylor Series, Binomial Series **Vectors**: Basics, Magnitude, Unit Vector, Arithmetic, Dot product, Cross Product scalar and vector projections, plane curves specified by vector equations, **Complex numbers**: arithmetic of complex numbers, addition,	**Electricity and magnetism:** Electric charge and field, conductors and insulators, electric potential, capacitance, resistance, electric circuits, magnetic field, Faraday's law of induction, Maxwell's equations, electromagnetic waves. Applications to electronics, household electricity and power supply, magnetosphere, communications **Special relativity:** Frame transformations, relativity of space and time, modification of classical mechanics, mass-energy equivalence. Applications to particle physics, twin paradox **Quantum physics:** photons, blackbody radiation, matter waves, quantisation in atoms,	**Physical Chemistry:** Kinetic theory of gases, energy, thermodynamic laws, redox chemistry and electrochemistry, chemical kinetics, structure determination, elementary quantum theory, atomic structure, atomic spectra, spectroscopy. **Inorganic Chemistry:** Periodic behaviour of structure, bonding and chemical properties of Groups 1,2, 13-18. Transition metalchemistry (Groups 3-12). Coordination chemistry. **Water Pollution** - Water Chemistry,Toxic Heavy Metals Ground and subsurface water contamination; Water pollution sources; Ground Water Pollution; Ocean Pollution.	**Cell biology:** Structure and function of cell components – nucleus, chloroplast, golgi complex, endoplasmic reticulum, mitochondria, lysosomes, vesicles, membrane, cell wall, flagella and cilia, - cytoskeleton, spore, glycocalyx. **Endosymbiosis:** chloroplast and mitochondria. **Cellular junctions:** Desmosomes, Adherens junctions, tight junctions, gap junctions **Cell division:** binary fission, budding, mitosis and meiosis, cell cycle, differentiation, aging and death **Types of cells and Multicellularity**: different types of cells involved in embryonic development, level of organization - cells/tissues/organs, stem cells, cellular signaling

subtraction, multiplication, division, sketching regions in the complex plane, De-Moivre's Theorem, roots of polynomials~~,~~	interaction of light with matter, x- rays. Application to atomic physics, lasers, and spectroscopy **Nuclear physics:** Atomic nucleus, radioactive decay, half-life, ionising radiation, nuclear fission and fusion. Application tonuclear energy, radiation safety, nucleogenesis, carbon dating. Effects of radiation on living tissue, background radiation, radon; units for radiation exposure; applications of nuclear technology, nuclear medicine, contaminant tracing, ion beam analysis		**Central Dogma:** RNA, DNA , Chromosome structure and function, genetic code and central dogma of life(Replication, Transcription and Translation during cellular growth), Protein trafficking, Gene expression – prokaryotic, eukaryotic.

Semester 3

MATHS 201	PHYSICS 201	CHEMISTRY 201	BIOLOGY 201
Linear Algebra: Systems of linear equations, matrices and determinants; Real and complex vector spaces and linear maps,- cross product, scalar triple product, lines and planes; vector spaces, subspace of a vector space, linear dependence-independence of vectors,	**Quantum mechanics:** Quantum theory of light, the particle nature of matter, matter waves, quantum mechanics in one dimension and tunnelling phenomena, atomic and molecular orbitals, the chemical bond. Applications to atoms, molecules, particle in a box.	**Reactions and synthesis:** Synthesis and design of organic and inorganic molecules, molecular architecture and the energy transformations associated with chemical and physical processes. Topics covered include synthesis of simple poly-functional organic	**Principles of physiology:** Energy management, maintenance of homeostasis, salts and water, metabolic processes (anabolism, catabolism), respiration and fermentation, regulation of metabolism (molecular signaling, genetic), growth kinetics, survival strategies

dimension; linear transformations, eigen values, eigenvectors, inner products, diagonalization **Vector Calculus:** Vector fields, flow lines, curvature, torsion, gradient, divergence, curl and Laplacian. Integrals over paths and surfaces topics; line, surface and volume integrals; change of variables; averages, moments of inertia, centre of mass; Green's theorem, Divergence theorem in the plane, Gauss' divergence theorem, Stokes' theorem; curvilinear coordinates. **Probability and Statistics 1**: Probability: Theory basis of statistical inference. Probability and, random variables - Standard probability distribution – Binomial, Poisson, Namal (definition, simple environmental examples, additive properties) applications to common univariate probability models. Joint behaviour of random	**Thermodynamics:** Thermal equilibrium, ideal gas and kinetic theory, equipartition of energy, heat and work, heat capacity, latent heat, enthalpy, thermodynamic processes; thermal systems and statistics, interacting systems, statistics of large systems, entropy, temperature and heat, pressure, chemical potential; heat engines, Carnot cycle, refrigerators, heat engines, throttling process; Helmholtz and Gibbs Free energies, and phase transformations Heat Energy And Kinetic Theory Heat and Temperature. Internal Energy, Specific Heat. Ideal gas Equation. Kinetic theory interpretation of pressure and temperature. Work, heat, and the first law of thermodynamics. Adiabatic lapse rate. Radiant energy. Blackbody radiation.	compounds, thermodynamically controlled reactions of s-, p- and d- block elements and thermodynamics (Organic Synthesis C-C bond Forming Reactions, Organo-metallic Reagents in Synthesis, Carbonyl Compounds and Reactions, Redox (and important acid-base) Reactions, Exchange reactions., Substitution Reactions., Metal centered reactions.) Energy Transformations and Thermodynamics, Energy quantization and Boltzmann distribution **Soil Pollution -** Soil around us; Soil - Water Characteristics; Soil Erosion; Soil & Pollution; Water resources: Irrigation and Wetlands; Soil Pollution Management;	(symbiosis, defense) **Animal physiology (Human)**: Respiration, digestion, nutrition and metabolism. Nervous system, Endocrine system, Excretion and osmo-regulation (water and salt balance), Cardiovascular system. Thermal regulation, Reproduction and development **Plant physiology:** Water balance. Mineral nutrition and nutrient assimilation, Solute transport across membranes; Phloem translocation; Photosynthesis; respiration and lipid metabolism; Secondary metabolism and defense; Growth and development (signal transduction, cell walls, growth and development, light responses, hormones); Control of flowering; Abiotic stress **Microbial physiology:** Aerobic and anaerobic respiration; Extremophiles; Symbiotic

