HINDUSTAN
INSTITUTE OF TECHNOLOGY & SCIENCE
(DEEMED TO BE UNIVERSITY)

DEPARTMENT OF CIVIL ENGINEERING

CURRICULUM AND SYLLABUS

(Applicable for Students admitted from Academic Year 2020-21)

M. Tech. Sustainable Environmental Engineering

DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF BUILDING SCIENCES

M.TECH SUSTAINABLE ENVIRONMENTAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

PEO 1: Graduates will exhibit proficiency in state of the art technologies to assess environmental impact of multi-disciplinary projects and design economic engineering solutions.

PEO 2: Graduates will be accomplished environmental engineers and entrepreneurs, who will provide sustainable alternatives to existing practices and solve societal problems.

PEO 3: Graduates will exhibit an attitude towards ethical practices, knowledge sharing, lifelong learning and research.

M.TECH: SUSTAINABLE ENVIRONMENTAL ENGINEERING

PROGRAMME OUTCOMES (POs)

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings**.**

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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M.TECH – SUSTAINABLE ENVIRONMENTAL ENGINEERING

SEMESTER I

M.TECH – SUSTAINABLE ENVIRONMENTAL ENGINEERING								
(65 CREDIT STRUCTURE)								
SEMESTER – I								
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**TCH**
1.	PC	CEB4701	Applied Probability and Statistics For Engineers	3	0	0	3	3
2.	PC	CEB4702	Design of Water and Wastewater Treatment Systems	3	1	0	3	4
3.	PC	CEB4703	Sustainable Solid Waste Management	3	1	0	3	4
4.	Ele		Elective –I	3	0	0	3	3
5.	Ele		Elective -II	3	0	0	3	3
6.	MLC	ZZZ4715	Research Methodology & IPR	2	0	0	2	2
7.	PC	CEB4791	Environmental Engineering laboratory	0	0	4	2	4
8.	MLC	CEB4796	Seminar	0	0	3	2	3
Total				**17**	**0**	**7**	**21**	**24**
SEMESTER – II								
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**TCH**
1	PC	CEB4704	Chemistry & Microbiology for Environmental Engineering	3	0	0	3	3
2	PC	CEB4705	Air Pollution Control & Management	3	1	0	3	4
3	PC	CEB4706	Environmental Impact and life cycle Assessment	3	1	0	3	4
4	Ele		Elective- III	3	0	0	3	3
5	Ele		Open Elective	3	0	0	3	3
6	PC	CEB4792	Environmental Engineering Software Studio	0	0	4	2	4
7	PC	CEB4781	Mini project	0	0	6	2	6
Total				15	0	10	19	25

*One of the course shall be a MOOC. (Same course to all students)

SEMESTER - III								
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**TCH**
1	Ele		Elective-IV	3	0	0	3	3
2	MLC	CEB4897	Internship*	0	0	3	2	-
3	MP	CEB4898	Project Work-Phase-I	0	0	24	8	-
Total				3	0	27	13	3
*Internship to be undergone during vacation between 2nd and 3rd semesters								
SEMESTER - IV								
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**TCH**
1	MP	CEB4899	Project Work-Phase-II	0	0	24	12	24
Total				0	0	24	12	24

TOTAL CREDITS: (21+19+13+12) = 65

LIST OF ELECTIVE COURSES

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
1	CEB4723	Energy Management	3	0	0	3	3
2	CEB4724	Ground Water Contamination and Transport Modeling	3	0	0	3	3
3	CEB4725	Mass Transfer in Air - Water - Soil interaction	3	0	0	3	3
4	CEB4726	Ecological Engineering	3	0	0	3	3
5	CEB4727	Geo Environmental Engineering	3	0	0	3	3
6	CEB4728	Environmental Economics	3	0	0	3	3
7	CEB4729	Coastal Pollution and Integrated Coastal Zone Management	3	0	0	3	3
8	CEB4730	Marine Pollution Monitoring	3	0	0	3	3
9	CEB4731	Sustainable Development and Environment	3	0	0	3	3
10	CEB4732	Remote Sensing and GIS for Environmental Applications	3	0	0	3	3
11	CEB4733	Principles of Sustainable Development	3	0	0	3	3
12	CEB4734	Industrial Wastewater Management	3	0	0	3	3
13	CEB4735	Indoor Air Quality	3	0	0	3	3
`14	CEB4736	Instrumental Monitoring of Environment	3	0	0	3	3
15	CEB4737	Environmental Policies and Legislation	3	0	0	3	3
16	CEB4738	Safety and Hazard Control Management	3	0	0	3	3
17	CEB4739	Environmental Risk Assessment	3	0	0	3	3
18	CEB4740	Nano and Biotechnology Applications in Environmental Engineering	3	0	0	3	3
19	CEB4741	Sustainable Environment and Climate Change	3	0	0	3	3
20	CEB4742	Sustainable Energy in Built Environment	3	0	0	3	3
21	CEB4743	Environmental Microbiology	3	0	0	3	3
23	CEB4744	Sustainable Alternative Fuels	3	0	0	3	3
24	CEB4745	Advanced Wastewater Treatment Technologies	3	0	0	3	3
25	CEB4746	Modelling of Environmental systems	3	0	0	3	3
26	CEB4747	Sustainable Water Management	3	0	0	3	3
27	CEB4748	Advanced Environmental Chemistry	3	0	0	3	3
28	CEB4749	Physio-Chemical and Biological Treatment of Water and Wastewater	3	0	0	3	3

SEMESTER 1

COURSE TITLE	APPLIED PROBABILITY AND STATISTICS FOR ENGINEERS			CREDITS	3
COURSE CODE	CEB4701	COURSE CATEGORY	PE	L-T-P	3-0-0-1
CIA	60%			ESE	40%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Apply random variables, correlation and regression.	1,2,5
2	Estimate the parameters using correlation and regression.	1,2,5
3	Apply the test of hypothesis for the available or generated data.	1,2,5
4	Adopt randomized design.	1,2,5
5	Apply Exponential smoothing and Auto Regressive Processes appropriately.	1,2,5

MODULE 1 PROBABILITY AND RANDOM VARIABLE **9**

Probability - Random variables - Moments - Moment generating function - Standard distributions - Functions of random variables - Two-dimensional R. Vs - Correlation and Regression.

MODULE 2 ESTIMATION THEORY **9**

Principle of least squares - Regression - Multiple and Partial correlations - Estimation of Parameters - Maximum likelihood estimates - Method of moments

MODULE 3 TESTING OF HYPOTHESIS **9**

Sampling distributions - Test based on Normal, t-distribution, chi-square, and F-distributions - Analysis of variance, One-way and two way classifications

MODULE 4 DESIGN OF EXPERIMENTS **9**

Completely Randomized Design - Randomized Block Design - Latin Square Design - 2 Factorial Designs.

MODULE 5 TIME SERIES **9**

Characteristics and Representation - Moving averages - Exponential smoothing - Auto Regressive Processes.

TEXT BOOKS

1. Angela M.Dean and Daniel Voss, Design and Analysis of Experiments, Springer texts in Statistics, 2000
2. Freund John, E and Miller, Irvin, "Probability and Statistics for Engineering", 5th Edition, Prentice Hall, 1994.

REFERENCE BOOKS

1. Montgomery D.C and Johnson, L.A, "Forecasting and Time series", McGraw Hill.
2. Anderson, O.D, "Time series Analysis: Theory and Practice", I. North-Holland, Amsterdam, 1982.
3. Gupta, S.C and Kapoor, V.K., "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, New Delhi, 1999.

COURSE TITLE	DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS			CREDITS	4
COURSE CODE	CEB4702	COURSE CATEGORY	PE	L-T-P	3-1-0
CIA	60%			ESE	40%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Develop conceptual schematics required for the treatment of water and wastewater.	1,2,9.
2	Design water treatment plants.	1,2,3,4,5,6,7,9,10.
3	Design wastewater treatment plants.	1,2,3,4,5,6,7,9,10.
4	Identify the ways of treatment of sludge and its disposal.	1,2,3,4,6,9,10,11.
5	Plan and organize the operations and maintenance of treatment plant..	1,2,3,4,5,6,9,10.

