

Environmental engineering syllabus

Environmental engineering examinations

Group A - Compulsory examinations (six required)

18-Env-A1 Principles of Environmental Engineering

Population, economic growth, industrialization, urbanization and energy-use, as causes of environmental pollution. Mass and energy balance for environmental engineering systems under steady state and unsteady state conditions. Physical and transport properties of homogeneous and heterogeneous mixtures. Contaminant partitioning and transport in air, water and solids. Characteristics of particles, chemistry of solutions and gases, material balances, reaction kinetics, microbiology and ecology, as related to the environment. Application of environmental principles (technical and non-technical) to: water resource management, water and wastewater treatment, air pollution control, solid waste management, environmental impact assessment, and environmental ethics. Thermal pollution, noise pollution, greenhouse effect, acid precipitation, ozone depletion, air toxics, and ground-level ozone and fine particulates (photochemical smog). Sustainable development, life cycle analysis, and principles of environmental quality objectives, standards and guidelines. Soils as a treatment system.

Textbooks (most recent edition is recommended):

- Ni-Bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, published: October 26th 2010, ISBN 9780071630054
- Edward S. Rubin, Introduction to Engineering and the Environment, published: November 30th 2000, ISBN: 9780072354676
- David Cornwell, Mackenzie Davis, Introduction to Environmental Engineering, McGraw-Hill Education, January 31st 2012 - 1056 pages.
- Kiely, G., Environmental Engineering. McGraw Hill, 1996. ISBN: 007091272

18-Env-A2 Hydrology and Municipal Hydraulics Engineering

Components and processes of natural hydrologic systems. Precipitation and snow melt, runoff, infiltration, storm frequency and duration analysis, conceptual models of runoff, stream flow and hydrograph analysis, frequency and probability with application to precipitation, floods and droughts; evaporation and evapotranspiration. Hydraulics of closed pipe systems and open channel flow including flow under uniform and gradually varied conditions, sediment transport. Water distribution systems, storage reservoirs and wastewater collection systems, pipe networks and network design, sanitary sewer and storm water collection system design, basic pumps/prime movers, urban drainage and runoff control. Climate change, its impact on the design of drainage systems and the need for integration of ecological considerations.

Textbooks (most recent edition is recommended):

- N/A Water Environment Federation, N/A American Society of Civil Engineers/ Environmental & Water Resources Institute, Design of Urban Stormwater Controls, MOP 23, published: May 8th 2012 ISBN: 9780071704441
- N/A Water Environment Federation, Prevention and Control of Sewer System Overflows, 3e - MOP FD-17, published: July 19th 2011, ISBN: 9780071738606
- Wanielista, M., Kersten, R., and R. Eaglin. Hydrology: Water Quantity and Quality Control. Wiley Interscience, 1996. ISBN: 0471072591
- Zipparro, V.J., Davis' Handbook of Applied Hydraulics Fourth Edition. McGraw Hill, 1993. ISBN: 0070730024
- Franzini, J., Freyberg, D., Linsley, R., and G. Tchobanoglous, Water Resources Engineering. McGraw Hill, 1991. ISBN: 0070380104

18-Env-A3 Geotechnical and Hydrogeological Engineering

Soil composition, properties, identification and classification. Particle size distribution. Seepage and permeability. Concepts of pore water pressure and effective stress. Compressibility. Capillary pressure and hydraulic head. Principles of effective stress, stress-deformation and strength characteristics of soils, consolidation, compaction, slope stability, infiltration, stress distribution with soils and settlements.

Fundamental physics and properties of groundwater flow in porous geologic material; anisotropy, heterogeneity. Introduction to the theory of groundwater flow; groundwater flow equations and patterns, recharge and discharge, flow nets, aquifer pumping, two-phase flow, well hydraulics and non-aqueous phase liquids. Numerical modeling concepts. Aquifer development and management. Wellhead protection. Impact of surface activities and over pumping on aquifer quality.

Textbooks (most recent edition is recommended):

- Cernica, J.N., Geotechnical Engineering: Soil Mechanics. Wiley Interscience, 1995. ISBN: 0471308846
- Fredlund, D.G. and H. Rahardjo., Soil Mechanics for Unsaturated Soils. Wiley Interscience, 1993. ISBN: 047185008X
- Spitz, K. and J. Moreno., A Practical Guide to Groundwater and Solute Transport Modeling. Wiley Interscience, 1996. ISBN: 0471136875
- LaMoreaux, P.E., and LaMoreaux, J.W., Environmental Hydrogeology. Lewis Publisher, 1997. ISBN: 0873719492

18-Env-A4 Water and Wastewater Engineering

Characteristics of water: physical, chemical and biological parameters, standard methods of water analyses, impact in streams and treatment of urban and agricultural runoff, population forecasting, prediction of water demand and wastewater generation, water and wastewater quality, water and wastewater treatment plants and systems: physical, chemical and biological systems, primary, secondary and tertiary treatment, sedimentation, coagulation, flocculation, filtration, adsorption, ammonia removal, aeration, anaerobic and aerobic digestion, activated sludge and trickling filter, ion exchange, lagoons, disinfection, natural treatment systems, sludge treatment and disposal, industrial wastewater treatment: characteristics of industrial wastewater, treatment levels and available technologies. Design of isolated wastewater treatment systems. Emphasis on need to consider nutrient and heat recovery as well as impact of emerging contaminants and its implication for wastewater treatment plant design.

Textbooks (most recent edition is recommended):

- N/A Metcalf & Eddy, Inc., George Tchobanoglous, H. David Stensel, Ryujiro Tsuchihashi, Franklin L. Burton, Wastewater Engineering: Treatment and Resource Recovery, published: September 3rd 2013, ISBN: 9780073401188
- N/A Water Environment Federation, Wastewater Treatment Process Modeling, Second Edition (MOP31), published: August 9th 2013, ISBN: 9780071798426
- E.W. Bob Boulware, Alternative Water Sources and Wastewater Management, published: September 11th 2012, ISBN: 9780071719513
- N/A Water Environment Federation, Safety Health and Security in Wastewater Systems, Sixth Edition, MOP 1, published: September 5th 2012, ISBN: 9780071780933
- N/A American Water Works Association, N/A American Society of Civil Engineers, Water Treatment Plant Design, Fifth Edition, Published: July 10th 2012, ISBN: 9780071745727
- Casey, T.J., Unit Processes in Water and Wastewater Engineering. Wiley Interscience, 1997. ISBN: 0471966932
- Weber, W.J. and DiGiano, F.A. Process Dynamics in Environmental Systems. Wiley Interscience. ISBN: 0471017116
- McCarty, P., and Rittmann, B., Environmental Biotechnology: Principles and Applications. McGraw-Hill, 2000. ISBN: 0072345535
- Metcalf & Eddy, Inc., Wastewater Engineering: Collection and Pumping of Wastewater. McGraw-Hill, 1981. ISBN: 007041680X
- Burton, F., Metcalf and Eddy Inc, Tchobanoglous, G., Wastewater Engineering: Treatment, Disposal and Reuse. McGraw Hill, 1991. ISBN: 0070416907
- Reed, S.C. and Crites, R.W., Natural Systems for Waste Management and Treatment. McGraw Hill, 1996. ISBN: 0071346627
- Eckenfelder, W.W. (Jr.), Industrial Water Pollution Control, (2nd Ed). McGraw-Hill, 1989. ISBN: 007018903X.

- Guyer, H.H., Industrial Processes and Waste Stream Management. Wiley Interscience, 1998. ISBN: 0471299847.
- Bishop, P., Pollution Prevention: Fundamentals and Practice. McGraw Hill, 2000. ISBN: 0073661473
- American Water Works Association, Water Treatment Plant Design, (3rd Ed.). McGraw-Hill, 1997. ISBN: 0070016437.
- American Water Works Association, Water Quality and Treatment: A Handbook of Community Water Supplies. McGraw Hill, 1998. ISBN: 0070015406
- Kawamura, S., Integrated Design and Operation of Water Treatment Facilities. Wiley and Sons, 2000. ISBN: 0471350931
- Nyer, E.K., Groundwater Treatment Technology, (2nd Ed.). Wiley Interscience, 1992. ISBN: 0471284149.
- R.L. Droste, Wiley, Theory and Practice of Water and Wastewater Treatment, 1997.

18-Env-A5 Air Quality and Pollution Control Engineering

Sources and classification of atmospheric pollutants, indoor and outdoor air pollutants, health and ecological impacts, meteorology: influence of solar radiation and wind fields, lapse rate and stability conditions, characteristics of stack plumes, Dispersion and deposition modeling of atmospheric pollutants: Eddy and Gaussian diffusion models, Puff models, effective stack heights and spatial concentration distributions, Measurement techniques. Characteristics of various air pollutant particulates, health and nuisance/aesthetic considerations (PM_{2.5} and PM₁₀) and gaseous pollutants (CO, SO_x, NO_x, etc.), their behaviour in the atmosphere, monitoring. Control of particulates: collection mechanisms and efficiencies. Control of gases and vapours: adsorption, absorption, combustion, incineration. Control of sulphur oxides and oxides of nitrogen, desulphurisation, kinetics of NO_x formation. Photochemical reactions, role of nitrogen and hydrocarbons in photochemical reactions, air toxics, mobile sources of air pollutants, noxious pollutants, and odour control. Emissions trading. Olfactometry as a method of measuring odours; its science and application.

Textbooks (most recent edition is recommended):

- Alley, E.R, Stevens, L.B., and Cleland, W. L., Air Quality Control Handbook. McGraw-Hill, 1998. ISBN: 0-07-001411-6.
- Buonicore, A.J. (ed) and W.T. Davis (ed), Air Pollution Engineering Manual. Air & Waste Management Association. Wiley-Interscience, 1992. ISBN: 0-471-28441-6.

18-Env-A6 Solid Waste Engineering and Management

Engineering design and operational aspects of waste generation, collection, storage, transfer, processing, including composting of organic waste, treatment and disposal. Engineering evaluation of: integrated waste management, solid waste characterization and classification, reduction, reuse and recycling, resource recovery and utilization. Life cycle assessment of waste, physical and chemical treatment methods and composting. Landfill design and operation including: site selection, engineered sites, liners and covers, leachate control and treatment, gas recovery and control, including utilization of recovered gas (energy), and landfill monitoring and reclamation.

Textbooks (most recent edition is recommended):

- Franchetti, Matthew J., Solid Waste Analysis and Minimization: A Systems Approach, May 27th 2009, ISBN: 9780071605243
- Bagchi, A., Design, Construction, and Monitoring of Landfills, (2nd Ed). Wiley Interscience, 1994. ISBN 0-471-30681-9.
- Sharma, H.D., and Lewis, S.P., Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation. Wiley Interscience, 1994. ISBN: 0471575364.

Group B - Optional examinations (three required)

18-Env-B1 Environmental Assessment and Management Systems

Applicable federal and provincial environmental regulations. Analysis of environmental impact using

technical and non-technical parameters. Environmental impact assessment legislation and regulatory framework. Environmental impact assessment applied to solid and liquid waste management, effluent control, air pollution control, urban development, and transportation systems. Environmental audits. Introduction to geographical information systems (GIS). Environmental management systems (EMS) ISO 14000/14001 standards, and applications. Principles of sustainable development and implications of finite biosphere and complexities for engineering design and decision-making. Design of controlled environments to enhance health and protection of natural resources for sustainable development. Resource problems and design with ecological, economic, demographic and social dimensions. Techniques to integrate knowledge and define policy. Risk analysis. Life cycle analysis. Risk management. Environmental impact assessment methods.

Textbooks (most recent edition is recommended):

- Canter, L., Environmental Impact Assessment. McGraw Hill, 1996. ISBN: 0070097674
- Bartell, S., Kolluru, R., Pitblado, R., and Stricoff, S., Risk Assessment and Management Handbook: For Environmental, Health and Safety Professionals. McGraw Hill, 1996. ISBN: 0070359873
- Lerch, I. And Paleologos, E., Environmental Risk Analysis. McGraw Hill, 2001. ISBN: 0071372660
- McGraw, D., Environmental Auditing and Compliance Manual. Wiley Interscience, 1993. ISBN: 0471285854
- Woodside, G. Yturri, J. and Aurricho, P., ISO 14001 Implementation Manual. McGraw Hill, 1998. ISBN: 0070718520
- Curran, M., Environmental Life-Cycle Assessment. McGraw Hill, 1996. ISBN 007015063X
- Dorf, R.C., Technology, Humans and Society: Toward a Sustainable World. Academic Press, 2001. ISBN: 0122210905
- Pearce, D. and Barbier, E., Blueprint for a Sustainable Economy. Earthscan Publications, 2000. ISBN: 1853835153

18-Env-B2 Water Resources

Nature and response of waste inputs to water systems, point and non-point source loading rates. River flow and reservoir analysis. Availability of groundwater resources. Diffusion, dispersion and pollutant transport mechanisms, including two phase flow. Eutrophication reduction in natural water systems. Contaminant decay modeling. Oxygen sag equation and modifications, water quality and contaminant transport in rivers. Functions of watershed models for hydraulic design, environmental assessment and flood warning. Global and national water problems, laws and legislation. Water resources and sustainable development. Technology and impacts of water conservation practices and policies on municipal service infrastructure. Storm water models and management systems. Impact of climate change on water availability.

Textbooks (most recent edition is recommended):

- Mays, L., Water Resources Handbook. McGraw Hill, 1996. ISBN: 0070411506
- Biswas, A., Water Resources: Environmental Planning, Management, and Development, McGraw Hill, 1997. ISBN 0070054835
- Ward, R.C., Loftis, J.C. and McBride, G.B., Design of Water Quality Monitoring Systems. Wiley Interscience, 1990. ISBN: 0471283886
- Veissman, W. and Hammer, M., Water Supply and Pollution Control (6th Ed.) Addison Wesley, 1998. ISBN: 032101460X

18-Env-B3 Contaminant Transport

Major types of contaminants in air, surface water and ground water. Physical phenomena governing the transport of contaminants in different environments: advection, dispersion, diffusion, sorption, ion exchange, precipitation, dissolution, volatilization, equilibrium partitioning of contaminants amongst air, water, soil, sediments and biota. Development of governing transport equations, initial and boundary conditions, completely mixed and plug flow systems. Analytical and numerical solutions, model development, calibration, verification, sensitivity analysis, prediction and post audit.

Textbooks (most recent edition is recommended):

- Fetter, C.W., Contaminant Hydrogeology. 2nd Ed., Prentice Hall, 1998.

- Schnoor, J.L., Environmental Modeling: Fate of Chemicals in Water, Air and Soil. John Wiley & Sons, New York, 1996
- Wark, K., C.F. Warner and W.T. Davis, Air Pollution: Its Origin and Control. Addison and Wesley, 1998.
- Zheng, C. and G. D. Bennett, Applied Contaminant Transport Modeling, Theory and Practice. Van Nostrand Reinhold, New York, 1995.
- Chapra, Steven, Surface Water Quality Modelling, December 31st, 2008, Waveland Press Inc., Long Grove Illinois, USA, ISBN: 978-1577666059.

18-Env-B4 Site Assessment and Remediation

Introduction to engineering, regulatory and management aspects of site assessments and restoration. Fundamentals and interactions between soils, groundwater, contaminants, and microorganisms. Site characterization and investigations. Monitoring and sampling strategies and techniques. Remedial action screening. Engineered solutions for site remediation including: physical, chemical, biological and in-situ and ex-situ techniques. Risk assessment. Brownfields. Computer modeling for assessment and remediation.

Textbooks (most recent edition is recommended):

- Ewels, J., Bioremediation Principles. McGraw Hill, 1998. ISBN: 0070577323
- Lerch, I. And Paleologos, E., Environmental Risk Analysis. McGraw Hill, 2001. ISBN: 0071372660
- Spitz, K. and Moreno, J., A Practical Guide to Groundwater and Solute Transport Modeling. Wiley Interscience, 1996. ISBN: 0471136875
- Cookson, J.T., Jr., Bioremediation Engineering - Design and Application. McGraw-Hill, New York, NY, 1995.
- Ott, W., Environmental Statistics and Data Analysis. Lewis Publishers, 1994. ISBN: 0873718488

18-Env-B5 Industrial & Hazardous Waste Management

Definition and characteristics of industrial and hazardous wastes. Industrial and hazardous waste generation rates and prevention. Introduction to I&H waste collection, transportation, treatment, monitoring, and disposal. Applicable international, federal and provincial regulations and initiatives. Municipal services and planning associated with industrial and hazardous waste management. Physical, chemical and biochemical treatment technologies, and disposal methods, including landfilling and incineration. Environmental impact of industrial and hazardous waste management. Radioactive, nuclear and biomedical waste.

Textbooks (most recent edition is recommended):

- Freeman, H.M., and Harris, E.F., Hazardous Waste Remediation-Innovative Treatment Technologies. Tecomic Publishers Lancaster P.A., 1995.
- Bagchi, A., Design, Construction, and Monitoring of Landfills, (2nd Ed). Wiley Interscience 1994. ISBN: 0-471-30681-9.
- Sharma, H.D., and Lewis, S.P., Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation. Wiley Interscience, 1994. ISBN: 0471575364.
- Bellandi, R. (ed), Hazardous Waste Site Remediation: The Engineer's Perspective. Wiley Interscience, 1995. ISBN: 0471286931.

18-Env-B6 Agricultural Waste Management

Agricultural sources of pollution (pesticides, mineral fertilizers, on-farm crop and food processing wastes and livestock wastes, wastewaters and waste seepages) and their effect on the total environment. Physical, chemical and biological properties of agricultural waste materials. Design of storage and handling systems for agricultural wastes. Physical, chemical and biological treatment processes of agricultural wastes, their life-cycle analysis, and their potential for nutrient recycling. Various methods of land application of agricultural wastes in relation to pollution problems and fertilizing value. Technologies for utilization of agricultural wastes for biogas production. Air pollution (noise, odour, dust); agriculture as carbon sink. Water quality parameters and management.

Textbooks (most recent edition is recommended):

- Unger, P.W., Managing Agricultural Residues. Lewis Pub., 1994. ISBN: 0-873-71730-9.
- Loehr, Raymond, Pollution Control for Agriculture, ISBN: 978-0-12-455260-9.

18-Env-B7 Environmental Sampling and Analysis

Practical and essential principles of water, soil and air sampling. Basic concepts in quantitative analyses of physical, chemical, and biological parameters. Tolerable levels of contaminants in air, water and soil. Sampling, sample preparation and preservation techniques, and quality assurance and quality control. Development of optimum monitoring strategy, scheduling, and sampling frequency. Database management, data analysis, statistical treatment of data, sources of error, and seasonal effects. Instrumental methods of analysis for organic and inorganic contaminants in air, water, and soil: colorimetry, chromatography, spectroscopy, electrochemical probes, remote sensing and bioassays. Basic concepts of resolution, accuracy, precision, sensitivity, calibration and control of error. Laboratory certification and standardization. Introduction of Genomics potential for Environmental Monitoring.

Textbooks (most recent edition is recommended):

- Shugar, G.L., S.L. Bauman, D.A. Drum and J. Lauber, Environmental Field Testing and Analysis Ready Reference Handbook.
- Montgomery, D C, Design and Analysis of Experiments. (5th Ed.), Wiley, New York, 2000.
- Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada. Canadian Council of Ministers of the Environment The National Contaminated Sites Remediation Program March 1996.

18-Env-B8 Instrumentation and Process Control

Basic concepts of resolution, accuracy, precision, sensitivity, calibration and control of error. Analysis and interpretation of data. Transducers for the sensing of strain, displacement, velocity, acceleration, pressure, flow, temperature, humidity, moisture content, and electromagnetic radiation. Signal conditioning for noise reduction and control. Operational amplifiers. Systems for data acquisition, telemetry, display, recording and processing. Computer interfacing. Concept of transfer functions. Response of simple chemical processes to step, ramp, and sinusoidal inputs. Transient response of interacting elements in series. Frequency response analysis of simple systems. On-off control, proportional, integral, derivative, and combinations of these control actions. Feed-back and feed-forward control. Controller tuning and algorithms. Simple stability analysis. Dynamics and control of common chemical process units.

Textbooks (most recent edition is recommended):

- Nachtigal, C.L., Instrumentation and Control - Fundamentals and Applications. John Wiley & Sons, Inc., NY, 1990.

18-Env-B9 Environmental Chemistry and Microbiology

Chemistry of organic and inorganic contaminants in the environment. Natural chemical cycles in the biosphere, geosphere, hydrosphere and atmosphere, and consequences of anthropogenic disturbances. Chemical equilibrium and kinetics. Fundamentals of aquatic, atmospheric and soil chemistry. The fate of hazardous, refractory and heavy metal pollutants in the environment. Introduction to microbial taxonomy, ecology and growth kinetics of microorganisms. The microbes of public health importance in water, soil and air, including their detection, occurrence, transport, and survival in the environment. Introduction to the application of different processes to remove contaminants in natural and engineered systems.

Textbooks (most recent edition is recommended):

- Evangelou, V.P. Environmental soil and Water Chemistry: Principles and Application. Wiley Interscience, 1998. ISBN: 0471165158
- Maier, R.M., Pepper, I. and Gerba, C. Environmental Microbiology. Academic Press, 2000. ISBN: 012497570-4
- McCarty, P., Parker G. and C. Sawyer, Chemistry for Environmental Engineering. McGraw Hill, 1994. ISBN: 0070549788

- Connell, D.W., Basic Concepts of Environmental Chemistry. Lewis Publishers, 1997. ISBN: 0873719980