PG-Curriculum

(Structure and Course Contents)

Environmental Engineering

With effect from July 2018

EXPLORE INNOVATE EXCEL

Civil Engineering Department

Punjab Engineering College

(Deemed to be University)

Chandigarh

Index

PG Curriculum Structure

Sr. No.	Course Stream	Course Name	Credits	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}					
				1	2	3	4	5	6
Semester I									
1.	Soft Computing	Internet of Things	1.5						
		Machine Learning	1.5						
2.	Soft Skills and Management	Communication Skills (CS)	1.5						
		Management and Entrepreneurship(M)/IPR	1						
		Professional Ethics (PE)	0.5						
3.	Program Core-I	Physico-Chemical Processes in Water & Wastewater Engineering	3						
4.	Program Core-II	Environmental Chemistry &Microbiology	3						
5.	Program Elective-I: E1	• Solid & Hazardous waste management • Ecological & Ecosystem Engineering • Environmental Geo-technology • Environmental Hydraulics & Hydrology • Principles & Design of water supply treatment systems	1.5						
	Program Elective-II: E2	• Environmental Systems Analysis • Environmental Biotechnology • Fate & transport of contaminants in natural systems • Remote Sensing & GIS	1.5						
6.	Engineering Mathematics (EM)	Engineering Mathematics- I (Fourier Transform)	1						
		Engineering Mathematics- II (Optimization techniques)	1						
		Engineering Mathematics- III (Numerical Analysis)	1						
		Total Credits	**18**						

Sr. No.	Course Stream	Course Name	Credits	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}					
				1	2	3	4	5	6
Semester II									
1.	Design of experiments and research methodology	Design of Experiments and Research Methodology	3						
2.	Program Core III	Biological Processes - Design for Wastewater Treatment	3						
3.	Program Core-IV	Air & Noise Pollution & Control	3						
4.	Program Elective-III: E3	• Environmental Impact Assessment • Surface & Ground water Modeling • Environmental System Modeling • Energy Systems & Environment	1.5						
	Program Elective-IV: E4	• Industrial Wastewater Management • Indoor Air Quality • Life Cycle Analysis • Rural Water Supply & Environmental Sanitation	1.5						
5.	Open Elective	Climate Change & Sustainable Development	1.5						
		Clean Technology	1.5						
6.	Mini project/ Pre-dissertation		3						
		Total Credits	**18**						

Summer Term *

Sr. no.	Course Code	Course Name	Credits
1		Industrial Visit (3 days to 1 week of visit, Submission and presentation of visit report)	Satisfactory/ Non-satisfactory

***After Examination of second semester, in the first week of summer vacation industry visit can be undertaken.**

Course No.	Course Name	Credits	When it runs in a semester					
			1	2	3	4	5	6
Semester-III								
1.	Dissertation/Industry Project	14						

Course No.	Course Name	Credits	When it runs in a semester					
			1	2	3	4	5	6
Semester-IV								
1.	Dissertation/Industry Project	18						

Total credits – 68

- ***20% courses/ semester can be offered in blended mode MOOC's/Industry.***
- ***MOOC's/Industry offered course is having fractional credits. Industry offering course content will be designed by industry will be as per expert availability. Industry person will deliver and evaluate this subject. As per the duration of MOOC's/industry offered course, credits of this course can be decided (fractional credits).***

SEMESTER -I

SOFT COMPUTING

Course Name	**:**	**Internet of Things**
Course Code	**:**	**SCM 5011**
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures:-14
Total No. of Lab hours – 14

Course Objectives:

The student should be able to understand IoT architecture and market perspective. Also, student should be able to understand the basic principles and operation of different types of sensors commonly used on mobile platforms.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Introduction to IOT** What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market , Privacy issues in IOT	**2**
2.	**Setting Up Raspberry Pi/Arduino to Create Solutions** Explore Raspberry Pi, Setting up Raspberry Pi, Showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS.	**3**
3.	**Communication Protocols used in IoT** Types of wireless communication, Major wireless Short-range communication devices, properties, comparison of these devices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT, LPWAN)	**3**
4.	**IoTApplications** IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Smart Grids , Brownfield IoT, Smart Objects, Smart Applications	**3**
5.	**Sensors** Applications of various sensors: Google Maps, Waze, WhatsApp, Ola Positioning sensors: encoders and accelerometers, Image sensors: cameras Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion & Orientation Sensors: Accelerometer, Magnetometer, Proximity Sensor, Gyroscope, Calibration, - noise Modeling and characterization, and - noise filtering and sensor data	**3**

	processing, Privacy & Security, Selection of Sensors for Practical Applications	

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	Setting up Raspberry Pi and Arduino	**2**
2.	Build small scale wireless communicating IOT device	**4**
3.	Integrate positioning sensors to IOT device	**4**
4.	Integrate motion and orientation sensors to IOT device	**4**

Course Outcomes:

At the end of the course, students will have:	
1.	Understand the concept of IOT
2.	Study IOT architecture and applications in various fields
3.	Study the security and privacy issues in IOT.
4.	Understand various applications of sensor in Industrial, healthcare, commercial, and building automation.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", VPT, 1st Edition	**2014**
2.	Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", Apress Publications, 1st Edition	**2013**
3.	CunoPfister, "Getting Started with the Internet of Things", O-Reilly Media	**2011**
4.	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing	**2015**

Course Name	**:**	**Machine Learning**
Course Code	**:**	**SCM 5012**
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**

Total No. Lectures:-14
Total No. of Lab hours – 14

Course Objectives:

The students should be able to design and implement machine learning solutions to classification, regression and clustering problems; and be able to evaluate and interpret the results of the algorithms

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Python** Introduction, Conditional Statements, Looping, Control Statements, String Manipulation, Lists, , Tuple, Dictionaries, Functions, Modules, Input-Output, Exception Handling	**4**
2.	**Supervised Learning** Linear Regression, Support Vector Machines, Decision Tree Learning	**3**
3.	**Unsupervised Learning** K-means, hierarchical clustering, principal component analysis, Neural Networks	**4**
4.	**Reinforcement and Control Learning** Introduction to reinforcement and control learning, Algorithms of control learning	**3**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	A small scale gaming application	**8**
2.	Learn how to automate day-to-day tasks using Python.	**6**

Course Outcomes:

At the end of the course, students will have:	
1	Understand advantages and disadvantages of different machine learning algorithms
2	Identify suitability of machine learning algorithms for different domains

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	TanejaSheetal, Kumar Naveen, "Python Programming: A modular approach by Pearson", Pearson Education; First edition	**2016**
2.	Paul Barry, "Head First Python: A Brain-Friendly Guide", Shroff/O'Reilly; Second edition	**2016**
3.	Tom M. Mitchell, "Machine Learning", McGraw Hill Education;	**2017**

	First edition	
4.	Yuxi (Hayden) Liu, "Python Machine Learning By Example", Packt Publishing Limited	**2017**

SOFT SKILLS & MANAGEMENT

Course Name	**:**	**Communication Skills (CS)**
Course Code	**:**	**SSM 5021**
Credits	**:**	**1.5**
L T P	**:**	**0-1-4**

Total No. Tutorials:- 07
Total No. of Lab hrs:- 28

Course Objectives:

- To enhance competence in communication skills: verbal and nonverbal.
- To provide orientation in technical communication skills: spoken and written.
- To sensitize students to attitude formation and behavioural skills.

