ES	Environmental Science and Engineering

Section 1: Mathematics Foundation

Linear Algebra: Determinants and matrices, Systems of linear equations, Eigenvalues and eigenvectors.

Calculus: Functions, Limit, Continuity, Differentiability, Local maxima and minima, Taylor series, Tests for convergence, Definite and indefinite integrals, Application of definite integral to obtain area and volume, Partial and total derivatives.

Differential Equations: Linear and non-linear first order ordinary differential equations (ODE), Higher order linear ODEs with constant coefficients, Cauchy's and Euler's equations, Laplace transform and its application in solving linear ODEs.

Probability and Statistics: Descriptive statistics, Measurement of central tendency, Dispersion, Skewness and kurtosis, Probability concepts, Conditional probability, Bayes theorem, Risk and reliability, Probability distributions, Correlation, Single and multiple regression models, Hypothesis testing (t-test, F-test, chi-square test).

Section 2: Environmental Chemistry

Fundamentals of Environmental Chemistry: Covalent and ionic bonding; Chemical equations, concentration and activity; Structure and chemistry of organic molecules; Radioactivity of elements; Chemical equilibria; Thermodynamics and kinetics of chemical reactions.

Principles of Water Chemistry: Water quality parameters and their measurement; Acid-base equilibria; Buffer solution; Carbonate system; Solubility of gases in water; Complexation, precipitation, and redox reactions; Inorganic and organic contaminants in water and their speciation.

Soil Chemistry: Organic matter, nitrogen, phosphorous, potassium, cation exchange capacity, base saturation, and sodium absorption ratio.

Atmospheric Chemistry: Composition of the atmosphere; Reactivity of trace substances in the atmosphere; Urban atmosphere—smog and particulate pollution; Chemistry of ozone formation; Chemistry of stratosphere.

Section 3: Environmental Microbiology

Prokaryotic and Eukaryotic Microorganisms: Characteristics of diverse groups of microorganisms; Classification of microorganisms; Microbial diversity; Plant-microbe and soil-microbe interactions; Role of microorganisms in wastewater treatment, bioremediation and biogeochemical cycling.

Cell Chemistry and Cell Biology: Structure of proteins, nucleic acid (DNA & RNA), lipids and polysaccharides; Bonds in biomolecules; Stereoisomerism in biomolecules; Structure of cell; Structure and function of cytoplasmic membrane, cell wall, outer membrane, glycocalyx, chromosomes, endospores, storage products, mitochondria and chloroplasts.

Microbial Metabolism: Anabolism and catabolism; Phosphorylation; Glycolysis; TCA cycle;

Electron transport chain; Fermentation; Anaerobic respiration; Energy balances; Enzymes and Enzyme kinetics.

Growth and Control of Microorganisms: Bacterial nutrition and growth; Specific growth rate and doubling time; Monod's model; Types of culture media; Batch and continuous culture; Effects of environmental factors on growth; Control of microbes using physical and chemical methods.

Microbiology and Health: Pathogens and modes of transmission; Indicator organisms; Quantification of coliforms using MPN and membrane filtration techniques.

Section 4: Water Resources and Environmental Hydraulics

Global Water Resources: Structure, properties and distribution of water; Water quality; Threats to water resources; Water conservation.

Surface Water Resources: Hydrological cycle and water balance - precipitation, infiltration, evapotranspiration, runoff; Flow hydrographs; Unit hydrographs; Stage-discharge relationship; Reservoir capacity; Reservoir and channel routing; Surface run-off models; Surface water management; Rain water harvesting and storage.

Groundwater Resources: Geologic formations as aquifers; Vadose and saturated zones; Confined and unconfined aquifers and their parameters - porosity, permeability, transmissivity and storage coefficient; Darcy's law and applications; Steady state well hydraulics.

Environmental Hydraulics: Concepts of mechanics; Properties of fluids; Pressure measurement; Hydrostatic force on surfaces; Buoyancy and flotation; Laminar and turbulent flow; Flow through pipes; Pipe networks; Boundary layer theory; Forces on immersed bodies; Flow measurement in channels and pipes; Kinematics of flow; Continuity, momentum and energy equations; Channel hydraulics - specific energy, critical flow, hydraulic jump, rapid and gradually varied flow; Design of lined and unlined channels.