MODULE 1 PRINCIPLES OF TREATMENT **9**

Pollutants in water and wastewater – characteristics, standards for performance, treatment processes – Selection criteria-types of reactor- kinetics – physical treatment principles - screening, skimming, floatation – mixing, equalization, sedimentation, filtration – gas transfer – adsorption – Isotherms – membrane separation, electro dialysis – stripping -principles of chemical treatment – neutralization - coagulation flocculation – precipitation – stabilization – disinfection, Ion exchange – advanced oxidation /reduction – principles of biological treatment – aerobic and anaerobic treatment - kinetics of biological growth – attached and suspended growth.

MODULE 2 DESIGN OF WATER TREATMENT PLANTS **9**

Design of treatment plant units – selection of process - upgrading existing plants – ultimate residue disposal - aerators – chemical feeding – flocculator – clarifier – filters – rapid sand filters, pressure filter, dual media filters – disinfectors- design of softeners – demineralizers –reverse osmosis plants – process flow chart Layout and Hydraulic profiles for treatment plants

MODULE 3 DESIGN OF WASTEWATER TREATMENT PLANTS **9**

Design of treatment units - screens- grit chamber - settling tanks - design of aerobic treatment systems - activated sludge process and variations, sequencing batch reactors, membrane biological reactors-trickling filters-Bio Tower-RBC-Moving Bed Reactors- aerated lagoons – natural treatment systems, waste stabilization ponds, constructed wet land – Disinfection – reclamation and reuse – recent trends – Design of anaerobic treatment system - UASB, up flow filters, septic tanks – Nutrient removal systems - process flow chart Layout and Hydraulic profiles for treatment plants.

MODULE 4 RESIDUAL MANAGEMENT **9**

Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering (mechanical and gravity) - sludge drying beds - Layout hydraulics profile PID

MODULE 5 CONSTRUCTION OPERATION AND MAINTENANCE ASPECTS **9**

Construction, Operation and Maintenance aspects – Trouble shooting – Planning, Organizing and controlling of plant operations – capacity building, case studies of Retrofitting

On Completion of the course, the Students have to submit the term project report

TEXT BOOKS

1. Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.

REFERENCE BOOKS	
1	Qasim, S.R., Motley, E.M. and Zhu.G. "Water works Engineering – Planning, Design and Operation", Prentice Hall, New Delhi, 2002.
2	Manual on “Sewerage and Sewage Treatment” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1993.
3	Qasim, S.R. "Wastewater Treatment Plant, Planning, Design & Operation", Technomic Publications, New York, 1994.
4	Manual on Water Supply and Treatment, CPHEEO, Govt. of India, New Delhi (2003).

COURSE TITLE	SUSTAINABLE SOLID WASTE MANAGEMENT			CREDITS	3
COURSE CODE	CEB4703	COURSE CATEGORY	PE	L-T-P	3-0-0
CIA	60%			ESE	40%
LEARNING LEVEL	BTL 3				

CO	COURSE OUTCOMES	PO
The students will be able to		
1.	Identify the sources and types of solids and hazardous wastes.	1,2,3.
2.	Select proper waste sampling and adopt source reduction of wastes	1,2,3,4,7,9,11.
3.	Adopt appropriate hazardous waste handling techniques.	1,2,3,4,5,6,7,9,10.
4.	Suggest sustainable waste processing technology and energy recovery.	1,2,3,4,6,9,10,11.
5	Suggest sustainable ways of hazardous waste disposal.	1,2,3,4,5,6,9,10.

Prerequisites : Nil

MODULE 1: INTRODUCTION TO SOLID WASTE MANAGMENET **9**

Sustainability in the Context of SWM - Types and Sources of solid and hazardous wastes - The Framework for Sustainability Assessment - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, plastics and fly ash – Solid Waste Management Using a Community-Based Social Marketing Approach - Sensors and Sensor Networks for Solid Waste Management.

MODULE 2: WASTE CHARACTERISATION AND SOURCE REDUCTION **9**

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes - Hazardous Characteristics - TCLP tests - waste sampling and characterization plan - Source reduction of wastes - Recycling and reuse - Waste exchange – Optimizing Urban Material Flows and Waste Streams in Urban Development Through Principles of Zero Waste and Sustainable Consumption.

MODULE 3: STORAGE, COLLECTION AND TRANSPORT OF WASTES **9**

Handling and segregation of wastes at source - storage and collection of municipal solid wastes - Analysis of Collection systems - Need for transfer and transport - Transfer stations Optimizing waste allocation - compatibility, storage, labeling and handling of hazardous wastes - hazardous waste manifests and transport.

MODULE 4: WASTE PROCESSING TECHNOLOGIES AND ZERO EMISSION **9**

Material separation and processing technologies - biological and chemical conversion technologies - methods and controls of Composting - thermal conversion technologies and energy recovery - incineration - solidification and stabilization of hazardous wastes - treatment of biomedical wastes, Integrated Solid Waste Management Based on the 3R Approach - Refuse-Derived Fuel Process for sustainable Solid Waste Management - Case studies

MODULE 5: WASTE DISPOSAL	9
Waste disposal options - Disposal in landfills - Landfill Classification, types and methods - site selection - design and operation of sanitary landfills, secure landfills and landfills bioreactors - leachate and landfill gases management - landfill closure and environmental monitoring - closure of landfills - landfill remediation, - Comparative Study of Municipal Solid Waste Treatment Technologies Using Life Cycle Assessment Method.	
On Completion of the course, the Students have to submit the term project report	
TEXT BOOKS	
1	Ludwig, Christian, Hellweg, Stefanie, Stucki, Samuel, Municipal Solid Waste Management Strategies and Technologies for Sustainable Solutions, Springer, 2003
2	Syeda Azeem Unnisa, S. Bhupatthi Rav, Sustainable Solid Waste Management, Apple Academic Press, 2012.
REFERENCE BOOKS	
1	CPHEEO "Manual on Municipal Solid Waste Management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000.
2	LaGrega, M., et al., Hazardous Waste Management, McGraw-Hill, c. 1200 pp., 2nd ed., 2001.
3	Ni-Bin Chang, Ana Pires, Sustainable Solid Waste Management: A Systems Engineering Approach, Wiley-IEEE Press, 2015
4	Amalendu Bagchi, Design of Landfills and Integrated Solid Waste Management, John Wiley & Sons, 2004
5	George Tchobanoglous, Hilary Theisen and Samuel A, Vigil "Integrated Solid Waste Management, McGraw-Hill International edition, New York, 1993.

COURSE TITLE	RESEARCH METHODOLOGY & IPR			CREDITS	2
COURSE CODE	ZZZ4715	COURSE CATEGORY	MLC	L-T-P	2-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL 2				

CO	COURSE OUTCOMES	PO
Students will be able to		
1.	Formulate research problem.	1,2,3,4,6
2.	Adopt creative ideas and concepts appropriately for various societal problems.	1,2,3,4,6,7
3.	Interpret and analyse data to be used in solving problems	1,2,3,4,6,9
4.	Utilize the knowledge gained on IPR for Environmental Projects	1,2,3,4,9,10,11
5.	Apply for patent for novel ideas and product or process development through IPR	1,2,3,4,5

Prerequisites : Nil

MODULE 1 : RESEARCH PROBLEM FORMULATION (6)

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

MODULE 2 : RESEARCH PROPOSAL AND ETHICS (6)

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

MODULE 3 : DATA ANALYSIS AND INTERPRETATION (6)

Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.

MODULE 4 : NATURE OF INTELLECTUAL PROPERTY (6)

Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual

Property. Procedure for grants of patents, Patenting under PCT.