variables, conditional probability, Markov chains. Statistics: Scope of statistics in environmental studies, Types of data- raw, grouped; Representation of data using frequency distribution diagram (Simple/Multiple/Subdivided bar diagram, Pie diagram),Graphs (Histogram, polygon, curve) Stem and leaf diagram; Population, sample and sampling methods (random, Stratified sampling); Descriptive statistics- Measure of central tendancy (Mean, Mode, Median, Quartile), Measure of dispersion- Variance, Standard deviation, coefficient of variance; Skewness; Kurtosis			associations; Enzymes

Semester 4

MATHS 202	**PHYSICS 202**	**CHEMISTRY 202**	**BIOLOGY 202**
Differential Equations: Linear differential equations, both ordinary and partial, use of linear algebra to provide the general structure of	**Electricity and Magnetism:** Electric field, Gauss's law in integral and differential form, scalar potential and gradient, Poisson and	**Structure and properties:** Stereochemical and electronic properties of molecules and the methods central to their study. Important elements of	**Mechanisms of evolution:** Mendelian genetics**;** Genetic diversity (mutation, recombination)**;** Genetic structure of populations

solutions for ordinary differential equations and linear systems. Initial value problems, boundary value problems and eigen value problems arising from common classes of partial differential equations. Laplace transforms methods; separation of variables applied to simple second order partial differential equations. Fourier series solutions of the heat and wave equations; Fourier transforms. **Probability and Statistics 2**: Classical and Bayesian statistical methods; maximum likelihood, sufficiency, unbiased estimation, confidence intervals, hypothesis testing and significance levels. Inferential Statistics- Hypothesis, sampling distribution errors (Type I and II), Testing of hypothesis for mean and variance, Chi square test for fitting of distribution	Laplace equations), the magnetic field (e.g. Ampere's law in integral and differential forms), Maxwell's equations in vacuum (differential forms), Maxwell's equations in matter (polarization, electric displacement, magnetic vector potential), time-varying electric and magnetic fields (Maxwell's equations in general form, wave equations for E and B, plane electromagnetic wave, Poyntingvector) **Optics:** Fourier optics, Fourier transforms in 1 and 2D, Dirac delta function and comb, discrete Fourier transforms and the sampling theorem, convolution, cross and autocorrelation. Fresnel and Fraunhofer diffraction, Polarized light including production and control of polarisation. **Energy Sources** Chemical energy. Energy in	the subject include the spectroscopic characterisation and quantification of materials by a range of spectroscopic techniques, molecular orbital techniques and the application of approaches based on molecular symmetry and group theory to the understanding of molecular properties, stereo- selective reactions, bonding and spectroscopy. These topics have applications to advancedmaterials, light emitting polymers, chemical analysis and catalysis in biological and industrial systems. **Water Pollution Treatment -** Introduction; Technological Approach; Chemical Degradation of wastes and Chemicals; Coagulation and flocculation; Photo-catalytic degradation of pollutants; Supercritical water oxidation.	(random mating/Hardy-Weinberg equilibrium)**;** Selection**;** Speciation and species concepts**;** Mechanisms of speciation (geographical, sexual, temporal, ecological) **Population biology:** Nature of populations**;** Distribution and abundance of populations**;** Density independent, density dependent growth**;** Managing populations for production**;** Conservation biology**;** Epidemiology **Community ecology:** Nature of communities**;** Community structure**;** Intracommunity interactions**;** Symbiosis**;** Predation**;** Competition**;** Host- parasite interactions**;** Niche**.** Dynamics of communities (perturbation and succession)**;** Biomes (communities on a global scale) **Ecosystems:** Pond ecosystem; Food chains and webs; Pyramids (numbers,

and Independence of attributes, ANOVA (one way and two way), Correlation, Scatter Diagrams, Covariance, Multiple and partial correlation. Environmental Applications include distribution free methods, goodness of fit tests, correlation and regression; the analysis of one-way and two-way classifications.	biology, photosynthesis, respiration. Energy use in the human body, energy content of food. Fossil fuels and their origin (coal, oil, natural gas). Problems with fossil fuels, greenhouse pollution, peak oil. Alternatives to fossil fuels.		biomass, energy); Productivity (Primary and secondary); Biogeochemical cycles (water, C, N, P)