GATE Syllabus

Environmental Science and Engineering (ES)

Section 1: Mathematics Foundation

Linear Algebra: Matrices, systems of linear equations, eigenvalues and eigenvectors.
Calculus: 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: Sources, 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 (Baghouse 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: Leaching of contaminants into groundwater.
Management of Biomedical, Plastic 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; ISO 14000 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.