MODULE 5 : PATENT RIGHTS AND NEW DEVELOPMENTS IN IPR (6)

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCES BOOKS

1	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', 1996.
2	Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", 2004.
3	Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners", SAGE, 2005.
4	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5	Mayall , "Industrial Design", McGraw Hill, 1992.
6	Niebel , "Product Design", McGraw Hill, 1974.
7	Asimov, "Introduction to Design", Prentice Hall, 1962.
8	Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
9	T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
10	C.R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques , New Age International, 2004.
11	International publishers, Third Edition. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005
12	Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition, 2006
13	Creswell, John W. Research design: Qualitative, quantitative, and mixed methods, approaches. Sage publications, 2013

COURSE TITLE	ENVIRONMENTAL ENGINEERING LABORATORY			CREDITS	2
COURSE CODE	CEB4791	COURSE CATEGORY	PC	L-T-P	0-0-2
CIA	60%			ESE	40%
LEARNING LEVEL	BTL-4				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Determine the Basic characteristics of Water properties	1,2,5,6,8,9,11
2	Determine the Basic characteristics of Air samples.	1,2,5,6,8,9,11
3	Conduct Air quality Monitoring Experiments.	1,2,5,6,8,9,11
4	Analyse soil for its properties and apply it for various purposes.	1,2,5,6,8,9,11

LAB / MINI PROJECT/FIELD WORK

1. **Physical and Chemical Analysis of Water:**
   pH, Conductivity, Turbidity, Solids, Chlorides, Sulphates, Alkalinity, Fluorides, Nitrate and heavy metals.
2. **Physical and Chemical Analysis of Wastewater:**
   Phosphate, COD, BOD, Organic and Ammonical nitrogen, Oil & grease.
3. **Air Quality Analysis:**
   SPM, SO_2, CO, NOx
4. **Soil Analysis:**
   pH, Conductivity, Cation exchange capacity, Sodium Absorption ratio

REFERENCE BOOKS

1	Modi, P.N., “Environmental Engineering Vol. I & II”, Standard Book House, 2006, Delhi - 6
2	Garg, S.K., “Environmental Engineering Vol. I & II”, Khanna Publishers, 1994, New Delhi
3	Guidelines For The Measurement Of Ambient Air Pollutants, Central Pollution Control Board Ministry Of Environment & Forests, 2013.

COURSE TITLE	SEMINAR			CREDITS	2
COURSE CODE	CEB4796	COURSE CATEGORY	MLC	L-T-P	0-0-3
CIA	-			ESE	100%
LEARNING LEVEL	BTL3				

CO	COURSE OUTCOMES	PO
Students will be able to		
1.	Independently study and investigate current research areas and share ideas through presentation	4, 6,7,8
2.	Develop writing skills and prepare reports	4, 6,7,8
3.	Present and defend their research at seminars and conferences	4, 6,7,8

Prerequisites : Nil

This work should consist of soft bound report on any technical topic of interest associated with the post graduate course and should be submitted in a standard format having the following contents.

(i) Introduction
(ii) Literature survey
(iii) Theoretical contents
(iv) Field applications, case studies
(v) Relevance to the present national and global scenario of Environmental Engineering
(vi) Strength and weaknesses of the particular area of seminar
(vii) R & D in the particular area
(viii) Benefit cost studies – feasibility studies
(ix) Vendors associated
(x) Conclusions
(xi) References

Students should prepare a power point presentation to be delivered in fifteen minutes and should be able to answer questions asked in remaining five minutes. Where ever possible, the topic for the seminar may be decided on the mini project or the main project work to be done in semester II, III. The students will be evaluated through an end semester examination by a team of internal staff.

SEMESTER II

COURSE TITLE	CHEMISTRY AND MICROBIOLOGY FOR ENVIRONMENTAL ENGINEERING			CREDITS	3
COURSE CODE	CEB4704	COURSE CATEGORY	PC	L-T-P	3-0-0
CIA	60%			ESE	40%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Describe the characteristics and degradation of aquatic pollutants.	1,2,4,6,7,9,10
2	Describe the chemical reactions in atmospheric and soil environment	1,2,4,6,7,9,10
3	Identify the type and characteristics of microorganisms.	1,2,4,6,7,9.
4	Identify the biological reactions in wastewater	1,2,4,6,7,9.
5	Point out the solutions for degradation of chemical and biological pollutants	1,2,4,6,7,8.

MODULE 1 AQUATIC CHEMISTRY **9**

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product(Ksp), Chemical kinetics , Fate of chemicals and typical pollutants in aquatic environment, -Characteristics of water pollution, volatilization, coagulation, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals-Metals, complex formation, oxidation and reduction

MODULE 2 ATMOSPHERIC AND SOIL CHEMISTRY **9**

Atmospheric structure –-chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, Acid rain- origin and composition of particulates, Nature and composition of soil-Clays- ion-exchange reactions in soil – Agricultural chemicals in soil, Heavy metals-Chemical speciation and their Toxicity- Nano materials, CNT, titania, composites,

MODULE 3 CLASSIFICATION AND CHARACTERISTICS OF MICROORGANISMS **9**

Classification and Distribution of microorganisms - Biogeochemical cycles – Role of Micro Organism in nutrient cycle-Nutrition and metabolism in microorganisms, growth phases, carbohydrate, protein, lipid metabolism – respiration, aerobic and anaerobic-fermentation, glycolysis, Kreb‟s cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, Bioenergetics

MODULE 4 PATHOGENS IN WASTEWATER **9**

Water Borne pathogens and their effects, Transmission of pathogens, Indicator organisms of water – Coliforms - total coliforms, E-coli, Streptococcus, Clostridium, Concentration and detection of virus. Factors influencing toxicity. Effects – acute, chronic, Test organisms – toxicity testing, Bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring, bioleaching.- Emerging Contaminants

MODULE 5 APPLICATIONS **9**

Chemical process and their applications in water and wastewater treatment-Microbiology of biological treatment processes – aerobic and anaerobic, Nutrients Removal – BOD, Nitrogen, Phosphate. nitrification and denitrification, eutrophication

On Completion of the course, the Students have to submit the term project report

REFERENCE BOOKS	
1	Sawyer,C.N., MacCarty, P.L. and Parkin, G.F., "Chemistry for Environmental Engineering and Science", Tata McGraw – Hill, Fifth edition, New Delhi 2003
2	Colin Baird and Michael Cann „Environmental Chemistry", Freeman and company, New York, 2012.
3	Manahan, S.E., "Environmental Chemistry", 8th Edition, CRC press, 2005.
4	Raina M. Maier, Ian L. Pepper, Charles P. Gerba, "Environmental Microbiology", Academic Press. 2009
5	S C Baatiak, Handbook of Microbiology", vol.1, Atlantic Publications., 2007

COURSE TITLE	AIR POLLUTION CONTROL AND MANAGEMENT			CREDITS	3
COURSE CODE	CEB4705	COURSE CATEGORY	PC	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Apply sampling techniques.	1,2,3,9,11.
2	Suggest suitable air pollution prevention equipments and techniques for various gaseous and particulate pollutants to industries.	1,2,3,4,7,9,11.
3	Apply modelling techniques	1,2,3,4,5,6,7,9,10.
4	Discuss the types and the sources of Indoor Air Pollution with emission standards	1,2,3,4,6,9,10,11.
5	Point out sustainable solutions for air quality management.	1,2,3,4,5,6,8,9,10.

MODULE 1 INTRODUCTION **9**

Structure and composition of Atmosphere – Sources and classification of air pollutants - Effects of air pollutants on human health, vegetation and animals, Materials and Structures – Effects of air Pollutants on the atmosphere, Soil and Water bodies – Long- term effects on the planet – Global Climate Change, Ozone Holes – Ambient Air Quality and Emission Standards – Air Pollution Indices – Emission Inventories – Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants.

MODULE 2 CONTROL OF PARTICULATE AND GASEOUS CONTAMINANTS **9**

Factors affecting Selection of Control Equipment – Gas Particle Interaction – Working principle, Design and performance equations of Gravity Separators (cyclone) - Centrifugal separators Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters –- Process Control and Monitoring – Costing of APC equipment – Case studies for stationary and mobile sources.

MODULE 3 AIR POLLUTION MODELING AND SOFTWARE PACKAGE APPLICATIONS **9**

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport and Dispersion of Air Pollutants – Modeling Techniques – Air Pollution Climatology. Introduction to Meteorological Modeling – Dispersion Modeling – Fugitive Modeling & Deposition Modeling

MODULE 4 INDOOR AIR POLLUTION **9**

Indoor Air Pollutants - Volatile Organic Compounds , Inorganic Gaseous Pollutants Respirable Particulates ,Bioaerosols, Radon and its decay products-Infectious disease transmission- A/C units in indoor- Odours and sick building syndrome-Indoor Air quality Models – Ventilation Models.