Total No. Tutorials:- 07

Sr.No	Course Contents	No. of Lectures
1.	**Introduction to Communication Skills, Soft Skills and Interpersonal Communication**	1
2.	**Speech:** Structure, Elements, Content, Organization and Delivery J-a-M	1
3.	**Writing Skills:** Letters, Minutes of Meeting	1
4.	**Technical Report Writing:** Concept & Structure	1
5.	**Research Writing:** Concept & Structural Framework	1
6.	**Power Point Presentation:** Project Presentation	1
7.	**Interviews**	1

Lab Work

Sr.No	Lab. Contents	No. of Hours
1.	Self- Introduction	2
2.	Negotiation Skills & Role Play	2
3.	J-a-M Session	2
4.	Building Word Power through Reading	2
5.	Group Discussion and Case Study	4
6.	Writing Skills: Letters, Minutes of Meeting	2
7.	Technical Report Writing: Concept & Structure	4
8.	Research Writing: Concept & Structural Framework	4
9.	Power Point Presentation: Project Presentation	4
10.	Interviews	2

Course Outcomes

At the end of the course, students will be able to	
1	Enhance their competence in communication and technical communication and develop awareness of attitude formation and behavioural appropriateness.
2	The course will address the gap which exists between employer expectations and student proficiency.

Bibliography:

Sr.No	Book Detail	Year of Publication
1.	Technical Communication, Meenakshi Raman and Sangeeta Sharma, Oxford University Press	2015
2.	English for Research Paper Writing, Adrian Wallwork, Springer, London	2011
3.	English Vocabulary In Use: Advanced+ CD, McCarthy Michael, CUP, Cambridge	2004
4.	Advanced English Grammar, Martin Hewings, CUP, Cambridge	2003
5.	Study Listening, Lynch Tony, CUP, Cambridge	2004
6.	Study Speaking , Anderson Kenneth, CUP, Cambridge	2010
7.	Study Reading , Glendenning H. Eric, CUP, Cambridge	2004
8.	Study Writing , Lyons Liz Hamp& Ben Heasley, CUP, Cambridge	2004
9.	Study skills in English, Michael J. Wallace, CUP, Cambridge	2004

Course Name	**:**	**Management and Entrepreneurship/ IPR**
Course Code	**:**	**SSM 5022**
Credits	**:**	**1**
L T P	**:**	**0-3-0**

Total No. Tutorials:- 14

Course Objectives:

The main aim of this course is to make students familiar with the concepts of Management and Entrepreneurship and understand how to develop new start-up and manage it effectively. It also aims to create awareness about the concepts of Innovation, Ideation and IPR.

Sr.No	Course Contents	No. of Tutorials
1.	Principles and Functions of Management	1
2.	Planning Process - Hypothetical Planning of an Event/Activity	1
3.	Form of Organization Structure - Case Study	1
4.	Human Resource Planning and Process, Current HR Practices	2
5.	Elements of Directing and Effective Control Mechanism Activity: Role Playing/Management Game	2
6.	Concepts of Entrepreneurship and Characteristics of Entrepreneurs	1
7.	Development Phases of Entrepreneurship -Idea Generation -Project Formulation and Validation -Business plan	4
8.	Ecosystem for Entrepreneurship Development and IPR	2

Course Outcomes

At the end of the course:	
1	The students will learn to develop and manage new project/start-up.
2	The students will be able to use management skills for success of business venture.

Bibliography:

Sr.No	Book Detail	Year of Publication
1	"Entrepreneurship", TrehanAlpana, Dreamtech Press/Wiley India Publication.	2018
2	"Management Principles and Practice", Srinivasan R. and Chunawalla S.A., Himalaya Publishing House.	2017
3	"Essentials of Management: International and Leadership Perspective", WeihrichH.and Koontz H., 9th Edition, Pubs: McGraw Hill.	2012
4	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	2014
5	"Principles & Practice of Management", Prasad L.M., 8th Edition, Pubs:	2015

	Sultan Chand & Sons.	
6	"Management: Text and Cases", Rao V.S.P. and Krishna V.H., Pubs: Excel Books.	2008
7	"Management: Concept, Practice and Cases", Aswathappa K. and GhumanKarminder, Pubs: McGraw Hill Education.	2010
8	"Dynamics of Entrepreneurial Development & Management", Desai V., 5th Edition, Pubs: Himalaya Publishing House.	2012
9	"Projects: Planning, Analysis, Selection, Financing, Implementation and Review", Chandra P., 8th Edition, Pubs: McGraw-Hill Education (India).	2014
10	"Entrepreneur's Toolkit", Harvard Business School, Pubs: Harvard University Press.	2004
11	"Essentials of Project Management", Ramakrishna K, Pubs: PHI Learning.	2010
12	Harvard Business Review: Entrepreneur's Handbook	2018
13	WIPO Annual Publications	

Course Name	**Professional Ethics**
Course Code	**SSM 5023**
Credits	**0.5**
L T P	**0-3-0**

Total No. Tutorials:- 07

Course Objectives:

The main aim of this course is to provide basic knowledge about ethics, values, norms and standards and their importance in professional life.

Course Contents:

Sr.No	Course Contents	No. of Tutorials
1.	**Introduction to Ethics:** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics.	2
2.	**Self-Awareness & Self Development:** Concept of Self Awareness – Need, Elements, Self-Assessment – SWOT Analysis, Self-Concepts – Self-Knowledge, Assertiveness and Self-Confidence, Self-Esteem, Concept of Self-Development, Social Intelligence, Emotional Intelligence, Managing Time and Stress, Positive Human Qualities (Self-Efficacy, Empathy, Gratitude, Compassion, Forgiveness and Motivation	2
3.	**Ethics and Business:** Concept of Business Ethics – Nature and Objectives.Ethical dilemmas in business ethics.	1
4.	**Professionalism in engineering and its relation to ethics:** Ethics in Practice: Professional accountability, Roles of Professionals.	2

Course Outcomes:

At the end of the course:	
1.	The students will be able to distinguish between right and wrong in both personal and professional life.
2.	The students will learn about their strengths, weaknesses, opportunities & threats and work enthusiastically to transform weaknesses into strengths and threats into opportunities.

Bibliography:

Sr.No	Book Detail	Year of Publication
1.	"Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Pubs: Himalaya Publishing House.	2014
2.	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Pubs: Oxford University Press.	2007
3.	"Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Pubs: Tata McGraw Hill	2006

4.	"Business Ethics and Professional Values", Rao A.B., Pubs: Excel Books	2006
5.	"Business Ethics – Concepts and Cases", Velasquez M.G., 5th Edition, Pubs: Prentice Hall	2001
6.	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Pubs: Brooks/Cole, Cengage Learning	2010
7.	"Theories of Personality", Hall C.S., Lindzey D. and Cambell J.B., 4th Edition, Pubs: Hamilton Printing Company	1997

PROGRAM CORE

Course Name	**:**	**Physico-Chemical Process in Water & Wastewater Engineering**
Course Code	**:**	**CEM 5011**
Credits	**:**	**3**
L T P	**:**	**2-0-2**
No. of Segments	**:**	**1-6**

Total No. of Lectures: 28
Total No. of Lab Hours: 28

Course Objectives:

	The main objectives of this course are:
1.	To introduce the concept of water quality.
2.	To understand the various physico-chemical unit processes and operations as applied to water and wastewater systems.
3.	To provide a hands on experience in environmental quality monitoring of Water and wastewater systems.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Water Quality** Physical, chemical and biological parameters of water- Water Quality requirement - Potable water standards -Wastewater Effluent standards - Water quality indices	**6**
2.	**Water Purification Systems in Natural Systems** Physical processes-chemical processes and biological processes - Primary, Secondary and tertiary treatment-Unit operations – unit processes.advance oxidation, Membrane, ion exchange etc.	**5**
3.	**Clarification, Sedimentation** Types; Tube & Plate Settlers, Aeration& gas transfer; Coagulation & flocculation, coagulation processes, stability of colloids, destabilization of colloids, transport of colloidal particles, Clariflocculation.	**5**
4.	**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.	**5**
5.	**Adsorption** Adsorption equilibria - adsorption isotherms, Disinfection - chlorine dioxide; chloramines; ozonation; UV radiation Ion Exchange-processes, Application Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodyalisis.	**5**
6.	**Introduction to water supply system of smart cities and use of software EPANET**	**2**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Testing of various physico- chemical properties (like BOD, COD, Chlorides, alkalinity, sulphates, nitrates etc) of water and wastewater, Project based testing of water & wastewater quality parameters	8
2	Project based testing of water quality parameters	10
3	Project based testing of wastewater quality parameters	10

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Design various physico-chemical unit processes andoperations to achieve the desired water quality in water and wastewater systems.

