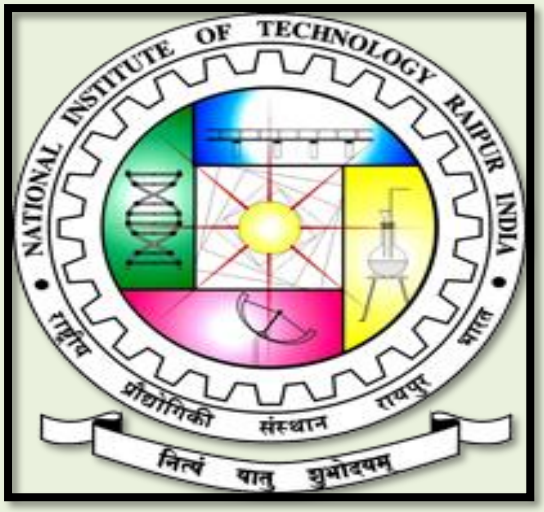
SCHEME AND DETAILED SYLLABUS FOR

MASTER OF TECHNOLOGY

IN

ENERGY AND ENVIRONMENT



2022-23

DEPARTMENT OF CHEMICAL ENGINEERING

National Institute of Technology Raipur, Chhattisgarh – 492010

Department Academic Committee:

Chairperson:	Dr. A. K. Poonia, Associate Professor & Head, Chemical Engineering Department, NIT Raipur
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M. Tech. in Energy and Environment

National Institute of Technology, Raipur (C.G.)

Department of Chemical Engineering

Course of Study				M. Tech. : Energy and Environment								First Semester	
S. No.	Board of Studies	Sub.Code	Subject Name	Periods/Week			Examination Scheme					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Chemical Engineering	CH311101CH	Wastewater Treatment	3	1	-	20	15	15	100	-	150	4
2	Chemical Engineering	CH311102CH	Energy, Environment & Climate Change	3	1	-	20	15	15	100	-	150	4
3	Chemical Engineering	CH311103CH	Solid and Hazardous Waste Management	3	1	-	20	15	15	100	-	150	4
4	Chemical Engineering	CH311201CH - CH311210CH	Elective-01	3	1	-	20	15	15	100	-	150	4
5	Chemical Engineering	CH311211CH - CH311213CH	Elective-02	3	1	-	20	15	15	100	-	150	4
6	Chemical Engineering	CH311401CH	Advanced Analytical Laboratory	-	-	3	75	-	-	-	50	125	2
7	Chemical Engineering	CH311402CH	Environmental Engineering Laboratory	-	-	3	75	-	-	-	50	125	2
			Total	**15**	**5**	**6**	**250**	**75**	**75**	**500**	**100**	**1000**	**24**

List of Electives:

CH311201CH: Environmental Impact Assessment
CH311202CH: Nuclear Energy
CH311203CH: Cleaner Technologies and Sustainability
CH311204CH: Integrated Energy Systems

CH311211CH: Environmental Biotechnology
CH311212CH: Advanced Numerical Techniques and Computer Programming
CH311213CH: Basics of Disaster Management

Wastewater Treatment

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Core	CH311101CH

[Pre-requisites: NIL]

Course Objectives

1. To understand and apply the basic concepts of wastewater treatment.
2. To know the basic characteristics of wastewater and the kinetics of the biological system.
3. To understand the design and working principle of various treatment methods.
4. To select an appropriate treatment process for a specific application.

Course Content

Unit-1. Introduction:

Biosphere, hydrologic cycle, nutrient cycle, sources of wastewater and their characteristics, physical and chemical water quality parameters, classification of water pollutants and their impact, sampling and analysis of wastewater, assessment of pollutants strength in wastewater, and its management. Tolerance limits for effluent discharges and legal aspects of water quality.

Unit-2. Preliminary and primary treatment methods:

Waterborne disease, self-purification of streams, preliminary, primary, secondary, and tertiary treatment technologies. Theories of physico-chemical treatment methods, screening, equalization, grit removal facilities, coagulation, settling operations, filtration.

Unit-3. Biological treatment:

Principles of biological treatment, role of microorganisms in wastewater treatment, types of biological processes for wastewater treatment. Biological methods for nitrogen and phosphorus removal. Aerobic and anaerobic treatment of wastewater, suspended and attached growth biological treatment processes.

Unit-4. Advanced treatment methods:

Recent developments in wastewater treatment like advanced oxidation, electrochemical, membrane separation process, etc. Factors affecting the treatment process, mechanisms and kinetics of the treatment processes, and application of treatment processes, softening, disinfection.

Unit-5. Industrial treatment process:

Scenario of industrial pollution, typical industrial waste characteristics, treatment planning of sugar industry, distillery, petroleum industry, textile industry, pulp, paper industry, etc. General standards for disposal of effluents, concept of the common effluent treatment plant.

Course Materials

Required Text: Text books

1. 1. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental engineering, McGraw Hill Book Company, 1985.
2. Rao C.S, Environmental pollution control engineering, New Age International Publishers, revised second edition 2006.

Optional Materials: Reference Books.

1. Inc. Metcalf & Eddy, George Tchobanoglous, H. Stensel, Ryujiro Tsuchihashi, Franklin Burton, Wastewater Engineering: Treatment and resource recovery, McGraw Hill; 5th edition, 2013.
2. Pollution control Acts, Rules and notification issued thereunder, 5th edition, CPCB, Ministry of environment and forest, GOI, 2006.
3. R.B. Baird, A.D. Eaton, E.W. Rice, Standard methods for the examination of water and wastewater, American public health association, Washington DC, 23rd edition., 2017.

Energy, Environment and Climate Change

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Core	CH311102CH

[Pre-requisites: NIL]

Course Objectives

1. To learn about the earth's energy condition, environment, and climate change.
2. To understand the relationship of the terrestrial energy-environment-climate system.
3. To understand the perturbing effects of anthropogenic activities on the system.
4. To study the climate change quantification and mitigating adverse climate change impacts.

Course Content

Unit-1. Introduction:

Beginning of earth and living things; structure of atmosphere; World energy use and current energy scenario; energy and carbon emissions; environmental pollution; climatic conditions.

Unit-2. Energy balance and management:

Solar and terrestrial radiation; absorption of radiation by gases; earth's energy balance; stern's report; carbon credits; energy usage patterns (oil, coal, gas etc.). Alternative energy sources: solar, wind, hydropower, and nuclear energy, clean technology.

Unit-3. Environmental Variability:

Pollution of the environment; natural (volcanoes, forest fires) and anthropogenic (antarctic ozone hole, global warming). Effects of urbanization, landscape changes, the influence of irrigation, desertification, and deforestation; environmental life cycle assessment (LCA).

Unit-4. Atmospheric Issues:

The global temperature record; global warming and its possible effects; atmospheric chemistry on climate change. Atmospheric aerosol and cloud effects on climate. Composition of the present-day atmosphere. Greenhouse gas theory; greenhouse gases; ozone depletion problem.

Post-industrial revolution scenario.