MODULE 5 AIR QUALITY AND SUSTAINABLE DEVELOPMENT **9**

Sustainable cities – cost effective air quality monitoring systems – aligning air quality with sustainable development – prioritizing sources on the basis of impact and future trends – cost benefit approach to reduce emissions-Sustainable Development Goals, Kyoto Protocol, COP21 Paris Agreement, Climate change adaptation and mitigation.

On Completion of the course, the Students have to submit the term project report

TEXT BOOKS

1. Lawrence K. Wang, Norman C Perelra, Yung-Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
2. Noel de Nevers, Air Pollution Control Engg., McGraw-Hill, New York, 1995.

REFERENCE BOOKS	
1	Anjaneyulu, Y, "Air Pollution & Control Technologies", Allied Publishers (P) Ltd., India, 2002.
2	Richard W. Boubel, Donald L. Fox and D. Bruce Turner, "Fundamentals of Air Pollution" 3rd Edition, Academic Press, 1994.
3	Karl B. Schnelle, Jr., and Partha R. Dey, "Atmospheric Dispersion Modeling Compliance Guide", McGraw-Hill, 2000.
4	Deaton and Wine Brake, “Dynamic Modeling of Environmental Systems”, Wiley & Sons, 2002.

COURSE TITLE	ENVIRONMENTAL IMPACT AND LIFE CYCLE ASSESSMENT			CREDITS	3
COURSE CODE	CEB4706	COURSE CATEGORY	PC	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

CO	COURSE OUTCOMES	PO
The students will be able to		
1.	Apply the basic knowledge of EIA and its process	1,2,3,9,11.
2.	Work on the impact prediction, and mathematical modeling while preparing EIA assessment.	1,2,3,4,7,9,11.
3	Adhere to the Auditing procedure in EIA process.	1,2,3,4,5,6,7,9,10.
4.	Recognize the basics of Life cycle assessment and ISO series	1,2,3,4,6,9,10,11.
5.	Prepare ISO & LCA reports to various Industries	1,2,3,4,5,6,8,9,10.

Prerequisites : Nil

MODULE 1: INTRODUCTION AND COMPONENTS OF EIA **9**

Environmental Impact Assessment (EIA) - Environmental Impact Statement - EIA in Project Cycle - Legal and Regulatory aspects in India according to Ministry of Environment and Forests - Types and limitations of EIA - - Participation of Public and Non-Governmental Organizations in environmental decision making-Components of EIA – Screening – Scoping – Matrix –networks – Analysis of Alternatives – Software Packages in EIA .

MODULE 2: PREDICTION, ASSESSMENT OF IMPACTS AND REPORTING **9**

Prediction tools for EIA - Mathematical modeling for impact prediction - Assessment of impacts - air - water - soil - noise - biological - socio-cultural environments - Cumulative Impact Assessment - Documentation of EIA findings - planning - organization of information and visual display materials - Report preparation.

MODULE 3: ENVIRONMENTAL MANAGEMENT PLAN AND AUDITING **9**

Environmental Management Plan - preparation, implementation and review - Mitigation and Rehabilitation Plans -Post project audit - Ethical and Quality aspects of Environmental Impact Assessment – EIA Case Studies

MODULE 4: LIFE CYCLE ASSESSMENT AND ENVIRONMENTAL MANAGEMENT SYSTEMS **9**

Elements of LCA – Life Cycle Costing – Eco Labelling – Design for the Environment – International Environmental Standards – ISO 14001 – Environmental audit, Green building & green energy concepts and management.

MODULE 5: LCA CASE STUDIES **9**

Industrial applications of CP, LCA, EMS and Environmental Audits, green energy and green process management.

On Completion of the course, the Students have to submit the term project report

REFERENCE BOOKS

1. David P. Lawrence, Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John

	Wiley & Sons, Inc., 2017
2	Ralph E Horne, Tim Grant, Karli Verghese, Life Cycle Assessment: Principles, Practice and Prospects, CSIRO Publishing 2009.
3.	Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell Science London. 1999
4.	Biswas, A.K., and Agarwala, S.B.C. Environmental Impact Assessment for Developing Countries, Butterworth Heinemann, London. 1994.
5.	The World Bank Group, Environmental Assessment Source Book Vol. I, II and III. The World Bank, Washington, 1991.
6.	Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards, Kluwer Academic Publishers 2004

COURSE TITLE	ENVIRONMENTAL ENGINEERING SOFTWARE STUDIO			CREDITS	2
COURSE CODE		COURSE CATEGORY	PC	L-T-P	0-0-2
CIA	60%			ESE	40%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Use Basic software on air models	1,2,5,6,8,9,11
2	Work with air models and give solutions to pollution problems.	1,2,5,6,8,9,11
3	Use Basic software on oil spill models.	1,2,5,6,8,9,11
4	Work with basic Hydrodynamic modelling.	1,2,5,6,8,9,11

LAB / MINI PROJECT/FIELD WORK

1. Introduction to Meteorology data and Software
2. Introduction to Wind rose Diagrams
3. Plotting of Windrose with WR plot software
4. Introduction to air dispersion modeling
5. Creating the Input files to the air Dispersion modeling
6. Calculating the Ground level concentration of pollutants by using ISC models
7. Introduction to Aermod Model
8. Introduction to Coastal Models
9. Calculating the concentration of oil spill using ADIOS,GNOME model
10. Basics of Sediment Transport Modeling
11. Introduction to Noise Modeling
12. Calculating the L_{eq} Noise by using continuous Noise Models.

REFERENCE BOOKS

1	John Wainwright and Mark Mulligan, Environmental Modeling Finding Simplicity in Complexity, John Wiley and sons Ltd, USA, 2004.
2	Dynamic Modeling of Environmental Systems by Deaton and Wine brake, Wiley & Sons, 2002.
3	Karl B. Schnelle, Jr., and Partha R. Dey, "Atmospheric Dispersion Modeling Compliance Guide", McGraw-Hill, 2000.
4	Coastal Engineering Manual Part 1 to Part 6, US ARMY CORPS OF ENGINEERS, 2002

COURSE TITLE	MINI PROJECT			CREDITS	2
COURSE CODE	CEB4781	COURSE CATEGORY	PC	L-T-P	0-0-6
CIA	40%			ESE	60%
LEARNING LEVEL	BTL4				

CO	COURSE OUTCOMES	PO
The students will be able to		
1.	Identify and work for the real life needs of the society.	1,2,4,6,8
2.	Provide practical solutions to the societal problems.	1,2,4,6,8,10
3.	Apply relevant engineering concepts for various Environmental problems	1,2,4,6,8,10
4.	Prepare Reports based on the study	6,8,9,11

Prerequisites : Knowledge on Basic Core courses

The project work will start in semester II and should preferably be a live problem in the industry or macro - issue having a bearing on performance of the Environmental fields. The student individually works on a specific topic approved by the head of the division under the guidance of the faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of Environmental Engineering. The topic may be theoretical or case studies and involve scientific research, design, collection, and analysis of data, determining solutions and must preferably bring out the individual contribution.

At the end of the semester, a detailed report should be presented in a standard format, in soft bound hard copy, preferably printed on single side paper, containing the following contents.

(i) Introduction including objectives, limitations of study.

(ii) Literature survey, background to the research.