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/ Reprint
1.	Water works engineering, S. R. Qasin. PHI, New Delhi	2015
2.	Environmental Engineering, Howard S. Peavy, Donald R. Rowe, George Tchobanoglous Mc Graw Hill Publishing	2015
3.	Standard Methods for examination of water and wastewater: 23rd Edition APHA	2017

MOOCs on this course are available at:

1) https://www.Courses.edx.org/Courses/CourseV-I: T Singhua x
2) https://onlinecourses.nptel.ac.in (Course on Water Supply Engineering by IIT Madras by Prof. Ligy Philips at NPTEL.ac.in

Course Name	**:**	**Environmental Chemistry and Microbiology**
Course Code	**:**	**CEM 5021**
Credits	**:**	**3**
L T P	**:**	**2-0-2**
No. of Segments	**:**	**1-6**

Total No. of Lectures: 28
Total No. of Lab Hours: 28

Course Objectives:

	The main objective of this course are:
1.	To familiarize the students with the chemical and biological principles as applied to Environmental Engineering.
2.	To apply these concepts to Water and Wastewater Treatment and Pollution Control.

Course Contents:

Sr. No.	Course Contents	No. of Lectures
1.	**Introduction** Importance of Chemistry and Microbiology in Environmental Engineering; The related uses and applications. Catalysis, colloidal and surface chemistry, chemistry of organic pollutants, heavy metals and nanomaterials ,green chemical processes	**4**
2.	**Chemical Equations** Types, solutions, activity and activity coefficients, chemical equilibria, chemical thermodynamics.	**2**
3.	**Acid Base Equilibria** Equilibrium diagrams, carbonic acid system, buffering, Solubility Equilibria, effect of other solutes on salt solubility, removal of heavy metals.	**2**
4.	**Oxidation Reduction Equilibria** Ectrochemistry and electrochemical cells, stability diagrams measuring redox potentials.	**3**
5.	**Water Stabilization** Water softening and water conditioning, chemical precipitation, ion exchange.	**2**
6.	**Basic of Quantitative Chemistry** Analytical methods, instrumentation: Organic pollution: BOD, COD, And TOC.	**2**
7.	**Microbiology** Classification, identification, Taxonomy, Reproduction and growth, cultures & characteristics, Enzymes, Microbial metabolism - energy production, biosynthesis, Mixed and pure culture, Growth rate; Application.	**7**

8.	**Fungi, Bacteria, Molds and Yeasts** Algae, protozoa, viruses. Control of microorganisms.	**3**
9.	**Microbiology of Domestic Water & Waste Water** Industrial microbiology. Epidemiology of infectious diseases, microbial agents of diseases.	**3**

Lab Works:

Sr. No.	Lab Contents	No. of Hours
1.	Water & Wastewater Quality, Bacteriological Quality (like MPN, Plate Count etc.)	8
2.	experiments involving use of GC-MS and Ion Chromatography	10
3	Air & Noise Testing, Project based testing of water & wastewater	10

Course Outcomes:

At the completion of this course, students will be able to:	
1.	The student is able apply the principles of Chemistry and Microbiology in Environmental Engineering practice.
2.	Analyze and interpret the environmental engineering systems from the chemistry and microbiological point of view.

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/ Reprint
1.	Chemistry for Environmental Engineering: Sawyer, McGraw Hill Book Company, New York.	2015
2.	Microbiology – Concepts and applications: Pelczar, McGraw Hill Book Company, New York.	2015
3.	Process Chemistry for water and wastewater treatment: Benefield, Printice-Hall Inc, New Jersey.	2015
4.	Microbiology for Environmental Scientists and Engineers: Gaudy and Gaudy McGraw Hill Book Company, New York.	2014
5.	Standard Methods for examination of water and wastewater: 23rd Edition APHA	2017

MOOCs on this course are available at:

1) https://onlinecourses.nptel.ac.in (Course on Environmental Engineering-Chemical Processes by Prof. Bhanu Prakash Vellanki, Department of Civil Engineering, IIT Roorkee

PROGRAM ELECTIVE

Course Name	**:**	**Solid and Hazardous Waste Management**
Course Code	**:**	**CEM 5101**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments	**:**	**1-3**

Total Number of Lectures: 17
No. of Tutorials: 04

Course Objectives:

	The main objectives of the course are:
1.	To have knowledge of solid waste and management.

Course contents

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Solid and Hazardous Wastes:** Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management - Legislations on management and handling of municipal solid wastes, hazardous wastes, and biomedical wastes, Elements of integrated waste management	**2**
2.	**Waste Characterization and Analysis:** Waste generation rates – Composition - Hazardous Characteristics – TCLP tests – waste sampling- Source reduction of wastes – Recycling and reuse.	**3**
3.	**Management of Solid Waste:** 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 - labeling and handling of hazardous wastes.	**3**
4.	**Processing of Waste:** Waste processing – processing technologies – biological and chemical conversion technologies – Composting - thermal conversion technologies - energy recovery –incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes.- Biomass waste valorisation	**3**
5.	**Disposal on Landfill:** Disposal in landfills - site selection - design and operation of sanitary landfills- secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – landfill remediation.	**3**
6.	**MSW Management of Smart Cities, e-waste, bio-medical waste, hazardous waste management, IOT technologies involving solid & hazardous waste management.**	**3**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Students will be able to know processing and handling of solid waste in better way.

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/Reprint
1.	Integrated Solid Waste Management, George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, , McGraw- Hill, New York.	2013
2.	Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization (CPHEEO), Government of India (GOI), New Delhi.	2000

MOOCs on this course are available at:

1. https://onlinecourses.nptel.ac.in(Course on Integrated waste management for a Smart City by Prof. B K Dubey of IIT, Kharagpur)

Course Name	**:**	**Ecological and Ecosystems Engineering**
Course Code	**:**	**CEM 5102**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments		**1-3**

Total Number of Lectures: 17
No. of Tutorials: 04

Course Objectives:

	The main objectives of the course are:
1.	To understand the concept and application of ecological modeling.
2.	To familiarize the students with the basics of ecological systems and introduce them to the concept of ecological engineering.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	Development and Evolution of ecosystems- Principles and concepts	**1**
2.	Energy flow and material cycling- productivity- classification of eco-technology- ecological engineering.	**3**
3.	Classification of systems- Structural and functional interactions of environmental systems- Mechanisms of steady- state maintenance in open and closed systems.	**3**
4.	Modeling and eco-technology- Classification of ecological models- Applications- Ecological economics- Self – organizing design and processes- Multi seeded microcosms.	**3**
5.	Interface coupling in the ecological systems- concepts or energy- determination of sustainable loading of ecosystems.	**3**
6.	Eco-sanitation; soil infiltration systems- Wetlands and ponds- Source Separation systems- Aqua cultural systems- Agro ecosystems- Detritus based Treatment for solid wastes –marine systems- Case studies.	**4**

Course outcomes:

At the completion of this course, students will be able to:	
1.	The students shall able to apply the concept of ecological engineering in real life environmental engineering problems.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/Reprint**
1.	Ecological Engineering: Principles and Practice, Kangas, P.C and Kangas, P., Lewis Publishers, New York.	2003
2.	Ecological Engineering for Wastewater Treatment, Etnier, C. and Guterstam, B., Lewis Publishers, New York	2007
3.	Basic Ecology, E .P. Odum, H.S Publication	2000
4.	Energy and Ecological Modelling, W.J Mitch, R. W. Bosserman and J N Klopatik, Elsevier Publication	2001

Course Name	**:**	**Environmental Geo-Technology**
Course Code	**:**	**CEM 5103**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments	**:**	**1-3**

Total Number of Lectures: 17
No. of Tutorials: 04

Course Objectives:

