JNTUA College of Engineering (Autonomous), Ananthapuramu
DEPARTMENT OF CHEMICAL ENGINEERING

M. Tech Environmental Engineering
Course Structure & Detailed Syllabus

I SEMESTER

Course No.	Name of the course	Periods per week			Maximum marks			Credits
		Lec	Lab	Total	Ext	Int	Total	
16D62101	Principles of Environmental Science	4	-	4	60	40	100	4
16D62102	Environmental Policies &Legislation	4	-	4	60	40	100	4
16D62103	Environmental Impact Assessment	4	-	4.	60	40	100	4
16D62104	Mathematical Modeling and Simulation	4	-	4	60	40	100	4
16D62105	Instrumental Techniques in Environmental Analysis	4	-	4	60	40	100	4
	Elective - I	4	-	4	60	40	100	4
16D62110	Lab-I: Environmental Pollution Monitoring Laboratory	-	4	4	60	40	100	2
	Total	24	4	28	420	280	700	26

Elective – I

1. **16D62106**-Water Resources Systems Management
2. **16D62107**-Occupational Health & Safety
3. **16D62108**-Environmental Economics and Management
4. **16D62109**-Environmental Biotechnology

II SEMESTER

Course No.	Name of the course	Periods per week			Maximum marks			Credits
		Lec	Lab	Total	Ext	Int	Total	
16D62201	Transport of Water and Wastewater	4	-	4	60	40	100	4
16D62202	Physicochemical Processes in Water and Waste Water	4	-	4	60	40	100	4
16D62203	Principles and Design of Biological Treatment Systems	4	-	4	60	40	100	4
16D62204	Atmospheric Environmental Pollution And Control	4	-	4	60	40	100	4
16D62205	Solid & Hazardous waste Management	4	-	4	60	40	100	4
	Elective-II	4	-	4	60	40	100	4
16D62210	Lab-II: Environmental Pollution Control Lab		4	4	60	40	100	2
15D54201	Research Methodology (Audit course)	2	-	2	-	-	-	-
	Total	24	4	36	420	280	700	26

Elective – II

1.**16D62206-**Energy and Environment
2. **16D62207-**Principles of Cleaner Production
3. **16D62208 -**Environmental Sustainability
4. **16D62209 -** RS and GIS for Environmental Management

III & IV SEMESTER

Course No.	Name of the course	Period	Max. marks		
			Exam	Sess.	Total
	Seminar	One Semester	Internal	100	100
	Project	Two Semesters	Viva-Voce	----	----

PRINCIPLES OF ENVIRONMENTAL SCIENCE

UNIT I:

Introduction:

Law of Mass Action – Chemical equilibria – Chemical kinetics – Colloidal Chemistry, Corrosion, Solubility of gases in water (Henry's Law) and the Carbonate system.

UNIT II:

Aim - scope and applications of Ecology, Ecological Engineering and Ecotechnologyandtheir relevance to human civilization - Development and evolution of ecosystems -Principles and concepts pertaining to communities in ecosystem - Energy flow andmaterial cycling in ecosystems - Productivity in ecosystems.

UNIT III:

Water Quality-Physical, Chemical and Biological parameters of water- Water Qualityrequirement - Potable water standards -Wastewater Effluent standards -Water quality indices.

UNIT IV:

Chemistry of Atmosphere &Aquatics:

Structure of the atmosphere – Photochemistry of the atmosphere – ozone layerdepletion – Acid rain – Greenhouse gases and global warming.

Soil Physical& Chemical properties – Cation Exchange Capacity. Soil pH – Salt affected soil – Trace metals in soils

Types of Reactions for Various Water bodies including Marine environment.

UNIT V:

Global Environmental Issues:

Ecological and Carbon Foot Print, Carbon Credits, Carbon sequestration, Clean Development Mechanism.

Case Studies: Major Environmental Disasters – Chernobyl Incident – Fukushima Incident – Tsunamis.

Text Books:

1. Biswarup Mukherjee, Environmental Biology, Tata McGraw Hill Publishing Company Limited, New Delhi, 1997.
2. IgnaciMuthu S, 'Ecology and Environment' Eastern Book Corporation, 2007.

References:

3. Manohaan, S.E., Environmental Science and Technology, Lewis Publication, New York, 1997.
4. Sawyer, C.N., McCarty, P.L. and Parkin, G.F. Chemistry for Environmental Engineers, 4th Edition, McGraw Hill, New Delhi, 1994.
5. De, A.K. Environmental Chemistry, New Age International Limited, New Delhi, 1995.
6. Krebs, Charles J. 2001. Ecology: The Experimental Analysis of Distribution and Abundance.5th edition.
7. Mitsch, J.W. and Jorgensen, S.E., Ecological Engineering, An Introduction to Ecotechnology, John Wiley & Sons, New York, 1989.

ENVIRONMENTAL POLICIES AND LEGISLATION

UNIT I

Introduction: Indian Constitution and Environmental Protection – National Environmental policies –Precautionary Principle and Polluter Pays Principle – Concept of absolute liability – multilateral environmental agreements and Protocols – Montreal Protocol, Kyotoagreement, Rio declaration – Environmental Protection Act, Water (P&CP) Act, Air(P&CP) Act – Institutional framework (SPCB/CPCB/MoEF)

UNIT II

Water (P&CP) Act, 1974: Power & functions of regulatory agencies - responsibilities of Occupier Provision relating toprevention and control Scheme of Consent to establish, Consent to operate – Conditionsof the consents – Outlet – Legal sampling procedures, State Water Laboratory – AppellateAuthority – Penalties for violation of consent conditions etc. Provisions forclosure/directions in apprehended pollution situation.

UNIT III

Air (P&CP) Act, 1981: Power & functions of regulatory agencies - responsibilities of Occupier Provision relating toprevention and control Scheme of Consent to establish, Consent to operate – Conditionsof the consents – Outlet – Legal sampling procedures, State Air Laboratory – AppellateAuthority – Penalties for violation of consent conditions etc. Provisions forclosure/directions in apprehended pollution situation.

UNIT IV

Environment (Protection) Act 1986: Genesis of the Act – delegation of powers – Role of Central Government - EIA Notification– Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodiesmitigation scheme etc., for Municipal Solid Waste Management - Responsibilities ofPollution Control Boards under Hazardous Waste rules and that of occupier, authorization – Biomedical waste rules – responsibilities of generators and role of Pollution ControlBoards

UNIT V

Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC – PublicInterest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

REFERENCES

1. CPCB, “Pollution Control acts, Rules and Notifications issued there under “PollutionControl Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
2. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “OxfordUniversity Press, New Delhi, 2001.
3. GregerI.Megregor, “Environmental law and enforcement”, Lewis Publishers, London.1994.

ENVIRONMENTAL IMPACT ASSESSMENT

Unit -I:

Basic concept of EIA and Methodologies: Initial environmental Examination, Elements of EIA,factors affecting EIA Impact evaluation and analysis, preparation of Environmental Base map,Classification of environmental parameters.

Unit-II:

EIA Methodologies: Introduction, Criteria for the selection of EIA Methodology, EIA methods, Ad-hoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods, cost/Benefit Analysis.

Unit-III:

Impact of Developmental Activities and Land use. Introduction, Methodology for theassessment of soil and ground water, Delineation of study area, Identification of activities.Assessment of Impact of development Activities on Vegetation and wildlife, environmental Impactof Deforestation – Causes and effects of deforestation.

Unit-IV:

Prediction and Assessment of Impact: Quality, Impact prediction, Assessment of Impactsignificance, Identification and Incorporation of mitigation measures. EIA in surface water, Airand Biological environment: Methodology for the assessment of Impacts on surface waterenvironment, Air pollution sources, generalized approach for assessment of Air pollution Impact.

Unit-V:

Environmental Audit & Environmental legislation: objectives of Environmental Audit, Types ofenvironmental Audit, Audit protocol, stages of Environmental Audit, on-site activities, evaluationof Audit data and preparation of Audit report. Casestudies and preparation: of Environmental Impact assessment statement for various Industries.

TEXT BOOKS:

1. Environmental Impact Assessment Methodologies, by Y. Anjaneyulu, B.S.Publication, Sultan Bazar, Hyderabad.
2. Environmental Science and Engineering, by J. Glynn and Gary W. Hein Ke, Prentice Hall Publishers

REFERENCE BOOKS:

1.Cauter R.L, Environmental impact Assessment, McGrawHill International Edition,1997
2. John G Rau and David C Wooten, Environmental impact Analysis hand book, McGrawHill Book Company 1980
3. Environmental Science and Engineering, by Suresh K. Dhaneja – S.K.,Katania&Sons Publication., New Delhi
4. Environmental Pollution and Control, by Dr H.S. Bhatia – Galgotia Publication (P)Ltd

MATHEMATICAL MODELING AND SIMULATION

UNIT-1:Fundamentals of modeling:
Principles & uses of modeling, classification of mathematical models-steady state Vs dynamic models, lumped Vs distributed parameter models, deterministic Vs stochastic models.
Examples of mathematical models-Two heated tanks, constant volume CSTRs, Gravity flow tank, Dynamics of first order & second order systems (Mercury in glass thermometer, Damped vibrator)
UNIT-2:Empirical model building- method of least squares, linear, polynomial and multiple regression, non-linear regression.**Solution of simultaneous algebraic equations***:* Direct methods: Gauss-elimination method, Gauss–Jordan method, Iterative methods: Jacobi's method, Gauss-Siedal method.
UNIT-3:Solution of ODEs:Euler method, Runge-Kutta method, Milne's Predictor-Corrector method **Solution of PDEs**: Elliptic equations-one dimensional, parabolic equation-hyperbolic equation- partial differential equations-separation of variables-wave equation.

UNIT-4:Finite Difference: Difference operator (Δ), operator E, Interpolation, Formulation of linear and non-linear finite difference equations. **Advanced methods for Differential Equations**: method of lines, Orthogonal Collocation, Finite Volume Method.

UNIT-5:
Distributions: Binomial, Poisson and Normal distributions - Definitions, Simple problemsonly (Derivations not included). Sampling Distributions - Tests based on Normal, t, Chi-Square and FDistributions.One way and Two way classification of ANOVA.

Text Books:

1. S.C. Chapra and R.P.Canale, "Numerical methods for Engineers", Tata McGraw Hill, New Delhi, 2002.
2. Erwin Kreyzig, "Advanced Engineering Mathematics", John Wiley & Sons, 2004.

References:

1. Jenson and Jeffery, Mathematical Methods in Chemical Engineering,
2. Mickley, Reid and Sherwood, Applied Mathematics in Chemical Engineering, Tata-McGraw-Hill, New Delhi
3.Zill, Dennis and Cullen, Michael Advanced Engineering Mathematics,3rd Edition, 2006, Jones and Bartlett, Publisher

INSTRUMENTAL TECHNIQUES IN ENVIRONMENTAL ANANLYSIS

Unit I:

Treatment of Data in Quantitative Analysis: Accuracy, Precision, Standard deviation, Types of errors, Minimization of errors. Significant figures, Criteria for rejection of data, Principles of instrumentation.

Unit II:

Spectrophotometric Methods: Principles, applications, advantages & limitations of the following Spectrophotometric methods: UV Spectrophotometer,Fluorimetry, Nephelometry and Turbidimetry.

Unit III:

Spectrophotometric Methods: Atomic absorption spectrophotometry, Flame photometry, Inductively coupled plasma spectroscopy & Mass spectroscopy.

Unit IV:

Electrochemical Methods: Principles, applications, advantages & limitations of following electrochemical methods: Pulse polarography, cyclic voltametry& anode stripping voltametry, Electrophoresis.

Unit V:

Chromatography: Principles, applications, advantages & limitations of following chromatographic methods: Adsorption, Partition, Column chromatography, Paper chromatography, Gas chromatography, High Performance Liquid Chromatography (HPLC), Ion-chromatography.

BOOKS & REFERENCES:

1. Instrumental Methods of analysis, Willard H H& Dean LL, John Willey, 1976.
2. Modern Methods of chemical analysis Recsok RL, & Shields LD, John Willey & sons, Inc 1990.
3. Instrumental Methods of chemical analysis, Ewing GW, McGrw Hill Book Company, Inc. 1975.
4. Fundamental of molecules spectroscophy. Banwell CN, McGraw Hill, NY, 1990.
5. Vogels textbook of Quantitative chemical analysis, Third Ed.

ELECTIVE-I
WATER RESOURCES SYSTEMS MANAGEMENT

UNIT I

Rainwater Harvesting and Management – Different Types and Methods of Harvesting in urban and agricultural areas.

UNIT II

Design of Dams, Non gravity dams, Weirs and Barrages, Conjunctive use of Irrigation water,Quality of Irrigation water, Contaminants and their effects on various crops

UNIT III

Reservoir Planning, Management, Multi Reservoir Systems, Real Time Operation, River Basin Planning, Water Logging, Soil Salinity, Salinity Control.

UNIT IV

Draught analysis, NCA classification, Direct and Indirect losses, Drought severity assessment,Drought Monitoring, Drought Management

UNIT V

Global Efforts - Think Globally: Act Locally on water resources - Man ware on water resource management Local water organizations; WUGs, WUAs, - World water organizations; UN, GWP, WWC, etc.

REFERENCES

1. Dilip Kumar Majumdar, “Irrigation Water Management (Principles & Practices)”, Prentice Hall ofIndia (P), Ltd, 2004.
2. Water Resources Systems, “Vedula&Mujumdar”, McGrawHill, 2005.
3. Daniel P. Loucks “Water Resources systems Planning and Management(Studies and Reports inHydrology) “, 2006.

ELECTIVE-I
OCCUPATIONAL HEALTH & SAFETY

Unit – I

Introduction, Factors Contributing to the Costs of Accidents, List of some Notable accidents in the process industry/selected case histories, some common features of high cost accidents, reasons for high priority towards safety.

Unit – II

Material hazards1: Introduction Hazardous substances-categories, Toxicity, Radiation, Flammability, Ignition, Fires and explosions.

Unit – III

Material hazards 2: Fire balls, Fire damage, run away chemical reaction, incompatible materials, material safety and data sheets

Process and plant Hazards: Hazards of pressure, causes of over pressures, flow deviations, effects of leakages/releases, hazards of temperatures.

Unit – IV

Hazard analysis: process safety management, process hazards analysis, hazards analysis methods, check list, preliminary hazard analysis, what-if / check list, hazard and operability analysis, FMEA, Fault tree analysis, cause and consequence analysis.

Unit – V

Preventive and protective measures: Safety options, process safety approaches, inherent safety and design, plant layout, inherent security, explosion prevention and protection, personal protective systems, plant modifications and management change, relief valves and rupture discs, breather vents for storage tanks, explosions vents, flame arresters, flare systems

TEXT BOOK:

1. Chemical process industry safety by K S N Raju, Mc-Graw Hill education (India) Pvt.Ltd,2014
2. Chemical process Safety by Crowl

REFERENCES:

1. Chemical process safety by sanders

OUTCOMES:

- The student will be equipped with the knowledge by which thorough safety is ensured in the organization.
- Classify and identify hazards in chemical industries
- Take precautions in chemical storage and handling
- Perform fault tree and event tree risk analysis and quantify them
- Suggest and make others in the plant about emergency management plans

ELECTIVE-I
ENVIRONMENTAL BIOTECHNOLOGY

UNIT I

Environmental Biotechnology – Principles and concepts –usefulness to mankind. Degradation of highconcentrated toxic pollutants – halogenated non halogenated, petroleum hydrocarbons, metals-Mechanisms of detoxification – oxidation – dehalogenation- biotransformation of metals –biodegradation of solid wastes.

UNIT II

Biotechnological remedies for environmental pollution- decontamination of groundwaterbioremediation– Production of proteins- biofertilizers – Physical, chemical and microbiological factorsof composting – health risk- pathogens- odor management.

UNIT III

Mircobial cell/enzyme technology – adapted microorganisms – biological removal of nutrients – algalbiotechnology – extra cellular polymers – Biogas technology.

UNIT IV

Concept of rDNA technology – expression vectors – cloning of DNA mutation – construction of microbial strains – radioactive probes – protoplast fusion technology applications.

UNIT V

Environmental effects and ethics of microbial technology – genetically engineered organisms – Microbial containment – Risk assessment.

TEXT BOOKS:

1. Chaudhury, G.R. Biological degradation and bioremediation of toxic chemicals, Dioscorides Press, Oregon, 1994.
2. Martin. A.M. Biological degradation of wastes, Elsevier Applied Science, London, 1991.
3. Blaine Metting .F (Jr.,) Soil Microbiology Ecology, Marcel Dekker Inc., 1993.
4. Wainwright, M, “An Introduction to Environmental Biotechnology”, 2009

ELECTIVE-I
ENVIRONMENTAL ECONOMICS AND MANAGEMENT

Unit– I

Sustainable Development: Introduction to sustainable development - Economy-Environment inter-linkages - Meaning ofsustainable development - Limits to growth and the environmental Kuznets curve – Thesustainability debate - Issues of energy and the economics of energy – Non-renewable energy,scarcity, optimal resources, backstop technology, property research, externalities, and theconversion of uncertainty.

Unit– II

Environmental Degradation: Economic significance and causes of environmental degradation - The concepts of policy failure,externality and market failure - Economic analysis of environmental degradation - Equi-marginalprinciple.

Unit– III

Economics of Pollution: Economics of Pollution - Economics of optimal pollution, regulation, monitoring andenforcement - Managing pollution using existing markets: Bargaining solutions – Managingpollution through market intervention: Taxes, subsidies and permits.

Unit– IV

Cost – Benefit Analysis: Economic value of environmental resources and environmental damage - Concept of TotalEconomic Value - Alternative approaches to valuation – Cost-benefit analysis and discounting.

Unit – V

Economics of biodiversity**:** Economics of biodiversity conservation - Valuing individual species and diversity of species -Policy responses at national and international levels. Economics of Climate Change – strenReport

Reference Books

1. D.W. Pearce, A. Markandya and E.B. Barbier (1989), Blueprint for a Green Economy,Earthscan, London.
2. R.K. Turner, D.W. Pearce and I. Bateman (1994), Environmental Economics: AnElementary Introduction, Harvester Wheatsheaft, London.
3. D.W. Pearce and R.K. Turner (1990), Economics of Natural Resources and theEnvironment, Harvester Wheatsheaf, London.
4. Michael S. Common and Michael Stuart (1996), Environmental and ResourceEconomics: An Introduction, 2nd Edition, Harlow: Longman.
5. Roger Perman, Michael Common, Yue Ma and James McGilvray (2003), NaturalResource and Environmental Economics, 3rd Edition, Pearson Education.
6. N. Hanley, J. Shogren and B. White (2001), An Introduction to EnvironmentalEconomics, Oxford University Press.

ENVIRONMENTAL POLLUTION MONITORING LABORATORY

1. To determine pH of a given sample using (i) Universal indicator (ii) pH paper (iii) Digital pH meter
2. To determine the total dissolved solids content indistilled water double distilled water, tap water and reverse osmosis water.
3. To measure mineral acidity and total acidity
4. To determine the alkalinity of given samples.
5. To illustrate the various operations involved in gravimetric analysis and to determine the various categories of solids that are commonly defined in water and wastewater.
6. Energy Auditing of various Engineering Departments of Institute
7. Experiment on determination of total hardness
8. Experiment on determination of Residual chlorine of a given sample
9. Heavy Metal Ion detection using AAS
10. Estimation of Calorific Value of Hazardous Waste

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II SEMESTER
TRANSPORT OF WATER AND WASTEWATER

Unit – I:

General hydraulics and flow measurement: Fluid properties; fluid flow – continuity principle,energy principle and momentum principle; frictional head loss in free and pressure flow, minorheads losses, Carrying Capacity–Flow measurement.

Unit – II:

Water transmission and distribution: Need for Transport of water and wastewater-Planning of Water System –Selection of pipe materials, pipe thickness calculations. Water transmission maindesign- gravity and pumping main; Selection of Pumps- characteristics-economics; Specials,Jointing, laying and maintenance, water hammer analysis.

Unit – III:

Water distribution systems: Water distribution pipe networks, Methods, Design, analysis andoptimization – appurtenances – corrosion prevention – minimization of water losses – leakdetection Storage reservoirs.

Unit – IV:

Wastewater collection and conveyance: Planning factors – Design of sanitary sewer; partialflow in sewers, economics of sewer design. Handling and transport of slurry. Wastewaterpumps and pumping stations- sewer appurtenances; material, construction, inspection andmaintenance of sewers; Design of sewer outfalls-mixing conditions; conveyance of corrosivewastewaters.

Unit – V:

Storm water drainage: Necessity- - combined and separate system; Estimation of storm water run off Formulation of rainfall intensity duration and frequency relationships- Rational methods.

REFERENCES:

1. Bajwa, G.S. Practical Handbook on Public Health Engineering, Deep Publishers, Simla, 2003
2. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. “Manual on Sewerage and Sewage Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1993.

PHYSICOCHEMICAL PROCESSES IN WATER AND WASTEWATER

Unit-I

Mixing, Clarification - Sedimentation; Types; Aeration and gas transfer – Coagulation andflocculation, coagulation processes - stability of colloids - destabilization of colloids, transportof colloidal particles.

Unit-II

Adsorption, adsorption equilibria- adsorption isotherms,
Disinfection - chlorine dioxide;chloramines; ozonation; UV radiation, Ion Exchange-processes

Unit-III

Filtration - theory of granular media filtration; Classification of filters; slow sand filter andrapid sand filter; mechanism of filtration; modes of operation and operational problems;negative head and air binding; dual and multimedia filtration.

UNIT IV

Membrane Processes and Systems: Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis-Pervaporation. Membrane Modules: Plate and Frame, Spiral Wound, Tubular, Hollow Fiber module.

UNIT V

Membrane Bioreactors: Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, BiomassSeparation MBR Principles, Fouling and Fouling Control, MBR Design Principles, DesignAssignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

Books:

1. Weber, W.J. *Physicochemical processes for water quality control*, John Wiley and sons, Newyork, 1983.
2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. *Environmental Engineering*, McGraw Hills, New York 1985.
3. Metcalf and Eddy, *Wastewater engineering, Treatment and Reuse*, Tata McGraw-Hill, New Delhi, 2003.
4. M.J. Hammer, *Water and Waste Water Technology*, John Wiley & Sons, 1986

PRINCIPLES AND DESIGN OF BIOLOGICAL TREATMENT SYSTEMS

Unit – I:

Principles

Objectives of biological treatment – significance – aerobic and anaerobic treatment kinetics of biological growth – Factors affecting growth – attached and suspended growth Determination of Kinetic coefficients for organics removal – Biodegradability assessment - Selection of processreactors-batch-continuous type-kinetics

Unit – II:

Design of Aerobic Treatment Systems

Design of sewage treatment plant units –Activated Sludge process and variations, Sequencing Batch reactors, Membrane Biological Reactors-Trickling Filters-Bio Tower-RBC-Moving Bed Reactors-fluidized bed reactors, aerated lagoons, waste stabilization ponds – nutrient removal systems – natural treatment systems, constructed wet land – Disinfectant – disposal options – reclamation and reuse – Flow charts, layout, hydraulic profile, recent trends.

Unit – III:

Anaerobic Treatment of Wastewater

Attached and suspended growth, Design of units – UASB, up flow filters, Fluidized beds, septic tank and disposal – Nutrient removal systems – Flow chart Layout and Hydraulic profile – Recenttrends.

Unit – IV:

Sludge Treatment and Disposal

Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering (mechanical and gravity) Layout PID hydraulics profile – upgrading existing plants – ultimate residue disposal – recent advances.

Unit – V:

Construction Operations and Maintenance Aspects

Construction and Operational Maintenance problems – Trouble shooting – Planning, Organising and Controlling of plant operations – capacity building, Case studies – sewage treatment plants – sludge management facilities.

References:

1. Arceivala, S.J., Wastewater Treatment for Pollution Control, TMH, New Delhi, Second Edition, 2000.
2. Manual on “Sewerage and Sewage Treatment” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. Metcalf & Eddy, INC, ‘Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
4. Qasim, S.R. Wastewater Treatment Plant, Planning, Design & Operation, Technomic Publications, New York, 1994.

ATMOSPHERIC ENVIRONMENTAL POLLUTION AND CONTROL

UNIT I

Introduction: sources, effects on – ecosystems, characterization of atmospheric pollutants, air pollution episodes of environmental importance. Indoor Air Pollution– sources, effects.

UNIT II

Meteorology - composition and structure of the atmosphere, wind circulation, solar radiation, lapse rates, atmospheric stability conditions, wind velocity profile, Maximum Mixing Depth (MMD), Temperature Inversions, Windrose diagram.

UNIT III

General characteristics of stack emissions, plume behaviour, heat island effect. Pollutants dispersion models – description and application of point, line and areal sources.

Monitoring of particulate matter and gaseous pollutants –respirable, non-respirable and nano - particulate matter. CO, CO_2, Hydrocarbons (HC), SO_X and NO_X, photochemical oxidants.

UNIT IV

Air Pollution Control equipment for particulate matter & gaseous pollutants– gravity settling chambers, centrifugal collectors, wet collectors, fabric filters, electrostatic precipitator (ESP).

– Adsorption, Absorption, Scrubbers, Condensation and Combustion.

UNIT V

Noise - sources, measurements, effects and occupational hazards. Standards, Noise mapping, Noise attenuation equations and methods, prediction equations, control measures, Legal aspects of noise.

REFERENCES

1. WarkK ., Warner C.F., and Davis W.T., "Air Pollution - Its Origin and Control", Harper & Row Publishers, New York.
2. Lee C.C., and Lin S.D., "Handbook of Environmental Engineering Calculations", McGraw Hill, New York.
3. Perkins H.C., "Air Pollution", McGraw Hill.
4. Crawford M., "Air Pollution Control Theory", TATA McGraw Hill.
5. Stern A.C., "Air Pollution", Vol I, II, III.
6. Seinfeld N.J.,, "Air Pollution", McGraw Hill.
7. Stern A.C. Vol. V, "Air Quality Management".
8. M N Rao and HVN Rao, Air Pollution" Tata McGraw Hill publication

SOLID AND HAZARDOUS WASTE MANAGEMENT

UNIT-I

Types and Sources of solid and hazardous wastes - Need for solid and hazardous wastemanagement - Legislations on management and handling of municipal solid wastes,hazardous wastes, and biomedical wastes, E-waste.

UNIT-II

Waste generation rates – Composition - Hazardous Characteristics – TCLP tests – wastesampling- Source reduction of wastes – Recycling and reuse.

UNIT-III

Handling and segregation of wastes at source – storage and collection of municipal solidwastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations -labeling and handling of hazardous wastes.

UNIT-IV

Waste processing – processing technologies – biological and chemical conversiontechnologies – Composting - thermal conversion technologies - energy recovery –incineration – solidification and stabilization of hazardous wastes - treatment of biomedical
wastes.

UNIT-V

Disposal in landfills - site selection - design and operation of sanitary landfills- securelandfills and landfill bioreactors – leachate and landfill gas management – landfill closure andenvironmental monitoring – landfill remediation.Elements of integrated waste management

Books:

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, Integrated *Solid Waste Management,*
McGraw- Hill, New York, 1993
2. CPHEEO, *Manual on Municipal Solid waste management, Central Public Health and EnvironmentalEngineering Organization*, Government of India, New Delhi, 2000.
3. Vesilind P.A., Worsel, W.A., and Reinhart, D. R., *Solid waste Engineering*, Thomson Brooks/code, 1st Ed 2002
4. Lagrerer, M.D., Buckingham, P.L and Evans, J.C, *Hazardous Waste Management*, 2ndEdn, McGrawhill, 2011

ELECTIVE-II
ENERGY AND ENVIRONMENT

Unit-I:
Importance of Energy, Focus on Energy & Environment, Definition of Energy & Energy Terms, Overview of Energy Sources & Sinks, Basic Energy Problems.

Unit-II:
Oil & Gas Exploration & Production, Oil & Gas Refining, Distribution & Markets, Conventional & Unconventional Reserves & Resources, Oil & Gas Industry Impacts on Water Resources.

Unit-III:
Electric Industry Overview, Ongoing Evolution of the Electric Industry, Electric Industry Impacts on Air Quality, The Science of Climate Change, The Evidence for and Emerging Impacts of Climate Change. Buildings & Energy, Transportation & Energy.

Unit-IV:
Biofuels, Wind Energy, Solar Energy, Other Renewables: Geothermal & Ocean Energy.

Unit-V:
Nuclear Energy, Nuclear Waste, Carbon Capture & Storage, Domestic Energy Policy, International Energy Policy.

TEXT BOOK:

1. Twidell, J.W. and Weir, A., Renewable Energy Sources, 3rd Edn. T&F Ltd., 2015
2. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
3. Daniel B. Botkin and Edward A. Keller, Environmental Science: Earth as a Living Planet,New York: John Wiley and Sons, 2014, 9th Edition.

REFERENCES:

1. Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 1978.
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.
3. Veziroglu, T.N., Alternative Energy Sources, Vol 5 and 6, McGraw-Hill, 1990
4. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production,Academic Press, 1980.
5. Bridgurater, A.V., Thermochemical processing of Biomass, Academic Press, 1981.
6. Hart, A.B., and Womack, G. J., Fuel Cells: Theory & Applications, Prentice Hall, 1997.
7. Khandelwal K.C, Mahdi S.S., Biogas Technology - A Practical Handbook, Tata Mc-Graw Hill, 1986.

ELECTIVE-II
PRINCIPLES OF CLEANER PRODUCTION

UNIT-I:

Industrial Activity and Environment – Industrialization and Sustainable Development – Indicators of Sustainability-Sustainability Strategies – Barriers to Sustainability – Industrial Ecology – Pollution Prevention (PP) and Cleaner Production (CP) in achieving Sustainability-Prevention versus Control of Industrial Pollution - Environmental Policies and Regulations to encourage Pollution Prevention and Cleaner Production – Regulatory versus Market-based approaches

UNIT-II:

Concept of Pollution Prevention and Cleaner Production – Definition – Importance - Historical Evolution – Benefits - Promotion - barriers – Role of Industry, Government and Institutions - Environmental Management Hierarchy – Source Reduction techniques – Process and Equipment Optimization, Reuse, Recover, Recycle, Raw material substitution - Internet information and Other PP and CP Resources

UNIT-III:

Pollution Prevention and Cleaner Production- Project development and implementation – Overview of CP Assessment steps and skills, Preparing the site, Information gathering, and Flow diagram, Material balance, PP and CP Option generation, Technical and Environmental Feasibility analysis, Total Cost analysis - PP and CP Financing, Establishing a Program - Organizing a Program- Preparing a program plan - Measuring progress – Pollution Prevention and Cleaner Production Awareness Plan - Waste Audit- Environmental Statement

UNIT-IV:

Life Cycle Assessment and Environmental Management Systems: Elements of LCA - Life Cycle Costing – Eco labeling – Designs for the Environment - International Environmental Standards- ISO 14001 - Environmental Audit.

UNIT-V:

Case Studies: Industrial Applications of PP and CP, LCA, EMS and Environmental Audits.

Reference Books:

1. Paul L. Bishop, "Pollution Prevention: Fundamentals and Practice", McGraw-Hill International, 2000.
2. World Bank Group, "Pollution Prevention and Abatement Handbook-Towards Cleaner Production", World Bank and UNE, Washington D.C., 1998.
3. Freeman, H.M, Industrial Pollution Prevention Handbook", McGraw Hill", 1995.
4. James G. Mann and V.A. Liu, "Industrial Water Reuse and Wastewater Minimization", McGraw Hill, 1999.
5. Prasad Modak, C. Visvanathan and MandarParasnis, "Cleaner Production Audit Environmental System Reviews", No. 38, Asian Institute of Technology; Bangkok, 1995.

ELECTIVE-II
ENVIRONMENTAL SUSTAINABILITY

UNIT-I

Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems

UNIT-II

Sustainable Development: Defining the Concept, The Population Problem, NaturalResource Economics: An Overview, Energy, Water, Agriculture

UNIT-III

Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary-Source Local AirPollution, Acid Rain and Atmospheric Modification, Transportation

UNIT-IV

Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes,Global Warming.

UNIT-V

Development, Poverty, and the Environment, Visions of the Future, Environmentaleconomics and policy by Tom Tietenberg, Environmental Economics.

REFERENCES

1. Andrew Hoffman, Competitive Environmental Strategy -A Guide for the ChangingBusiness Landscape, Island Press.
2. Stephen Doven, Environment and Sustainability Policy : Creation, Implementation,Evaluation, The Federation Press, 2005.

ELECTIVE-II
RI AND GIS FOR ENVIRONMENTAL MANAGEMENT

UNIT I

Environment

Water - Air-Land-Marine Environment Global Climatologic, urbanEnvironment:

UNIT II

Introduction to Remote Sensing

Role of RS in different types of Environments - Air, Water, Land.GIS formarineenvironment, urban environment.

UNIT III

Concept of Geology

Introduction - spectral characteristics of water, soil, rock-water parameter,pollution studies.

UNIT IV

Introduction to GIS

GIS-introduction-role of GIS - data analysis-thematic maps preparation,modeling.

UNIT V

Application of GIS

GIS for - soil erosion-Land degradation-Ecology-degradation-Coastal marinestudies-water Quality, monitoring and management.

REFERENCES

1. Lilliesand, T.M. and Kiefer, R, W., *"Remote Sensing and ImageInterpretation"*, John Wily and sons, 2004.
2. Burrough, P.A. and, McDonnell, R.A., *"Principles of Geographical Information Systems"*, Oxford University Press, 2009.
3. Lintz, J. and Simonet, *"Remote Sensing of Environment"*, AddisonWesley Publishing Company, 2004.

ENVIRONMENTAL POLLUTION CONTROL LAB

1. Detection of Metals using Atomic Absorption Spectrometer (AAS)
2. Determination of Absorption spectra of liquid samplesusing UV-Vis Spectrometer
3. Determination of IR spectra of liquid samples using FTIR spectrometer
4. Determination of crystallite size of standard crystalline samples using X-ray Diffractometer (XRD)
5. Separation and analysis of compounds using Gas Chromatograph (GC)
6. Separation and analysis of compounds using High Performance Liquid Chromatography (HPLC)
7. Determination of oxidative and reductive peaks of Ferri/Ferro Cyanide couple using Potentiostat.

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RESEARCH METHODOLOGY

(Audit Course For M.Tech. –II Semester Program from 2015 admitted batches onwards)

UNIT I

Meaning of Research – Objectives of Research – Types of Research – Research Approaches – Guidelines for Selecting and Defining a Research Problem – research Design – Concepts related to Research Design – Basic Principles of Experimental Design.

UNIT II

Sampling Design – steps in Sampling Design –Characteristics of a Good Sample Design – Random Sampling Design.

Measurement and Scaling Techniques-Errors in Measurement – Tests of Sound Measurement – Scaling and Scale Construction Techniques – Time Series Analysis – Interpolation and Extrapolation.

Data Collection Methods – Primary Data – Secondary data – Questionnaire Survey and Interviews.

UNIT III

Correlation and Regression Analysis – Method of Least Squares – Regression vs Correlation – Correlation vs Determination – Types of Correlations and Their Applications

UNIT IV

Statistical Inference: Tests of Hypothesis – Parametric vs Non-parametric Tests – Hypothesis Testing Procedure – Sampling Theory – Sampling Distribution – Chi-square Test – Analysis of variance and Co-variance – Multi-variate Analysis.

UNIT V

Report Writing and Professional Ethics: Interpretation of Data – Report Writing – Layout of a Research Paper – Techniques of Interpretation- Making Scientific Presentations in Conferences and Seminars – Professional Ethics in Research.

Text books:

1. Research Methodology:Methods and Techniques – C.R.Kothari, 2nd Edition,New Age International Publishers.
2. Research Methodology: A Step by Step Guide for Beginners- Ranjit Kumar, Sage Publications (Available as pdf on internet)
3. Research Methodology and Statistical Tools – P.Narayana Reddy and G.V.R.K.Acharyulu, 1st Edition,ExcelBooks,New Delhi.

References:

1. Scientists must Write - Robert Barrass(Available as pdf on internet)
2. Crafting Your Research Future –Charles X. Ling and Quiang Yang (Available as pdf on internet)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) :: ANANTHAPURAMU
Ananthapuramu – 515 002, Andhra Pradesh, India

Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF CHEMICAL ENGINEERING

ENVIRONMENTAL ENGINEERING

I SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D82101	Environmental Chemistry and Microbiology	PC	3	0	0	3
2	21D82102	Water Quality Management	PC	3	0	0	3
3	**Professional Elective – I**						
	21D82103	Machine Learning & Data Analytics for Technologist	PE	3	0	0	3
	21D81104	Numerical Methods for Researchers					
	21D82104	Mathematical Modeling and Simulation					
4	**Professional Elective – II**						
	21D82105	Environmental Policies and Legislation	PE	3	0	0	3
	21D82106	Environmental Economics and Management					
	21D82107	Environmental Sociology					
5	21D11109	Research Methodology and IPR	MC	2	0	0	2
6	21D11110	English for Research Paper Writing	AC	2	0	0	0
	21D11111	Value Education					
	21D11112	Pedagogy Studies					
7	21D82108	Environmental Pollution Monitoring Lab	PC	0	0	4	2
8	21D82109	Design and Simulation Lab	PC	0	0	4	2
Total				**16**	**00**	**08**	**18**

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) :: ANANTHAPURAMU
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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF CHEMICAL ENGINEERING

ENVIRONMENTAL ENGINEERING

II SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D82201	Air Quality Monitoring and Control	PC	3	0	0	3
2	21D82202	Solid and Hazardous Waste Management	PC	3	0	0	3
3	**Professional Elective – II**						
	21D82203	Physicochemical Process for Water and Waste Water Treatment	PE	3	0	0	3
	21D82204	Transport for Water and Waste Water					
	21D82205	Principles and design of biological treatment systems					
4	**Professional Elective – II**						
	21D82206	Environmental Impact Assessment	PE	3	0	0	3
	21D82207	Air Pollution Metrology and Modelling					
	21D82208	Climate Change and Adaptation					
5	21D11209	Technical Seminar	PR	0	0	4	2
6	21D11210	Disaster Management	AC	2	0	0	0
	21D11211	Constitution of India					
	21D11212	Stress Management by Yoga					
7	21D82209	Water and Waste Water Treatment Laboratory	PC	0	0	4	2
8	21D82210	Air Quality & Solid Waste Management Laboratory	PC	0	0	4	2
Total				**14**	**00**	**12**	**18**

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Ananthapuramu – 515 002, Andhra Pradesh, India

Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF CHEMICAL ENGINEERING

ENVIRONMENTAL ENGINEERING

III SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	**Professional Elective – V**						
	21D82301	Environmental Sustainability	PE	3	0	0	3
	21D82302	Environmental health and Safety					
	21D82303	Noise Pollution and Control					
2	**Open Elective**						
	21D80302	Instrumentation Techniques in Environmental Analysis	OE	3	0	0	3
3	21D82304	Dissertation Phase – I	PR	0	0	20	10
4	21D00301	Co-Curricular Activities	PR				2
Total				**06**	**00**	**20**	**18**

IV SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D82401	Dissertation Phase – II	PR	0	0	32	16
Total				**00**	**00**	**32**	**16**

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82101	ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY (21D82101)	L	T	P	C
Semester	I		3	0	0	3

Unit I

Physico-chemical principles and processes – Stoichiometry – Mass Balance – Ideal solutions and Gases – Concentration – Standard solutions – Primary and Secondary standards– Chemical Equilibrium – Acid base – Oxidation-reduction and Solubility equilibria – Adsorption isotherms – Photochemicalprocesses.

Unit II

Water Chemistry - Water Quality parameters – Significance and determination– traceelement contamination – Contaminationby fertilizer and pesticides – Eutrophication and Environmental tolerances. Water Treatment Processes – Softening – Principles of precipitation, coagulation and filtration – Ion exchange – Acid minedrainage.

Unit III

Atmospheric chemistry - Structure of atmosphere – Thermo chemical and Photochemical reactions – Atmospheric cycles – Ozone chemistry – acid rain – Green house gases – Global warming – Air quality parameters – Hazardous air pollutants effects and determination – Electromagnetic radiation audits effects.

Unit IV

Instrumentation techniques -Error analysis –sources of errors and determination – Introduction to spectro photometric analysis – Colorimetry – Nephlometry – UV-VIS spectroscopy – FTIR spectroscopy – Chromatography – Gas and Liquid.

Emerging areas - Principle of Green Chemistry– Renewable energy systems– Biomass utilization – Hydrogen energy – NanoTechnology – Carbon materialsand composites – Environmental applications.

Unit V

Atmospheric Microbiology: Aerofungi, algae and bacteria – Microbial aeroallergens– Deposition of microbes in atmosphere – Gravitational setting, Surface impaction and rain and electrostatic deposition – Air borne microbial diseases –Pertussis, Q fever – Methods of air sampling – Impingement, Centrifugation, Filtration and Deposition. *Instrumentation in Microbiology***:** Compound and Electron (SEM and TEM) Microscopes – pH meter – Colorimeter–Autoclave–Laminarairflowchamber–Colonycounter–Hemocytometer.

REFERENCES

1. Clair NSawyer,Perry L. McCarty & Gene. F.Parkin, "Chemistryfor Environmental Engineering", Tata McGraw Hill, Fourth Edition,2000.
2. Dara. S.S., "EnvironmentalChemistry",3rdEdition, S.Chand& Co, New Delhi, 2001.
3. De. A. K, " EnvironmentalChemsitry", New Age International (P) Limited,3rdEdition 1994.
4. Sharma B.K and Kaur H., "Environmental Chemistry", Goel Publishing House 3rd Edition,1996-97.
5. Stanley E.Manohar, "Environmental Chemistry", WilliardGrant Press, Beston,

Massachutes.

6. Atlas,R.A.and Bartha, R., "MicrobialEcology–Fundamentalsand Application", Benjamin Cummings, New York,2000.
7. Egbert Boeker and RienkVangrondella, "Environmental Science", John Wiley & Sons Ltd., USA,2001.
8. Grant, Wd. and Long, PL., "Environmental Microbiology", Blackie Glasgow, London,1981.
9. Grerard J. Tortora, Berdell R. Funke, Christine and L. Case, "Microbiology: An Introduction", Benjamin Cummings, U.S.A.,2004.
10. PelczarJr. MJ, Chan ECS and Krieg, NR., "Microbiology",McGraw Hill. Inc, New York,1993.
11. Prescott, L.M., Harley, J.P. and Klein, D.A., "Microbiology", McGraw Hill, New York,2006.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82102	WATER QUALITY MANAGEMENT (21D82102)	L	T	P	C
Semester	I		3	0	0	3

UNIT I
Water quality and health linkage; impurities (pollutants and contaminants) in water, their significance and estimation techniques; water borne diseases; standards of potable water.Impact of water pollutants on environment; self-purification of waste in streams; zones of purification; eutrophication; disposal standards and philosophy of MINAS. Lakes systems: thermal stratification, dissolved oxygen. The module addresses 1. Water Quality as a core thread 2. Water quality and health 3. Potable water quality criteria: desirable vs rejection 4. Wastewater discharge standards. Impairment of natural water bodies.

UNIT II
Water treatment The objective of this module is to introduce Aeration and types of aerators; purpose and mechanism of flocculation; coagulants used in water treatment; factors influencing coagulation; estimation of coagulant dose; types of flash mixers and flocculators; sedimentation; analysis of discrete and flocculent settling; sedimentation tanks; Filtration: types and design of filters, factors effecting efficiency of filtration; operational issues in filtration; Disinfection: chemical and non-chemical methods; chick's law; Tertiary treatment methods for removal of colour, salinity, hardness, fluorides, Arsenic, iron and manganese, Treatment process including Adsorption, Reverse Osmosis; Electro-dialysis; Ion-exchange; Chemical; and Distillation techniques

UNIT III
Wastewater treatment: Physical treatment methods-screen chamber; grit separators; primary and secondary settling tanks. Biological treatment: Biology of sewage treatment; BOD growth curve and analysis; estimation of BOD rate constant; types of biological treatment processes; process description and design principals; removal of nitrogen and phosphorus. Sludge stabilization and dewatering systems; Low cost sewage treatment technologies-septic tanks; reed bed; oxidation ponds and lagoons

UNIT IV
Waste water treatment by using electro coagulation, activated sludge method, and constructed wetland system (CW): Vertical CW, Horizontal CW, hybrid CW, UV Irradiation

UNIT V
Water resources and quality management in India This module connects various issues and themes discussed and leads to Water availability; water stress index; status and trend of surface and groundwater; issues and policy interventions; pollution of rivers, lakes and ground water; GAP and National River Action Programme; role of national and international agencies in water health and sanitation

TEXT BOOKS
1. Gilbert M. Masters and Wendell P. Ela (2017) Introduction to Environment Engineering and Science. 3rd ed. Pearson,
2. Garg S.K. (2007) Sewage Disposal and Air Pollution Engineering, 20th ed, Vol. II, New Delhi, Khanna Publisher.

3. Garg S.K. (2007) Water Supply Engineering, 18th ed, Vol.I, New Delhi, Khanna Publisher.
4. REFERENCES
5. Birde G.S. and Birde J.S. (2004) Water Supply and Sanitary Engineering, 7th ed., New Delhi, DhanpatRai Publishing.
6. Chatterjee A.K. (2010) Water Supply, Waste Disposal and Environmental Engineering, 8th ed., New Delhi, Khanna Publisher.
7. Eckenfelder W.Jr. (1999) Industrial Water Pollution Control, 3rd ed., New York, McGraw-Hill.
8. Metcalf and Eddy (2003) Wastewater Engineering: Treatment and Reuse, 4th ed., New Delhi, Tata McGraw-Hill.
9. Nathanson J.A. (2009) Basic Environmental Technology: Water Supply, Waste Management and Pollution Control, 4th ed., New Delhi, PHI Learning.

JOURNALS

1. American Society of Civil Engineering, Environmental Engineering.
2. Indian Water Works Association
3. Water Research
4. Water Science and Technology
5. Environment Pollution 6. Chemosphere

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82103	MACHINE LEARNING & DATA ANALYTICS FOR TECHNOLOGISTS (21D82103)	L	T	P	C
Semester	I		3	0	0	3

UNIT I
Review of Statistical methods: Descriptive Statistics, Probability Distributions, (Binomial , Poisson, Normal), Sampling Distributions (Chi-squared, t, F)

UNIT II
Inferential Statistics: Estimation, Test of Hypothesis

UNIT III
Regression &Analysis of Variance (ANOVA): Regression, ANOVA

UNIT IV
Introduction to Machine Learning: Introduction and Concepts, Differentiating algorithmic and model based frameworks, Regression : Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours,
Regression & Classification
Supervised Learning with Regression and Classification techniques -1: Bias-Variance, Dichotomy Model, Validation, Approaches, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant, Analysis,
Regression and Classification, Trees, Support Vector Machine (SVM),

UNIT V
Learning, Regression and Classification techniques: Supervised and Unsupervised Learning concepts,
Regression and Classification techniques, Neural Networks , Clustering, Association Rule Mining, Deep learning Concepts, Challenges for Big data |Analytics.
Prescriptive analytics: Creating data for analytics through Active learning, Creating data for analytics through Reinforcement learning, Python Machine Learning & Data Analysis Tutorial/Lab

TEXT BOOK:

1. Montgomery, Douglas C., and George C. Runger. Applied Statistics and Probability for Engineers. John Wiley & Sons, 2010
2. Artificial Intelligence: A Modern Approach, Stuart Russel& Peter Norvig, Pearson, 2009
3. Machine Learning: A probabilistic perspective ,kevin P. Murphy
4. Pattern Recognition and Machine Learning, Chris Bishop
5. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie, Robert Tibshirani, Jerome Friedman

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

REFERENCE:

1. Business Intelligence: A Managerial Perspective on Analytics, Ramesh Sharda, DursunDelon, EfraimTurbal, David King, Prentice Hall
2. ModellindTechniuqes in Predictive Analytics, Thomas W Miller, Pearson
3. Introduction to Machine Learning with Python, A. C. Muller & S. Guido, O'Reilly.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D81104	NUMERICAL METHODS FOR RESEARCHERS (21D81104)	L	T	P	C
Semester	I		3	0	0	3

UNIT-I
Errors in approximation, Absolute, Relative and percentage errors. Solution of algebraic and transcendental equations: Bisection method, RegulaFalsi method, Newton Raphson method. Systems of simultaneous Equations: Gauss elimination method, Gauss Jordon method, LU decomposition method, Iterative methods: Jacobi method and Gauss-Seidel method.
Curve fitting: Straight line fitting, parabolic curve fitting, fitting of exponential curve, fitting of other curves.

UNIT-II
Finite Differences, Interpolation techniques: Interpolation with equal intervals-Newton Forward, Newton Backward, Gauss forward, Gauss Backward, Stirling, Bessel formulae.

UNIT-III
Interpolation with unequal intervals-Newton's divided difference, Lagrange interpolation technique. Numerical Differentiation using Newton Forward, Newton Backward formulae.

UNIT-IV
Numerical Integration: Newton-Cotes Formulas, Trapezoidal rule, Simpson rule, Romberg's integration, Gauss-Legendre, Gauss-Chebychev formulas. Solution of Ordinary differential equations: Single step methods: Taylor series method, Picard's method, Euler method, Euler modified method, Runge – Kutta methods, Multistep methods: Milne's and Adam's predictor and corrector methods

UNIT-V
Classification of PDEs. Solution of partial differential equations by finite difference method. Solution of Laplace equation: standard and diagonal five point formula for solving Laplace and Poisson equations, Solution of One dimensional Heat equation: Schmidt method, Crank-Nicolson method, Solution of wave equation.

REFERENCES:
1. Mathews, J. H. Numerical Methods for Mathematics, Science and Engineering. PrenticeHall International Editions, 1992.
2. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. Numerical Methods for Scientific &Engg. Computation. New Age International, 2012.
3. Thangaraj, P. Computer Oriented Numerical Methods. PHI Learning Pvt. Ltd, 2013.
4. Chapra, S. C. and Canale, R. P. Numerical Methods for Engineers. McGraw Hill International Edition, 1998.
5. Bartels, R. H. Bealty, J. C. and Beatty, J. C. An Introduction to Spline for use in Computer Graphics and Geometric Modeling. Morgan Kaufmann Publisher, 2006. 6. Boor, C. D. A Practical Guide to Splines. Springer Verlag, 2001.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82104	MATHEMATICAL MODELING AND SIMULATION (21D82104)	L	T	P	C
Semester	I		3	0	0	3

UNIT – I

Fundamentals of modeling:

Principles & uses of modeling, classification of mathematical models-steady state Vs dynamic models, lumped Vs distributed parameter models, deterministic Vs stochastic models.

Examples of mathematical models-Two heated tanks, constant volume CSTRs, Gravity flowtank, Dynamics of first order & second order systems (Mercury in glass thermometer, Dampedvibrator)

UNIT – II

Empiricalmodelbuilding-method of least squares, linear, polynomial and multipleregression, non-linear regression.

Solution of simultaneous algebraic equations: Directmethods: Gauss-elimination method, Gauss–Jordan method, Iterative methods: Jacobi's method,Gauss-Siedal method.

UNIT – III

Solution of ODEs:Euler method, Runge-Kutta method, Milne's Predictor-Correctormethod

Solution of PDEs: Elliptic equations-one dimensional, parabolic equation-hyperbolicequation-partial differential equations-separation of variables-wave equation.

UNIT – IV

Finite Difference: Difference operator (Δ), operator E, Interpolation, Formulation of linear and non-linear finite difference equations.

Advanced methods for DifferentialEquations: method of lines, Orthogonal Collocation, Finite Volume Method.

UNIT – V

Distributions: Binomial, Poisson and Normal distributions - Definitions, Simple problemsonly(Derivations not included).

Sampling Distributions - Tests based on Normal, t, Chi-Square andF- Distributions.One way and Two way classification of ANOVA.

TEXT BOOKS:

1. S.C. Chapra and R.P.Canale, "Numerical methods for Engineers", Tata McGraw Hill,New Delhi, 2002.
2. Erwin Kreyzig, "Advanced Engineering Mathematics", John Wiley & Sons, 2004.

REFERENCES:

1. Jenson and Jeffery, Mathematical Methods in Chemical Engineering,
2. Mickley, Reid and Sherwood, Applied Mathematics in Chemical Engineering,Tata-McGraw-Hill, New Delhi
3. Zill, Dennis and Cullen, Michael Advanced Engineering Mathematics,3rdEdition, 2006, Jonesand Bartlett, Publisher

Course Code	21D82105	ENVIRONMENTAL POLICIES AND LEGISLATION	L	T	P	C

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Semester	**I**	**(21D82105)**	**3**	**0**	**0**	**3**

UNIT I

Introduction: Indian Constitution and Environmental Protection – National Environmentalpolicies –Precautionary Principle and Polluter Pays Principle–Concept of absolute liability –multilateral environmental agreements and Protocols – Montreal Protocol, Kyotoagreement, Riodeclaration – Environmental Protection Act, Water (P&CP) Act, Air(P&CP) Act – Institutionalframework (SPCB/CPCB/MoEF)

UNIT II

Water (P&CP) Act, 1974: Power & functions of regulatory agencies - responsibilities ofOccupier Provision relating toprevention and control Scheme of Consent to establish, Consent tooperate – Conditionsof the consents – Outlet – Legal sampling procedures, State WaterLaboratory – AppellateAuthority – Penaltiesfor violation of consent conditions etc. Provisionsforclosure/directions in apprehended pollution situation.

UNIT III

Air (P&CP) Act, 1981: Power & functions of regulatory agencies - responsibilities of OccupierProvision relating toprevention and control Scheme of Consent to establish, Consent to operate –Conditionsof the consents – Outlet – Legal sampling procedures, State Air Laboratory –AppellateAuthority – Penalties for violation of consent conditions etc. Provisions forclosure/directions in apprehended pollution situation.

UNIT IV

Environment (Protection) Act 1986: Genesis of the Act – delegation of powers – Role ofCentral Government - EIA Notification– Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodiesmitigation scheme etc., for Municipal Solid Waste Management -Responsibilities ofPollution Control Boards under Hazardous Waste rules and that of occupier,authorization – Biomedical waste rules – responsibilities of generators and role of PollutionControlBoards

UNIT V

Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC – PublicInterest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

REFERENCES

1. CPCB, “Pollution Control acts, Rules and Notifications issued there under “PollutionControlSeries – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
2. Shyam Divan and Armin Roseneranz “Environmental law and policy in India“OxfordUniversity Press, New Delhi, 2001.
3. GregerI.Megregor, “Environmental law and enforcement”, Lewis Publishers, London.1994.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82106	ENVIRONMENTAL ECONOMICS AND MANAGEMENT (21D82106)	L	T	P	C
Semester	I		3	0	0	3

UNIT – I

Economy and the natural environment

The human economy – natural environment interaction. Biophysical Foundations of production and consumption of human economy Sources and Sink functions of the ecosystem. Material Balance approach: the concept and conditions of sustainability of the human economy.

Classification and characterization of resources and pollution as a public good or bad, Role of Externalities as the fundamental determinants.

Property Rights, Market, Spatial-temporal dimensions of externality.

UNIT – II

Theory of Environmental Regulation and Policy

The socially optimal level of pollution and Pareto optimal allocation of resources. How to ensure the attainment of optimal pollution :

Assignment of Property Rights: Coase Theorem and its limitations

Government interventions - Command and Control: standard setting, Market based instruments: Pigouvian taxes - emission charges, ambient charges, product charges, subsidies, noncompliance fees, Tradable pollution permits.

Uncertainty and choice of regulatory instrument

UNIT – III

Anoverview of the economy and the natural environment interaction using an input-output based general equilibrium approach to show how ecological limits and scarcity of eco-services would affect the resource allocation and prices. Approach to environmentally adjusted national income.

UNIT – IV

Valuation of Environmental Goods and Services

Theory of environmental valuation and conceptual basis of its methods: Compensating Variations and Surplus, Equivalent Variations and Surplus, Willingness to pay or accept for improvement or loss of environmental goods and services

Empirical approaches in environmental valuation: Indirect Methods of environmental valuation: The following topics will be discussed with illustrations from some case studies and refer to the econometric or statistical methods to be applied.

Revealed Preference Methods: (a) Hedonic Pricing, (b) Household Production Function approach - defensive cost, health cost and travel cost methods

The direct method of environmental valuation: Stated preference: Contingent valuation method.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

UNIT – V

Sustainable Economic Development

Capital theoretic basis of the notion of sustainable development: Sustainable Development as non-declining intertemporal utility or that of the value of the wealth. Concepts of Genuine investment or savings and Green National Income

Natural capital stock and sustainable resource accounting. Strong and weak Sustainability, Environmental Adjustment of National Income.

TEXTBOOKS

1. Nick Hanley, Jason F Shorgen and Ben White, 1997/2006, Environmental EconomicsTheory and Practice, First/Second Edition, MacMillan.
2. Charles D Kolstad, 2012, Intermediate Environmental Economics, Indian Edition, Oxford University Press, New Delhi
3. David W Pearce and R Kerry Turner, 1990, Economics of Natural Resources and the Environment, Harvester WheatsheafEcott J. Callan and Janet M. Thomas, 2013, Environmental Economics and Management: Theory, Policy and Applications, Cengage Learning, Delhi.
4. RamprasadSengupta, 2013, Ecological Limits and Economic Development, Oxford University Press, New Delhi
5. Ahmed Hussen, 2013, Principles of Environmental Economics and Sustainability: An integrated economic and ecological approach, Routledge, UK.
6. Per-Olov Johansson, 1987, The Economic Theory and Measurement of Environmental benefits, Cambridge University Press.

ADDITIONAL REFERENCE*:

1. Robert U Ayres and Allen V Kneese, 1969, 'Production, Consumption, and Externalities', American Economic Review, LIX (June): 282-97.
2. William J Baumol, 1972, 'On Taxation and the Control of Externalities', American Economic Review, LXII (3): 307-22
3. R H Coase, 1960, 'The Problem of Social Cost', The Journal of Law and Economics, III: 1-44
4. G M Grossman and Alan B Krueger, 1995, 'Economic Growth and the Environment', The Quarterly Journal of Economics, CX (2): 353-377.
5. Thomas M Parris and Robert W Kates, 2003, 'Characterizing and Measuring Sustainable Development', Annual review of Environment and Resources, XXVIII (1): 559-586.
6. Peter Bartelmus, Ernst Lutz and Jan Van Tongeren, 2001, 'Environmental Accounting: An Operational Perspective', in UlanganathanSankar (ed.) Environmental Economics, Oxford University Press, New Delhi.
7. David I Stern, 1998, 'Progress on the environmental Kuznets curve?', Environment and Development Economics, III (2): 173-196.
8. Michael Trebilcock, Robert Howse and AntariaEliason, 2013, The Regulation of International Trade, Routledge, Abingdon, OX14 4RN, (Chapter 17: Trade and the environment): 656-715

Course Code	21D82107	ENVIRONMENTAL SOCIOLOGY (21D82107)	L	T	P	C

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Semester	**I**		**3**	**0**	**0**	**3**

UNIT – I
Introduction: Environment – Environmental Sociology - Emergence and development of Environmental Sociology – Sociological Approaches to Environment

UNIT – II
Environmental Issues pertaining to population, water, Sanitation, Pollution, Energy, Housing and Urban Development – Social Impact Assessment of Environmental Issues.

UNIT – III
Social Consequences of Environmental Disruption: Body, Health and Environment – Environmental Management of Water, Air, Soil and Land - Solid waste management – Tackling social AwarenessProgramme.

UNIT – IV
Nature Vs Nurture debate – Systemic causes of Environmental Disruption: Risk, Technology and Society.

UNIT – V
Development, displacement, Relocation and Environmental Problems.

REFERENCES
1. King, Leslie and Deborah Mecarthy, “Environmental Sociology: From analysis to action”, Rowman & Littlefield Publishers, Inc.,2009.
2. Riley, E. Dunlap, “Handbook of Environmental Sociology”, William Michelson (eds.), Rawat,2008.
3. Jules Pretty, Andrew S Ball, Ted Benton, Julia S Guivant, “Handbook of Environmental Sociology”, Sage,2006.
4. Mahesh Rangarajan., “Environmental Issues in India: A Reader”, Pearson, Longman, Section V, Global issues, New Delhi,2007.
5. Mohan,I., “Environmental Issues and Programmes”, Asia Publishing house, New Delhi, 1989.
6. Verma, Manish Kumar, “Development, Displacement and Resettlement”, Rawat Publication, Jaipur,2004.
7. Rohan D’Souza, ‘Environment, Technology and Development: Critical and Subversive Essays”, Orient Blacksman,2012.
8. Archana Prasad, “Environment, Development and Society in Contemporary India. An Introduction”, Macmillan India, Part Four: Global Environmental Issues, New Delhi.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82108	ENVIRONMENTAL POLLUTION MONITORING LABORATORY (21D82108)	L	T	P	C
Semester	I		3	0	0	3

LIST OF EXPERIMENTS

1. To determine pH of a given sample using
   a. Universal indicator
   b. pH paper
   c. Digital pH meter
2. To determine the total dissolved solids content indistilled water double distilled water,tap water and reverse osmosis water.
3. To measure mineral acidity and total acidity
4. To determine the alkalinity of given samples.
5. To illustrate the various operations involved in gravimetric analysis and to determine thevarious categories of solids that are commonly defined in water and wastewater.
6. Energy Auditing of various Engineering Departments of Institute
7. Experiment on determination of total hardness
8. Experiment on determination of Residual chlorine of a given sample
9. Heavy Metal Ion detection using AAS
10. Estimation of Calorific Value of Hazardous Waste

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82109	DESIGN AND SIMULATION LABORATORY (21D82109)	L	T	P	C
Semester	I		3	0	0	3

LIST OF EXPERIMENTS

1. General introduction to MATLAB
2. Functions (log, exp, conv, roots).
3. MATLAB Scripts and function files
4. Gravity Flow tank.
5. Three CSTRs in series – open loop
6. Three CSTRs in series – Closed loop
7. Non isothermal CSTR
8. Binary Distillation column
9. Batch Reactor isothermal; Batch reactor non isothermal – closed loop
10. Isothermal batch reactor – open loop
11. Heat Exchanger
12. Interacting System- two tank liquid level
13. Non interacting system-two tank liquid level
14. Plug flow reactor
15. Bubble point calculations
16. Dew point calculations

TEXT BOOKS:

1. A Guide to MATLAB for Chemical Engineering Problem Solving, Kip D. Hauch
2. Understanding MATLAB A Textbook for Beginners by S.N. Alam

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82201	AIR QUALITY MONITORING AND CONTROL (21D82201)	L	T	P	C
Semester	II		3	0	0	3

COURSE OBJECIVES:

- To impartknowledge on air quality measurement in compliance with the standards.
- To enable students to learn about various air pollution control systems, related theory, working principles, engineering design andmanagement.

UNIT-1

Composition and structure of atmosphere-Definition-Air Pollution-Sources-Classification-Types - On meteorological conditions-Ozone layer disturbance, green houseeffects.

Introduction- Standards-ambient air quality standards-emission standards-Air sampling methods-Modern air pollution measurement sensors-working principle-Emission inventory-Air quality index-Measurement-ambient and source sampling-pressure-gas flow rate-relative humidity-Sample train-determination particle size distribution-Gas stream calculations and conditioning.

UNIT-II

Air Pollution Control – General-Gravitational settling chambers-Inertial separators-Cyclone-introduction-industrial application-multiple cyclone-Fabric filtration-introduction-principle and theory-application-engineering design-operation. *Electrostatic precipitation*-introduction-principles of operation-design methodology and considerations-application-problems and corrections-Dry and wet Scrubbing-introduction-dry scrubbers-wet scrubbers.

UNIT-III

Condensation-introduction-pre and post treatment-engineering consideration and design-management .Flare process-introduction-pretreatment-engineering consideration and design-management. *Thermal and Catalytic oxidation*-introduction- pretreatment and engineering consideration-supplementary fuel requirements-design and operation-management. Gas-phase activated carbon adsorption-introduction and definitions-adsorption theory-carbon adsorption pretreatment-design andoperation.

UNIT-IV

Gas Phase Bio-filtration-introduction-types of air treatment systems-operational consideration-design consideration/parameters-case studies-process control and monitoring-limitations of the technology. Emerging air Pollution Control Technologies-introduction-process modification-vehicle air pollution and its control-mechanical particulate collectors-Entrainment separation- IC engines-Membrane process-UV photolysis-High efficiency particulate air filters-Technical and economical feasibility of selected emerging technologies.

UNIT-V

Indoor air quality management: Measurement, control and preventive measures of indoor air quality measures and management. Control Measures for Industrial Applications: Control methods – Processes based control mechanisms – mineral products – asphaltic concrete, cement plants and glass manufacturing plants; Thermal power plants, Petroleum refining and storage plants, Fertilizers, Pharmaceuticals and wood processingindustry.

REFERENCES:

1. Lawrence K.Wang, Norman C.Pereira and Yung-Tse Hung. "Air Pollution Control Engineering", Humana Press, New Jersey,2004.
2. Noel De Nevers, "Air Pollution control Engineering", McGraw-Hill International Edition, Civil Engineering Series, Singapore,2000.
3. Arthur C.Stern, "Air Pollution", Volume-III, Academic Press, NewDelhi, 2006.
4. Wayne T.Davis, "Air Pollution Engineering Manual", John Wiley & Sons Inc., New Delhi,2000.
5. J.R.Mudakavi, "Principles and Practices of Air Pollution Control and Analysis", I.K. International Publishing House Pvt. Ltd., New Delhi,2012.
6. Louis Theodore, "Air Pollution Control Equipment Calculation", John Wiley & Sons Inc, New Delhi,2006.
7. "Programme Objective Series (PROBES)", Open Source of Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Govt. of India (www.cpcb.nic.in).

COURSE OUTCOMES:At the end of the course students will be able to

1. Conduct air quality monitoring programmefor routine or site specific air quality parameters with conventional as well as modernsensors.
2. Design air pollution controlsystems.
3. Select the appropriate cost effective control system with high efficiency to be adopted in any type of air pollutingindustry.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82202	SOLID AND HAZARDOUS WASTE MANAGEMENT (21D82202)	L	T	P	C
Semester	II		3	0	0	3

UNIT I:
SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK
Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes , plastics and fly ash – Financing waste management.

UNIT II
WASTE CHARACTERIZATION AND SOURCE REDUCTION
Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse Practical: Composition of MSW, Determination of Physical and Chemical Properties of MSW

UNIT III
STORAGE, COLLECTION AND TRANSPORT OF WASTES
Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes – hazardous waste manifests and transport

UNIT IV
WASTE PROCESSING TECHNOLOGIES 12 Objectives of waste processing – material separation and processing technologies – biological &chemical conversion technologies – methods and controls of Composting - thermal conversion technologies, energy recovery – incineration – solidification & stabilization of hazardous wastes- treatment of biomedical wastes

UNIT V
WASTE DISPOSAL
Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation

Text books:

1. George Techobanoglous et al,‖Integrated Solid Waste Management‖, McGraw - Hill, 2014.
2. Manual on Municipal Solid waste Management, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi, 2000.
3. TechobanoglousThiesenEllasen; Solid Waste Engineering Principles and Management, McGraw - Hill 1997.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

REFERENCES :

1. R.E.Landrefh and P.A.Rebers, Municipal Solid Wastes -Problems & Solutions ,Lewis, 1997.
2. Blide A.D.&Sundaresan, B.B, Solid Waste Management in Developing Cou ntries, INSDOC, 1993.
3. Georges E. Ekosse, Rogers W'O Okut-Uma, Pollution control & Waste management in Developing Countries, Commonwealth Publishers, New Delhi, 2000.
4. B. B. Sundaresan, A. D. Bhide – Solid Waste Management, Collection, Processing and Disposal, Mudrashilpa Offset Printers, 2001.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82203	PHYSICOCHEMICAL PROCESS FOR WATER AND WASTE WATER TREATMENT (21D82203)	L	T	P	C
Semester	II		3	0	0	3

Unit-I:
Mixing, Clarification - Sedimentation; Types; Aeration and gas transfer – Coagulation and flocculation, coagulation processes - stability of colloids - destabilization of colloids, transport of colloidal particles.

Unit-II:
Adsorption, adsorption equilibria- adsorption isotherms, Disinfection - chlorine dioxide; chloramines; ozonation; UV radiation, Ion Exchange-processes.

Unit-III :
Filtration - theory of granular media filtration; Classification of filters; slow sand filter and rapid sand filter; mechanism of filtration; modes of operation and operational problems; negative head and air binding; dual and multimedia filtration.

UNIT IV:
Membrane Processes and Systems: Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis-Pervaporation. Membrane Modules: Plate and Frame, Spiral Wound, Tubular, Hollow Fiber module.

UNIT V:
Membrane Bioreactors: Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies.

TEXT BOOKS:

1. Weber, W.J. Physicochemical processes for water quality control, John Wiley and sons, Newyork, 1983.
2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.
3. Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.
4. M.J. Hammer, Water and Waste Water Technology, John Wiley & Sons, 1986.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82204	TRANSPORT FOR WATER AND WASTE WATER (21D82204)	L	T	P	C
Semester	II		3	0	0	3

Unit – I:
General hydraulics and flow measurement: Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor heads losses, Carrying Capacity–Flow measurement.

Unit – II:
Water transmission and distribution: Need for Transport of water and wastewater-Planning of Water System –Selection of pipe materials, pipe thickness calculations. Water transmission main design- gravity and pumping main; Selection of Pumps- characteristics-economics; Specials, Jointing, laying and maintenance, water hammer analysis.

Unit – III:
Water distribution systems: Water distribution pipe networks, Methods, Design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection Storage reservoirs.

Unit – IV:
Wastewater collection and conveyance: Planning factors – Design of sanitary sewer; partial flow in sewers, economics of sewer design. Handling and transport of slurry.Wastewater pumps and pumping stations- sewer appurtenances; material, construction, inspection and maintenance of sewers; Design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters.

Unit – V:
Storm water drainage: Necessity- - combined and separate system; Estimation of storm water runoff Formulation of rainfall intensity duration and frequency relationships- Rational methods.

REFERENCES:
1. Bajwa, G.S. Practical Handbook on Public Health Engineering, Deep Publishers, Simla, 2003
2. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. “Manual on Sewerage and Sewage Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1993.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82205	PRINCIPLES AND DESIGN OF BIOLOGICAL TREATMENT SYSTEMS (21D82205)	L	T	P	C
Semester	II		3	0	0	3

Unit – I:
Principles Objectives of biological treatment – significance – aerobic and anaerobic treatment kinetics of biological growth – Factors affecting growth – attached and suspended growth Determination of Kinetic coefficients for organics removal – Biodegradability assessment - Selection of process reactors-batch-continuous type-kinetics.

Unit – II:
Design of Aerobic Treatment Systems Design of sewage treatment plant units –Activated Sludge process and variations, Sequencing Batch reactors, Membrane Biological Reactors-Trickling Filters-Bio Tower-RBC-Moving Bed Reactors-fluidized bed reactors, aerated lagoons, waste stabilization ponds – nutrient removal systems – natural treatment systems, constructed wet land – Disinfectant – disposal options – reclamation and reuse – Flow charts, layout, hydraulic profile, recent trends.

Unit – III:
Anaerobic Treatment of Wastewater Attached and suspended growth, Design of units – UASB, up flow filters, Fluidized beds, septic tank and disposal – Nutrient removal systems – Flow chart Layout and Hydraulic profile – Recent trends.

Unit – IV:
Sludge Treatment and Disposal Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering (mechanical and gravity) Layout PID hydraulics profile – upgrading existing plants – ultimate residue disposal – recent advances.

Unit – V:
Construction Operations and Maintenance Aspects Construction and Operational Maintenance problems – Trouble shooting – Planning, Organizing and Controlling of plant operations – capacity building, Case studies – sewage treatment plants – sludge management facilities.

REFERENCES:

1. Arceivala, S.J., Wastewater Treatment for Pollution Control, TMH, New Delhi, Second Edition, 2000.
2. Manual on “Sewerage and Sewage Treatment” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. Metcalf & Eddy, INC, ‘Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82206	ENVIRONMENTAL IMPACT ASSESSMENT (21D82206)	L	T	P	C
Semester	II		3	0	0	3

Unit -I:
Basic concept of EIA and Methodologies: Initial environmental Examination, Elements of EIA, factors affecting EIA Impact evaluation and analysis, preparation of Environmental Base map, Classification of environmental parameters.

Unit-II:
EIA Methodologies: Introduction, Criteria for the selection of EIA Methodology, EIA methods, Ad-hoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods, cost/Benefit Analysis.

Unit-III:
Impact of Developmental Activities and Land use.Introduction, Methodology for the assessment of soil and ground water, Delineation of study area, Identification of activities. Assessment of Impact of development Activities on Vegetation and wildlife, environmental Impact of Deforestation – Causes and effects of deforestation

Unit-IV:
Prediction and Assessment of Impact: Quality, Impact prediction, Assessment of Impact significance, Identification and Incorporation of mitigation measures. EIA in surface water, Air and Biological environment: Methodology for the assessment of Impacts on surface water environment, Air pollution sources, generalized approach for assessment of Air pollution Impact.

Unit-V:
Environmental Audit & Environmental legislation: objectives of Environmental Audit, Types of environmental Audit, Audit protocol, stages of Environmental Audit, on-site activities, evaluation of Audit data and preparation of Audit report. Case studies and preparation: of Environmental Impact assessment statement for various Industries.

TEXT BOOKS:
1. Environmental Impact Assessment Methodologies, by Y. Anjaneyulu, B.S.Publication, Sultan Bazar, Hyderabad.
2. Environmental Science and Engineering, by J. Glynn and Gary W. Hein Ke, Prentice Hall Publishers

REFERENCE BOOKS:
1. 1.Cauter R.L, Environmental impact Assessment, McGrawHill International Edition,1997
2. John G Rau and David C Wooten, Environmental impact Analysis hand book, McGrawHill Book Company 1980 3. Environmental Science and Engineering, by Suresh K. Dhaneja – S.K.,Katania& Sons Publication., New Delhi
3. Environmental Pollution and Control, by Dr H.S. Bhatia – Galgotia Publication (P)Ltd.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82207	AIR POLLUTION METROLOGY AND MODELLING (21D82207)	L	T	P	C
Semester	II		3	0	0	3

COURSE OBJECTIVES:

- To enlighten the students in the various aspects of Air pollution and associated Meteorology particularly fordispersion.
- To have the exposure of fundamentals Planetary Boundary LayerCharacteristics.
- To understand the different approaches of pollutant transporttheories.
- To learn the popular Gaussian Plume Model used widely for regulatorypurposes.
- To provide numerical dispersion modeling for the advancement towards research and development.

Unit I:

Air pollution micrometeorology–primary and secondary measurement – projection-Sources of meteorologicaldata.Planetary Boundary Layer (PBL) – Introduction and definition–Earth and atmosphere Exchange process-Thermodynamic variables and their vertical distribution in the PBL- Atmospheric stability –lapse rate- stability classes. Conservation laws-Atmosphericdynamics Large scale inviscid and small scale viscous flows- Application.

Unit II:

Scales ofAtmospheric.motion –Macro, synoptic, meso and Micro scale system and dispersion - Characteristic plume shapes – Inversion breakup and shoreline fumigation. Gradient Transport Theories – Eulerian approach to describe diffusion-Mass conservation and diffusion equations- Molecular diffusion-Turbulent diffusion constant K (Fickian Diffusion) theory- Variable K-theory-Limitations and experimental verification of gradient transport theories –Application of K-theories to atmosphericdispersion

Unit III:

Statistical Theories of Diffusion-Lagrangian approach to describing diffusion-Statistical theory of absolute diffusion-Plume diffusion from continuous sources- Statistical theory of relative diffusion-Puff diffusion from Instantaneous Release – Fluctuating Plume Models-Experimental Verification of Statistical Theories-Application to Atmospheric Dispersion and Limitation.

Unit IV:

Gaussian Plume Model- assumptions and approximation-Diffusion experiments- Pasquill Stability classes-Empirical dispersion parameterization schemes – Pasquill-Gifford-Brookhaven National Laboratory-Tennessee Valley Authority-Briggs Urban Dispersion-Maximum Ground Level Concentration-Model evaluation – Tracer release experiments. Plume rise theory-Briggs- Plume Concentrations for differing sampling time averaging-Gravitational Settling of Particles- DryDeposition

Unit V:

Numerical Dispersion Models-Introduction-Short range gradient transport Models-Turbulent Kinetic Energy (TKE) models- Higher order closure models. Urban and regional Air Quality Models-Introduction_ Components of an air quality model – Urban Diffusion and air quality models-Regional air quality models- Applications.

REFERENCES

1. S.PalArya., "Air Pollution Meteorology AndDispersion", Oxford University Press, 1999.
2. Arthur C. Stern., "Air Pollution" (Third Edition) Volume I- Air Pollutants, Their Transformation and Transport, Academic Press (An imprint ofElsevier), 2006.
3. Roland.B. Stull., "An Introduction to Boundary Layer Meteorology", Kluwer Academic Press, London,1993.
4. J.R. Garratt, "The Atmospheric Boundary Layer", Cambridge University Press,1999.
5. D.BruceTurner,"Workbook ofAtmosphericDispersionEstimates",Lewis Publishers, London,1994.
6. Lyons, T.J., and Scott, W.D., **"**Principles of Air Pollution Meteorology", CBS Publishers and Distributors (P) Ltd., New Delhi,1992.
7. James R. Holton, "An Introduction to Dynamic Meteorology", Academic Press Inc., London, 1989

COURSE OUTCOMES: At the end of the course students will be able to

1. Investigate the spatial and temporal air pollutionproblems.
2. Model the transport, diffusion and dispersion of pollutants by either Gaussian or numerical methods with better air pollution meteorologicalbackground.
3. Develop new site specific air quality model codes and to investigate the present existing regulatory model codes under practiceglobally.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82208	CLIMATE CHANGE AND ADAPTATION (21D82208)	L	T	P	C
Semester	II		3	0	0	3

COURSE OBJECTIVES:

- Tounderstand the earth's climate change and its systemclassification.
- To introduce the observed changes in the climate and concept ofmodeling and Institutional arrangements existing for monitoring thisphenomenon.

Unit I:

Earth's Climate System: Introduction – Climate in the spotlight – The Earth's Climate Machine – Climate Classification – Global wind systems – Trade Wind Systems– Trade Winds and the Hadley Cell – The Weserlies – Cloud formation and Monsoon Rains – Storms and Hurricanes – The Hydrological Cycle – Global Ocean Circulation – EI Nino and its Effect – Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – CarbonCycle.

Unit II:

Observed Changes and Its Causes: Observation of Climate Change – Changes in pattern of temperature, precipitation and sea level rise – Observed effects of ClimateChanges
Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – Climate Change modeling.

Unit III:

Impacts Of Climate Change: Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts fordifferent.

Unit IV:

Climate Change Adaptation and Mitigation Measures: Adaptation Strategy/options in various sectors – Water – Agriculture – Infrastructure and Settlement including coastal zones. Human Health – Tourism – Transport – Energy – Key Mitigation Technologies andpractices–Energysupply–Transport–Buildings–Industry–Agriculture–Forestry Carbon sequestration – Carbon Capture and Storage (CCS) – Waste (MSW &Biowaste, Biomedical, Industrial waste – International andRegional co-operation.

Unit V:

Clean Technology and Energy: Clean Development Mechanism – Carbon Trading – Examples of future Clean Technology – Biodiesel – Natural Compost – Eco-friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels–SolarEnergy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptationfunding.

REFERENCES

1. Al core 'Inconvenient Truth" – videoform
2. Dash SushilKumar, "Climate Change – An Indian Perspective", Cambridge University Press India Pvt. Ltd,2007.

3. IPCC Fifth Assessment Report –www.ipcc.ch
4. Jan C. van Dam, "Impacts of Climate Change and Climate Variability on Hydrological Regimes", Cambridge University Press,2003.

COURSE OUTCOMES: At the end of the course students will be able to

1. Understand the earth's climate change and its systemclassification.
2. Introduce the observed changes in the climate and conceptofmodeling and Institutional arrangements existing for monitoringthe phenomenon.
3. Show the impact of climate change on various sectors and itsirreversibility.
4. Prepare the adaptation and mitigation measures of climate change on various sectors.
5. Choose the clean Technology for the Fuel and energy through natural and ecofriendlytechniques.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82209	WATER AND WASTE WATER TREATMENT LABORATORY (21D82209)	L	T	P	C
Semester	II		0	0	4	2

LIST OF EXPERIMENTS:

1. Determination of pH, Turbidity and conductivity
2. Determination of Hardness
3. Determination of Alkalinity and Acidity
4. Determination of Chlorides
5. Determination of Phosphates and Sulphates
6. Determination of iron and fluoride
7. Determination of Optimum Coagulant dosage
8. Determination of residual chlorine and available chlorine in bleaching powder
9. Determination of Oil, and Grease
10. Determination of suspended, settleable, volatile and fixed solids
11. Determination Dissolved Oxygen and BOD for the given sample
12. Determination of COD for given sample
13. Determination of SVI of Biological sludge and microscopic examination
14. Determination of MPN index of given water sample.

REFERENCE:

1. https://www.slideshare.net/valarmathibalan/ce8512-water-waste-water-analysis-lab-manuval

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82210	AIR QUALITY AND SOLID WASTE MANAGEMENT LABORATORY (21D82210)	L	T	P	C
Semester	II		0	0	4	2

LIST OF EXPERIMENTS:

1. Monitoring of gases and particulates in ambient air.
2. Study of sampling and preservation methods and significance of characterization of water and waste water
3. Determination of pH
4. Optimum Coagulant Dosage by Jar Test
5. Determination of Residual Chlorine
6. Determination of hardness 6 Determination of chloride
7. Turbidity 8 Determination of Available Chlorine in Bleaching Powder
8. Total, Fixed and Volatile Solids
9. Suspended and Dissolved Solids
10. Total Settleable solids
11. Determination of Dissolved Oxygen
12. Estimation of Sulphate
13. Determination of Fluorides
14. Determination of Ammoniacal Nitrogen
15. Determination of COD
16. Determination of Iron
17. Biochemical Oxygen Demand
18. Introduction to Bacteriological Analysis

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D82301	ENVIRONMENTAL SUSTAINABILITY (PE – V)	L	T	P	C
Semester	III		3	0	0	3

UNIT-I
Valuing the environment: concepts, methods, property rights, externalities and environmental problems.

UNIT-II
Sustainable development: defining the concept, the population problem, natural resource, economics: an overview, energy, water agriculture

UNIT-III
Biodiversity, forest habitat, commercially valuable species, stationary source, local air pollution, acid rain and atmospheric modification, transportation

UNIT-IV
Water pollution, solid waste and recycling, toxic substances and hazardous wastes, global warming

UNIT-V
Development, poverty, and the environment, visions of the future, environmental economics

REFERENCES
1. Andrew Hoffirman, Competetive environmental strategy-A guide for the changing business landscape, island press
2. Stephen Doven, Environment and sustainability Policy: Creation, implementation, evaluation, The Federation press, 2005

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF CHEMICAL ENGINEERING
(ENVIRONMENTAL ENGINEERING)

Course Code	21D80302	INSTRUMENTATION TECHNIQUES IN ENVIRONMENTAL ANALYSIS (OPEN ELECTIVE)	L	T	P	C
Semester	III		3	0	0	3

Unit I:
Treatment of Data in Quantitative Analysis: Accuracy, Precision, Standard deviation, Types of errors, Minimization of errors. Significant figures, Criteria for rejection of data, Principles of instrumentation.

Unit II:
Spectrophotometric Methods: Principles, applications, advantages & limitations of the following Spectrophotometric methods: UV Spectrophotometer,Fluorimetry, Nephelometry and Turbidimetry.

Unit III:
Spectrophotometric Methods: Atomic absorption spectrophotometry, Flame photometry, Inductively coupled plasma spectroscopy & Mass spectroscopy.

Unit IV:
Electrochemical Methods: Principles, applications, advantages & limitations of following electrochemical methods: Pulse polarography, cyclic voltametry& anode stripping voltametry, Electrophoresis.

Unit V:
Chromatography: Principles, applications, advantages & limitations of following chromatographic methods: Adsorption, Partition, Column chromatography, Paper chromatography, Gas chromatography, High Performance Liquid Chromatography (HPLC), Ion-chromatography.

BOOKS & REFERENCES:
1. Instrumental Methods of analysis, Willard H H& Dean LL, John Willey, 1976.
2. Modern Methods of chemical analysis Reesok RL, & Shields LD, John Willey & sons, Inc 1990.
3. Instrumental Methods of chemical analysis, Ewing GW, McGrw Hill Book Company, Inc. 1975.
4. Fundamental of molecules spectroscophy. Banwell CN, McGraw Hill, NY, 1990.
5. Vogels textbook of Quantitative chemical analysis, Third Ed.