(iii)Problem statement and methodology of work

(iv)Theoretical contents associated with topic of research

(v) Field applications, case studies

(vi)Data collection from field/organizations or details of experimental work/analytical work

(vii) Part analysis / inferences

(viii)Details of remaining work to be completed during the project work stage II

(ix) References

Students should prepare a power point presentation to be delivered in 15 minutes and should be able to answer questions asked in remaining five minutes. (It is preferable that at least one paper on the research area be presented in a conference or published in a referred journal)

The students will be evaluated through a viva – voce examination by a panel of internal examiners

The method of assessment for both phase I and Phase II is shown in the following table:

Assessment	**Tool**	**Weightage**
In –semester	I review	10%
	II review	10%
	III review	20%
End semester	Final viva voce examination	60%

SEMESTER – III

COURSE TITLE	INTERNSHIP			CREDITS	2
COURSE CODE	CEB4897	COURSE CATEGORY	MLC	L-T-P	0-0-3
CIA	100 %			ESE	-
LEARNING LEVEL	BTL 4				

CO	COURSE OUTCOMES	PO
The students will be able to		
1.	Develop and apply knowledge gained for various Environmental Quality monitoring, Experimental Analysis, Operation and maintenance problems	1,2,3,4,6,11
2.	Utilize the experience gained from the field for professionalism in the business sphere.	1,2,7,8
3.	Develop practical problem-solving skills to tackle the societal problems	1,2,3,4,6,11

Prerequisites: Nil

The students individually undertake training in various Environmental Labs/Consultancies and organizational operations pertaining to Environmental activities during the summer vacation for a specified duration of two months.

The final evaluation of the practical training will be based on the following.

(i) Environmental labs/Consultancies training

(ii) Experimental Analysis and Environmental Design

(iii) Field Monitoring Studies

(iv) Environmental Report documentation

The students individually undertake training in reputed Environmental Firms during the summer vacation for a specified duration of two months. Students should send their report on the work assigned from the date of joining, weekly program report and completion report during the period of practical training. At the end of training period, a detailed report on the work done should be submitted within ten days from the commencement of the semester.

The students will be evaluated through by a team of internal staff.

COURSE TITLE	PROJECT WORK PHASE-I			CREDITS	8
COURSE CODE	CEB4898	COURSE CATEGORY	MP	L-T-P	0-0-24
CIA	40%			ESE	60%
LEARNING LEVEL	BTL 4&5				

CO	COURSE OUTCOMES	PO
The students will be able to		
1.	Identify current needs of the society and collect information related to the same through detailed review of literature	1,2,3,4,6,7
2.	Develop the methodology to solve the identified problem.	1,2,4,5,7
3.	Prepare project report and face reviews and viva-voce examination	7,8
4.	Identify the area to work on and carry out the remaining phase II work in a systematic way.	1,2,3,4,6,7

Prerequisites: Nil

The project work will start in semester III and should preferably be a live problem in the industry or macro - issue having a bearing on performance of the Environmental Engineering field. The student individually works on a specific topic approved by the head of the division under the guidance of the faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of Environmental Engineering. The topic may be theoretical or case studies and involve scientific research, design, collection, and analysis of data, determining solutions and must preferably bring out the individual contribution.

At the end of the semester, a detailed report stage I should be presented in a standard format, in soft bound hard copy, preferably printed on single side paper, containing the following contents.

(i) Introduction including objectives, limitations of study.

(ii) Literature survey, background to the research.

(iii) Problem statement and methodology of work

(iv) Theoretical contents associated with topic of research

(v) Field applications, case studies

(vi) Data collection from field/organizations or details of experimental work/analytical work

(vii) Part analysis / inferences

(viii) Details of remaining work to be completed during the project work stage II

(ix) References

Students should prepare a power point presentation to be delivered in 15 minutes and should be able to answer questions asked in remaining five minutes. (It is preferable that at least one paper on the research area be presented in a conference or published in a referred journal)

The students will be evaluated through a viva – voce examination by a panel of internal examiners

The method of assessment for both phase I is shown in the following table

Assessment	**Tool**	**Weightage**
In –semester	I review	10%
	II review	10%
	III review	20%
End semester	Final viva voce examination	60%

SEMESTER – IV

COURSE TITLE	PROJECT WORK PHASE-II			CREDITS	12
COURSE CODE	CEB4899	COURSE CATEGORY	MLC	L-T-P	0-0-24
CIA	70%			ESE	30%
LEARNING LEVEL	BTL 5,6				

CO	COURSE OUTCOMES	PO
The students will be able to		
1.	Solve the identified problem based on the formulated methodology	1,2,3,4,6,7
2.	Analyse, Interpret and discuss the test results obtained and make conclusions	1,2,4,5,7
3.	Take up any challenging practical problems in the field of Environmental Engineering and management and find suitable solutions to it.	1,2,3,4,5,6,7,8,9,10

Prerequisites: PROJECT PHASE I

The student should continue the phase I project work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and the review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report and the viva – voce examination (end semester assessment) by a panel of examiners including one external examiner

The method of assessment for both phase I and Phase II is shown in the following table:

Assessment	Tool	Weightage
In –semester	I review	10%
	II review	20%
	III review	40%
End semester	Final viva voce examination	30%

student will be allowed to appear in the viva voce examination only if he /she has submitted his/her project work in the form of paper presentation/publication in a conference /journal and produced the proof of acknowledgement of receipt of paper from the organizers/publishers.

LIST OF ELECTIVE COURSES

COURSE TITLE	ENERGY MANAGEMENT			CREDITS	3
COURSE CODE	CEB4723	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Apply the principles of energy consumption and conservation.	1,2,3,9,11.
2	Conduct energy auditing and assessment	1,2,3,4,7,9,11.
3	Suggest various ways of Energy Conservation in various industries.	1,2,3,4,5,6,7,9,10.
4	Adopt economical ways of energy conservation and management.	1,2,3,4,6,9,10,11.
5	Solve Energy related problems in practical situations.	1,2,3,4,5,6,9,10.

MODULE 1 SOURCE OF ENERGY **9**

Energy Scenario - Principles and Imperatives of Energy Conservation - Various Sources - Alternative - non conventional energy sources - Alternative energy sources-wind-Solar energy - Energy Consumption Pattern - Resource Availability - Role of Energy Managers in Industries.

MODULE 2 ENERGY AUDITING **9**

Energy Audit - Purpose, Methodology with respect of Process Industries - Power Plants, Boilers etc, - Characteristic Method Employed in Certain Energy Intensive Industries - Various Energy" Conservation Measures in Steam System - Losses in Boiler, Methodology of Upgrading Boiler Performance; Energy Conservation in Pumps, Fans, Aerators Compressors, Air conditioning and refrigeration systems, Function, Necessity

MODULE 3 ENERGY CONSERVATION **9**

Total Energy Systems - Concept of total Energy - Advantages & Limitations - Total Energy System & Application - Potential & Economics of total Energy systems, water heat recovery. Potential Areas for Conservation in Various Industries - Energy Management Opportunities in Electrical Heating, Lighting System, Cable Selection - Energy Efficient Motors - Factors Involved in Determination of Motor Efficiency

MODULE 4 ENERGY ECONOMICS **9**

Importance of Energy Management, Energy Economics - Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Costing

MODULE 5 APPLICATIONS **9**

Case studies on Sugar Industry, Thermal Power Plant; Petrochemical Industries, Educational Institutions.

TEXT BOOKS

1	Stephen Doven, Environment and Sustainability Policy : Creation, Implementation, Evaluation, The Federation Press, 2005
2	Trivedi, P R, Jolka K R, Energy Management, Commonwealth Publication, New Delhi, 2007.

REFERENCE BOOKS	
1	Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington, 2008.
2	CB Smith, Energy Management Principles, Pergamon Press, New York, 3rd Edition, 2004.

COURSE TITLE	GROUND WATER CONTAMINATION AND TRANSPORT MODELING			CREDITS	3
COURSE CODE	CEB4724	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
On successful completion of the course the student will be able to :		
1	Identify the various sources of ground water contamination and its movement.	1,2,4,9,10,11.
2	Describe the concept of flow nets and steady state flow.	1,2,3,4,9,11.
3	Conduct laboratory tests on the ground water availability and quality.	1,2,3,4,5,6,7,9,10.
4	Interpret and analyze chemical properties and characteristics of ground water	1,2,3,4,6,9,10,11.
5	Identify various contaminants and their transport process.	1,2,3,4,5,6,7,9,10,11.