Unit-5. Climate change and safeguarding:

Photosynthetic mechanism and global climate change; various impacts of global warming; prediction of future climate changes; global climate models; The role of international bodies. Kyoto and Montreal protocols and Kigali agreement. Intergovernmental panel on climate change (IPCC). Moral problems and responses.

Course Materials

Required Text: Text books

1. Peter E Hodgson, Energy, the environment and climate change, Imperial College Press, 2010.
2. Richard Wolfson, Energy, environment, and climate, W. W. Norton & Company; 2nd edition, 2011.

Optional Materials: Reference Books

1. Wilbanks, T., Bilello, D., Schmalzer, D., & Scott, M, Climate change and energy supply and use: Technical report for the U.S. department of energy in support of the national climate assessment. Washington, DC: Island Press. 2013.
2. Frank T. Princiotta, Global climate change - The technology challenge, Springer, 2011.
3. IPCC (Intergovernmental Panel on Climate Change) 1990. Climate Change: The IPCC Assessment. Cambridge University Press, Cambridge.
4. Sorokhtin, O.G.,Chilingar, G.V. and Khilyuk, L.F. Global warming and global cooling: Evolution of climate and earth, Elsevier, 2007.
5. Fouquet R., Handbook on energy and climate change, Edward Elgar Publishing, U.K., 2015.
6. Cherian A., Energy and global climate change: Bridging the sustainable development divide, Wiley Publisher, 2015.

Solid and Hazardous Waste Management

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Core	CH311103CH

[Pre-requisites: NIL]

Course Objectives

1. To understand the solid waste management, sources, characteristics, and problems with solid waste.
2. To understand the collection and transport of municipal solid waste.
3. To know the processing of solid waste and its recovery.
4. To understand hazardous waste disposal and handling.

Course Content

Unit-1. Introduction:

Definition of solid wastes, types of solid wastes, sources- industrial, mining, agricultural, and domestic, characteristics of solid waste, problems - impact on environmental health, concepts of waste reduction, recycling, and reuse.

Unit-2. Collection and transport of solid waste:

Waste composition and analysis, handling of solid waste. Waste collection systems and alternative techniques. Transport means and methods, transfer stations, and their design.

Unit-3. Processing of solid waste and energy recovery:

Unit operations for separation and processing, materials recovery; waste transformation and energy recovery through thermal methods, aerobic and anaerobic methods.

Unit-4. Hazardous waste:

Legislations, toxicological principles, dose-response, toxic effects, and toxic response. Industrial dangerous waste (textiles, tanneries, electroplating, distilleries, etc.), disposal and handling methods, case studies.

Unit-5. Integrated waste management:

Requirements and technical solution, designated waste landfill, remediation, Integrated waste management facilities. Toxicity characteristic leaching procedure (TCLP) tests and leachate studies. Economics of the on-site v/s off-site waste management options. Natural attenuation process and its mechanisms.

Course Materials

Required Text: Text books

1. Worrell W. and Vesilind P.A., Solid waste engineering, Cengage Learning Inc. 2nd edition, 2011.
2. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, Integrated solid waste management, Mc-Graw Hill International edition, 1993.

Optional Materials: Reference Books.

1. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans, Hazardous waste management, Waveland Pr Inc, 2010.
2. CPHEEO, Manual on municipal solid waste management, central public health, and environmental engineering organisation, Ministry of housing and urban affairs, GOI, 2016.
3. Paul T Williams, Waste treatment and disposal, Wiley, 2nd edition, 2013.

Environmental Impact Assessment

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-I	CH311201CH

[Pre-requisites: NIL]

Course Objectives

1. To learn the usefulness of environmental impact assessment and develop the skill for preparation of environmental management plan.
2. To provide knowledge related to the broad field of environmental risk assessment.
3. To learn important processes that control contaminant transport and tools to predict and manage human health risks.

Course Content

Unit-1. Introduction:

Historical development of Environmental Impact Assessment (EIA). EIA in the project cycle. Legal and regulatory aspects in India. Types and limitations of EIA; EIA process, screening, scoping, setting, analysis. Cross-sectoral issues and terms of reference in EIA, Public participation in EIA.

Unit-2. Impact identification and prediction:

Assessment of impacts;air, water, soil, noise and biological, cumulative impact assessment. Matrices, networks, checklists, cost-benefit analysis. Social impact assessment.

Unit-3. EIA documentation:

Analysis of alternatives, software packages for EIA, expert systems in EIA. Prediction tools for EIA; mathematical modeling for impact prediction. EIA findings; planning and report preparations.

Unit-4. Environmental management plan:

Environmental Management Plan; Preparation, Implementation, and review; mitigation and rehabilitation plans; policy and guidelines for planning and monitoring programs; post-project audit; ethical and quality aspects of EIA; Case Studies.

Unit-5. Environmental risk assessment and management:

Environmental risk assessment; hazard identification; dose-response evaluation; exposure assessment; exposure factors, tools for environmental risk assessment; HAZOP and failure modes and effects analysis (FMEA) methods; event tree and fault tree analysis; multimedia and multipath way exposure modeling of contaminant; risk characterization risk communication; emergency preparedness plans; design of risk management programs.

Course Materials

Required Text: Text books

1. Lawrence, D. P., Environmental Impact Assessment–Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
2. Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
3. Kolluru Rao, Bartell Steven, Pitblado R, and Stricoff, Risk assessment and management handbook, McGraw Hill Inc., 1996.

Optional Materials: Reference Books

1. Canter, L.W., Environmental impact assessment, McGraw Hill, 1996.
2. K. V. Raghavan and A A. Khan, Methodologies in hazard identification and risk assessment, Manual by CLRI, 1990.
3. Sam Mannan, Lees' Loss prevention in the process industries, hazard identification, assessment and control, 4th Edition, Butterworth-Heineman, 2012.
4. Technical EIA guidance manuals for various industry, Ministry of Environment Forest & Climate Change, GOI.

Nuclear Energy

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-I	CH311202CH

[Pre-requisites: NIL]

Course Objectives

1. To learn fundamental issues important to a discussion of nuclear energy today.
2. To introduce the basic sciences & technologies involved, i.e., fission & fusion and Reactor theory.
3. To learn about the facts & issues connected with radioactive waste management and nuclear safety.
4. To assess nuclear energy in the context of sustainable development (economics & international law).

Course Content

Unit-1. Introduction:

Scope of nuclear energy (fission and fusion energy), typical reactions basics concepts: binding energy of a nuclear reaction, mass-energy equivalence and conservation laws, nuclear stability and radioactive decay, radioactivity calculations.

Unit-2. Interaction of neutrons with matter:

Compound nucleus formation, elastic and inelastic scattering, cross-sections, energy loss in scattering collisions, poly-energetic neutrons, critical energy of fission, fission cross-sections, fission products, fission neutrons, and energy released in fission, γ-ray interaction with matter and energy deposition, fission fragments.

Unit-3. The fission reactor:

The fission chain reaction, reactor fuels, conversion and breeding, the nuclear power resources, nuclear power plant & its components, power reactors, and current status.

Unit-4. Reactor theory:

Neutron flux, Fick's law, continuity equation, diffusion equation (DE), boundary conditions, solutions of the DE, group diffusion method, Neutron moderation (two group calculation), one group reactor equation, and the slab reactor.