	The main objectives of this course are:
1.	To know the geo-techniques used in environment.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Soil Profile:** Soil as a multiphase system; Soil – environment interactions; Properties of water in relation to porous media; Water cycle with special reference to soil medium.	**2**
2.	**Soil Mineralogy:** Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization.	**2**
3.	**Mechanisms of Soil-Water Interactions:** Diffuse double layer models; Force of attraction and repulsion; Soil- Water-contaminant interaction; Theories of Ion exchange; Influence of organic and inorganic chemical interaction.	**2**
4.	**Soil Mechanics:** Introduction to unsaturated soil mechanics; water retention property and soil-water characteristic curve; flow of water in unsaturated soil.	**3**
5.	**Waste & its Transport in Soil:** Concepts of waste containment facilities; desirable properties of soil; contaminant transport and retention; contaminated site remediation.	**3**
6.	**Remedial Techniques:** Introduction to advanced soil characterization techniques; volumetric water content; gas permeation in soil; electrical and thermal properties; pore –size distribution; contaminant analysis.	**3**
7.	**AnAqSimEDU (analytic aquifer simulator-educational)**	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Better understanding of soil science and methods to preserve it.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/Reprint**
1.	Funtamentals of Soil Behavior, Mitchell, J.K and Soga, K, John Wiley and Sons Inc.	2005

2.	Introduction to Environmental Geotechnology, Fang, H-Y, , CRS press	2016
3.	Geotechnical Practice for Waste Disposal, Daniel, D.E, , Chapman and Hall	2012
4.	Geotechnical and Geoenvironmental Engineering Handbook, Rowe , R. K, , Kluwer Academic Publishers	2001
5.	Geo-environmental Engineering Principles and Applications, Reddi, L.N. And Inyang, H.F, Marcel Dekker Inc.	2000

Course Name	**:**	**Environmental Hydraulics & Hydrology**
Course Code	**:**	**CEM 5104**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments	**:**	**1-3**

Total Number of Lectures: 17
No. of Tutorials: 04

Course Objectives:

	The main objectives of thiscourse are:
1.	To familiarize the students with the basics of hydrology and introduce them to the concept of hydraulics.
2.	To understand the concept and application of hydrology modeling.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	Uniform and Non-uniform flow in channels and sewers	4
2.	Hydrologic cycle and its interaction with human activity, Hydrologic processes, Transport processes, Porous medium flow.	3
3.	Atmospheric and subsurface water, Surface water	4
4.	Hydrologic analysis, Hydrologic statistics	4
5.	**Introduction to softwares** **FLO-2D Software, EPANET**	2

Course Outcomes:

At the completion of this course, students will be able to:	
1.	The students shall able to apply the concept of hydrology engineering in real life environmental engineering problems.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/Reprint**
1.	Environmental Hydraulics of Open Channel Flows, Chanson, H., Butterworth-Heinemann.	2004
2.	Applied Hydrology, Chow, V.T., Maidment, D.R. and Mays, L.W., McGraw Hill Inc.	2010
3.	Open Channel Hydraulics, Chow, V.T., McGraw Hill Inc.	2009

Course Name	**:**	**Principles and Design of Water Supply And Treatment System**
Course Code	**:**	**CEM 5105**
Credits	**:**	**1.5**
LTP	**:**	**2-1-0**
No. of Segments	**:**	**1-3**

Total Number of Lectures: 14
No. of Tutorials: 07

Course Objectives:

	The main objectives of this course are:
1.	To understand the process and designing of the subject

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction:** Definition and Concepts: Water sources, philosophy of water treatment, review of water quality characteristics and potable and industrial waste standard unit operations, unit processes	**2**
2.	**Water Supply:** Theory and design of water supply systems; Estimation of water quantity, Review of flow in pipes and open channel flow, Review of pump characteristics.	**2**
3.	**Distribution Network:** Design of water distribution networks& Smart water distribution systems	**3**
4.	**Water Treatment Techniques:** Theory and design of conventional unit operations used in water treatment ; Sedimentation , Floatation , Coagulation , Flocculation , Filtration And Disinfection Process ; Theory and design of advanced unit operation used in water treatment ; Membrane Process , Ion Exchange , Aeration/Stripping , Precipitation , Adsorption , Oxidation-Reduction And Advanced Oxidation Processes.	**2**
5.	**Treatment Plant Designing:** Water Treatment Plant Design; selection of raw water source, Planning and Siting of Water Treatment Plant; Hydraulics of Water Treatment Plant, Chemical Requirement and Residuals Management.	**2**
6.	**Introduction to softwares** WATERCAD& PFCALC	**3**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Students able to do the implementation of knowledge into designing of the treatment plant.

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher:	Year of Publication/Reprint
1.	Water works engineering, S.R Qasim, PHI	2015
2.	Environmental Engineering,Peavy Rowe Tchobanoglous, McGraw Hill Inc	2015

MOOCs on this course are available at:

https//www.Courses.edx.org (Course on Water Management by Delf University)

Course Name	**:**	**Environmental System Analysis**
Course Code	**:**	**CEM 5201**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments	**:**	**4-6**

Total Number of Lectures: 17
No. of Tutorials: 04

Course Objectives:

	The main objectives of this course are:
1.	To learn about analytical & design methods for environmental systems.
2.	To study various optimization models for environmental systems.
3.	To study various stochastic models for environmental systems

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**System Engineering:** Analysis – Design- Synthesis – applications to environmental engineering Systems.	**4**
2.	**Role of Optimization Models:** Deterministic models/ linear programming, Dynamics programming, Separable and Nonlinear program models. Formulation of objective functions and constraints for environmental engineering planning and design.	**5**
3.	**Probabilistic Models**: Fuzzy models – Simulation models.	**4**
4.	**Modern Tools**: Experts - Neural Networks – Genetic Algorithm- Case studies. Remote Sensing & GIS technologies	**4**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Knowledge of analytical & design methods for environmental systems.
2.	Knowledge of optimization models for environmental systems.
3.	Knowledge of stochastic models for environmental systems.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/Reprint**
1.	Environmental System Engineering, Rich L.G., McGraw Hill.	1973
2.	System Analysis & Water Quality control, Thoman R.V., McGraw Hill.	1978
3.	Environmental System Analysis with MATLAB, Stefano Marsili- Libelli, , CRC Press	2016
4.	Environmental Systems – Philosophy, Analysis and Control, Robert Bennett, Richard Chorley, Princeton Legacy Library.	2018

Course Name	**:**	**Environmental Biotechnology**
Course Code	**:**	**CEM 5202**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments	**:**	**4 to 6**

Total Number of Lectures: 17
No. of Tutorials: 04

Course Objectives:

	The main objectives of this course are:
1.	To have the better knowledge of bio-techniques on environment

Course Contents:

Sr. No.	**Course Contents:**	**No. of Lectures**
1.	**Introduction to Environmental Biotechnology:** Principles and concepts - usefulness to mankind.	4
2.	**Degradation of Pollutants:** Degradation of high concentrated toxic pollutants- halogenated, non-halogenated, petroleum hydrocarbons, metals - Mechanisms of detoxification – oxidation - dehalogenation - biotransformation of metals - biodegradation of solid wastes.	4
3.	**Biotechnology Remedies:** Biotechnological remedies for environmental pollution - decontamination of groundwater – bioremediation - Production of proteins – bio fertilizers - Physical, chemical and Microbiological factors of composting – health risk – pathogens – odor management – Microbial cell/enzyme technology – adapted microorganisms – biological removal of Nutrients – algal biotechnology– extra cellular polymers - Biogas technology, Concept of rDNA technology – expression vectors – cloning of DNA – mutation – construction of microbial strains - radioactive probes - protoplast fusion technology –applications.	5
4.	**Impact on Environment:** Environmental effects and ethics of microbial technology–genetically engineered organisms- Microbial containment-Risk assessment.	4

Course outcomes:

At the completion of this course, students will be able to:	
1.	To know the importance of biological techniques and application of them.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/Reprint**
1.	Biological degradation and Bioremediation of toxic chemicals, Chaudhury, G.R., Dioscorides Press, Oregon.	2010
2.	Biological degradation of wastes, Martin A.M, Elsevier	2014

	Applied Science, London.	
3.	Environmental Biotechnology: Principles and Applications, Bruce E. Rittmann, Perry L. McCarty Tata McGraw-Hill Education.	2012

MOOCs on this course are available at:

https//www.onlinecourses.nptel.ac.in (Course on Environmental Biotechnology)

Course Name	**:**	**FATE and Transport of Contaminants in NaturalSystem**
Course Code	**:**	**CEM 5203**
Credits	**:**	**1.5**
LTP	**:**	**2.5-0.5-0**
No. of Segments	**:**	**4-6**

Total Number of Lectures: 17
Total No. of Tutorials: 04

Course Objectives:

	The main objectives of this course are:
1.	To learn about physico- chemical and bio transformations of pollutants in natural systems.
2.	To study various models of predicting contaminant/ pollutant transport.