MODULE 1 INTRODUCTION **9**

Ground water and the hydrologic cycles - Ground water as a resource - Ground water contamination - Water quality standards - Sources of contamination - Land disposal of solid wastes - Sewage disposal on Land. Ground water and geologic processes. Physical properties and principles - Darcy's Law - Hydraulic Head and Fluid Potential - Piezometers and Nests. Hydraulic conductivity and permeability - Homogeneity and Anisotropy - Porosity and voids Ratio - Unsaturated flow and the water table - Steady state flow and Transient flow - Compressibility and effective stress - Transmissivity and storativity - Equations of Ground water Flow - Limitations of Darcian Approach - Hydro dynamic dispersion.

MODULE 2 HYDROLOGIC CYCLE AND FLOW NETS **9**

Flow nets - Graphical construction - Flow nets by numerical simulation. Steady state Regional Ground Water flow - steady state hydrologic budgets - Fluctuations in ground water levels.

MODULE 3 RESOURCE EVALUATION **9**

Development of Ground Water resources - Exploration for Aquifers - the response of Ideal aquifers to pumping - Measurement of parameters - Laboratory tests - Piezometer test - Pumping tests - Estimation of saturated hydraulic conductivity - Numerical simulation for aquifer yield prediction - Artificial recharge and induced infiltration - Land subsidence - Sea water intrusion.

MODULE 4 CHEMICAL PROPERTIES AND PRINCIPLES **9**

Constituents - Chemical equilibrium - Association and Dissociation of dissolved species - effects of concentration gradients - Mineral dissolution and solubility - Oxidation and reduction Process - Ion exchange and Adsorption - Environmental isotopes - Field Measurement of Index parameters. Chemical Evolution: Hydro Chemical sequences and facies - graphical methods - Hydro chemical Facies - Ground water in carbonate terrain - Ground Water in crystalline rocks - Ground Water in complex sedimentary systems - Geochemical interpretation of 14C Dates - Process rates and molecular diffusion.

MODULE 5 SOLUTE TRANSPORT	9
Transport process - non-reactive constituents in homogeneous media and Heterogeneous media - Transport in Fracture media - Hydro chemical behaviour of contaminants - Trace metals - Trace nonmetals - Nitrogen, organic substances - Measurement of parameters - Velocity - Dispersivity - chemical partitioning. Modeling Principles - MOC Modeling. Case studies	
TEXT BOOKS	
1	Todd David Keith, Ground water Hydrology, Fourth edition, John Wiley and Sons, New York, 2004.
REFERENCE BOOKS	
1	Randall J. Charbeneau, "Ground water Hydraulics and Pollutant transport "Prentice Hall, Upper Saddle River, 1999.
2	Allen Freeze, R. and John A. Cherry, "Ground Water", Prentice Hall, Inc., 2001.

COURSE TITLE	MASS TRANSFER IN AIR - WATER - SOIL INTERACTION			CREDITS	3
COURSE CODE	CEB4725	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Apply equilibrium principles for Environment.	1,2,3,9,11.
2	Apply the working principles of mass transfer and diffusion in Chemical industries.	1,2,3,4,7,9,11.
3	Use the exchange rate principle theories to quantify the mixing rate of gases and chemicals in water and in air.	1,2,3,4,5,6,7,9,10.
4	Use the concepts to quantify the exchange rate concentration between water and the earthen material	1,2,3,4,6,9,10,11.
5	Implement the knowledge of mass transfer rates between air and soil in real time.	1,2,3,4,5,6,9,10.

MODULE 1 EQUILIBRIUM AT ENVIRONMENTAL INTERFACE 9

.Ideal solutions - air - water equilibrium occurrences - pure gases in contact with water - pure liquid in contact with air - partition coefficient for the air - water system. Earthen solid - waste equilibrium occurrences - pure solid and liquid chemicals in contact with water and earthen solids. Earthen solid - air equilibrium occurrences - water - liquid chemical equilibrium occurrences - thermal equilibrium at environmental interfaces

MODULE 2 TRANSPORT MECHANISMS 9

Diffusion and mass transfer - molecular diffusion - eddy diffusion - mass transfer theories - mass transfer coefficients - binary mass transfer coefficients in two phases and two resistance theory of inter-phase mass transfer turbulence in the environment - fundamentals of heat transfer - analogy theories of momentum, heat and mass transfer.

MODULE 3 EXCHANCE RATES BETWEEN AIR AND WATER 9

De-sorption of gases and liquids from aerated basins and rivers - completely mixed basin - plug flow basin - gas exchange rates between the atmosphere and the surface of rivers - exchange of chemical across the air - water interface of lakes and oceans.

MODULE 4 EXCHANGE RATES BETWEEN WATER AND THE EARTHERN MATERIAL 9

Dissolution of chemicals on the bottom of flowing streams - geometric forms - stream bottom mass transfer coefficients - natural convection dissolution - the upsurge of chemicals from the sediment - water interface of lakes - a Fikian analysis - annual upsurge rate at sediment - water interface - mass transfer coefficients at the sediment - water interface. Flux of chemicals between sediment and the overlying seawater - movement of chemicals through the benthic boundary layer.

MODULE 5 EXCHANGE RATES BETWEEN AIR AND SOIL 9

Turbulence above the air - soil interface - the Richardson number - chemical flux rates through the lower layer of the atmosphere - Thronthwaite - Holzman equation - evaporation of liquid chemicals spilled on land - chemicals flux rates through the upper layer of earthen material.

TEXT BOOKS

1. Thibodeaux, L.J, "Environmental Chemo dynamics" Movement of Chemicals in Air, Water and Soil", 3rd Edition, Wiley-Interscience, New York, 2003.

REFERENCE BOOKS

1. Cusssler, E.L., "Diffusion: Mass Transfer in Fluid Systems, "Cambridge University Press, 2004.

COURSE TITLE	ECOLOGICAL ENGINEERING			CREDITS	3
COURSE CODE	CEB4726	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the concept of evolution, principles and concepts of ecosystem.	1,2,9,11.
2	Use various ecological models and their functional interaction with the systems.	1,2,3,4,7,9,11.
3	Determine sustainable loading of ecosystem.	1,2,3,4,5,6,7,9,10.
4	Apply the concept of ecosystems on the treatment of waste water.	1,2,3,4,6,9,10,11.
5	Identify and Analyze integrated ecosystems.	1,2,3,4,5,6,9,10.

MODULE 1 INTRODUCTION TO ECOLOGY AND ECOLOGICAL ENGINEERING 10

Aim, scope and applications of ecology - Development and evolution of ecosystems - Principles and concepts pertaining to communities in ecosystem - Energy flow and material cycling in ecosystems - productivity in ecosystems - Rationale of ecological engineering and ecotechnology - Classification of ecotechnology - Principles of ecological engineering

MODULE 2 SYSTEMS APPROACH IN ECOLOGICAL ENGINEERING 10

Principles, components and characteristics of systems - Classification of systems - Structural and functional interactions of environmental systems - Environmental systems as energy systems - Mechanisms of steady - state maintenance in open and closed systems - Modeling and ecotechnology - Elements of modeling - Modeling procedure - Classification of ecological models - Applications of models in ecotechnology - Ecological economics.

MODULE 3 ECOLOGICAL ENGINEERING PROCESSES 8

Self-organizing design and processes - Multi seeded microcosms - Interface coupling in ecological systems - Concept of energy - Determination of sustainable loading of ecosystems

MODULE 4 ECOTECHNOLOGY FOR WASTE TREATMENT 12

Ecosanitation - Principles and operation of soil infiltration systems - Wetlands and ponds - Source separation systems - Aquacultural systems - Agro ecosystems - Detritus based treatment for solid wastes - Applications of ecological engineering for marine systems

MODULE 5 CASE STUDIES 5

Case studies of Integrated Ecological Engineering Systems and their commercial prospects

TEXT BOOKS

1. Kangas, P.C. and Kangas, P., Ecological Engineering, Principles and Practice, Lewis Publishers, New York, 2003.

REFERENCE BOOKS

1. Etnier, C. and Guterstam, B., Ecological Engineering for Wastewater Treatment, Lewis Publishers, New York, 2007.
2. White, I.D., Mottershed, D.N. and Harrison, S.J., Environmental Systems - An Introductory Text, Chapman Hall, London. 2004.

COURSE TITLE	GEO ENVIRONMENTAL ENGINEERING			CREDITS	3
COURSE CODE	CEB4727	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the fundamentals of geo technical Engineering	1,2,9,11.
2	Characterize systems for the disposal of solid waste.	1,2,3,4,7,9,11.
3	Identify the various modes of transport of contaminants.	1,2,3,4,5,6,7,9,10.
4	Conduct tests on contaminated soil	1,2,3,4,6,9,10,11.
5	Suggest remedial measures to improve soil fertility.	1,2,3,4,5,6,9,10,11.

MODULE 1 SOIL- POLLUTANT INTERACTION **9**

Introduction to geo environmental engineering – environmental cycle – sources, production and classification of waste – causes of soil pollution – factors governing soil-pollutant interaction Physico-chemical behavior and modelling -failures of foundations due to pollutants

MODULE 2 CHARACTERIZATION, STABILIZATION AND DISPOSAL **9**

Principles, components and characteristics of systems - Classification of systems - Structural Safe disposal of waste – site selection for land fills – characterization of land fill sites – waste characterization –stability of land fills – current practice of waste disposal- passive contaminant system - Hazardous waste control and storage system – mechanism of stabilization - solidification of wastes – micro and macro encapsulation – absorption, adsorption, precipitation-detoxification — organic and inorganic stabilization

MODULE 3 TRANSPORT OF CONTAMINANTS **9**

Contaminant transport in sub surface – advection – diffusion – dispersion – governing equations – contaminant transformation – sorption – biodegradation – ion exchange – precipitation – hydrological consideration in land fill design – ground water pollution – bearing capacity of compacted fills – pollution of aquifers by mixing of liquid waste – protecting aquifers

MODULE 4 DETECTION AND TESTING METHODS **9**

Methodology- review of current soil testing concepts – Proposed approach for characterization and identification of contaminated ground soil for engineering purposes

MODULE 5 REMEDIATION OF CONTAMINATED SOILS **9**

Rational approach to evaluate and remediate contaminated sites – monitored natural attenuation – exsitu and insitu remediation – solidification, bio – remediation, incineration, soil washing, electro kinetics, soil heating, verification, bio venting – Ground water remediation – pump and treat, air sparging, reactive well-application of geo synthetics in solid waste management – rigid or flexible liners.

TEXT BOOKS

1. Marcel Vander Perk, Soil and Water Contamination from Molecular to Catchment Scale, Taylor & Francis, 2006.

2	Calvin Rose, An Introduction to the Environmental Physics of Soil, Water and Water Sheds, Cambridge University Press, 2004.
REFERENCE BOOKS	
1	Daniel, B.E., Geotechnical practice for waste disposal, Chapman and Hall, London, 1993.
2	Fang, H.Y. Introduction to environmental Geotechnology, CRC press New York, 1997.
3	Lagrega, M.d., Bukingham, P.L., and Evans, J.C., Hazardous Waste Management, McGraw Hill,Inc. Singapore, 2004.

COURSE TITLE	ENVIRONMENTAL ECONOMICS			CREDITS	3
COURSE CODE	CEB4728	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Adopt the basic economic concepts in environmental engineering.	1,2,3,7,9,11.
2	Apply various regulatory and economic taxes for the environmental protection	1,2,3,4,7,9,11.
3	Use economic principles and tools to quantify various natural resource exploitation.	1,2,3,4,5,6,7,9,10.
4	Conduct Economic analysis and quantify the pollution prevention options by using profitability analysis	1,2,3,4,6,7,9,10,11.
5	Apply profitability analysis for real life problem.	1,2,3,4,5,6,7,9,10.

MODULE 1 INTRODUCTION **8**

Human Environment relationship - Valuation of asset - Normative criteria for decision making: Static and dynamic efficiency - Economy and the Environment - Resource use in Society - Consumer Choice theory - Efficiency and welfare - Monetary economy and markets - Competition and efficiency - monopoly - public goods - externalities - Trade and environment - International environmental agreements.

MODULE 2 ECONOMIC INSTRUMENTS FOR ENVIRONMENTAL PROTECTION **9**

Regulatory versus Economic Instruments - Charges and Subsidies - Non Compliance fees, bonds and deposit refunds - Marketable permits - Pigovian and Pollution Taxes - Polluter pays Principle - Evaluation of Instruments - Choice of instruments for Environmental policy.

MODULE 3 ECONOMICS OF NATURAL RESOURCE EXPLOITATION **9**

Types, scarcity and classification of Natural Resources - renewable and non renewable resources - Capital theory - Production costs and Environmental Costs - Economics of Forestry and fisheries exploitation - Utilitarianism and discounting - efficient and optimal use of environmental resources

MODULE 4 VALUATION OF ENVIRONMENTAL COSTS AND BENEFITS **9**

Principles of Cost benefit analysis - Valuing the Environment - Direct and indirect methods - Surrogate markets - travel cost - Non-market valuation - Alternatives to valuation - Measuring Resource Scarcity-Costs of Sustainability - Assessment of Loss of Ecology - Uncertainties - Environmental accounting Environmental indicators

MODULE 5 METHODS OF PROFITABILITY ANALYSIS **10**

Payback period - Present value estimation - Internal rate of return - Opportunity costs - Economic analysis of Pollution Prevention options - Lending Agencies - Case studies.

TEXT BOOKS

1. Nick Haniey, Jaison F. Shogren and Ben White, "Environmental Economics", theory and practice" Macmillan India Ltd, New Delhi. (2007)

REFERENCE BOOKS

1. Roger Perman, Yue Ma and James McGilvray "Natural Resources and Environmental economics", Second edition, Addison Wesley Longman Ltd., Singapore. (1997)
2. John Bowers "Sustainability and Environmental Economics", Addison Wesie Longman Ltd., Singapore. (1997)

COURSE TITLE	COASTAL POLLUTION AND INTEGRATED COASTAL ZONE MANAGEMENT			CREDITS	3
COURSE CODE	CEB4729	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Apply the basic concepts and principles associated with the biogeochemical processes and the consequences of pollutants.	1,2,3,9,11.
2	Identify the basic sources and sinks of chemicals on marine Corrosion.	1,2,3,4,7,9,11.
3	Identify the marine toxicants.	1,2,3,4,5,6,7,9,10.
4	Suggest ICZM for coastal and ocean interaction.	1,2,3,4,6,9,10,11.
5	Form impact matrix with ICZM tools.	1,2,3,4,5,6,9,10.

MODULE 1 COASTAL POLLUTION BASICS **10**

Coastal Pollution: Definition, categories of additions, Pollutant and its classification. Organic wastes: BOD, COD, dilution factor, Fluctuations in DO, Consequences of organic discharges to estuaries with examples; Consequences of sludge dumping at sea. Sewage treatment: Primary, Secondary and Tertiary treatment processes. Solid waste pollution: Classification and disposal of solid wastes in Coastal region.

Project: An exercise on nature of waste found along the coast from field visit

MODULE 2 COASTAL POLLUTION AND ITS IMPACTS **10**

Industrial pollution: sources, nature and their treatment processes with reference to wastes from paper and pulp and soap manufacturing industries. Marine corrosion: Definition, corrosion reactions, classification of corrosion, factors affecting corrosion of metals in sea water and prevention of marine corrosion. The state of some seas in the world (pollution aspect).

Project: Exercise on factors contributing to coastal pollution in Indian waters

MODULE 3 MARINE ECOTOXICOLOGY AND TOXICANTS **10**

General introduction and principles on marine toxicology - General chemistry of different types of pesticides and toxicants like Organochlorine, organophosphate, PCBs, POPs, PAH, Dioxins, heavy metals - Effect of Toxicants on animal physiology - Global transport of POPs - Mercury and

Lead cycling in the environment.

Project: Exercise on design of sewers subjected to various flows

MODULE 4 ICZM FUNDAMENTALS AND FRAME WORK **6**

Introduction: The Coasts – Unique, Valuable and Threatened –Examples of Interactions among Coastal and Ocean Uses and Their Environments – Early Efforts at Coastal Management – The Need for ICM -

Developing an ICM framework - Principles – Goals – defining boundaries - Identification and Prioritizing issues - Stages in Developing an ICM Program - Pathway through the framework.