Section 5: Water & Wastewater Treatment and Management

Water and wastewater quality parameters; Eutrophication and thermal stratification in lakes; River pollution - Oxygen sag curve.

Water treatment methods - screening, sedimentation with and without coagulation, filtration, desalination, disinfection; Water distribution and storage

Point and non-point sources of wastewater; Population forecasting methods; Design of sewer and storm water sewers; Sewer appurtenances; Preliminary, primary, secondary and tertiary sewage treatment; Sludge generation, processing and disposal methods; Sewage farming.

Sources and characteristics of industrial effluents; Concept of Common Effluent Treatment Plants (CETP); Wastewater recycling and zero liquid discharge.

Kinetics and reactor design: Mass and energy balance, Order and rate of reactions, Batch reactors, Completely mixed flow reactors, Plug flow reactors.

Section 6: Air and Noise Pollution

Structure of the atmosphere; Natural and anthropogenic sources of pollution; Atmospheric

sources, sinks, transport; Indoor air pollution; Effects on health and environment; Air pollution: gases and particulate matter; Air quality standards; Primary and secondary pollutants; Criteria pollutants, ambient and source standards, air quality indices, visibility.

Particulate Pollutants: Measurement and control methods; Control of particulate air pollutants using gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP).

Gaseous Pollutants: Measurement and control methods; Control of gaseous contaminants: absorption, adsorption, condensation and combustion; Control of sulphur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons; Vapour-liquid and vapour-solid equilibria; Diffusion, Fick's law and interfacial mass transfer. Automotive emission controls, fuel quality, diesel particulate filters, catalytic convertors.

Air Quality Management: Point, line and area sources; Inventory; Influence of meteorology - wind rose diagrams, stability, mixing height, topography, dispersion modelling, monitoring.

Noise Pollution: Sources; Health effects; Standards; Measurement and control methods.

Section 7: Solid and Hazardous Waste Management

Integrated solid waste management; Waste hierarchy; Rules and regulations for solid waste management in India.

Municipal solid waste management: Sources, generation, characteristics, collection and transportation, waste processing and disposal (including reuse options, biological methods, energy recovery processes and landfilling).

Hazardous waste management: Characteristics, generation, fate of materials in the environment, treatment and disposal. Soil contamination and leaching of contaminants into groundwater.

Management of biomedical waste, plastic waste and E-waste: Sources, generation and characteristics; Waste management practices including storage, collection and transfer.

Section 8: Global and Regional Environmental Issues

Global effects of air pollution: Greenhouse gases, global warming, climate change, urban heat islands, acid rain, ozone hole.

Ecology and various ecosystems; Biodiversity; Factors influencing increase in population, energy consumption, and environmental degradation.

Section 9: Environmental Management and Sustainable Development

Environmental Management Systems; ISO14000 series; Environmental Auditing: Environmental Impact Assessment; Life cycle assessment; Human health risk assessment.

Environmental Law and Policy: Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties.

Energy and Environment: Energy Sources: Overview of resources and reserves; Renewable

and non-renewable energy sources; Energy-Environment nexus.

Sustainable Development: Definition and concepts of sustainable development; Sustainable development goals; Hurdles to sustainability; Environment and economics.

GA General Aptitude

Verbal Aptitude

Basic English grammar: tenses, articles, adjectives, prepositions, conjunctions, verb-noun agreement, and other parts of speech

Basic vocabulary: words, idioms, and phrases in context.

Reading and comprehension, Narrative sequencing.

Quantitative Aptitude

Data interpretation: data graphs (bar graphs, pie charts, and other graphs representing data), 2- and 3-dimensional plots, maps, and tables

Numerical computation and estimation: ratios, percentages, powers, exponents and logarithms, permutations and combinations, and series Mensuration and geometry Elementary statistics and probability.

Analytical Aptitude

Logic: deduction and induction, Analogy, Numerical relations and reasoning.

Spatial Aptitude

Transformation of shapes: translation, rotation, scaling, mirroring, assembling, and grouping paper folding, cutting, and patterns in 2 and 3 dimensions.