Unit-5. Nuclear fusion and health hazards:

Fusion reactions, reaction cross-sections, reaction rates, fusion power density, radiation losses, ideal fusion ignition, ideal plasma confinement & Lawson criterion. Health hazards: Radiation protection & shielding.

Course Materials

Required Text: Text books

1. J. R. Lamarsh, Introduction to nuclear engineering, Addison Wesley Publishing Co. Inc. 1975.
2. R. A. Gross, Fusion energy, John Wiley & Sons Inc., 2008.

Optional Materials: Reference Books.

1. Nuclear Energy Today, OECD Publication, 2, rue andré-pascal, 75775 Paris Cedex 16 printed in France (32 2003 04 3 p) – no. 52983 2003

Cleaner Technologies and Sustainability

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-I	CH311203CH

[Pre-requisites: NIL]

Course Objectives

1. To introduce concepts of green chemistry and different techniques to achieve sustainability.
2. To provide acquaintance with modern, cleaner production processes and emerging energy technologies.
3. To facilitate understanding of the need and application of green and renewable technologies for sustainable development of the society.
4. To understand steps and skills in designing technically viable cleaner production systems.

Course Content

Unit-1. Sustainability:

Industrialization and sustainable development; cleaner production (CP) in achieving sustainability; clean development mechanism; source reduction techniques: raw material substitution; process modification, process technology innovations; equipment modification; waste prevention and minimization of waste generation; reuse and recycling strategies; treatment and disposal; pollution prevention programs.

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Unit-2. Cleaner production:

Overview of CP assessment steps and skills; fundamental analysis of material and energy flows; Green chemistry; identifying and reducing losses; new and low waste technologies; product modification; good housekeeping; resource recovery/by-product recovery from the manufacturing process by cleaner production technology (CPT).

Unit-3: Green design:

Green productivity - benefits and challenges; public policies and market-driven initiatives; adequate green specifications; energy-efficient design; green power; green materials, rating

systems.

Unit-4. Energy audit:

Energy audit methodology; detail of Energy audit and energy conservation; energy conservation via cleaner technology options; use of clean fuels.

Unit-5. Cleaner production technology:

Green Processes; implementation of CP and cleaner technology; typical case studies of cleaner production technology in chemical engineering industries.

Course Materials

Required Text: Text books

1. Kirkwood RC and Longley, AJ(Eds.), Clean Technology and the Environment, Chapman & Hall, 1995.
2. Modak P, Visvanathan C, and Parasnis M, Cleaner Production Audit, Course Material on Cleaner Production and Waste Minimization; United Nations Industrial Development Organization (UNIDP), 1995.
3. P. M. Randall, Engineers Guide to Cleaner Production Technologies, 1st edition, CRC Press, 1996.

Optional Materials: Reference Books

1. V. K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions, 2nd Edition, CRC Press, 2012.
2. W. Hoyleand and M. Lancaster, Clean Technology for manufacture of Specialty Chemicals, Royal Society of Chemistry, 2001.
3. Rao S and Parulekar BB, Energy Technology: Non-conventional; Renewable and Conventional; Khanna Pub. 2005..

Integrated Energy Systems

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-I	CH311204CH

[Pre-requisites: NIL]

Course Objectives

1. To provide an understanding of interrelations between various forms of energy
2. To provide overall understanding on the various energy sources, economic aspects and sustainability.
3. To provide knowledge on thermodynamic analysis of energy systems and improvement using integration and multigeneration.

Course Content

Unit-1. Introduction:

Energy classification, thermodynamics-energy and exergy, exergy and sustainability, and energy and exergy analysis of some standard components.

Unit-2. System integration:

System design, thermodynamic analysis, integration and multigeneration, comparative analysis of the conventional and renewable based single and multigeneration system.

Unit-3. Integration of conventional energy systems:

Introduction, power cycle and combined cycle brainstorming for system integration, compressed air energy storage (CAES) for integrated turbine power plant, integrated gasification combined cycle for hydrogen production, integrated SOFC and coal gasification system.

Unit-4. Integration of nuclear energy:

Fundamentals, a nuclear energy-based multigeneration, high-temperature nuclear reactor for - electricity, hydrogen, and hot water production, CANada deuterium uranium 6 (CANDU 6) and sodium-cooled fast reactors for desalination and electricity.

Unit-5. Renewable energy integration:

Renewable energy sources, solar heliostat-based multigeneration, solar and geothermal energy integration, integrated concentrated solar energy system, renewable energy integration in India, exergo-economic analysis, life cycle assessment, exergo-enviro sustainability.

Course Materials

Required Text: Text books

1. Ibrahim Dincer and Yusuf Bicer, Integrated energy systems for multigeneration, Elsevier, 2019.
2. Yatish T. Shah, Energy and fuel systems integration, CRC press 2015.

Optional Materials: Reference Books

1. Felix A. Farret and M. Godoy Simoe, Integration of alternative sources of energy, Wiley, 2006.
2. Giorgio Graditi, Marialaura Di Somma, Technologies for integrated energy systems and networks,Wiley, 2022.

Environmental Biotechnology

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-II	CH311211CH

[Pre-requisites: NIL]

Course Objectives

1. To apply the basic knowledge of biotechnology in environmental engineering.
2. To understand the fundamentals of the biological system involved in environmental sustainability.
3. To develop skills to manage the environment.

Course Content

Unit-1. Principles and concepts of the environment:

Ecosystem types, characteristics, structure, and function. concept of the biosphere. Food chains, food webs, and trophic structures. Ecological pyramids, biodiversity and its conservation strategies: global scenario, natural resources, current status of major resources. Population ecology.

Unit-2. Environmental pollution and current environmental issues:

Environmental pollution and its impacts, global warming and greenhouse effect, global ozone problem, acid rain, land degradation, and biomagnification.

Unit-3. Conventional and advanced treatment technology:

Methanogenesis, methanogenic, acetogenic, and fermentative bacteria, emerging biotechnological processes in wastewater treatment, eutrophication, effects of eutrophication on the quality of water environment, and factors influencing eutrophication. Algae in eutrophication, algal blooms.

Unit-4. Environment protection through biotechnology:

Biodegradation and bioremediation of pollutants, biomineralization, biofertilizers, biopesticides and vermicomposting, degradative plasmids, and the release of genetically engineered microbes in the environment.

Unit-5. Biomass energy and biofuels:

Production of biodiesel, production of bioethanol, bioelectricity, microbial fuel cells, direct biomass combustion, and co-firing technologies.

Course Materials

Required Text: Text books

1. M. C. Dash, Fundamentals of ecology, Tata Mc-Graw Hill Publication, 2nd edition, 2001**.**
2. P. K. Mohapatra, Textbook of environmental biotechnology, I K International Publishing House Pvt. Ltd. 2006.

Optional Materials: Reference Books

1. Inc. Metcalf & Eddy, George Tchobanoglous, H. Stensel, Ryujiro Tsuchihashi, Franklin Burton, Wastewater engineering: Treatment and resource recovery, McGraw Hill; 5th edition, 2013.
2. David Sheehan, Bioremediation protocols, Springer, 1997.
3. S. Kannaiyan, Biotechnology of biofertilizers, Alpha Science International, 2002.
4. C. J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Manual of environmental microbiology, ASM Press; 3rd edition, 2007.

Advanced Numerical Techniques and Computer Programming

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-II	CH311212CH

[Pre-requisites: NIL]

Course Objectives

1. To understand error and interpolation for the data.
2. To understand integration for the solution of problems.
3. To obtain the solution of non-linear equations and curve fitting.
4. To understand the solution of ordinary and partial differential equations.

Course Content

Unit-1. Errors and interpolation:

Concept of error in computation; Interpolation: introduction of finite differences, operators, forward interpolation formula, backward interpolation formula, central difference formula, Lagrange's interpolation formula, inverse interpolation, bivariate interpolation, spline interpolation, computer programming.

Unit-2. Curve fitting:

Principle of least squares, fitting a straight line and other curves for a given set of data points. Multiple linear regression, weighted least square method, orthogonal polynomials, Gram-Schmidt orthogonalization process, computer programming.

Unit-3. Integration:

Formulae for derivatives, Newton-cotes's quadrature formula, trapezoidal rule, Simpson's one-third rule, Simpson's three-eighths rule, Weddle's rule, Romberg's method, double integration, Gauss-Legendre quadrature formula, Gauss Chebyshev quadrature formula, computer programming.

Unit-4. Non-linear equations:

Numerical solution of algebraic & transcendental equations, Newton-Raphson method, its applications, non-linear simultaneous equations, Newton-Raphson method for multiple roots, method for complex root, comparison of various techniques, computer programming.

Unit-5. Ordinary and partial differential equations

Picard's method, Taylor's method, Euler's method, Runge–Kutta method, modified Euler's method, predictor-corrector methods: Adam's method, Milne's method, classification of PDEs of 2^{nd} order, elliptic equations, Poisson's equation, parabolic equation, Bender-Schmidt method, Crank-Nicholson method, computer programming.

Course Materials

Required Text: Text books

1. S.S. Sastry (2009), Introductory methods for numerical analysis, Prentice Hall of India.
2. B.S. Grewal (2010), Numerical methods in engineering and science with programs in C & C++, Khanna Publisher.

Optional Materials: Reference Books

1. M.K. Jain, S.R.K. Iyenger and R.K. Jain (2007), Numerical methods for scientific and engineering computation, New Age International.
2. S.D. Conte and C. de Boor (1980), Elementary numerical analysis - an algorithmic approach, Mc Graw Hill, New York.

Basics of Disaster Management

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-II	CH311213CH

[Pre-requisites: NIL]

Course Objectives

1. To familiarize with the concepts, terminologies, and developments in the field of disaster management
2. To learn how to assess disaster risk and prepare disaster risk management plans and their implementation
3. To learn about the nature and characteristics of major natural disasters and how to mitigate the risk involved with such disasters
4. To narrate India's institutional disaster risk management processes to regulate disaster management activities.

Course Content

Unit-1: Introduction to disasters:

Understanding disasters, geological disasters; hydro-meteorological disasters; biological disasters; technological disasters and artificial disasters; global disaster trends-emerging risks of disasters, climate change and urban disasters.

Unit-2: Disaster management cycle and framework:

Disaster management cycle, pre-disaster, risk assessment and analysis, risk mapping, prevention and mitigation of disasters, early warning system; preparedness, capacity development; evacuation, disaster communication, search and rescue, emergency operation center, incident command system, relief and rehabilitation, post-disaster: damage and needs assessment, restoration of critical infrastructure, early recovery, reconstruction and redevelopment.

Unit-3: International disaster management experience:

International disaster management efforts during Spanish flu (1918), tsunamis (2004), and Covid (2019). The Cuban model of hurricane risk management. Japan's emergency

management and response system. Bangladesh multi-hazard risk reduction model. Critical analysis of international disaster management experience, identifying gaps and best practices.

Unit-4: Disaster administration:

United Nations and its disaster management mechanism UNDP, UNDRR, WHO. Disaster management in India, allied governmental bodies, institutions, and mechanisms/resources for disaster management; state and federal disaster mitigation funds. Gaps in disaster policy and administration.

Unit-5: Applications of science and technology for disaster management:

Geo-informatics in disaster management (GIS, GPS, and RS), disaster communication system, land use planning and development regulations, disaster safe designs and constructions, structural and non-structural mitigation of disasters, S&T institutions for disaster management in India, case studies.

Course Materials

Required Text: Text books

1. Damon P. Coppola, Introduction to international disaster management, Elsevier Science 3rd edition, 2015.
2. H. N. Srivastava, Management of natural disasters in developing countries, Daya Books, 2006.
3. S L Goel, Encyclopedia of disaster management (3 Vols-Set), Deep and Deep Publication Pvt. Ltd., 2020.

Optional Materials: Reference Books

1. Angus M. Gunn, Encyclopedia of disasters: Environmental catastrophes and human Tragedies, Vol. 2, Greenwood Publishing Group, 2007.
2. Angus Macleod Gunn, Encyclopedia of disasters: Environmental catastrophes and human tragedies, Vol. 1, Greenwood Press, 2010.
3. David C. Alexander, Natural disasters, CRC Press, 1993.
4. Anu Kapur, Disasters in India: Studies in grim reality, Rawat (Publisher), 2006.
5. Pardeep Dhameja, Disaster mitigation: Experiences and reflections, Prentice Hall of India, 2004.
6. Sharma, R. K. and Sharma, G. Natural disaster, APH Publishing Corporation, 2005.
7. National Disaster Management, Toolkit for Urban Planning, 2014, Amit Bose, Director, DDF Consultants Pvt. Ltd, New Delhi.
8. National Disaster Management Plan, National Disaster Management Authority Ministry of Home Affairs, Government of India, November 2019.
9. National Disaster Management Policy, 2009, Government of India.
10. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management.

Advanced Analytical Laboratory

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	0-0-3, 2	Laboratory	CH311401CH

[Pre-requisites: NIL]

Course Objectives

1. To understand the principle and working of the various analytical instrument.
2. To understand the application of analytical instruments

Course Content

List of Experiments:

1. To determine the concentration of different ions (fluorides, cyanides, sulfates, etc.) in the sample by using an ion meter.
2. To determine the concentration of toxic heavy metals in the sample by using atomic absorption spectroscopy (AAS).
3. To determine the solute concentration in the sample by using a UV-Visible spectrophotometer.
4. To determine and quantify each component in the sample mixer by using High-performance liquid chromatography (HPLC).
5. To determine the presence of various functional groups present in the solid/liquid sample by using *Fourier-transform infrared spectroscopy* (FTIR).
6. To determine the Zeta potential of the sample by using Zeta potential analyzer.
7. To determine particle size and molecular weight of the sample by using a particle size analyzer.
8. To determine the trace amounts of water in a sample by Karl Fischer volumetric titration.
9. To determine the concentrations of anions and cations by using ion chromatography (IC).
10. To determine the gas composition in a given sample by using a gas chromatograph (GC).
11. To determine the fraction of components available in the liquid/gaseous mixer by using gas chromatography-mass spectrometry (GC-MS).
12. To determine the material's thermal stability and its fraction of volatile components by using thermogravimetric analysis (TGA).

Environmental Engineering Laboratory

[I Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	0-0-3, 2	Laboratory	CH311402CH

[Pre-requisites: NIL]

Course Objectives

1. To analyze the experimental results based on theory taught in the introductory environmental engineering course.
2. To learn the various analytical techniques available for water and wastewater treatment
3. To learn about water, wastewater, soil, and air quality standards and their tests.
4. To learn the fundamentals of water chemistry.

Course Content

List of Experiments:

1. To determine the given water sample's turbidity, electrical conductivity, and pH.
2. To determine the optimum coagulant dosage for given water sample using Jar test apparatus.
3. To determine the acidity, alkalinity, and types of hardness in a given water sample.
4. To determine the chloride content of wastewater sample.
5. To determine the various types of solids in the given water sample.
6. To determine the nitrate, sulfate, and sulfide in the given water sample.
7. To determine the DO and BOD in the given water sample.
8. To determine the COD in the given water sample.
9. To determine the oil and grease in the given water sample.
10. To determine the chlorine demand, residual chlorine, and breakpoint.
11. To determine the toxic heavy metals concentration in the given water/soil sample using AAS.
12. To determine alkali and alkaline earth metals in the given water/soil sample using the Flame Photometer.
13. To prepare the media and inoculation and Identification of microbes by Gram staining.

14. To determine the plate count, coliforms, fecal coliforms, E. coli, S. fecalis, M.P.N., and M.F. techniques.
15. To isolate microbes from soil by serial dilution methods and perform colony count using colony counter.
16. To determine the specific gravity, bulk density, and moisture content of soil sample.
17. To determine the different components of NOM by TOC analyzer and spectrophotometer.
18. To determine the NOx, SOx, CO and CO2 in air sample.
19. To determine the noise/sound level of different locations.
20. To determine the particulate matter in the air sample.
21. To construct the wind rose diagram & demonstrate the stack monitoring kit.

Note: Student has to perform at least 10 (ten) experiments.

Course Materials

Reference Books.

1. APHA (2012), Standard Methods for the Examination of Water and Wastewater, 22nd Edition. American Public Health Association, Washington, DC.
2. Guidelines for Measurement of Ambient Air Pollutants, Volume 1, CPCB, 2011.
3. Guide Manual: Water and Wastewater Analysis, CPCB 2011.
4. Handbook of Instrumental Techniques for Analytical Chemistry, Frank A. Settle, 1st Edition, Prentice-Hall.
5. S K Maiti. Handbook of methods in Environmental analysis (Vol 1 & 2). Oxford, India.

M. Tech. in Energy and Environment

National Institute of Technology, Raipur (C.G.)

Department of Chemical Engineering

Course of Study				M. Tech. : Energy and Environment								Second Semester	
S. No.	Board of Studies	Sub. Code	Subject Name	Periods/Week			Examination Scheme					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Chemical Engineering	CH312101CH	Air Pollution Control	3	1	-	20	15	15	100	-	150	4
2	Chemical Engineering	CH312102CH	Non-Conventional Energy Sources	3	1	-	20	15	15	100	-	150	4
3	Chemical Engineering	CH312103CH	Energy Auditing and Management	3	1	-	20	15	15	100	-	150	4
4	Chemical Engineering	CH312201CH - CH312210CH	Elective-03	3	1	-	20	15	15	100	-	150	4
5	Chemical Engineering	CH312211CH - CH312213CH	Elective-04	3	1	-	20	15	15	100	-	150	4
6	Chemical Engineering	CH312401CH	Energy Engineering Laboratory	-	-	3	75	-	-	-	50	125	2
7	Chemical Engineering	CH312402CH	Environmental Simulation Laboratory	-	-	3	75	-	-	-	50	125	2
			Total	**15**	**5**	**6**	**250**	**75**	**75**	**500**	**100**	**1000**	**24**

List of Electives:

CH312201CH: CO_2 Sequestration and Utilization
CH312202CH: Remote Sensing and GIS
CH312203CH: Solar Photovoltaic Devices and System
CH312211CH: Environmental Management
CH312212CH: Nanotechnology in Energy and Environment
CH312213CH: Safety in Process Industries

Air Pollution Control

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Core	CH312101CH

[Pre-requisites: NIL]

Course Objectives

1. To understand and apply basic concepts of air pollution control.
2. To know the sources of pollutants, sampling, and legislation.
3. To study air pollution control methods and their application.

Course Content

Unit-1. Sources and effects of air pollution:

Introduction, sources and classification of air pollutants, behavior and fate of air pollutants, effects of air pollution, sampling, estimation, and analysis of air pollutants, air quality standards, air pollution laws, and air pollution management.

Unit-2. Meteorological aspects in air pollution:

Temperature inversions, lapse rates, atmospheric stability conditions, wind velocity profile, plume behavior, dispersion of air pollutants, general characteristics of stack emissions, plume dispersion model, and effective stack height calculations.

Unit-3. Control of particulates:

Type of particulates, airborne particulate matter, classification of particulates, control equipment for particulate matter, and selection of the particulate collector.

Unit-4. Control of gaseous pollutants:

Absorption, adsorption, condensation and conversion of gaseous pollutants, incineration process, and catalytic converter.

Unit-5. Case study and future challenges:

Impact assessment studies of some cases, Bhopal gas tragedy, London smog, Chernobyl explosion, Donora smog, etc., future challenges.

Course Materials

Required Text: Text books

1. Peavy H. S., Rowe D. R., and Tchobanoglous G., "Environmental engineering," McGraw Hill Book Company, 1985.
2. Rao C.S, Environmental pollution control engineering, New Age International Publishers, Revised Second Edition, 2006.
3. Rao M.N., Rao H. V. N., "Air pollution," Tata McGraw Hill Publishing Company Limited, New Delhi, 2007.

Optional Materials: Reference Books

1. Anjaneyulu Y., "A textbook of air pollution and control technology," Allied Publishers, New Delhi, 2002.
2. Boubel R. W., FOX D. L., Turner D. B., Stern A. C., "Fundamentals of air pollution," 4th edition, Academic Press, 2008.
3. Gopala Rao M., Sittig M., "Dryden's outlines of chemical technology for the 21st Century", 3rd edition, WEP East-West Press, 2010.
4. Theodore L, Air pollution control equipment calculations, John Wiley & Sons, Inc., Hoboken, 2008.
5. Noel de Nevers, Air pollution control engineering, McGraw Hill, Singapore, 1995.

Non-Conventional Energy Sources

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Core	CH312102CH

[Pre-requisites: NIL]

Course Objectives

1. To know about the world energy scenario and non-conventional energy sources.
2. To appreciate the advantages of energy production from renewable energy resources.
3. To learn the technology involved in the extraction/conversion of renewable energy sources into useful energy.
4. To get updated with alternative and new sources of energy.

Course Content

Unit-1. Introduction:

Global & Indian energy scenario, potential, and advantages of non-conventional energy resources, energy conservation, renewable energy.

Unit-2. Solar energy:

Solar radiation and its measurement, solar collectors–types, and constructional details. Solar water heating, applications of solar energy for heating, drying, space cooling, water desalination, solar concentrators, and photovoltaic power generation using solar cells.

Unit-3. Wind & Bio-energy:

Principle of wind energy, windmill construction and operational details, and electricity generation and mechanical power production. Combustion, pyrolysis, and another thermochemical conversion of biomass to energy, biogas.

Unit-4. Tidal energy and ocean thermal energy:

Tidal Energy, Ocean thermal energy conversion (OTEC), geothermal energy, and other alternative & new sources of energy.

Unit-5: Hydrogen energy and fuel cell:

Classification of fuel cells; operating principles; fuel cell thermodynamics. Hydrogen energy and its applications. Energy storage and distribution.

Course Materials

Required Text: Text books

1. Twiddle, J. Weir, T. "Renewable energy resources," Cambridge University Press, 1986.
2. Rai, G.D., "Non-conventional energy sources," Khanna Publishers, New Delhi, 2001.
3. Sukhatme, S. P., "Solar energy: Principles of thermal collection and storage," 2nd ed., Tata McGraw-Hill, 2001.

Optional Materials: Reference Books

1. Sorenson, B, "Renewable energy," 3rd ed., Elsevier Science, 2004.
2. Kreith, F. and Kreider, J. F., "Principles of solar engineering," McGraw Hill, 1978.
3. Duffie, J. A., Beckman, W. A., "Solar engineering of thermal processes," John Wiley, 1980.
4. Veziroglu, N., "Alternative energy sources," Volume 5 & 6, McGraw-Hill, 1978.
5. Garg, H.P., and Prakash, J., "Solar energy: Fundamentals and applications," Tata McGraw-Hill, 2001.
6. S. Rao and B.B. Parulekar, Energy technology, nonconvential, renewable, and conventional, Khanna Publishers, 1994.
7. G. N. Tiwari and M K Ghosal, Fundamentals of renewable energy sources, Narosa Publishing House, 2007.

Energy Auditing and Management

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Core	CH312103CH

[Pre-requisites: NIL]

Course Objectives

1. To identify and describe the present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in the energy audit of a utility.
3. To describe the energy performance evaluation of some standard installations.

Course Content

Unit-1. Introduction:

Global & Indian energy scenario, types, forms, and energy consumption. Energy conservation, Acts and related policies, and energy ratings.

Unit-2. Energy audit:

Objectives and background of energy management, energy audit: types & methodology, energy audit report format, instruments.

Unit-3. Energy costs and financial analysis:

Understanding energy costs, benchmarking and energy performance, fuel, and energy substitution, material & energy balance, financial techniques for assessing energy conservation measures, fixed and variable cost, interest charges, simple payback period, net present value, and discounted cash flow method.

.

Unit-4. Energy efficiency and conservation:

Review of different thermal loads, energy conservation opportunities in the steam distribution system, assessment of steam distribution losses, steam leakages, steam trapping, condensate, and flash steam recovery system. General fuel economy measures in boilers and furnaces, waste heat recovery, use of insulation- types and application.

Unit-5. Case studies:

Green building, application of non-conventional and renewable energy sources. Case studies of an energy audit in different industries

Course Materials

Required Text: Text books

1. Smith CB, Energy management principles, Pergamon Press, New York, 2015.
2. T. D. Eastop and D. R. Croft,Energy efficiency for engineers and technologists, Longman Harlow,1996..

Optional Materials: Reference Books

1. LC Witte, PS Schmidt and DR Brown, Industrial energy management and utilization, Hemisphere Publishing Corporation, Washington Energy Management, 1998.
2. A. K. Tyagi, Handbook on energy audits and management, Tata Energy Research Institute (TERI).
3. Geofry Stokes, Handbook of electrical installation practice, Blackwell Science.
4. Anil Valia, Designing with light: Lighting handbook, Lighting system.
5. Dale R. Patrick, S. Fardo, Ray E. Richardson, energy conservation guidebook, Fairmont Press.
6. Albert Thumann, W. J. Younger, T. Niehus, Handbook of energy audits, CRC Press.
7. www.energymanagertraining.com
8. www.bee-India.nic.in

CO_2 Sequestration and Utilization

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-III	CH312201CH

[Pre-requisites: NIL]

Course Objectives

1. To learn about Carbon storage.
2. To understand the fundamentals of CO_2 sequestration and utilization.
3. To work towards a low carbon future.

Course Content

Unit-1.

Carbon cycle, global warming, The carbon budget of our atmosphere, carbon capture and storage (CCS) in a nutshell.

Unit-2.

Carbon neutrality, policy and regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U).

Unit-3.

CO_2 capture technologies from power plants: Pre and post combustion capture, CO_2 captures agents: adsorption, ionic liquids, metal-organic frameworks. Oxy-fuel combustion, chemical looping combustion, calcium looping combustion,

.

Unit-4.

The transport of carbon dioxide, geological storage, rocks for geological carbon storage, reservoirs, seals and traps, storage in aquifers and depleted oil fields, trapping the carbon dioxide, leakage and monitoring, global storage capacity.

Unit-5.

CO_2 conversion and utilization, CO_2 to fuels and chemicals, photochemical, electrochemical, bio-chemical and catalytic conversion, future developments.

Course Materials

Required Text: Text books

1. Smit, B., Reimer, J.A., Oldenburg, C.M., Bourg, I.C. Introduction to carbon capture and sequestration. Imperial College Press, 2014.
2. Bandyopadhyay A., Carbon capture and storage, CO_2 management technologies, CRC Press, 1st edition, 2014.
3. Wilcox, J., Carbon capture. Springer, 2012.

Optional Materials: Reference Books

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the carbon cycle, Elsevier, 2015, 1st edition.
2. Goel M, Sudhakar M, Shahi RV, Carbon capture, storage and, utilization: A possible climate change solution for energy industry, TERI, Energy and Resources Institute, 2015, 1st edition.
3. Fennell P, Anthony B, Calcium and chemical looping technology for power generation and carbon dioxide (CO_2) capture, Woodhead Publishing Series in Energy: No. 82, 2015, 1st edition.
4. Mercedes Maroto-Valer, Developments in innovation inc carbon dioxide capture and storage technology: Carbon dioxide storage and utilization, M, Vol. 2, Woodhead Publishing Series in Energy, 2014, 1st edition.
5. Alireza Bahadori, Fundamentals of enhance oil and gas recovery from conventional and unconventional reservoirs, Elsevier Inc., 2018, 1st edition.

Remote Sensing and GIS

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-III	CH312202CH

[Pre-requisites: NIL]

Course Objectives

1. To understand the basic concepts of remote sensing and GIS.
2. To know various applications of remote sensing and GIS applications for environmental and energy management.
3. To learn the GIS software and data processing.

Course Content

Unit-1. Basic concepts of remote sensing:

Basic principles of remote sensing; components of remote sensing; energy source, electromagnetic spectrum, and radiation; energy interaction; spectral response pattern of earth surface features.

Unit-2. Technology of remote sensing:

Classification of remote sensing systems; energy recording technology; aerial photographs; photographic systems- across the track and along with track scanning; multispectral remote sensing; thermal remote sensing; microwave remote sensing-active and passive sensors, RADAR, LIDAR; satellites and their sensors; Indian space program-research and development.

Unit-3. Data processing:

Characteristics of remote sensing data, photogrammetry; satellite data analysis; visual image interpretation; Digital image processing-image rectification, enhancement, transformation, classification, data merging, RS-GIS Integration, image processing software.

Unit-4. Basics of GIS & analysis tools:

GIS concepts-spatial and non-spatial data; vector and raster data structures; data analysis; database management: GIS software.

Unit-5. Applications of remote sensing and GIS:

Different applications of remote sensing and GIS in energy, environmental, and resource management; case studies; contemporary issues.

Course Materials

Required Text: Text books

1. Peter A. Burrough, Rachael A. Mc Donnell and Christopher D. Lloyd, Principles of geographical information systems, Oxford University Press, 3rd edition, 2015.
2. T. Lille S., R. W. Kiefer and Jonathan Chripman, Remote Sensing and Image Interpretation, Wiley Publisher, 7th edition, 2015.
3. B. Bhatta, Remote Sensing and GIS, Oxford University Press, New Delhi, 2nd edition, Fourth Impression, 2012.

Optional Materials: Reference Books.

1. Paul Wolf, Bon DeWitt and Benjamin Wilkinson, Elements of photogrammetry with application in GIS, McGraw-Hill Education; 4th edition, 2014.
2. Burrough, P.A. and McDonnell, R.A., Principles of geographic information systems Oxford University Press, New York, 2001.
3. G S Srivastava (2014), an Introduction to geoinformatics, McGraw Hill Education (India) Private Limited.
4. Lintz, J. and Simonet, Remote sensing of environment, Addison Wesley Publishing Company, New Jersey, 1998.
5. M. Susan Moran (2001). Principles and applications of imaging radar, Manual of remote sensing, 3rd edition, Vol. 2.
6. Kang-tsung Chang (2015), Introduction to geographic information systems, McGraw-Hill Education; 8th edition.

Solar Photovoltaic Devices and System

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-III	CH312203CH

[Pre-requisites: NIL]

Course Objectives

1. To understand the various aspects of solar photovoltaic (PV) devices and systems.
2. To make familiar with the different solar cell technologies.
3. To understand the different materials and recent advances in solar PV technology

Course Content

Unit-1. Fundamentals of photovoltaic cells:

Classification of solar cells, solar cell working, testing of solar cells, applications and economics of PV cells.

Unit-2. Principle and Design of Photovoltaic cells:

Semiconductor physics and operating principle, design of solar cells-cell parameters limits, losses in solar cells, solar cell design for high short circuit current (I_{sc}), open-circuit voltage (V_{oc}), and fill factor (FF). Photovoltaic (PV) device characterization.

Unit-3. Solar cell technologies:

First, second, and third Generation silicon-based PV technologies. Materials and manufacturing processes (wafer, cell, and module) of solar cells and panels. Optics for concentrators, high concentrator solar cells.

Unit-4. PV module and PV system applications:

Solar PV systems, batteries for PV systems, stand-alone, hybrid, grid-connected systems, and standalone PV systems (lighting, water pumping, etc.).

Unit-5. Recent advances:

Emerging solar cell technologies: organic PV, heterostructure with intrinsic thin film, dye-sensitized solar cell, perovskite solar cells, etc.

Course Materials

Required Text: Text books

1. Mertens, K., Photovoltaics: Fundamentals, technology, and practice, Wiley, 2013.
2. Solanki, C. S., Solar photovoltaics: Fundamentals, technologies and applications, Prentice Hall India, 2009.

Optional Materials: Reference Books.

1. Mukerjee, A.K. and Thakur N., Photovoltaic systems: analysis and design, PHI, 2011.
2. Barbec, V. Dyakonov, V., Parisi, J., Saricifttci, N.S., Organic photovoltaics: Concepts and realization, Springer Verlag, 2003.
3. Tiwari, G.N., Solar energy: Fundamentals, design, modelling and application, Alpha Science International Ltd, 2012.

Environmental Management

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-IV	CH312211CH

[Pre-requisites: NIL]

Course Objectives

1. To apply the basic knowledge of environmental engineering.
2. To understand the various policies with regards to the environment.
3. To develop skills to manage the environment.

Course Content

Unit-1. Principle, policy and legal aspects:

Introduction of environmental management (EM), participants of EM, environmental ethics, environmental concerns in India, ecology and the environment, processes of ecosystem, environmental policies and program in India, environmental laws and legislation, legislation in Indian context.

Unit-2. Environmental impact assessment (EIA):

Evolution of EIA, forecasting environmental changes, strategic environmental assessment (SEA), environmental clearance (EC) procedure in India, preliminary stages of EIA, steps of EIA, EIA monitoring and auditing, review of EIA report.

Unit-3. Environmental auditing (EA) and life cycle assessment (LCA):

Audit methodology, elements of audit process, waste audits and pollution prevention assessments, auditing of environmental management system (EMS), report preparation and review report. LCA-stages, purpose, application and case study of different products.

Unit-4. Environmental management techniques:

Environmental monitoring & modeling, sensitivity analysis, remote sensing application in EM, environmental risk assessment.

Unit-5. Environmental design (ED) and economics:

Principle, benefits and motivation of ED, ED for building, developmental planning, economics and environment, environmental valuation, economic natural resources.

Course Materials

Required Text: Text books

1. Mary K., Theodore, Louis Theodore, Introduction to environmental management, CRC Press; 2nd edition, 2021.
2. T. V. Ramachandra, and Vijay Kulkarni, Environmental management" The Energy and Resources Institute, TERI, 2009.

Optional Materials: Reference Books

1. M. N. Rao, "Wastewater treatment" Oxford and IBH publishing Co. Pvt Ltd, 2007.
2. Christopher Sheldon, Environmental management systems.

Nanotechnology in Energy and Environment

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-IV	CH312212CH

[Pre-requisites: NIL]

Course Objectives

1. To acquaint with the synthesis and characterization of various nanomaterials.
2. To familiarize with the science related to various phenomena observed at the nanoscale.
3. To apply the knowledge of nanotechnology in various fields of energy and the environment.

Course Content

Unit-1. Nanotechnology:

Introduction and classification, electronic properties of atoms and solids, effects of nanoscale dimensions, making nanostructures: top-down and bottom-up.

Unit-2. Nanostructures and nanomaterials:

Physical chemistry of solid surfaces, electrostatic stabilization, steric stabilization, zero-dimensional nanostructures, 1-D nanostructures, 2-D nanostructures.

Unit-3. Characterization of nanomaterials:

Analytical and imaging techniques, microscopy techniques, diffraction techniques, spectroscopy techniques, surface analysis, and depth profiling.

Unit-4. Nanomaterials for energy applications:

High-efficiency perovskite solar cells, silicon solar cells, energy storage, conversion devices, hydrogen generation from solar water splitting, and rechargeable lithium batteries.

Unit-5. Nanomaterials for environmental applications:

Nanomaterials for groundwater remediation, membrane processes, nanomaterial as adsorbents. Potential Impacts of nanomaterials: Toxicological impacts of nanomaterials, ecotoxicological impacts of nanomaterials, assessing life-cycle risks of nanomaterials.

Course Materials

Required Text: Text books

1. R. Kelsall, I. Hamley, M. Geoghegan, Nanoscale science and technology, John Wiley & Sons, 2005.
2. S.M. Lindsay, Introduction to nanoscience, Oxford University Press, 2009.

Optional Materials: Reference Books

1. G. Cao, Nanostructures and nanomaterials, Imperial College Press, London, 2004.
2. Q. Li, Nanomaterials for sustainable energy, Springer Intl. Publishing, 2016.
3. M.R. Wiesner, J.-Y. Bottero, Environmental nanotechnology–Applications and impacts of manomaterials, Mc-Graw Hill Education, 2nd edition, 2017.
4. S. Thomas, E. H. M. Sakho, N. Kalarikkal, O. S. Oluwafemi, J. Wu, Nanomaterials for solar cells applications, Elsevier Science, 2019.
5. S. K. Kulkarni, Nanotechnology: Principles and practices, Capital Publishing Company, 2007.
6. F. Şen, A. Khan, A.M.A. Asiri, Nanomaterials for hydrogen storage applications, Elsevier, 1st edition, 2020.

Safety in Process Industries

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, 4	Elective-IV	CH312213CH

[Pre-requisites: NIL]

Course Objectives

1. To know about Industrial safety programs and toxicology.
2. To understand fire and explosion and their preventive methods.
3. To analyze industrial hazards and their risk assessment.
4. To understand the industrial laws, regulations, and source models.

Course Content

Unit-1. Introduction:

Safety programs, engineering ethics, accident and loss statistics, acceptable risk, public perceptions, nature of the accidental process, inherent safety, effect of toxicants on biological organisms, toxicological studies, dose versus responses and models, relative toxicity, threshold limit value, national fire protection association (NFPA).

Unit-2. Industrial hygiene and source models:

Government laws and regulations, OSHA, process safety management, EPA, risk management plan, industrial hygiene: anticipation and identification, evaluation, control, introduction to source models, the flow of fluids through holes and pipes, flashing liquids, pool evaporation and pool boiling.

Unit-3. Fire and explosion:

Fire triangle, flammability characteristics of liquids and vapors, limiting oxygen concentration, flammability diagram, ignition energy, auto-ignition, auto-oxidation, adiabatic compression, ignition sources, sprays and mists, prevention of fires and explosions: inerting, static electricity, and its control, explosion-proof equipment and instruments, ventilation, sprinkler systems and fire extinguishers.

Unit-4. Hazard identification:

Process hazard checklist, hazard surveys, HAZOP & HAZAN, safety reviews, risk assessment; event trees, fault trees, QRA, and LOPA.

Unit-5. Accident investigations:

Learning from accidents, investigation process, case studies: chemical reactivity, system designs, procedures, significant disasters.

Course Materials

Required Text: Text books

1. D. A. Crowl and J.F.Louvar, Chemical process safety: Fundamentals with applications, Prentice Hall PTR, 2019.
2. R. E. Sanders, Chemical process safety: Learning from case histories, Butterworth-Heinemann, 2015.

Optional Materials: Reference Books.

1. R. King and R. Hirst, King's safety in the process industries, Wuerz Publishing Ltd., Canada, 2000.
2. R. K. Sinnott, Coulson & Richardson's, Chemical engineering design, Vol. 6, Elsevier India, 2006.
3. H.H. Fawcett and W.S.Wood, Safety and accident prevention in chemical operations, John Wiley and Sons Inc., 1965.
4. F. P. Lees, Loss prevention in the process industries: Hazard identification, assessment and control, Butterworth-Heinemann; 4^{th} edition, 2012.

Energy Engineering Laboratory

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	0-0-3, 2	Laboratory	CH312401CH

[Pre-requisites: NIL]

Course Objectives

1. To provide the understanding of testing of conventional fuels.
2. To provide the necessary skill for the study of the operation and performance of solar power, wind power, and waste heat recovery units.

Course Content

List of Experiments:

1. To determine the softening point of pitch bituminous/ solid fuel sample.
2. To determine the swelling index of coal.
3. To characterize the solid fuel (coal) using proximate analysis.
4. To characterize the solid fuel (coal) using ultimate analysis.
5. To determine the carbon residue in the given samples of oil.
6. To determine the flash and fire point of the lubricating oil using Abel's and Pensky-Martens apparatus.
7. To determine the kinematic and absolute viscosities of the given oil using red Wood viscometer.
8. To study the effect of temperature on the viscosity of the given sample by Saybolt viscometer.
9. To calibrate a bomb calorimeter and then use it to determine the calorific value of a fuel.
10. To study the performance of PV panels in series and parallel combinations.
11. To study the charging characteristics of a battery using a PV panel.
12. To study the effect of tilt angle on solar PV panels.
13. To study the effect of shadow on solar PV panel operation.
14. To study the characteristic of the fuel cell.
15. To study the characteristic of wind turbines.
16. To study the working and performance of a biomass gasifier.
17. To study the performance of solar water heater/solar distillation/evaporation.

NOTE: The student has to perform at least ten experiments.

Environmental Simulation Laboratory

[II Semester, First Year]

Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	0-0-3, 2	Laboratory	CH312402CH

[Pre-requisites: NIL]

Course Objectives

1. To provide an understanding of environmental simulation.
2. To apply software for environmental simulation problems.

Course Content

List of Experiments:

1. Introduction to simulation software.
2. To understanding the simulation package.
3. To study the plume behavior.
4. Studies on fluid flow transport of pollutants.
5. Studies on heat transfer between solids wastes.
6. Room temperature studies.
7. Food processing wastes modeling and simulation.
8. Studies on the rheology of fluid wastes.
9. Studies on mixing systems in liquid waste treatment.
10. Simulation models for reactors for treatment of waste.
11. Simulation of gas-solid separator.
12. Simulation of solid-solid separator.

Software: ANSYS / ASPEN / MATLAB

M. Tech. in Energy and Environment

National Institute of Technology, Raipur (C.G.)

Department of Chemical Engineering

Course of Study				M. Tech.: Energy and Environment								Third Semester	
S. No.	Board of Studies	Sub. Code	Subject Name	Periods/Week			Examination Scheme					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Chemical Engineering	CH313501CH	Preliminary work on Dissertation	-	-	24	100	-	-	-	200	300	12
2	Chemical Engineering	CH313601CH	Comprehensive Viva Voce & Seminar	-	-	-	-	-	-	-	200	200	4
			Total	**0**	**0**	**24**	**100**	0	0	0	**400**	**500**	**16**

National Institute of Technology, Raipur (C.G.)

Department of Chemical Engineering

Course of Study				M. Tech.: Energy and Environment								Fourth Semester	
S. No.	Board of Studies	Sub. Code	Subject Name	Periods/Week			Examination Scheme					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Chemical Engineering	CH314501CH	Dissertation	-	-	32	200	-	-	-	300	500	16
			Total	**0**	**0**	**32**	**200**	0	0	0	**300**	**500**	**16**

DEPARTMENT OF CHEMICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR

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