MODULE 5 ICZM TOOLS AND TECHNIQUES **9**

Administrative tools – policy and legislation, zoning, regulation and enforcement, spatial planning, marine spatial planning; Social tools: Stakeholder analysis, conflict resolution, customary practices, capacity building – Technical tools: strategic environmental assessment, risk assessment and evaluation, cost benefit analysis, problem tree analysis.

Project: Developing ICZM frame work with minimal factors

REFERENCE BOOKS

1	Kay, R and Jackie Alder. Coastal Planning and Management. Taylor and Francis. 2005.
2	NCSCM, Strategies and Guidelines for National Implementation of Integrated Coastal Zone Management, 2013.
3	Clark, R. B. Marine pollution, Fifth edition. Oxford University press, New York Inc., 2001.
4	Kay, R. and J. Aider, Coastal planning and management, 2/e. Taylor and Francis, 2005.

COURSE TITLE	MARINE POLLUTION MONITORING			CREDITS	3
COURSE CODE	CEB4730	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Identify the various factors acting on waves and tides.	1,2,3,4,6,8,
2	Analyze various marine resources and its economic and environmental benefits	1,2,3,4,6,7
3	Conduct hydrographic surveying.	1,2,3,4,5,6
4	Assess various pollution impacts on ocean.	1,2,3,4,6,7,11
5	Adopt pollution mitigation and international laws of marine pollution mitigation	1,2,3,4,6,7,8,11

MODULE 1 OCEANOGRAPHY **10**

General features of ocean - Conservation laws - Wave characteristics and theories - Sediment transport - Tides - Ocean Currents - Thermocline circulation - General circulation of ocean waters, Tsunamis, Storm surge - Principles of Marine geology

MODULE 2 COASTAL ENVIRONMENT **8**

Living resources - coral reefs, mangroves, seagrass, seaweeds, fishery potential - nonliving resources - manganese nodules, heavy minerals - Beaches, Estuaries, Lagoons - Shoreline changes

MODULE 3 MARINE SURVERYING **6**

Sea surveying planning and preparation - Oceanographic instrumentation - Hydrographic Surveying - Underwater surveying - Measurement of physical properties of ocean water - sea bed sampling

MODULE 4 MARINE POLLUTION AND MONITORING **14**

Physiochemical properties of sea water - Sources of marine pollution and impacts on coastal ecosystems, Oil pollution - oil spill detection, dispersion, impacts on adjacent area - Oil spill modeling, mitigation measures - Oil exploration and their effects - Marine outfalls - Impacts of Ports and Harbour on marine water quality - dredging - Human intervention in estuarine ecosystem - sea water classification - Physical modeling in Coastal Engineering - Ocean monitoring satellites - Applications of Remote sensing and GIS in marine studies.

MODULE 5 MARINE POLLUTION CONTROL **7**

National and International treaties, protocols in marine pollution - Exclusive Economic Zone - Sustainable development

REFERENCE BOOKS

1	Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.
2	Kennish, M.J., Pollution impacts on Marine Biotic Communities, CRC press, New York, 1998.
3	Newman, M.C., Roberts Jr. M.H., Male R.C. (Editors), Coastal and Estuarine Risk Assessment, Lewis Publishers, Washington, D.C., 2002.
4	U.S. Army Corps of Engineers, Shore Protection Manual, Washington D.C., 2002.

COURSE TITLE	SUSTAINABLE DEVELOPMENT AND ENVIRONMENT			CREDITS	3
COURSE CODE	CEB4731	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Develop knowledge on sustainable development concepts.	1,2,3,4,6,7,10
2	Describe social, economical and environmental issues of sustainable development.	1,2,3,4,6,7,10
3	Use performance indicators to asses sustainable development.	1,2,3,4,6,7,10
4	Identify the steps in action plan for implementation of sustainable development.	1,2,3,4,6,7,10
5	Adopt an integrated approach for resource protection and management	1,2,3,4,6,7,10,11

MODULE 1 CONCEPT OF SUSTAINABLE DEVELOPMENT **9**

Environment and Development - Population, Poverty and Pollution - Global and Local environmental issues - Resource Degradation - Greenhouse gases - Desertification - Industrialization - Social insecurity, Globalization and environment. History arid emergence of the concept of sustainable development - Objectives of Sustainable Development

MODULE 2 COMPONENTS AND DIMENSIONS OF SUSTAINABLE DEVELOPMENT **9**

Components of sustainability - Complexity of growth and equity - Social, economic and environmental dimensions of sustainable development - Environment - Biodiversity - Natural Resources - Ecosystem integrity - Clean air and water - Carrying capacity - Equity, Quality of Life, Prevention, Precaution, Preservation and Public participation-structural and functional linking of developmental dimensions.

MODULE 3 FRAMEWORK FOR ACHIEVING SUSTAINABILITY **9**

Operational guidelines - Interconnected prerequisites for sustainable development - Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities, Business and Industry - Science and Technology for sustainable development - Performance indicators of sustainability and Assessment mechanism - Constraints and barriers for sustainable development

MODULE 4 SUSTAINABLE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS **9**

Demographic dynamics of sustainability - Policies for socio-economic development - Strategies for implementing eco-development programmes - Sustainable development through trade - Economic growth - Action plan for implementing sustainable development - Urbanization and Sustainable Cities - Sustainable Energy and Agriculture - Sustainable Livelihoods.

MODULE 5 SUSTAINABLE DEVELOPMENT AND INTERNATIONAL RESPONSE **9**

Role of developed countries in the development of developing countries - International summits - Stockholm to Johanesburg - Rio Principles - Agenda 21 - Conventions - Agreements - Tokyo Declaration - Doubling statement - Transboundary issues - Integrated approach for resource protection and management

TEXT BOOKS

1. Sayer, J. and Campbell, B., The Science of Sustainable Development: Local Livelihoods and the Global Environment (Biological Conservation, Restoration & Sustainability), Cambridge University Press, London, 2003.

REFERENCE BOOKS

1. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publications, London, 1998.
2. Bowers, J., Sustainability and Environmental Economics - An Alternative Text, Longman London, 1997

COURSE TITLE	REMOTE SENSING AND GIS FOR ENVIRONMENTAL APPLICATIONS			CREDITS	3
COURSE CODE	CEB4732	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Apply knowledge on concept of remote sensing to solve practical problems.	1, 2,,3,4,4,10,11
2	Use various remote sensing platforms and sensors.	1, 2, 3,4,5,9,10,11
3	Identify the steps in Image processing software	1, 2, 3,4,5,9,11
4	Solve societal problems using GIS software.	1, 2, 3,4,5,10,11
5	Describe the environmental problem using remote sensing and GIS.	1, 2, 3,4,9,10,11

MODULE 1 PRINCIPLES OF ELECTRO MAGNETIC RADIATION **5**

Concepts of Remote Sensing - Energy sources and radiation principles, Energy interactions in the atmosphere - Spectral reflectance of earth surface features.

MODULE 2 REMOTE SENSING PLATFORMS **12**

Aerial Photographs, Photographic Systems - Visible, Infra-Red and Microwave sensing - Active and passive sensors - Satellites and their sensors, Indian Space Programme - Satellite data products.

MODULE 3 DATA PROCESSING **10**

Photogrammetry - Satellite data analysis - Visual Interpretation, Interpretation equipment - Digital Image Processing - Image rectification, enhancement, classification, data merging and biophysical modeling - Image Processing software.

MODULE 4 GEOGRAPHIC INFORMATION SYSTEM **6**

Introduction to GIS concepts - Data base structure - Data analysis - GIS software

MODULE 5 REMOTE SENSING AND GIS APPLICATIONS **12**

Management and monitoring of environment, conservation of resources, coastal zone management - Limitations.

TEXT BOOKS

1. Lillesand, T.M. and Kiefer, R.W., Remote Sensing and Image Interpretation, John Wiley and Sons, New York, 2004

REFERENCE BOOKS

1. Burrough, P.A. and McDonnell, R.A., Principles of Geographic Information Systems, Oxford University Press, New York, 2001.
2. Lintz, J. and Simonet, Remote Sensing of Environment, