School of Infrastructure

Curriculum and Syllabus for
M. Tech. (Environmental Engineering)

Eligibility Criteria for M. Tech. (Environmental Engineering)

Preceding Degree
B.E./B.Tech or equivalent degree in Civil Engineering/Environmental Engineering/ Chemical Engineering/ Biochemical Engineering

Intake: 15

Compliance Report of M. Tech. (Environmental Engineering) Curriculum

		Proposed M. Tech. Curriculum	
Components	**As per Institute Guideline**	**Proposed in M. Tech. (Environmental Engineering)**	
	No.s		**Credits**
1. Theory	**9-10**	**9 No.s**	**31-36**
2. Labs	**3-4 No.s**	**3 No.s**	**6**
3. Thesis	**2 Parts**	**2 Parts**	**30**
4. Others (Seminar)		**1 No.**	**2**
TOTAL	**65/74**		**69/74**

Curriculum for M. Tech. (Environmental Engineering)

Subject Name	Course Code	Type	L-T-P	Credit	Contact Hours
Semester-1					
Water Treatment and Supply	CE6L101	DC1	3-1-0	4	4
Wastewater Treatment	CE6L102	DC2	3-1-0	4	4
Air Pollution Control	CE6L103	DC3	3-1-0	4	4
Elective-I	CE6LXXX	DE1	3-0-0 / 3-1-0	3 / 4	3 / 4
Elective-II	XXXXXXX	DE2/OE1	3-0-0 / 3-1-0	3 / 4	3 / 4
Environmental Monitoring Laboratory	CE6P101	Lab 1	0-0-3	2	3
			Total	**20/22**	**21/23**
Semester-2					
Solid Waste Management	CE6L108	DC4	3-1-0	4	4
Elective-III	CE6LXXX	DE3	3-0-0 / 3-1-0	3 / 4	3 / 4
Elective-IV	CE6LXXX	DE4	3-0-0 / 3-1-0	3 / 4	3 / 4
Elective-V	XXXXXXX	DE5/OE2	3-0-0 / 3-1-0	3 / 4	3 / 4
Advanced Environmental Engineering Laboratory	CE6P102	Lab 3	0-0-3	2	3
Environmental Design Sessional	CE6P103	Lab 4	1-0-2	2	3
Seminar	CE6S101	Seminar	0-0-0	2	2
			Total	**19/22**	**21/24**
Industrial Internship (Optional)*					
Semester-3					
Thesis : Part-I (Environmental Engineering)	CE6D101	Thesis Part - 1	-	15	-
			Total	**15**	
Semester-4					
Thesis : Part-II (Environmental Engineering)	CE6D102	Thesis Part - 2	-	15	-
			Total	**15**	
			Grand Total	**69/74**	**42/47**

*Industrial internship is an optional subject included in the curriculum for the benefit of the student and does not carry any credit. The duration of this internship shall be a maximum of six months. The student is permitted to go for an industrial internship based on the consent from the allotted supervisor after the completion of the second semester from the month of May, which shall continue up to the month of October.

Tentative plan for the M.Tech thesis evaluation.		
Thesis	M.Tech Student (With no industrial internship)	M.Tech Student (With industrial internship)
Part-I	During the second semester	During the second semester
Part-II	November or December (Autumn)	Jan or Feb (Spring)
Part-III	April or May (Spring)	June or July (During summer vacation)

List of Departmental Core Subjects

Sl No.	Subject Code	Name	L-T-P	Credit
1	CE6L101	Water Treatment and Supply	3-1-0	4
2	CE6L102	Wastewater Treatment	3-1-0	4
3	CE6L103	Air Pollution Control	3-1-0	4
4	CE6L108	Solid Waste Management	3-1-0	4

List of Departmental/Specialisation Elective Subjects (I to III)

Sl No.	Subject Code	Name	L-T-P	Credit
1	CE6L104	Environmental Impact Assessment	3-0-0	3
2	CE6L105	Advanced Water and Wastewater Treatment	3-1-0	4
3	CE6L106	Environmental Economics	3-0-0	3
4	CE6L107	Environmental Hydraulics	3-1-0	4
5	CE6L109	Industrial Pollution Prevention	3-0-0	3
6	CE6L110	Environmental Chemistry and Microbiology	3-1-0	4
7	CE6L111	Highway Environment and Noise Pollution Control	3-0-0	3
8	CE6L112	Environmental Nanotechnology and Applications	3-0-0	3
9	CE6L113	Water Quality Modeling and Management	3-0-0	3
10	CE6L114	Thermal Techniques for Waste Management	3-0-0	3
11	CE6L115	Biological Waste Treatment	3-0-0	3
12	CE6L116	Biomass to Energy Conversion	3-0-0	3
13	CE6L117	Life Cycle Analysis and Design for Environment	3-0-0	3
14	CE6L118	Faecal Sludge Management	3-0-1	4
15	CE6L119	Environment Health and Occupational Safety	3-0-0	3
16	CE6L120	Bioenergy Resources and Technologies	3-0-0	3
17	MA6L001	Mathematical Methods	3-1-0	4
18	MA6L002	Advanced Techniques in Operation Research	3-1-0	4

NB: Any other subjects of same level floated by any other specialisations of SIF or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators

Syllabus of Departmental Core Subjects

Subject Code: CE6L101	Name: Water Treatment and Supply	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Water requirements, Types of water demands, Water demand forecasting,Surface water and ground water sources, Water quality and drinking water standards, Water treatment systems, Physico-chemical processes, Sedimentation, Coagulation, Flocculation, Granular media filtration, Disinfection, Water softening, Adsorption and ion exchange processes,Desalination, Membrane filtration, Treatment of specific contaminants: Fluoride, Nitra and Arsenic, Water supply schemes, Determination of reservoir capacity, Gravitational, pumping and combined water supply schemes, Water-lifting arrangements, Distribution reservoirs and service storage, Pumping and design considerations for pumps, Design and hydraulic analysis of water distribution system, Distribution system components, Aqueducts, Hydraulics of conduits, Appurtenances and valves, water pipes, Storage tanks, Optimization of pipe network systems, Planning of urban and metropolitan water supply project and its implementation

Text/Reference Books:

1. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Ed.
2. Bhave P. R. and Gupta R., Analysis of Water Distribution Networks, Narosa publishing house, New Delhi.
3. Qasim S. R., Motley E. M. and Zhu G., Water Works Engineering- Planning, Design and Operation, Prentice Hall.
4. Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, 2nd Ed, Ministry of Urban Development, New Delhi December.1999 (Check)
5. Hammer M. J., Water and Waste water Technology, PHI Learning.
6. McGhee T. J., Water Supply and Sewerage, McGraw Hill International.
7. Relevant BIS Codes

Subject Code: CE6L102	Name: Wastewater Treatment	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Wastewater- Sources, nature and characteristics, Population equivalent, Municipal wastewater collection, Systems of sanitation and water carriage, Estimation of wastewater flows and variation in wastewater flow, Estimation of storm water runoff, Process Flow sheets, Reactor Analysis, Unit operations and processes, Theory and Design of biological treatment processes, Aerobic treatment such as activated sludge process, Extended Aeration, oxidation ditches, Biofilm Processes: trickling filters, biotowers, MBBR and Natural Processes: waste stabilization ponds, aerated lagoon, Anaerobic treatment: upflow anaerobic sludge blanket reactor, Anaerobic Filters, sludge treatment and disposal, Design of a wastewater treatment plant.

Text/Reference Books:

1. Metcalf & Eddy., Wastewater Engineering- Treatment and Reuse (Revised by G. Tchobanoglous, F. L. Burton and H. D. Stensel), Tata McGraw Hill.
2. Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, 2nd Ed, Ministry of Urban Development, New Delhi December.
3. Hammer M. J., Water and Waste water Technology, PHI Learning.
4. McGhee T. J., Water Supply and Sewerage, McGraw Hill International.
5. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Ed.
6. Quasim S. R., Motley E. M. and Zhu G., Water Works Engineering- Planning, Design and Operation, Prentice Hall.
7. Eckenfelder, W. W., Jr. (2000) Industrial Water Pollution Control, 3d ed., McGraw-Hill

Subject Code: CE6L103	Name: Air Pollution Control	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Air pollution, Sources of air pollution, Types of pollutant, Gases and particulate; Atmospheric sources, sinks, transport; Effects on health and environment; Criteria pollutants, ambient and

source standards. Characterization of aerosols, size distributions, Gaseous Pollutants, Control systems, Air quality management, dispersion modeling. Industrial and Vehicular sources of air pollution, Behaviour of pollutants in atmosphere, Emission factors, regulations, control strategies and policies; Monitoring of air pollutants, Particulate and Gaseous Pollutant Control, Control technologies for removal of SO_2, NOx, VOC, Control technologies for motor vehicles.

Text/Reference Books:

1. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Edition.
2. Nevers N. D., Air Pollution Control Engineering, Mc. Graw Hill International Edition.
3. Buonicore A.J., and Davis W.T., Air Pollution Engineering Manual, van Nostrand-Reinhold, New York.
4. Flagan R.C., and Seinfeld J.H., Fundamentals of Air Pollution Engineering, Prentice Hall, New Jersey.
5. Wark K., Warner C. F. and Davis W., Air Pollution Its Origin and Control, 3rd edition, Harper and Row, New York.
6. Rao M. N., Air Pollution, Tata McGraw Hill, New Delhi.
7. Griffin R. D., Principles of Air Quality Management, CRC Press, Boca Raton, USA.

Subject Code: CE6L108	**Name: Solid Waste Management**	**L-T-P: 3-1-0**	**Credit: 4**

Prerequisite: None

Solid waste management: Sources, Composition and Properties of Municipal Solid Waste, Engineering principles; Generation, Onsite handling, storage and processing including segregation; Collection, Recycling, Transfer and transport,Waste processing, Recovery of resources, Waste processing technologies, Biological, chemical and thermal technologies – Composting, Anaerobic digestion, Incineration and pyrolysis,Disposal of solid waste including sanitary landfill, planning, siting, design, closure and post-closure monitoring; Regional/Integrated solid waste management related issues. Principles of E-waste Management.

Biomedical waste: Regulatory framework, categorization; generation, collection, transport, treatment and disposal.

Hazardous Waste Fundamentals, Definition, Classification, Generation, Regulatory process, Current Management Practices, Treatment and Disposal Methods, Physicochemical processes, Biological processes, Stabilization and solidification; Thermal methods; Land disposal, Remediation of Contaminated Sites.

Text/Reference Books:

1. Tchobanoglous G., Theisen H., and Vigil S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company, 1993.
2. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Edition.
3. LaGrega, M.D., Buckingham P.L., and Evans J.C., Hazardous Waste Management, McGraw-Hill International Editions, 1994.
4. Martin E.J. and Johnson J.H., Hazardous Waste Management Engineering, van Nostrand-Reinhold, 1987.
5. Wentz C.A., Hazardous Waste Management, 2nd Edition, McGraw Hill, 1995
6. VesilindP.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.
7. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2000.
8. Bhatia, S. Solid and Hazardous Waste Management, Atlantic Publishers & Distributors

Syllabus of Elective Subjects

Subject Code: CE6L104	Name: Environmental Impact Assessment	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept of environmental impact, Introduction to Environmental impact assessment (EIA) – definitions, terminology and concepts, Evolution of EIA in the USA, Key features of the National Environmental Policy Act and its implementation and the Council on Environmental Quality (CEQ) guidelines, Role of the USEPA, Evolution of
EIA in India, Sustainable development, Generalised EIA process flow chart, Screening, Initial environmental examination (IEE), Scoping, Public participation.
Environment Risk assessment, Pollution prevention and Waste minimization, sustainable development (SD), Life cycle assessment. Global Environmental Issues.
EIA - Screening and scoping criteria, Rapid and comprehensive EIA, Impact assessment methods, checklists, matrices, quantitative methods, networks, overlay mapping, Impact prediction and evaluation, Legislative and environmental clearance procedures in India and other countries, Siting criteria, CRZ, Public participation, Resettlement and rehabilitation.
Practical applications of EIA, EIA methodologies, Baseline data collection, Prediction and assessment of impacts on physical, biological and socio-economic environment, Environmental management plan, Post project monitoring, initial environmental examination (IEE), environmental impact statement (EIS), environmental appraisal, environmental audit (EA), Environmental impact factors and areas of consideration, measurement of environmental impact, organisation, scope and methodologies of EIA, case studies stressing physical aspects of environment, Evolution of EIA, EIA at project, Regional and policy levels, Strategic EIA, EIA process.

Text/Reference Books:

1. Canter L., Environmental Impact Assessment, McGraw Hill.
2. Asolekar S. R. and Gopichandran R. Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK).
3. Rau G.J. and Wooten, C.D., Environmental Impact Analysis Handbook, McGraw Hill.
4. Dhameja S. K., Environmental Engineering and Management, S. K. Kataria& Sons
5. Anjaneyulu Y. , Environmental impact assessment methodologies, B.S. Publications
6. World Bank 'Environmental Assessment Source Book', Environment Dept., Washington D.C.
7. Welford R., Corporate Environmental Management, Earthscan Publications Limited, London.
8. Sayre D., Inside ISO 14000: Competitive Advantage of Environmental Management, St. Louis Press, Florida.

Subject Code: CE6L105	Name: Advanced Water and Wastewater Treatment	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Capabilities and limitations of conventional water and waste water treatment methods, Need for advanced treatment of water and waste water, Advanced water treatment- Iron and manganese removal, colour and odour removal, activated carbon treatment, carbonate balance for corrosion control, ion exchange, electro-dialysis, reverse osmosis and modern methods and flouride management.

Nitrogen and phosphorus removal methods including biological methods, Methods for the removal of heavy metals, oil and refractory organics, Micro-screening, ultra-filtration, centrifugation and other advanced physical methods- aerobic/anaerobic digestion, anaerobic filtration, novel methods of aeration etc.,

Combined physico-chemical and biological processes, Pure oxygen systems, Filtration for high quality effluents, Multistage treatment systems, Land treatment and other resources recovery systems. Decentralised wastewater treatment systems; Reliability and cost effectiveness of wastewater systems. Natural treatment systems- floating aquatic plant treatment systems,

constructed wetlands. Industrial Wastewater management and reuse, removal of industry specific pollutants

Text/Reference Books:

1. Metcalf & Eddy., Wastewater Engineering- Treatment and Reuse (Revised by G. Tchobanoglous, F. L. Burton and H. D. Stensel), Tata McGraw Hill.
2. PeavyH. S.,Rowe D. R.,and Tchobanoglous G., Environmental Engineering, McGraw-Hill InternationalEdition.
3. Nemerow N. L and Dasgupta A., Industrial and Hazardous Waste Treatment, Van Nostarnd Reinhold (New York).
4. Arceivala S.J. and Asolekar S.R., Wastewater Treatment for Pollution Control and Reuse, Tata McGraw Hill.
5. Eckenfelder, W. W., Industrial Water Pollution Control, McGraw-Hill.
6. Nemerow, N. L., Zero Pollution for Industry: Waste Minimization through Industrial Complexes, John Wiley & Sons.
7. Cites R W., Middlebrooks E J., Reed S C., Natural wastewater Treatment Systems, CRC Taylor and Francis.
8. Patwardhan A.D., Industrial Wastewater Treatment, PHI Learning
9. S.R. Qasim, Edward and Motley and Zhu, H., "Water Works Engineering – Planning, Design and Operation", Prentice Hall, India.
10. S. Vigneswaran and C. Visvanathan, "Water Treatment Processes: Simple Options", CRC Press.

Subject Code: CE6L106	**Name: Environmental Economics**	**L-T-P: 3-0-0**	**Credit: 3**

Prerequisite: None

Introduction to Environmental Economics: Scope of the problem, Interaction between economy and environment, Economist's perspectives on environmental problems. Brief idea about Quality of natural Environment and Environmental problems (Air Pollution, Water Pollution, Toxic Emission, ecosystem health).Introduction to Environmental Policy Instruments: Choice of policy instrument, command and control instruments, taxation, tradable permits, Environmental performance bonds

Public and environmental goods, negative externality and market failure, Internalization Environmental Valuation: Contingent valuation methods, travel cost method, hedonic price method

Economics of natural resources: Natural Resources (renewable and non-renewable), Population dynamics, extraction of non-renewable resources, depletion, resource modeling,

Green and Natural resource accounting: GDP, NDP and sustainable development, Environmental accounting

Social efficiency and benefit-cost analysis: Efficiency and competitive markets, supply, demand and efficiency, benefit and cost analysis

Sustainable development and irreversibility in environmental policy: definition, economical efficiency, economic growth and environment

Global Environmental Issues and policies: Climate Change: Causes; possible effects; costs of mitigating greenhouse gas emissions; Carbon Trading, adaptation measures, Design of international agreements, Environmental conflict, bargaining and cooperation, Environmental issues and policies in India

Text/Reference Books:

1. KolstadC.D., Environmental Economics, Oxford University Press.
2. Conrad J. M., Resource Economics. Cambridge University Press
3. Bhattacharya R.N., Environmental economics: an Indian perspective, Oxford University Press, New Delhi.
4. Hanley N., Shogren, J. F., and White, B., Environmental economics in theory and practice. Oxford university press, New York.
5. CommonM. and Stagi, S., Ecological Economics an introduction, Cambridge University Press.
6. GraftonR. Q. andAdamowicz W., The economics of the environment and natural resources, Wiley Blackwell Publication.

7. Baumol W.J. and OatesE.E., The Theory of Environmental Policy, Cambridge University Press
8. TitenbergT., Environmental Economics and Policy, Addision-Wesley

Subject Code: CE6L107	Name: Environmental Hydraulics	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Introduction to the principles of fluid dynamics, continuity, momentum and energy equations, Basic concepts in friction and flow in pipes, Flow formulation, turbulent and viscous flow, Hardy-Cross, Tong O Conner and other methods of analysis of pipe networks, Basic concepts in open channel hydraulics, Energy and momentum equations, critical flow, channel control and transitions, uniform flow, gradually varied flow, flow profiles and their computation, unsteady flow, hydraulic jumps, Design of drainage systems, Ground water hydraulics, estimation of aquifer parameters, confined and unconfined aquifers, steady and unsteady flow into wells, Dupuit approximations, single and multi-well system, well losses, recharging, well developments etc., movement of pollutants in ground water and wastewater treatment plants hydraulics. Different Flow measurement devices in channels and pipes

Text/Reference Books:

1. Chow V T, Flow through open channel, McGraw-Hill, 1973.
2. Ranga Raju K. G., Flow through Open Channels, Second edition, TATA McGraw-Hill, 1997.
3. Garde R. J. and Ranga Raju K. G., Mechanics of sediment transportation and alluvial stream problems, Third edition, New Age International (P) Limited, New Delhi, 2000.
4. Bhave P. R., Analysis of Flow in Water Distribution Network, Technomic Publishing Co., Lancaster, USA, 1996.
5. Todd D. K. Groundwater Hydrology , John Wiley publishers , 2004
6. Jacob and Bear, Hydraulics of Groundwater, McGraw Hill, 1997
7. Raghunath, Groundwater & Well Hydraulics, Wiley Eastern Ltd, New Delhi, 1992

Subject Code: CE6L109	Name: Industrial Pollution Prevention	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Principles and techniques for industrial pollution prevention and waste minimization; Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Source reduction tools and techniques:raw material substitution, toxic use reduction and elimination, process modification and procedural changes; Recycling and reuse; Opportunities and barriers to cleaner technologies; Pollution prevention economics; Waste audits, emission inventories and waste management hierarchy for process industries; Material balance approach;
Material and process mapping approach; Emission sources; Estimation of fugitive emissions; Environmental impact of VOCs; Energy and resource (material and water) audits for efficient usage and conservation. Unit operations in separation technology; Pollution prevention for unit operations: Boilers and Heat Exchangers;
Storage tanks; Distillation columns; Application of separation technologies for pollution prevention; Process optimization for cleaner industrial processes: Flow sheet analysis: qualitative and quantitative approaches using mass exchange networks; Thermodynamic constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks. Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries. Presently used wastewater treatment systems such as MBR, MBBR, SBR, UASB reactor, Anammox, etc

Text/Reference Books:

1. Freeman H. M. Industrial Pollution Prevention Handbook, McGraw Hill.
2. Shen T. T., Industrial Pollution Prevention, Springer
3. Bishop P.E. Pollution Prevention: Fundamentals and Practice, McGraw Hill.
4. Allen D.T. and Rosselot, K.S. Pollution Prevention for Chemical Processes, John Wiley.
5. Allen D.T., Bakshani, N. and Rosselot, K.S., Pollution Prevention: Homework and Design Problems for Engineering Curricula, American Institute for Pollution Prevention, and Center for Waste Reduction Technologies.

6. Johansson A., Clean Technology, Lewis Publishers, Boca Raton.
7. Theodore, L. and McGuinn, Y. C.Pollution prevention, Van Nostrand Reinhold, NewYork.
8. Eckenfelder, W. W., Industrial Water Pollution Control, McGraw-Hill.
9. Nemerow, N. L., Zero Pollution for Industry: Waste Minimization through Industrial Complexes, John Wiley & Sons.

Subject Code: CE6L110	Name: Environmental Chemistry and Microbiology	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Environmental chemistry-basic concepts from general chemistry, Chemical equations, chemical reactions, calculation from chemical reactions, solutions, activity and activity coefficients, Chemical Equilibria and Kinetics Fundamentals, Acid-Base equilibria – fundamentals, equilibrium diagrams, Acidity, Alkalinity, Buffers and Buffer Intensity, Chemical equilibrium calculations, pC-pH diagram, Langelier index, Solubility diagram, Oxidation and Reduction equilibria.

Water and wastewater quality parameters and their analysis, Basic concepts of quantitative analytical chemistry, instrumental methods of analysis.

Types of microorganisms found in the environment, Metabolic classification of organisms, Enzyme and enzyme kinetics, indicator organisms, coliforms - fecal coliforms - E.coli, Streptococcus fecalis differentiation of coliforms - significance - MPN index, M.F. technique, standards, Microbiological Parameter Analysis, Measurements and Isolation of Microorganism, Different Cultures, Media and Techniques of Staining and Enumeration of microorganism, Staining and detection of microbes, Methods of enumerating microbes, Multiple tube fermentation technique, Membrane filter technique.

Text/Reference Books:

1. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineers, 4th Edition, McGraw Hill, New Delhi, 1994.
2. Benefield, Judkins and Weand – Process Chemistry for Water and Wastewater Treatment, Prentice Hall
3. Maier R. M., Pepper I. L., and Gerba C. P., Environmental Microbiology, Second Edition, Elsevier- AP, 2009.
4. Pelczar, Jr, M.J., Chan, E.C.S., Krieg, R.N., and Pelczar M. F, Microbiology, 5thEdn., Tata McGraw-Hill Publishing Company Limited, New Delhi, 1996.
5. Rittman B, McCarty P L McCarty P, Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000

Subject Code: CE6L111	Name: Highway Environment and Noise Pollution Control	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Sources and Classification of Noise, Effects of Noise, Noise Measuring Instruments and Survey: Sound level meter, audiometer, dose meter, octave band analyzer; Noise Indices: Leq, Ldn, TNI, NII, Noise Control Measures: noise control at source, path and receiver, acoustic barriers, enclosures, control of machinery noise, community and industrial noise control strategies; Noise Standards in India and Abroad; Noise Impact Assessment and Prediction Techniques.

Human factors in road user behaviour, vehicle characteristics, driver, road and environment. Environmental Factors: impacts and mitigation measures of air quality, noise, severance, visual intrusion, impact on water quality, use of limited resources, impact on flora & fauna, vibration, dust ; Transport related pollution. Urban and non urban traffic noise sources, Noise pollution. Traffic calming, Measures, Road transport related air pollution, sources of air pollution, effects of weather conditions, Vehicular emission parameters, pollution standards, measurement and analysis of vehicular emission; control measures; EIA requirements of Highways projects.

Text/Reference Books:

1. Tripathy D.P., Noise Pollution, APH Pub., New Delhi.
2. Sengupta M., Environmental Engineering (Vol. 2), CRC Press, Boca Raton.
3. Pandey G.N. and Carney G.C., Environmental Engineering, Tata McGrawHill, New Delhi.
4. Beranek L., Noise and Vibration Control, McGrawHill Co, NY.

5. Trivedy P.R. Int. Encyclopedia of Ecology & Environment, Noise Pollution (Vol. 13), IIEE, New Delhi.
6. Wark K., Warner C.F. and Davi, W.T., Air Pollution: Its Origin and Control, Prentice Hall.
7. Boubel R.W. Fundamentals of Air Pollution, Academic Press.
8. Vallero D., Fundamentals of Air Pollution, Academic Press.
9. Canter L., Environmental Impact Assessment, McGraw-Hill International.

Subject Code: CE6L112	Name: Environmental Nanotechnology and Applications	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to nanotechnology, Nanomaterial properties and classification, Synthesis of nanomaterials - top-down approach and bottom-up approach, synthesis of nanocrystals and membranes, development of carbon nanotubes (CNTs), structure and properties of fullerene, C60, carbon nanotube and fibre, organized assembly of CNTs etc, Nanocomposites, Nanomaterial characterisation.

Environmental applications - Nanotechnology-based water/wastewater treatment strategies - – adsorption, hydrogen storage, photocatalysis - photocatalysts preparation and characterization, UV induced hydrophobicity, modification of photocatalysts, nanoscale biometal for subsurface remediation, nano-sensors- sensing materials, introduction to novel sensing materials, operation principle, mass and optical sensors, nano-sensing systems and applications.

Text/Reference Books:

1. Wiesner M., Bottero J-Y., Environmental Nanotechnology : Applications and Impacts of Nanomaterials Applications and Impacts of Nanomaterials, McGraw Hill Professional.
2. Pradeep T., Textbook of Nanoscience and Nanotechnology, McGraw Hill Education (India) Private Limited
3. Mittal V., Nanocomposites with Biodegradable Polymers: Synthesis, Properties, and Future perspectives., Oxford University Press

Subject Code: CE6L113	Name: Water Quality Modeling and Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanism-advection, diffusion, dispersion; River and streams, convective diffusion equation and its application. Estuaries, Estuarine hydraulics, Estuarine water quality models; Lakes and reservoirs, eutrophication; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes Contaminant transport in unsaturated flows, solute transport models for conservative species, solute transport in spatially variable soils; Contaminant transports in ground water advection, dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, bio degradation reaction; Water quality management, socio-economic aspects of water quality management, management alternatives for water quality control, waste load allocation process, lake quality management, ground water remediation.

Text/Reference Books:

1. Ramaswami A., Milford J. B., Small M. J., Integrated Environmental Modeling - Pollutant Transport, Fate, and Risk in the Environment John Wiley & Sons, 2005.
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems, Oxford University Press, 1998.
3. Snape J.B., Dunn I.J.,Ingham J., and Prenosil J., Dynamics of environmental bioprocesses, modelling and simulation Weinheim: VCH, 1995.
4. International Water Association - Activated sludge modelling ASM1 and ASM2
5. Chapra S. C., Surface Water Quality Modeling, McGraw-Hil, Inc., New York, 1997.
6. Garde R. J., and Ranga Raju K. G., Mechanics of sediment transportation and alluvial stream problems, Third edition, New Age International (P) Limited, New Delhi
7. Thomann, R.V. and Mueller, J.A. Principles of surface water quality modeling and control, Pearson, 1987

8. Chapra, S.C. Surface water quality modelling, Waveland Press, INC., 1997
9. Schnoor, J.L., Environmental Modeling Wiley, John & Sons, 1997
10. Thomann, R.V., Systems Analysis and Water Quality Management, McGraw Hill, 1972

Subject Code: CE6L114	Name: Thermal Techniques for Waste Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Fundamentals of Thermodynamics, Heat Transfer and Combustion as applied to Waste Incineration. Introduction to fuels, reactor design, fluidization engineering and furnace technology. Combustion of gaseous, liquid and solid fuels. Wastes as fuels. Low, medium and high temperature thermal treatment techniques, Pyrolysis, Gasification processes. Biochar, Hydrochar production. Energy recovery, pollution control techniques for thermal facilities, Design of thermal treatment facilities with pollution control devices.

Text/Reference Books:

1. Tchobanoglous G., Theisen H., and Vigil S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company, 1993.
2. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Edition.
3. LaGrega, M.D., Buckingham P.L., and Evans J.C., Hazardous Waste Management, McGraw-Hill International Editions, 1994.
4. Martin E.J. and Johnson J.H., Hazardous Waste Management Engineering, van Nostrand-Reinhold, 1987.
5. Wentz C.A., Hazardous Waste Management, 2nd Edition, McGraw Hill, 1995
6. VesilindP.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.

Subject Code: CE6L115	Name: Biological Waste Treatment	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Qualitative and quantitative characterization of wastes; Waste disposal norms and regulations; Indian regulations; Principles of biological treatment; Aerobic and anaerobic biological wastewater treatment systems; Suspended and attached cell biological wastewater treatment systems; Biological nutrient removal; Treatment plant design calculations; Treatment and disposal of sludge; biological means for stabilization and disposal of solid wastes; Anaerobic Digestion, Composting, Treatment of hazardous and toxic wastes; Degradation of xenobiotic compounds; bioremediation.

Text/Reference Books:

1. Evans, Gareth. Biowaste and biological waste treatment. Routledge, 2014.
2. Environmental Biotechnology: Concepts and Applications. Germany: Wiley. 2006
3. Tchobanoglous G., Theisen H., and Vigil S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company, 1993.
4. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Edition.

Subject Code: CE6L116	Name: Biomass to Energy Conversion	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Biomass and solid wastes, Broad classification, Second and Third Generation biofuels, Production of biomass, photosynthesis, Separation of components of solid wastes and processing techniques, Agro and forestry residues utilisation through conversion routes: biological, chemical and thermo chemical, Bioconversion into biogas, mechanism, Composting technique, Bioconversion of substrates into alcohols, Bioconversion into hydrogen, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuel, pyrolysis, gasification, combustion, chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Fuel combustion into electricity, case studies.

Text/Reference Books:

1. De Jong, Wiebren, and J. Ruud Van Ommen. Biomass as a sustainable energy source for the future: fundamentals of conversion processes. John Wiley & Sons, 2014.

2. Dahlquist, Erik, ed. Technologies for converting biomass to useful energy: combustion, gasification, pyrolysis, torrefaction and fermentation. CRC Press, 2013.

Subject Code: CE6L117	Name: Life Cycle Analysis and Design for Environment	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Engineering products and processes : Environmental health and safety, Product life cycle stages, Material toxicity, pollution, and degradation, Environmentally conscious design and manufacturing approaches, Sustainable development and industrial ecology. System life-cycles from cradle to reincarnation, Product life-extension, Organizational issues. Pollution prevention practices, Manufacturing process selection and trade-offs. Design for Environment : Motivation, concerns, definitions, examples, guidelines, methods, and tools. Recyclability assessments, Design for recycling practices. Re- manufacturability assessments, Design for Remanufacture / Reuse practices. Industrial ecology and Eco-industrial parks. Eco-Labels and Life-Cycle analysis (LCA): LCA methodology, steps, tools and problems, Life-Cycle Accounting and Costing. ISO 14000 Environmental Management Standards. New business paradigms and associated design practices.

Text/Reference Books:

1. Naushad, Mu, ed. Life cycle assessment of wastewater treatment. CRC Press, 2018.
2. Shaked, S., Crettaz, P., Saade-Sbeih, M., Jolliet, O., & Jolliet, A. Environmental life cycle assessment, 2015.

Subject Code: CE6L118	Name: Faecal Sludge Management	L-T-P: 3-0-1	Credit: 4

Prerequisite: None

Introduction to Faecal Sludge Management, Characteristics of Faecal Sludge, Containment system, Treatment mechanisms, Collection and transport of Faecal Sludge, Technologies for Faecal Sludge Management, Settling-thickening tank, Drying beds, Co-treatment of Faecal Sludge, Value-added products from Faecal Sludge, Shit-Flow Diagram (SFD), Planning of city wide Faecal Sludge Management systems.

Text/Reference Books:

1. Strande, L., Ronteltap, M. & Brdjanovic, D. (2014). Faecal sludge management: systems approach for implementation and operation. IWA publishing.
2. Velkushanova, K., Brdjanovic, D., Koottatep, T., Strande, L., Buckley, C., & Ronteltap, M. (2021). Methods for faecal sludge analysis. IWA publishing.

Subject Code: CE6L119	Name: Environmental Health and Occupational Safety	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Environmental Health, Right to Healthy Environment, Nature of Environmental Health Hazards, Workplace psychology and Environment, Occupational safety and health, Characteristics of the workplace environment, Identifying safety and health hazards, Accountability for safety and health hazards, Workplace hazards (Biological, Chemical, Physical and Ergonomic), Types of Exposure, Effects of Biological, chemical, Physical and Ergonomic agents, Risk management at workplace, Occupational diseases, Standards for categorization and recognition of occupational diseases, Workplace safety and health management, Employer's responsibilities, Health promotion, education and training, Waterborne diseases, Vector-borne diseases, Airborne diseases, Natural disaster and Health.

Text/Reference Books:

1. Gupta, P. (2024). Environmental Health and Occupational Safety. CRC Press.
2. Arezes, P. M., Baptista, J. S., Barroso, M. P., Carneiro, P., Cordeiro, P., Costa, N., ... & Perestrelo, G. (Eds.). (2019). Occupational and environmental safety and health. Springer International Publishing.

Subject Code: CE6L120	Name: Bioenergy Resources and Technologies	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to bioenergy, harvesting and availability assessment of biomass; Characterization and classification of biomass feedstock; Next Generation Biofuels: First, second, third and fourth generation biofuels; Different pre-treatment processes of biomass: Biophysical, Biochemical, Physicochemical, thermal; Cellular Bioenergetic Pathways; Enzyme Kinetics, Immobilized Enzymes; Microbial Growth kinetics, Metabolic engineering; Biochemical methods (anaerobic, enzymatic-saccharification and fermentation process, and dark fermentation, ABE fermentation) for biofuel production; Biodiesel production: chemical processes: trans-esterification, hydro-processing microemulsification; Thermochemical methods (combustion, gasification, pyrolysis, partial oxidation, auto-thermal reforming) for biofuels production including synthesis gas, ethanol, butanol, biogas, methanol and dimethyl ether for biofuel production; Different types of bioreactors and reactor analysis; Design, Analysis and Stability of Bioreactors; Production of Cellulosic Fuels: kinetics and thermodynamics; Bio-hydrogen production: Biophotolysis, Dark Fermentation, Poto-fermentation; Microbial Fuel Cell (MFC): Uncoupled bioreactor MFC, Integrated bioreactor MFC; Bio Jet Fuel Conversion, Technologies: Alcohol-to-Jet (ATJ) Fuel, Oil-to-Jet (OTJ) Fuel, Gas-to-Jet (GTJ) Fuel, Sugar-to-Jet (STJ) Fuel.

Text/Reference Books:

1. ByJohn Twidell, Tony Weir. Renewable Energy Resources , Taylor and Francis, 2015.
2. Jay J. C., Biomass to Renewable Energy Processes, Taylor and Francis, CRC Press, 2018.
3. Konur O., Bioenergy and Biofuels, Taylor and Francis, CRC Press, 2018.
4. Love J. and Bryant J. A., Biofuels and Bioenergy, John Wiley & Sons, 2017.
5. Henderson O. P., Biomass for Energy, Nova Science Publishers, 2011.

Subject Code: MA6L001	**Name: Mathematical Methods**	**L-T-P: 3-1-0**	**Credit: 4**

Prerequisite: None

Probability and Statistics : Random variables (rv) and their properties, some standard discrete and continuous rv, Expectation, Variance, moments, moment generating functions, functions of a rv, their distribution and moments, joint, marginal and conditional distribution and independence of rvs, Hypothesis testing.

Numerical solutions of systems of linear equations: Gauss elimination, LU decomposition, Gauss-Jacobi and Gauss-Seidel methods.

Numerical methods of ODE and PDE: Runge-Kutta and finite difference methods for ODE, Finite difference methods for solving 2-D Laplace's equation, Poisson's equation, 1-D heat equation : Bender Schmidt, Crank Nicholson method and Du Fort Frankel methods, 1-D wave equation using Explicit method. Consistency and stability analysis.

Text/Reference Books:

1. Grawel B.S. Numerical Methods
2. Jain M.K., Iyengar S.R.K. and Jain R.K., Numerical Methods-problem and solutions, Wiley Eastern Limited, 2001.
3. Ross S. Introduction to Probability Models, Wiley India
4. Gun A.M., Gupta M.K. and Gupta B.S. Fundamentals of Statistics
5. Hayter A.J., Probability and Statistics, Duxbury, 2002
6. Scarborough J.B., Numerical mathematical analysis, Oxford & IBH Publishing Co.Pvt.,2000
7. Hamming R.W., Numerical Methods for Scientist and Engineers, McGraw Hill, 1998
8. Mathews J.H. and Fink, K.D., Numerical Methods using MATLAB, Pearson Education, 2004.

Subject Code: MA6L002	**Name: Advanced Techniques in Operation Research**	**L-T-P: 3-1-0**	**Credit: 4**

Prerequisite: None

One variable unconstrained optimization, multivariable unconstrained optimisation, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization, quadratic programming, separable programming, convex and non convex programming, steepest and Quasi-Newton method. Dynamic Programming: Characteristics of dynamic problems, deterministic dynamic programming and probabilitistic dynamic programming, Network analysis, Shortest path problems, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, network simplex, interior point methods, stochastic programming, Nonlinear goal programming applications, Geometric Programming.

Multi-objective Optimization Problems: Linear and non linear programming problems, Weighting and Epsilon method, P-norm methods, Gradient Projection Method, STEM method, Convex Optimization.

Text/Reference Books:

1. Rao S.S., Engineering Optimization Theory and Practices, John Wiley and Sons, 2009
2. Ehrgott., M. Multi-criteria Optimization, Springer 2006
3. Miettien K.M., Non-linear multi-objective optimization, Kluwers International Series, 2004
4. Deb K., Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

Syllabus of Laboratory Subjects

Subject Code: CE6P001	Name: Environmental Monitoring laboratory	L-T-P: 0-0-3	Credit: 2

Physical and chemical characteristics of water and wastewater, Optimum coagulant dose, Break point Chlorination, DO, BOD and COD, Microbial characteristics of water – total and fecal coliforms, Settling Column Analysis, Indoor and Outdoor air quality Analysis, Detection of environmental noise.

Text/Reference Books:

1. Standard methods for the examination of water and wastewater, APHA, 20thEdition, Washington, 1998
2. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineers, 4thEdn. McGraw Hill, New Delhi, 1994.
3. Garg, S.K., "Environmental Engineering Vol. I & II", Khanna Publishers, New Delhi
4. Modi, P.N., "Environmental Engineering Vol. I & II", Standard Book House, Delhi-6

Subject Code: CE6P002	Name: Advanced Environmental Engineering laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Use of analytical instruments such as AAS, GC, HPLC, TOC for gas and micropollutant analysis, heavy metal detection, use of microscope, isolation and analysis of microbes, Proximity and Ultimate Analysis of Solid Waste, Ambient air quality Analysis - Determination of SPM, PM_{10}, $PM_{2.5}$, CO, NOx and SOx, Tracer Studies for Reactors, Adsorption Kinetics, Biodegradation Kinetics

Text/Reference Books:

1. Standard methods for the examination of water and wastewater, APHA, 20thEdition, Washington, 1998
2. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineers, 4th Edn. McGraw Hill, New Delhi, 1994.

Subject Code: CE6P003	Name: Environmental Design Sessional	L-T-P: 1-0-2	Credit: 2

Prerequisite: None

Environmental engineering hydraulic design: design of distribution systems, design of urban sanitary and storm water sewers, design of water and wastewater pumping systems. Design of intake structure, detailed design of water treatment plant, Design of wastewater treatment and disposal systems, use of ANOVA, statistical analysis of case studies, use of software in environmental design.

Text/Reference Books:

1. Bhave P R , Optimal Design Of Water Distribution Networks, Narosa publishing house, New Delhi., 2003
2. Bhave P R and Gupta R., Analysis of Water Distribution Networks, Narosa publishing house, New Delhi, 2006.
3. Montgomery, J.M., Water Treatment Principles and Design, John Wiley and Sons.
4. Check for R. Qasim Books for Design of Water Treatment Plant and Wastewater treatment Plant

5. Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, 2nd Ed, Ministry of Urban Development, New Delhi December 1999. - Check its date
6. Central Public Health and Environmental Engineering Organization, Manual on Sewerage and Sewage Treatment, 2nd Ed, Ministry of Urban Development, New Delhi, December 2014- Check 2014
7. Quasim, S. R., Motley E. M. and Zhu, G., Water Works Engineering- Planning, Design and Operation, Prentice Hall, 2000.