

Dhaka University of Engineering & Technology, Gazipur



Syllabus *for* Postgraduate Programs (Engineering Degrees)

Institute of Water and Environment (IWE)

Courses and Syllabus for Postgraduate Programs (Engineering Degrees)

List of Courses

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Detailed Syllabus

WE 6201 Advanced Groundwater Hydrology

3 Credits

Groundwater Hydrology: theoretical foundations, aquifer types, key terms, groundwater occurrence and movement; Flow Equations and Modeling: Darcy's law, analytical solutions for 1D–3D flow in confined, unconfined, and leaky aquifers, stream–aquifer interaction; numerical modeling, calibration, sensitivity, uncertainty analysis, integration with GIS and Python; Well Hydraulics and Testing: design, construction, drawdown analysis, pumping tests, specific capacity, cone of depression; Groundwater Recharge, Discharge, and Budgeting: natural and artificial recharge, discharge pathways, groundwater budgeting at basin scale; Geophysical and Remote Sensing Methods: resistivity, seismic tools, storage estimation; Water Quality and Contaminant Transport: pollutants transport modeling, quality standards, remediation; Seawater Intrusion: Ghyben-Herzberg relation, interface dynamics, control strategies, case studies; Sustainability, Resilience, and Innovation: Artificial intelligence applications, stakeholder inclusion, policy integration, climate-resilient groundwater management.

WE 6202 Advanced Surface Water Hydrology

3 Credits

Hydrological cycle dynamics: advanced concepts of precipitation, interception, infiltration, evapotranspiration, runoff, groundwater exchange; Surface water significance: ecological flows, water security, ecosystem services; Precipitation measurement and analysis: gauge, radar, satellite data, IDF curves; Catchment hydrology and runoff generation: land use, topography, rainfall–runoff response, HRUs; Evapotranspiration and infiltration: Penman-Monteith, Thornthwaite, SVPD, energy balance, soil moisture; Hydrograph and runoff analysis: unit hydrograph theory, base flow, peak flow, lag time; Watershed modeling; River hydraulics and routing; Hydrological Modeling of Extreme Events: Floods, droughts, and flash floods; Hydrological Processes in Urban Areas: Impact of urbanization on hydrological processes, Urban hydrology models; Climate change impacts: downscaled GCMs, trend analysis, resilience planning; Data-driven hydrology: Machine Learning/Artificial Intelligence in prediction, remote sensing integration; Interdisciplinary and innovative approaches: real-time monitoring, nature-based solutions, adaptive management, policy linkage.

WE 6203 Water Quality Engineering

3 Credits

Global water quality challenges: pollution from agriculture, industry, emerging contaminants; Water quality monitoring: advanced analytical techniques, in-situ and laboratory sampling, quality control; Pollution sources: point and non-point, urban runoff, industrial effluents; Chemical equilibria: acid-base, redox, solubility and precipitation of metals and nutrients; Contaminant transport: advection, dispersion, biodegradation, and chemical transformation; Water quality modeling; Machine learning for water quality prediction; Wastewater treatment: advanced treatment technologies, plant design, simulation; Drinking water treatment: conventional methods,

advanced, DBPs control; real-time monitoring: IoT sensors, smart water systems for automation and early warning; Water pollution control: policy, legal frameworks, and sustainable strategies; Climate change impact: water quality shifts, pollutant mobilization, adaptive management.

WE 6204 Environmental Fluid Mechanics

3 Credits

Fundamentals of fluid mechanics: fluid properties, pressure variation, Pascal's principle, buoyancy, stability of floating bodies, and hydrostatic forces; Fluid kinematics and dynamics: flow descriptions, streamlines, continuity and momentum equations, open-channel flow, Navier-Stokes equations, and flow resistance via Darcy-Weisbach formulation; Similitude and dimensional analysis: Buckingham Pi theorem, geometric, kinematic, and dynamic similarity, and model scaling; turbulence modeling; Multiphase and sediment-laden flows: two-phase air-water and sediment-water systems; Pollutant transport and fate modeling: advection-dispersion in rivers, lakes, and estuaries, advection-diffusion equation; Environmental flow applications in marine and coastal systems: circulation, waves, tides, storm surges, erosion, and flooding; Lakes, reservoirs, and estuarine systems: thermal stratification, mixing, salinity gradients, estuarine mixing, and sediment exchange; Machine learning in flow prediction, climate change impacts, and biological flows in aquatic and urban environments.

WE 6205 Coastal and Ocean Engineering

3 Credits

Coastal Features and Wave Dynamics: Coastal zones, shorelines, estuaries, tidal flats, wave generation, propagation, refraction, diffraction, breaking, and energy dissipation; Numerical wave models; Spectral wave modeling for nearshore hydrodynamics; Tidal Processes and Hydrodynamics: types of tides, equilibrium and dynamic theories; Tide prediction and tidal current modelling; Wave-current interaction and longshore sediment transport using coupled hydrodynamic-sediment models; Coastal Morphology and Sediment Transport: Shoreline evolution, erosion, deposition; Sediment budgets and transport pathways; Morphodynamic simulations; Wave-structure interaction and sediment scouring; Design and performance of coastal structures (breakwaters, seawalls, jetties); Structural response under hydrodynamic loads; Climate-resilient coastal defenses: sea-level rise, storm surges, saltwater intrusion; Vulnerability mapping; Ecosystem-based and adaptive planning using Bayesian networks, agent-based models, and dynamic pathways; AI, remote sensing, and digital twins for shoreline prediction, sediment analysis, and real-time coastal management.

WE 6206 Sustainable Water Resources Planning and Management

3 Credits

Concepts and evolution of Integrated Water Resources Management (IWRM); global water challenges and sustainability responses; system-based water planning approaches and the water-energy-food-ecosystem nexus; watershed hydrology and catchment processes: runoff generation, land use impacts, and urbanization; GIS and Remote Sensing for watershed analysis and monitoring; water demand assessment across sectors and scenario-based forecasting; equitable water allocation and conservation strategies including smart metering and reuse; water quality

assessment: emerging contaminants, IoT-based monitoring, and ecosystem risk frameworks; climate change impacts on water systems: vulnerability, adaptation, and resilience planning; planning tools and techniques: systems analysis, optimization, Decision Support Systems (DSS), and Multi-Criteria Decision Analysis (MCDA); sustainable infrastructure: water-sensitive urban design, green infrastructure, and stormwater management; governance frameworks: basin-scale management, stakeholder engagement, gender equity, and conflict resolution; environmental flow and ecosystem-based management approaches; innovation in water resources: applications of AI, machine learning, remote sensing, and real-time analytics in planning and decision-making.

WE 6207 Advanced Water Supply Systems and Engineering

3 Credits

Water supply systems: components, functions, smart infrastructure integration, resilience to variability; Water demand analysis and forecasting using time-series and machine learning models; Intake structures: site selection, design, construction, and maintenance; Conveyance and intake conduits: free-surface and pressurized flow, energy optimization, pump selection, capacity and head estimation, economic pipe sizing; Pipe hydraulics: flow analysis, head loss using Darcy-Weisbach and Hazen-Williams equations; Network design: branching, looped, grid layouts for urban/rural systems, hydraulic simulation, steady-state and dynamic modeling, demand- and pressure-driven approaches; Hardy Cross method and its advanced applications; Pipe network optimization; Non-revenue water management: leakage detection, metering, pressure control, economic analysis, and tools; Sustainable water loss reduction strategies; Exploration of resilience and sustainability in water supply systems under climate change and urban stressors; Application of IoT-based monitoring, digital twins, and artificial intelligence for system optimization; Integration of blockchain technologies for secure and transparent water governance.

WE 6208 Advanced Groundwater Modeling

3 Credits

Fundamentals of groundwater flow: Darcy's Law, governing equations for flow and transport in porous media, analytical solutions for steady-state and transient flow; Numerical methods for groundwater modeling: Finite Difference, Finite Element, and Finite Volume methods, mesh generation, temporal discretization, model conceptualization, discretization, and parameterization using field, lab, and remote sensing data; Groundwater flow modeling: steady-state and transient simulations, multi-aquifer systems, density-driven flow, unsaturated zone coupling, calibration, uncertainty propagation, sensitivity analysis, inverse modeling; Solute transport modeling: advection-dispersion, sorption, biodegradation; Coupled surface water-groundwater systems: river-aquifer interactions, wetland hydrology, managed aquifer recharge, model coupling; Variable density flow; Groundwater management: optimization, decision support, multi-objective models for sustainability and risk mitigation; GIS integration, machine learning, IoT-based real-time monitoring; Groundwater modeling under uncertainty and climate change.

WE 6209 Sustainable Water Engineering

3 Credits

Fundamentals of sustainable water engineering; global water demand-supply dynamics; Sustainability principles; sustainability indicators and SDG 6 alignment; Systems and nexus approaches: water-energy-food and water-energy-carbon-climate nexus modeling; Circular water economy; Nature-based solutions and ecosystem-based adaptation; Uncertainty and risk assessment in modeling, climate resilience, decision-making, and water governance under data and climate variability; Natural water retention; Landscape-scale ecosystem services; Watershed sustainability metrics; Sectoral applications: water allocation and distribution modeling; Urban water management and innovative treatment technologies; industrial symbiosis and zero-liquid discharge; Multi-criteria decision analysis; web-based decision support and simulation platforms; advanced water data analysis techniques; Climate resilience and adaptive management: climate impacts and hydroclimatic extremes; Climate-resilient and carbon-neutral water infrastructure; Governance and policy: transboundary water governance; policy tools; participatory management; equity, indigenous rights, behavioral economics; WASH–public health–water security nexus; socio-technical systems and stakeholder analysis.

WE 6210 Advanced Irrigation and Drainage Systems

3 Credits

Strategic importance of irrigation and drainage in enhancing global food security amid climate change, salinity, and water scarcity; Comparative evaluation and design of surface and pressurized irrigation systems; Performance analysis involving energy use, droplet dynamics, and system efficiency; Hydrological foundations of irrigation: estimating crop water needs, evapotranspiration models, soil-water-plant interactions, and water balance techniques; Irrigation scheduling and adaptive water management under climate variability; Drainage design: surface and subsurface system planning, layout optimization, water table control, and salinity mitigation; Reuse of treated wastewater in irrigation: quality assessment, health risks, and regulatory considerations; Integration of GIS, remote sensing, and sensor-based monitoring for real-time water management in irrigation systems; Analytical and numerical modeling of irrigation hydraulics and drainage behavior; Sustainability and resilience focus through case studies, participatory water governance, and data-driven irrigation decision support; Smart irrigation technologies, deficit irrigation strategies, and circular water systems.

WE 6211 Urban Drainage Systems

3 Credits

Urban hydrology and the altered urban water cycle; Components of drainage systems: sewers, drains, basins, and outfalls; System types: combined, separate, hybrid; Challenges: urbanization, climate change, aging infrastructure; Urban catchment characteristics and hydrological processes; Estimation of runoff and peak discharge using rational, unit hydrograph, SCS-CN, and time-area methods; Hydraulic principles and open/pressurized flow in networks; Drainage network design: layout optimization, hydraulic sizing, detention/retention facilities; Urban flood risk management: flood scenario modeling, 1D/2D simulations, resilience assessment; Green infrastructure and SuDS: permeable pavements, bioswales, rain gardens, performance evaluation; Conjunctive use

of stormwater, wastewater, and groundwater; Urban water balance and demand management; Data-driven decision-making using GIS, remote sensing, IoT, AI, and decision support systems to optimize urban drainage; integrated with urban planning, climate science, and policy to promote sustainability and resilience; innovation in drainage through smart systems, real-time control, digital twins, and nature-based solutions.

WE 6212 Green Infrastructure and Urban Water Management

3 Credits

Green Infrastructure (GI): Evolution and theoretical foundations grounded in systems thinking applied to urban hydrology; comparison between grey infrastructure and green-blue infrastructure emphasizing hydrological disruptions and sustainable restoration approaches; evaluation of GI performance through ecosystem services, hydrological trends, and socio-economic as well as climate impacts; advanced analytical modeling tools for GI systems; application of Multi-Criteria Decision Analysis, Machine Learning, and Artificial Intelligence for optimizing GI design and management; data-driven decision-making supported by IoT-enabled real-time monitoring and performance evaluation; development of decision-support tools tailored for urban planners; exploration of ecological, social, and economic interfaces including urban ecology, social equity considerations, and economic valuation methods; integration of GI with urban planning and landscape architecture disciplines; GI as a resilience strategy: its role in flood risk reduction, urban heat island mitigation, carbon sequestration, and alignment with broader sustainability frameworks; Use of mixed-methods research for comprehensive GI evaluation.

WE 6213 Transboundary Water Resources Management

3 Credits

Global Distribution of transboundary waters: spatial analysis of shared river basins and aquifers; hydroclimatic variability and basin morphology; integration of historical, geopolitical, legal, and ecological datasets; interdisciplinary synthesis bridging hydro-politics, international water law, and hydro-diplomacy for cooperative governance; Challenges in managing transboundary water resources: analytical and numerical modeling of water availability, consumption, and climate impact; Data-driven decision-making tools; Hydrology and characteristics of transboundary water systems: hydrological processes in transboundary river basins; Sustainability focus in freshwater systems under climate change; case studies of major basins; Environmental management practices for flood risk, sediment transport, and water quality; Water Allocation and management: water allocation methods; adaptive management strategies under uncertainty; conflict resolution in transboundary basins; case studies on international agreements; International water law: analysis of international treaties and conventions; Conflict resolution mechanisms; Frameworks for cooperation in transboundary water governance; Environmental management: environmental challenges in transboundary; use of decision support tools for integrated water management.

WE 6214 Air Pollution Modeling

3 Credits

Foundations of atmospheric pollution science: atmospheric thermodynamics, vertical stratification, chemical climatology, and advanced tropospheric and stratospheric chemistry;

Emissions and high-resolution inventories: source estimation, uncertainties; pollutant formation: PM_{2.5}, ozone, secondary aerosols, chemical kinetics; Transport processes: advection-diffusion, meteorology, turbulence, dispersion, deposition; box models: theory, development, sensitivity analysis; Gaussian models: assumptions, regulatory applications; grid-based Eulerian models: numerical structure, chemical transport, feedback mechanisms; Numerical methods: finite difference/volume, operator splitting, stability, convergence analysis; model evaluation; Uncertainty and sensitivity analysis; Meteorological data: reanalysis, satellite data assimilation, WRF integration; Machine learning: hybrid models, deep learning, anomaly detection, big data processing; Policy and health: health risk assessments, exposure-response, IAM, air quality standards; interdisciplinary links: climate, urban planning, environmental justice; Emerging technologies: low-cost sensors, mobile monitoring, IoT, citizen science.

WE 6215 Water Quality Modeling

3 Credits

Introduction to Water Quality Modeling: overview of water quality parameters, Types of models (deterministic, stochastic, empirical, mechanistic), applications and limitations, model selection criteria; Fundamentals of water quality processes: mass balance and reaction kinetics, advection, dispersion, and diffusion, fate and transport of pollutants, BOD, DO, nutrients, pathogens, heavy metals; Modeling in rivers and streams: one-dimensional steady and unsteady models, Streeter-Phelps equation, DO sag curve; Lake and reservoir modeling: stratification and mixing, eutrophication processes; Estuarine and coastal water quality models: tidal dynamics and salinity intrusion, sediment transport and nutrient cycling, 2D/3D modeling; Groundwater quality modeling: Solute transport modeling (advection-dispersion equation), Reactive transport; Model calibration and validation: parameter estimation techniques, Sensitivity and uncertainty analysis; Coupled hydrodynamic–water quality modeling: linking hydraulic models with quality models, integrated catchment-scale modeling, climate and land use impacts; Decision support systems and scenario analysis; Scenario development and impact forecasting, modeling for WASH and SDG targets; Recent Advances and Case Studies: Artificial intelligence and Machine learning in water quality prediction, Real-time monitoring and sensor integration, Case studies from Bangladesh and global context.

WE 6216 Environmental Informatics

3 Credits

Foundations of environmental informatics: systems thinking, environmental cybernetics, and information theory in ecological systems; Data acquisition and integration: advanced geospatial technologies, sensor networks, Internet of Things, and real-time environmental data assimilation; Advanced ML Techniques: Random forests, SVMs, CNNs, RNNs; Big Data Analytics: Hadoop, Spark, data mining, Big Data in climate, air quality, ecological forecasting; Impact Modeling: air quality, water resources, ecosystem services; Risk Assessment: Probabilistic models, Monte Carlo simulations; DSS: multi-criteria decision analysis, participatory decision-making, policy integration; Machine Learning for Prediction: AI-driven modeling for pollution, climate, ecology; Ethical Considerations: data privacy, environmental justice, inclusive decision-making; Adopting

Emerging Technologies: low-cost sensors, IoT, crowdsourced data, blockchain for environmental data transparency.

WE 6217 Sustainable Environmental Design and Assessment

3 Credits

Systems-based design and assessment of complex environmental systems under sustainability constraints; integration of environmental, economic, and social dimensions; Core theories: industrial ecology, regenerative design, exergy analysis, resilience theory, tipping points, complex systems; Assessment tools: advanced LCA methods, input-output analysis, energy and exergy metrics, uncertainty analysis; Modeling approaches: system dynamics, agent-based modeling, coupled human-natural systems; Sustainability indicators: Inclusive Wealth Index, ecological footprint, social LCA, aggregation using fuzzy logic and entropy; Circular economy strategies: industrial symbiosis, urban metabolism, blockchain in resource loops; Optimization and decision-making: multi-objective models, Bayesian networks, deep learning, adaptive pathways; Environmental-economic coupling: CGE models, carbon pricing, ecological economics; Nature-based and bio-inspired solutions: ecosystem services, biomimicry, green infrastructure, co-benefit analysis; Governance and policy: polycentric systems, institutional mismatches, transboundary justice; Emerging themes: net-zero systems, regenerative design, AI-driven sustainability, digital twins, critical material flows.