Course contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	Introduction	**1**
2.	Modeling of volatilization, sorption / desorption	**3**
3.	Chemical transformations, photochemical transformation.	**3**
4.	Biological transformation and bioturbation	**2**
5.	Concepts of scale in natural system, brief review of mass, momentum and energy balance, advection, molecular diffusion, dispersion.	**2**
6.	Modeling of rivers, lakes, large lakes, sediments, estuaries, wetlands, subsurface, flow and transport.	**2**
7.	Finite difference and linear algebraic methods to solve the system equations. Some special models.	**2**
8.	Introduction to MODFLOW, MATLAB	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understanding of the natural physic chemical and bio transformations of pollutants.
2.	Knowledge of various models of predicting contaminant/ pollutant transport.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/Reprint**
1.	Biostatistical Analysis, Zar, J.H., Pearson Education,.	2008
2.	Water Quality Engineering in Natural Systems, David A. Chin, Wiley	2013
3.	Groundwater Hydrology, Todd D.K., Wiley	2014

MOOCs on this course are available at:

1. www.ocw.mit(Course no. 1.061)

Course Name	**:**	**Remote Sensing & GIS for Environmental Engineering**
Course Code	**:**	**CEM 5204**
Credits	**:**	**1.5**
L T P	**:**	**2.5-0.5-0**
No. of Segments	**:**	**4-6**

Total No. of Lectures: 17
Total No. of Tutorials: 04

Course Objectives:

	The main objectives of this course are:
1.	Expose the students with concept of digital mapping.
2.	To make them aware of recent advancements/software in surveying like Remote sending, digital photogrammetric, GIS, DIP etc.

Course contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Modern Trends in Surveying and Mapping of Environmental Systems:** Digital Mapping, Uses and applications, data collection techniques (Conventional and Non-conventional), Present Status in India and abroad	**2**
2.	**Aerial Photogrammetry** Introduction, types, Stereoscopy, Scale of a photograph, flight planning, Mosaics	**2**
3.	**Geographical Information System (GIS) in relation to Environmental Systems** Introduction, advantages, objectives of GIS, Definitions of GIS, Components of GIS, Overlay analysis, Digital Terrain Modelling, Digital Elevation Model Applications of GIS in various engineering fields, Four M's, Elements of Image visualization	**2**
4.	**Introduction to Remote Sensing (RS) of Natural Environmental Systems** Introduction, EM spectrum, Ideal RS System, Real RS System, Visual Image interpretation, active and passive remote sensing, Reflectance; spectral reflectance of land covers; Spectral characteristics of solar radiation; energy interaction in the atmosphere; energy interactions with the Earth's surface, Spectral reflectance curves, Resolution	**2**
5.	**Digital Image Processing (DIP)** Introduction, Histogram and image statistics, Remote Sensing Image distortion and rectification: Radiometric errors and Geometric errors. Image Enhancement techniques, Image classification – Supervised and Unsupervised classification, Formats	**2**
6.	**Global Positioning System** Introduction, GPS, DGPS, Applications	**2**
7.	**Smart City & Geospatial Technology** Introduction, Applications of GIS/RS in smart city.	**1**

8.	**Software demonstrations and working** GIS/RS software	**2**
9.	**Remote Sensing & GIS Tools for Environmental systems**	**2**

Course outcomes:

At the completion of this course, students will be able to:	
1.	This course intends to make students aware recent advancements in surveying.
2.	They will be able to understand various terms in Geospatial Industry and relate with applications of RS/GIS in Smart City initiatives.

Bibliography:

Sr. No.	**Name of the Book/ Author/ Publisher:**	**Year of Publication/ Reprint**
1.	Geomatics Engineering, Manoj Arora and R C Barjatiya, Nem Chand Brothers, Roorkee.	2011
2.	Principles of GIS, Peter A. Burrough, Rachael A., Oxford University Press	2014
3.	Remote Sensing and Image Interpretation, Lillesand and Kiefer, Wiley Publishers	2010
4.	Introduction to GIS, Kang-tsung, Tata McGraw Hill, 5th Edition	2016
5.	Introduction to Remote sensing, Campbell & Wynne, Guilford Press	2014

MOOCs on this course are available at:

1. **https://www.coursera.org/spatial-analysis (Course on Geospatial and Environmental Analysis, University of California, Davis)**

ENGINEERING MATHEMATICS

Engineering Mathematics 1 (EM1)

Course Name	**:**	**FOURIER TRANSFORMS**
Course Code	**:**	**EMM 5011**
Credits	**:**	**01**
L T P	**:**	**2-1-0**
Segments	**:**	**1-2**

Total No. of Lectures– 10, Tutorials -5

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the concept of Fourier transform and be able to compute it for standard examples.
2	To make the students able to apply Fourier transforms to solve differential equations and partial differential equations.

Course contents:

S. No	Course Contents	No. of Lectures
1	**Fourier Transforms:** Fourier Integral formulas, Definition and examples, Basic properties, Fourier cosine and sine transforms and examples, Basic properties of Fourier cosine and sine transforms, Multiple Fourier transforms.	05
2	**Fast Fourier Transforms and Short Term Fourier Transforms:** Definition and examples, Basic properties, Applications.	05

Course Outcomes:

At the end of the course, students will be able to:	
1	Solve differential equations by using Fourier transforms
2	Solve partial differential equations by using Fourier transforms
3	Apply FFT and STFT to engineering problems

Bibliography:

S. No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Integral Transforms and Their Applications", LoknathDebnath, CRC Press, Inc.,	1995.
2	"Integral Transforms and their Applications", Brian Davies, 3rd Edition, Springer-Verlag, New York,Inc,	2001
3	"Fourier Transform and Its Applications", Ronald N. Bracewell, 2nd Edition, McGraw-Hill Inc.,US,	1986

Engineering Mathematics 2 (EM2)

Course Name	**:**	**NUMERICAL METHODS**
Course Code	**:**	**EMM 5013**
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segments	**:**	**3-4**

Total No. of Lectures – 10, Practical -10

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the basics of numerical methods.
2	To make the students able to solve problems on system of linear equations and Interpolation by numerical methods.

Course contents:

S. No.	Course Contents	No. of Lectures
1	**Error Analysis:** Definition and sources of errors, Propagation of errors, Floating-point arithmetic and rounding errors.	02
2	**Interpolation:** Interpolation using Finite differences, Numerical Differentiation and Numerical integration, Trapezoidal and Simpson's rules.	04
3	**Numerical Solution of Differential Equations:** Picard's method, Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Predictor-Corrector method.	04

Lab Work:

S. No.	Lab. Contents	No. of Hours
1.	Solving Interpolation, Numerical Differentiation and Numerical integration problems using Mathematica.	04
2.	Solving Differential equations numerically using Mathematica.	06

Course Outcomes:

By the end of the course, the students will be able to solve the following by numerical methods:

1. Problems on Interpolation
2. Problems on Differentiation, Integration.
3. Solve differential equations.

Bibliography:

S. No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Introduction to Numerical Analysis",Atkinson K. E., John Wiley.	1989
2	"Applied Numerical Analysis", Gerald C. F. and Wheatley P. O., Pearson	2004
3	"Numerical Methods for Scientific and Engineering Computation", Jain M. K., Iyengar S.R.K. and Jain R. K., New Age International Publisher.	2004
4	"Elements of Numerical Analysis", Gupta R.S., Macmillan India Ltd .	2008

Engineering Mathematics 3 (EM3)

Course Name	**:**	**OPTIMIZATION TECHNIQUES**
Course Code	**:**	**EMM 5019**
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segments	**:**	**5-6**

Total No. of Lectures – 10, Practical -10

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the need of Optimization Techniques and develop the ability to form mathematical model of optimization problems.
2	To make the students able to identify and solve linear and non-linear models of optimization problems.

Course contents:

S. No.	Course Contents	No. of Lectures
1	Linear Programming: Formulation, Graphical solution, Simplex method.	04
2	Non Linear Optimization Techniques: Unconstrained problems - Necessary and sufficient conditions for extreme points, Newton's method, Guass- Newton method, Parallel axis method. Constrained problems - Lagrangean method , KKT conditions, Nelder Mead method.	06

Lab Work:

S. No.	Lab. Contents	No. of Hours
1.	Solving linear problems using Mathematica/MATLAB.	04
2.	Solving non-linear problems using Mathematica/MATLAB.	06

Course Outcomes:

1	The students are able to form mathematical model of optimization problems.
2	The students are able to distinguish between linear and nonlinear models .
3	The students are able to solve simple problems using Mathematica/MATLAB

Bibliography:

S. No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Operations Research" ,Ravindran , Phillips , and Solberg , 2nd edition, John Wiley & sons .	2000
2	"Engineering Optimization" , S S Rao , 3nd edition, New Age .	2000
3	"Operations Research", Kantiswarup, Gupta P.K. & Sultan Chand & Sons	2007
4	"Operations Research", Sharma S.D., Kedarnath, Ramnath&Company .	1994
5	"Operations Research", Bronson R, Shaum's Outline Series .	1997

SEMESTER- II

PROGRAM CORE

Course Name	:	**Design of Experiments & Research Methodology**
Course Code	:	**DRM 5011**
Credits	:	**3**
L T P	:	**2-1-0**
Segments	:	**1-6**

Course Objectives

The main Objectives of this course are:	
1	To introduce the fundamentals of Statistical techniques, Sampling techniques, and Data collection and their interpretation.
2	To understand concept of research, need for research, types of research and steps in conducting research.

Total No. of contact hour: 42 (L= 28+T=14)

S.No.	Course Content	No. of Lectures
1	**Design of Experiment** Principles of Experimental design, sampling methods, probability sampling	**3**
2	**Modeling** Introduction to modeling, types of models, development of mathematical models	**4**
3	**Random variables** Random variables and its properties, probability distributions, probabilistic model estimation and its assessment	**6**
4	**Random Variables Data Analysis** Single and multi variables data analysis, estimation of parameters, splinessmoothing, Residual analysis, Analysis of Variances	**5**
4	**Random Variates** Simulation, Monte Carlo Method, Queuing Theory, Markovian process	**3**
5	**Geostatistics** Introduction to Geostatistics, Geostatistical data analysis methods	**3**
6	**Stochastic Processes** Time series analysis, model identification, forecast and uncertainty analysis	**2**
7	**Research Report Writing** Research objectives formulation, literature collection, data analysis methods, report writing and conclusions	**2**

Course Outcomes

At the completion of this course, students will be able to:	
1	make use of various Research methodologies and its applications in the relevant field of engineering.
2	Organize and conduct research (advanced project) in a more appropriate manner

Bibliography

S.No.	Name of Book/Authors/Publishers	Year of Publication/ Reprint
1	Probability and Statistics for Engineers and scientists, Walpole, Myers, Myers and Ye, Pearson Education.	7th edition, 2002
2	Statistics in Research, BernandOstle and Richard N.Mensing, Oxford & IBH Pub Co.	3rd edition, 1975
3	Probability and Statistics in Engineering, Hines, Montgomery, Goldsman and Borror, John Wiley & Sons.	4th edition, 2003
4	Experimental design, Theory & application, Federer, Oxford & IBH pub Co.	1955
5	Introduction to probability & statistics for Engineers and scientists, Sheldon M. Ross Elsevier Academic press, California, USA	2014

MOOCs on this course are available at:

1. http://professional.mit.edu/programs/short-programs/design-and-analysis-experiments
   By Prof. Paul Berger, MIT Professional Education

2. https://nptel.ac.in/courses/107108011/
   By Prof. AmareshChakrabarti, Indian Institute of Science, Bangalore

Course Name	:	**Biological Process Design for Wastewater Treatment**
Course Code	:	**CEM 5031**
Credits	:	**3**
L T P	:	**2 0 2**
Segments	**:**	**1 to 6**

Total No. of Lectures: 28

Total No. of Lab Hours: 28

Course Objectives:

	The main objectives of this course are:
1.	To introduce the various biological process in wastewater treatment: Design and application.
2.	To provide a hands on experience in environmental quality monitoring of Air, Soil and water systems.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Constituents of wastewaters** - sources –significant parameter - fundamentals of process kinetics, zero order, first order, second order reactions, enzyme reactions – bio reactors- types-classification – design principles.	**1**
2.	**Design of wastewater treatment systems**-primary, secondary and tertiary treatments	**5**
3.	Evaluation of bio-kinetic parameters- activated sludge and its process – modifications, biological nitrification and de nitrification.	**3**
4.	**Aeration**- fundamentals of gas transfer - attached growth biological treatment systems trickling filters-rotating biological contactors - activated biofilters.	**6**
5.	Waste stabilization ponds and lagoons: aerobic pond, facultative pond, anaerobic ponds- polishing ponds, aerated lagoons.	**5**
6.	**Anaerobic processes**-process fundamentals-standard, high rate and hybrid reactors, anaerobic filters-expanded/fluidized bed reactors – up flow anaerobic sludge blanket reactors, expanded granular bed reactors- two stage / phase anaerobic reactors, sludge digestion ,sludge disposal.	**6**
7.	**Introduction to MATLAB Software**	**2**

Lab Work:

Sr. No.	Lab Contents	No. of Lectures
1.	Air Quality Monitoring & Measurements, Soil Pollution Parameters & Measurements, Industrial Waste Water Characteristics, Absorption and Adsorption Kinetics Studies.	**28**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	analyse and design the biological processes in wastewater treatment. He shall be able to trouble shoot the biological wastewater treatment systems.
2.	making measurements and interpretation of a. Air quality b. Soil pollution c. Industrial wastewater characteristics d. Absorption and adsorption Kinetics

Bibliography:

Sr. No.	Name/ Author/Publisher	Year of Publication/ Reprint
1.	"Chemistry for Environmental Engineering", *Sawyer, C.N., McCarty, P.L. and Parkin, G.F., Tata*, McGrawHill, New Delhi.	2003
2.	"Microbiology", Pelczar, M.J., Chan E.C.S. and Krieg, N.R. Tata McGraw Hill, New Delhi.	2002
3.	Standard methods for examination of water & wastewater by AWWA.	2017

MOOC'S are available at:

1. https://www.edx.org/course/urban-sewage-treatment-delftx-ctb3365stx-1
2. https://nptel.ac.in/courses/105105048/ Wastewater Management

Course Name	**:**	**Air and Noise Pollution & Control**
Course Code	**:**	**CEM 5041**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Segments	**:**	**1 to 6**

Total No. of Lectures: 42

Course Objectives:

	The main objectives of this course are:
1.	To familiarize the students with the basics of air pollution including atmospheric physics and chemistry
2.	To apply these concepts to Air and noise Pollution Control and Environmental Management

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to air pollution** – environmental engineering significance – global issues – units	**2**
2.	**Effects of air pollution** – visibility – basic calculations Atmospheric composition – temperature profile	**2**
3.	**Meteorology** - lapse rate – stability conditions	**4**
4.	Maximum mixing depth – plume behaviour	**2**
5.	**Dispersion** – modelling – engineering decisions – maxi ground level concentration - effective stack height	**10**
6.	Air pollution sampling – Stack monitoring	**2**
7.	Engineered systems of AP control – particulates – gaseous pollutants, Vehicular AP – models – control measures	**9**
8.	**Air pollution control regulations – laws – Standards**	**2**
9.	**Noise pollutionand control**	**7**
10.	**Introduction to Air Pollution Modelling Software's: CALINE4, HIWAY2**	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	understand the importance of air and noise pollution.
2.	model the air and noise pollution and design control devices.

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/ Reprint
1.	"Air Pollution", *Perkins, H C*, McGraw Hill Book Company, New York.	1974
2.	"Environmental Pollution Control Engineering", *Rao, C S*, New Age Pub. New Delhi	2007
3.	"Air Pollution: Its origin and control", *Wark, K and Warner, C F.*, Harper and Row Pub. New York	1998
4.	"Environmental Engineering, A Design Approach", *Sincero, A P and Sincero, G A*, Printice Hall Pub. New Delhi	1996

MOOC'S are available at:

1. *https://nptel.ac.in/courses/105104099/ Environmental Air Pollution*
2. https://nptel.ac.in/courses/105101087/03-Ltexhtml/p6/p.html *Noise Pollution*

PROGRAM ELECTIVE

Course Name	**:**	**Environmental Impact Assessment**
Course Code	**:**	**CEM 5301**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segments	**:**	**1-3**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To learn the concept and methodology of EIA and its documentation.
2.	To learn the planning and mitigation methods

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Evolution of EIA:** Concepts – Methodologies – Screening- Scoping- Base line studies- Mitigation – Matrices - Check List.	**2**
2.	**Rapid and comprehensive EIA:** Legislative and Environmental Clearance procedures in India- Predication tools for EIA.	**4**
3.	**Assessment of impacts:** Air – Water – Soil- Noise- Biological.	**3**
4.	**Socio Cultural Environment:** Public participation- resettlement and rehabilitation.	**3**
5.	**Documentation of EIA:** Environmental management Plan- Post Project monitoring- Environmental Audit- Life cycle Assessment – EMS – case studies in EIA.	**9**

Course Outcomes:

At the end of the course, students will have:	
1.	Knowledge about EIA tools & methodologies, auditing and documentation of EIA.
2.	Knowledge about environment management systems and planning for pollution control

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	"Methods of Environmental Impact Assessment", *Peter Morris*, UBC Press/ Vancouver	2000
2.	"Introduction to Environmental Impact Assessment: Guide to Principles and Practice", *Bram F. N.*, Oxford University Press	2006

Course Name	**:**	**Surface and Groundwater Modelling**
Course Code	**:**	**CEM 5302**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**1-3**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of the course are:
1.	To learn about surface water hydrology.
2.	To learn about groundwater- occurrence and movement.
3.	To study well designing.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Land Processes – Subsurface and Channel Processes- Precipitation – Rain gauge network, Abstractions, Infiltration, Evaporation, Transpiration, Process and models	**4**
2.	Unit Hydrograph & S curve hydrograph, Dimensionless unit hydrograph, GUIH, Watershed Model and Conceptual Models.	**4**
3.	Occurrence and Movement of Ground water, Properties of aquifer, Groundwater flow equations, DupuitForchheimer assumptions, Well hydraulics, Partial penetration of wells, Interference of wells, Collector wells and Infiltration galleries.	**4**
4.	Pumping tests, Analysis for unconfined and non leaky and leaky confined aquifer and water table aquifer, locating hydro geologic boundaries, Well design criteria.	**5**
5.	Natural and Artificial Recharge of Ground water- Salt water intrusion, Application of Finite Difference in ground water.	**4**

Course Outcomes:

At the completion of this course, students will have:	
1.	Knowledge about the surface water hydrology
2.	Knowledge of Ground Water Aquifer development methods

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/Reprint
1.	"Applied Hydrology", *VenTe Chow*, Mc Graw Hill Science Publishers	2013
2.	"Elementary Hydrology", *Vijay Singh*, Prentice Hall	1994
3.	"GroundWater", *Raghunath*, Mc Graw Hill.	2007
4.	"Hydraulics of Groundwater", *Bear, J*., Mc Graw Hill.	2007

MOOCs are available at:

1. https://nptel.ac.in/courses/105105042/40
   Groundwater Hydrology Prof. AnirbanDhar, Department of Civil Engineering, Indian Institute of Technology – Kharaghpur

Course Name	**:**	**Environmental Systems Modelling**
Course Code	**:**	**CEM 5303**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**1-3**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of the course are:
1.	To understand the concept of system and its modeling.
2.	To learn different techniques used in modelling.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Mathematical modelling and simulation, Defining systems and its components, Types of models and their applications.	**3**
2.	Models for Fate and Transport of Contaminants	**2**
3.	Modelling of volatilization, chemical transformations, sorption/desorption, photochemical transformations, biological transformations. Brief review of mass, momentum and energy balance, advection, molecular diffusion, dispersion, their application in modelling of rivers, lakes, sediments, wetlands, subsurface flow and transport, air pollution modelling.	**5**
4.	Introduction to Soft Computing Techniques-Fuzzy set theory and logic, Fuzzy MCDM and FRBS, simple applications in environmental engineering. Neural networks and Genetic Algorithms.	**6**
5.	Introduction to GIS, concepts and data base structure, introduction to GIS software GIS Applications in Environmental Engineering. Introduction to Remote Sensing & its Applications in Environmental Engineering.	**5**

Course outcomes:

At the completion of this course, students will be able to:	
1.	make use of the software packages and its application in civil engineering projects
2.	Understand the various phenomena involved in pollution diffusion & dispersion

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/Reprint
1.	"Integrated Environmental Modeling - Pollutant Transport, Fate, and Risk in the Environment*", Ramaswami, A, Milford, J B, Small, M. J.*, John Wiley & Sons.	2005
2.	"Principles of Geographical Information Systems", *Burrough, P.A. and McDonnell, R.A.*, Oxford University Press.	1998

MOOCs are available at:

1. https://www.coursera.org/learn/modeling-simulation-natural-processes

Course Name	**:**	**Energy Systems and Environment**
Course Code	**:**	**CEM 5304**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**1-3**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of the course are:
1.	To familiarize the students with the basics of energy systems in relation to environment
2.	To explore the energy conversion choices to determine viable means of reducing the environmental impact of energy conversion that are economically and politically acceptable, and technologically feasible.

Course contents:

Sr. No.	Course contents	No. of Lectures
1.	Fundamental concepts of energy and environment	**1**
2.	Energy sources – conventional and non - conventional	**1**
3.	Energy generation – basics and environmental issues/impact	**3**
4.	Non-conventional sources – options, technology and issues	**5**
5.	Energy management – conservation, audit, modelling	**3**
6.	Case studies	**4**
7.	New sources and future energy problems, policies	**4**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Understand the interrelationship between energy and environment.
2.	Making decision with respect energy options on an environmental perspective

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/ Reprint
1.	"Non-conventional energy sources", *G D Rai*, Khanna Pub.	2005
2.	"Energy Management Principles", *Smith*, Pergamon Press	2000
3.	"Introduction to Chemical Engineering Thermodynamics" *J.M Smith, H.C Van Ness*, McGraw Hill.	2001

MOOCs are available at:

1. https://www.edx.org/course/energy-within-environmental-constraints-0

Course Name	**:**	**Industrial Wastewater Management**
Course Code	**:**	**CEM 5401**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segments	**:**	**4-6**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To learn about effluent treatment methods.
2.	To learn about essence of effluent and sludge management vis-à-vis EMS (ISO14000)

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Sources and types of industrial wastewater- Environmental impacts- Regulatory requirements- generation rates- characterization – Toxicity and Bioassay tests.	**3**
2.	Prevention vs Control of Industrial Pollution – Source reduction techniques- Waste Audit- Evaluation of pollution prevention options.	**3**
3.	Waste minimization- Equalization- Neutralization- Oil Separation- Flotation- Precipitation—Heavy metal Removal- adsorption- Aerobic and Anaerobic biological treatment- Sequencing batch reactors- chemical oxidation - ozonation- photocatalysis- Wet Air Oxidation – Evaporation – Ion Exchange- Membrane Technologies- Nutrient removal.	**7**
4.	Individual and Common Effluent Treatment Plants- Zero effluent discharge systems- wastewater reuse- Disposal of effluent on land- Quantification, Characteristics and disposal of sludge.	**3**
5.	Industrial manufacturing process description, wastewater characterization, source reduction options and waste treatment flow sheet for textiles- tanneries- pulp and paper- metal finishing- Petrochemical- Pharmaceuticals- Sugar and Distilleries- food processing- fertilizers- Thermal Power Plants and Industrial Estates, ISO 14000:2003- Waste Audit.	**5**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Have knowledge about treatment methods & design.
2.	Have knowledge about effluent and sludge management vis-à-vis EMS (ISO14000).

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher:	Year of Publication/Reprint
1.	"Industrial Water Pollution Control", *Eckenfelder, W.W.,* McGraw-Hill.	2002
2.	*"*Wastewater Treatment for Pollution Control*", Arceivala, S.J.,* McGraw- Hill.	2000
3.	*"*Industrial Waste treatment Handbook," *Frank Woodard*, Butterworth Heinemann, New Delhi.	2001

Course Name	**:**	**Indoor Air Quality**
Course Code	**:**	**CEM 5402**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**4-6**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To better know indoor air quality and its methods to maintain it.
2.	Design of mitigation methods of indoor pollution

Course Contents:

Sr. No.	Course Contents	No. of Lectures
1.	Indoor activities of inhabitants- level of pollutants in indoor and outdoor air- Design and operation of building for improvements of public health – IAQ policy issues- sustainability. Air pollutants in indoor environment- private residences - offices- schools- public building - ventilation.	**4**
2.	Concepts of several pollutant classes- radon- toxic organic gases- combustion byproducts- microorganisms such as molds and infectious bacteria.	**4**
3.	Concepts and tools - exposure - material balance models; statistical models.	**5**
4.	Indoor air pollution from outdoor sources- particulate matter and ozone- combustion	**3**
5.	Byproducts - Radon and its decay products- volatile organic compounds- odors- and sick building syndrome- Humidity- bio aerosols- infectious disease transmission- special indoor environment - A/C units in indoor- Measurement methods- Control technologies – Control strategies.	**5**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Understand the air quality parameters
2.	Apply the techniques of control of indoor air pollution

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher	Year of Publication/Reprint
1.	"Indoor air and Environmental Quality", *ThaddesGodish*, CRC press.	2000

MOOCs are available at:https://www.coursera.org/learn/intro-indoor-air-quality

Course Name	**:**	**Life Cycle Analysis**
Course Code	**:**	**CEM 5403**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segments	**:**	**4-6**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To understand the analysis techniques used in LCA.
2.	To understand the application methods for product LCA

Course Contents:

Sr. No.	Course Contents:	No. of Lectures
1.	Introduction to LCA, Scope and goal definition	**2**
2.	Inventory analysis, I/O and matrix LCI	**5**
3.	Impact assessment, Ecological risk and human risk, Eco-system impacts and un-certainty analysis	**5**
4.	Applications of LCA, Case-studies of product LCA, Case studies of process LCA, Limitations of LCA	**5**
5.	LCA project study.	**4**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Use the knowledge of LCA product design
2.	Understand and apply LCA for prevention & control of pollution

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher:	Year of Publication/Reprint
1.	"Environmental Life Cycle Analysis", *Ciambrone, D.F.*, CRC Press.	2007
2.	"Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards",*Guinee, J.B.*, Kluwer Academic Publishers.	2004

MOOCs are available at:https://onlinecourses.nptel.ac.in/noc17_ce10/preview

Course Name	**:**	**Rural Water Supply and Environmental Sanitation**
Course Code	**:**	**CEM 5404**
Credits	**:**	**1.5**
L T P	**:**	**3-0 0**
Segments	**:**	**4-6**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To learn about analytical the water supply in rural areas.
2.	To learn about environmental sanitation methods in rural areas.

Course Contents:

Sr. No.	Course Contents	No. of Lectures
1.	Rural water supply schemes - treatment and remedies.	**3**
2.	Epidemiology	**3**
3.	Sanitation of public	**3**
4.	Pasteurization, Industrial hygiene	**4**
5.	Occupational hazards, Radiological health	**5**
6.	Effluent disposal, Low cost treatment systems, Biogas plants, Composting.	**6**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Have knowledge about water supply scheme in rural areas.
2.	Have knowledge about environmental sanitation methods and there design in rural areas.

Bibliography:

Sr. No.	Name of the Book/ Author/ Publisher:	Year of Publication/Reprint
1.	*"*Environmental History of Water: Global Views on Community Water Supply and Sanitation*", Juuti, P., Tapio S. K., and Vuorinen H.*,Iwa Publishing (Intl. Water Assoc).	2007

OPEN ELECTIVES

Course Name	**:**	**Climate Change and Sustainable Development**
Course Code	**:**	**CEO 5001**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**1-3**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To understand the climate system and anthropogenic effects.
2.	To study various models of predicting climate change
3.	To emphasize upon climate protection for sustainable development.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Climate system	**2**
2.	Human impacts on the climate	**4**
3.	Modeling-interpretation and prediction of climate, Long term climate monitoring, Concepts of climate change, Potential causes of climate change, Integrated approach and sectoral approach, Climate change regimes	**11**
4.	Sustainable development, Climate protection pathways of development	**4**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Understand the climate system and anthropogenic effects.
2.	Understand the monitoring and modeling of predicting climate change.
3.	Understand the climate protection strategies for sustainable development.

Bibliography:

Sr. No.	Name/ Author/ Publisher	Year of Publication/ Reprint
1.	"Climate Change and Sustainable Development: Prospects for Developing Countries *", Anil Markandya*, Routledge.	2002
2.	"Interpreting Sustainability, in Sustainability: Dynamics and Uncertainty", *Heal, G. M.*, Kluwer Academic Pub.	2000

MOOCs are available at:

1. https://www.edx.org/course/climate-change-science-ubcx-climate1x-3

Course Name	**:**	**Clean Technology**
Course Code	**:**	**CEO 5002**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**4-6**

Total No. of Lectures: 21

Course Objectives:

	The main objectives of this course are:
1.	To understand the processes and technologies to keep environment clean.
2.	To understand use of preventive methods of pollution control

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**INTRODUCTION TO SOCIETY AND ITS PROBLEM** Industrial Society, Resource Limitations, Environmental Problems.	**2**
2.	**DEVELOPMENT AND ITS PROCESSES** Sustainable Development, Thermodynamics	**4**
3.	**ENERGY SYSTEM** Global Energy Situation, Energy System, Net Energy Analysis, Energy Saving, Energy Storage	**4**
4.	**ENGINEERING CHEMISTRY** Engineering Separation, Process Development, Photochemistry, Thermo-Chemistry	**4**
5.	**WASTES** Waste, Industrial Waste, Hazardous Waste	**2**
6.	**ECO- FRIENDLY TECHNOLOGIES** System Analysis, Flexible Processes, Materials & products eco-design, Material Recycling, Biodegradable Materials.	**5**

Course outcomes:

At the completion of this course, students will be able to:	
1.	Grasp the knowledge of different technologies used to maintain clean environment.
2.	Understand eco-friendly technologies and there applications

Bibliography:

S. No.	Name/ Author/ Publisher	Year of Publication/ Reprint
1.	"Clean Technology", *Allan Johansson,* CRC Press.	2001
2.	*"*Green Energy Technology*", Aswathanarayana U., Harikrishnan T., and Kadher-Mohien S. T.,*Economics and Policy, CRC Press.	2012

MOOCs are available at:

1. https://www.coursera.org/learn/sustainable-development
2. https://www.edx.org/course/sustainable-energy-design-a-renewable-future