WE 6218 Hazardous Waste Management

3 Credits

Emerging hazardous wastes: pharmaceuticals, e-waste, nanomaterials, microplastics; Advanced characterization: spectroscopy, chromatography, IoT monitoring, machine learning; Toxicity and hazard evaluation: nano-bio interactions, high-throughput in vitro/in silico platforms; Molecular fate modeling using quantum chemistry and reactive transport; Risk frameworks: Dynamic Adaptive Policy Pathways, Robust Decision Making, Real Options Analysis; Life cycle and circular economy: material recovery, techno-economic sustainability, waste upcycling; Waste minimization and industrial ecology; Treatment technologies: advanced physical, chemical, biological methods, synthetic biology-driven bioremediation, biosensors; Containment and landfill design with climate resilience, leachate treatment, environmental justice; Transport and storage safety enhanced by AI-driven digital twins, anomaly detection; Remediation methods: innovative in-situ/ex-situ, virtual scenario testing; Sector-specific case studies; Governance: polycentric models, stakeholder engagement, social license, ethics, global regulations; Blockchain for supply chain transparency and trafficking prevention; Climate adaptation for hazardous waste infrastructure.

WE 6219 Climate Change Engineering

3 Credits

Scientific basis of climate change: greenhouse gases, radiative forcing, climate feedbacks, climate sensitivity, attribution science, Earth System Models; advanced coupling of human-natural systems with socio-economic agent-based models; nonlinear tipping points and early warning systems; Climate modeling and scenarios: GCMs, downscaling, Shared Socioeconomic Pathways,

uncertainty analysis; Integrated Assessment Models for mitigation-adaptation; explainable AI for climate analytics; Climate impacts: atmosphere–ocean dynamics, cryosphere changes, sea-level rise, coastal flooding, saltwater intrusion, risks to megacities; hyper-resolution impact simulations; Resilient infrastructure and adaptation: structural resilience, green-blue infrastructure, heat mitigation, self-healing materials; IoT and AI structural monitoring; socio-environmental justice and participatory planning; Water-Energy-Food Nexus: systems modeling, emission reduction, resource efficiency, resilient agriculture; circular economy and decentralized renewables; Geoengineering: aerosol injection, cloud brightening, space reflectors; ethical/governance issues; Emerging tech: perovskites, advanced batteries, nanomaterials, smart grids; lifecycle assessment; AI and digital tools: machine learning, digital twins, IoT, big data; interpretable AI; Planetary monitoring: advanced satellite remote sensing; autonomous drone swarms for data and interventions.

WE 6220 Ecological Engineering

3 Credits

Systems ecology and energy dynamics: feedbacks, resilience, thermodynamics, entropy; Complex adaptive and eco-evolutionary systems; Landscape ecology with fractals and scaling laws; Biomimicry and nature-based design; Urban green infrastructure for stormwater and heat control; Ecological cyber-physical systems with IoT; Coupled hydrological–ecological modeling; Hybrid digital twins of ecological and socio-economic systems; Watershed health and ecosystem valuation under uncertainty; Biodiversity integration with habitat and corridors; Spatial and agent-based modeling with machine learning; Metabolic network engineering; Bioremediation, synthetic ecology, gene editing, ecological risk; Nanobiotechnology for contaminant detection and cleanup; Multi-omics and network analysis; Coastal and blue carbon ecosystems with nature-based protection; Quantum computing for ecosystem modeling; Blockchain for data integrity and ecosystem markets; Decision support with system dynamics and probabilistic methods; Coupled human–natural systems; Governance and ethics; Advanced monitoring and restoration with AI, UAVs, LiDAR, remote sensing, IoT, hyperspectral fusion, swarm robotics, and machine learning under uncertainty.

WE 6221 Data Mining in Environmental Engineering

3 Credits

Foundations of data mining and machine learning: supervised, unsupervised, and reinforcement learning; characterization of spatiotemporal environmental datasets and ethical issues: data privacy, bias, and model interpretability; applications: water quality prediction, hydrological forecasting, land-use change, pollution tracking, anomaly detection, and resource optimization; data acquisition and preprocessing: in-situ sensors, remote sensing, open repositories, including cleaning, imputation, normalization, and feature engineering; exploratory analysis: multivariate statistics, visualizations, dimensionality reduction, clustering-based anomaly detection; supervised learning: regression, classification, ensembles, with model validation; unsupervised learning: K-means, DBSCAN, PCA, t-SNE, latent pattern discovery; temporal modeling: ARIMA, LSTM for streamflow and groundwater forecasting; advanced methods: random forests, gradient boosting,

CNNs, reinforcement learning for adaptive management; emerging methodologies: explainable AI, uncertainty quantification, federated learning, causal inference, hybrid physics-informed ML, real-time data streaming and edge computing, graph-based learning and graph neural networks for spatial and networked environmental data.

WE 6222 Energy Systems and Environmental Impacts

3 Credits

Fundamentals of energy systems and environmental principles: entropy, efficiency, sustainability; Integration with science, economics, and policy; Environmental impacts and externalities; Fossil and renewable energy: production modeling—emissions, efficiency, carbon footprint; Renewables—solar, wind, bioenergy—with life cycle and environmental impact assessment and climate mitigation; Nuclear and storage: safety, waste, major incidents; Regulations, ethics, proliferation; Advanced storage tech—batteries, solid-state, thermal; Energy economics: market failures, subsidies, pricing; Regulations including carbon taxes and incentives; Equity, vulnerable populations, decentralized systems; Climate change and innovation: climate modeling, resilience, emissions reduction; Emerging tech—AI smart grids, hydrogen, carbon capture; Governance and ethics: regulatory frameworks, carbon markets, international accords; Energy justice and sustainability challenges; Advanced topics: integrated energy-water-carbon nexus; Multi-objective AI optimization; Sector coupling and power-to-X; Digital twins and real-time monitoring; Circular economy in supply chains; Socio-technical dynamics and equity in transitions.

WE 6223 Atmospheric and Environmental Chemistry

3 Credits

Atmospheric chemistry: atmospheric structure and composition; stratospheric ozone chemistry; catalytic ozone depletion cycles; polar ozone dynamics; mitigation strategies; Tropospheric chemistry: radical-mediated processes; photochemical smog; acid deposition; particulate matter formation; indoor air pollution; mechanistic pathways; mitigation approaches; Greenhouse effect: radiative transfer theory; molecular vibration–rotation interactions; spectroscopic characterization; radiative forcing of major (CO₂, H₂O) and minor (CH₄, N₂O, halocarbons) gases; observational and modeling evidence; molecular-level processes governing environmental transformations; advanced chemical kinetics and equilibria in complex natural systems; redox and photochemical reactions in atmospheric, aquatic, and terrestrial environments; pollutant speciation, transformation, and transport mechanisms; fate of emerging contaminants including pharmaceuticals, microplastics, and nanomaterials; isotopic and spectroscopic tracing techniques; thermodynamic modeling of environmental interfaces; reactive transport modeling; environmental catalysis and remediation chemistry; integration of molecular theory with global biogeochemical and climate processes.

WE 6224 Nanotechnology for Environmental Remediation

3 Credits

Fundamentals of nanotechnology and material behavior: quantum phenomena, surface reactivity, structure–property relationships; nanomaterials synthesis and sustainable methods: top-down,

bottom-up, advanced techniques, eco-friendly approaches; characterization: SEM, TEM, XRD, XPS, AFM for structure and surface analysis; environmental applications: adsorption, photocatalysis, redox targeting heavy metals, pathogens, organic pollutants in water, soil, air; soil remediation and phytotechnologies: nano-assisted decontamination with phytoremediation; monitoring and sensing: nanosensors for real-time pollutant detection integrated with intelligent systems; toxicity and regulation: nano–bio interfaces, mechanistic toxicity, environmental fate, bioaccumulation, regulatory frameworks, governance; climate mitigation and sustainable energy: nano-enabled carbon capture, solar energy, energy storage; advanced topics: multiscale modeling, stimuli-responsive nanomaterials, AI-integrated nanosystems, lifecycle assessment, eco-design, integration with synthetic biology and porous materials for enhanced remediation.

WE 6225 Advanced Wastewater Treatment and Resource Recovery

3 Credits

Wastewater characteristics: composition of domestic, industrial, and agricultural wastewater; Physical, chemical, biological properties; Emerging pollutants; Advanced treatment principles: mass balance, kinetics, computational modeling, process optimization, and AI-based process control; Biological treatment: aerobic/anaerobic systems, nutrient removal, novel bioreactors, synthetic biology with engineered microbial consortia; Physicochemical treatment: coagulation, flocculation, advanced oxidation processes including electrochemical AOPs, membrane filtration, nano-enabled membranes, fouling control, hybrid systems; Nutrient and energy recovery: phosphorus/nitrogen recovery, energy recovery via anaerobic digestion, microbial electrochemical technologies, fuel cells; Resource recovery beyond nutrients: critical metals and rare earth elements; Water reuse and nature-based solutions: decentralized systems, potable/non-potable reuse, constructed wetlands, hybrid solutions; Emerging contaminants and remediation: microplastics, pharmaceuticals, endocrine disruptors, detection/removal methods; Sustainability assessment: life cycle assessment and techno-economic analysis.

WE 6226 GHG Emissions and Mitigation

3 Credits

Greenhouse effect dynamics: radiative forcing, gas efficiencies, atmospheric lifetimes, energy balance; climate feedbacks: biogeophysical, biogeochemical, ecohydrological processes, agent-based and system dynamics approaches; IPCC assessments: evaluation of Special Reports, interdisciplinary and socio-economic integration; GHG inventories: emission factors, measurement, reporting, and verification using remote sensing and atmospheric inversion; emission trajectories: sectoral decomposition and decarbonization pathways in developed and developing economies; energy emissions: integrated system analysis and techno-economic optimization; mitigation strategies: urban planning, sustainable agriculture, methane abatement; methane emissions: quantification and mitigation technologies; deforestation: carbon flux and vegetation modeling; carbon pricing: taxation, cap-and-trade, market instruments; emerging frameworks: blockchain for carbon credit verification, AI in energy optimization; frontier themes: carbon dioxide removal, uncertainty in assessments, nonlinear climate-economy feedbacks, multi-scale mitigation, socio-behavioral dynamics, geoen지니어ing, solar radiation management.

WE 6227 Sustainable Urban Noise Management

3 Credits

Fundamental concepts: acoustic theory, psychoacoustics, measurement standards; Noise monitoring: advanced tools, signal processing, AI and deep learning for source identification; Urban noise profiling: case studies, GIS and remote sensing; Noise propagation: meteorological and climate effects, multiscale models, hybrid AI-physics simulations; Environmental acoustics: urban morphology, indoor-outdoor transitions, absorption, reflection, psychoacoustics, soundscape ecology; Noise mapping: real-time systems, big data, AI; Health and ecological impacts: cardiovascular, psychological effects, sleep disruption, wildlife responses; Policy and regulation: global standards, national frameworks, compliance, legal tools, public participation; Urban planning: zoning, green buffers, soundscaping, resilient design, noise audits; Smart city technologies: barriers, insulation, low-noise pavements, sensors, live dashboards, adaptive noise control; Advanced materials: acoustic metamaterials, nanomaterials; Mixed-use challenges: residential-commercial interfaces, interdisciplinary strategies; Community and research: citizen science, environmental justice, future trends.

WE 6228 Remote Sensing for Smart Urban Planning

3 Credits

Remote sensing fundamentals: electromagnetic spectrum; Sensor types; Data modalities; Platforms; Preprocessing: geometric, radiometric, atmospheric corrections; Image analysis: enhancement; Classification; Change detection; Temporal analysis; Machine learning and deep learning; Hyperspectral interpretation; Spectral unmixing; Land use and urban dynamics: thematic mapping; Urban growth modeling; GIS integration; Urban environment: urban heat island, land surface temperature, vegetation and built-up indices; Green infrastructure; Microclimate modeling; Infrastructure and mobility: feature extraction; Urban sprawl; Mobility analysis; Intelligent transport systems; Smart cities: 3D modeling; Digital twins; IoT; BIM; Real-time assimilation; Edge computing; Disaster management: hazard detection; Damage assessment; Resilience planning; Multisensor fusion for early warning; Field validation: UAV surveys; Ground truthing; Accuracy assessment; Participatory sensing; Hyperspectral UAVs; Urban metabolism; Explainable AI; 5G/6G-enabled monitoring.

WE 6229 Harbour and Infrastructure Port Engineering

3 Credits

Harbour infrastructure typologies and functional layouts; Hydrodynamic and morphodynamic: wave–current–sediment interactions, harbour resonance, siltation, and scour; Climate-resilient structural designs and performance assessments: breakwaters, quay walls, jetties, piers; Berthing–mooring facilities under dynamic marine and seismic loads; Foundation design in soft sediments; layout optimization; risk-based safety and fail-safe design; eco-friendly construction and noise mitigation; case studies on climate-sensitive harbors; Physical processes of port and harbour environments: wave hydrodynamics; Tidal oscillations; Coastal morphodynamics; Site selection criteria; Coastal defense mechanisms: shoreline stabilization; Storm surge mitigation; Marine conservation and sustainable development goals; Smart port technologies: real-time monitoring;

Data-driven operational optimization; Port logistics; Safety protocols; Emergency preparedness; Maritime regulations and environmental standards; Sustainable port operations; Ecosystem preservation; Environmental assessments; Logistics planning; Resilience and sustainability integration.

WE 6230 Ocean and Coastal Safety Engineering

3 Credits

Foundations of coastal safety: risk paradigms, resilience theory, socio-environmental and systems-based approaches, and Indigenous knowledge; Coastal hazards: sea-level rise, cyclones, flooding, tsunamis, erosion, and anthropogenic stressors; Safety governance: regulatory frameworks, Blue Economy, ESG, and adaptive policies; Hazard modeling dynamics, and adaptive planning; Climate risk and uncertainty: scenario analysis, tipping points, robust decision-making; Smart safety tools: remote sensing, autonomous systems, digital twins, and AI-based early warning; Social vulnerability and equity: SoVI, adaptive capacity, relocation, and justice-based frameworks; Infrastructure safety: design and retrofitting of sea walls, levees, dunes, and beach nourishment; Reliability and failure analysis; Nature-based solutions: mangroves, reefs, dunes, and hybrid defense systems; Maritime safety: port risk, autonomous vessel protocols, oil spill response, and cybersecurity.; nonlinear dynamics, compound events, deterministic/probabilistic approaches, extreme value and stochastic analysis; Coupled human–natural systems: behavioral feedbacks, institutional dynamics, governance mechanisms, risk perception, adaptation strategies, and socio-ecological resilience modeling.

WE 6231 Advanced River Engineering and Sediment Dynamics

3 Credits

Fluvial System Dynamics: River morphology; river responses to natural and anthropogenic changes; Sediment Transport and Riverbed Processes; Bed load, suspended load, incipient motion, sediment rating curves, bedform evolution; Modeling of River Systems: Analytical, numerical, and data-driven models; Adopting AI-integrated tools for morphodynamic simulation; River Training and Flood Management Structures: Design of groynes, guide bunds, revetments, levees; Nature-based solutions and hybrid systems; Complex sediment–morphodynamic systems: sediment yield, channel migration, bar dynamics, estuarine and deltaic deposition, and disruptions to sediment fluxes across planetary boundaries; Flow–sediment interactions: unsteady, turbulent, and backwater-influenced regimes; Sediment responses to extreme events including glacial outburst floods, cyclones, and channel avulsions; Urban sedimentation: stormwater-induced transport, impervious surface effects, and drainage-linked sediment pathways; Modeling frameworks: integrated numerical, data-driven, and physics-informed systems; Coupled hydro-sediment-biogeochemical processes; Sediment monitoring systems: UAV-based morphometrics, and IoT-enabled real-time sediment surveillance; Sediment source and contaminant tracing; Microplastics and pollutant transport within sediment matrices; Ecohydraulic linkages: sediment-driven nutrient fluxes, riparian system integrity, estuarine carbon burial, and habitat resilience under dynamic sediment regimes; Transboundary sediment governance.

WE 6232 Risk Management in Water and Environmental Systems

3 Credits

Hydrological and climatological risk factors: hydrologic variability, climate change, natural hazards, pollution; Socioeconomic impacts: economic losses, social vulnerability, environmental degradation; Risk assessment frameworks: risk tolerance, acceptable risk levels; Assessment tools: scenario analysis, probabilistic modeling, vulnerability mapping, cost–benefit analysis, multi-criteria decision analysis; Spatio-temporal risk dynamics: seasonal shifts, watershed dynamics, land-use change, climate impact modeling; Risk Mitigation Measures: Hazard reduction: structural controls (dams, levees), early warning systems; Vulnerability reduction: zoning, standards, capacity planning; Regulatory approaches: building codes, incentives, insurance models; Economic integration: risk-cost incorporation in infrastructure design, optimization, cost-effectiveness, risk-adjusted valuation; Residual risk and preparedness: post-mitigation risk characterization, emergency protocols, stakeholder engagement; Governance: multi-level institutional roles, legal frameworks, participatory policy instruments; Disaster response and recovery: inter-agency coordination, logistics, phased resilience building.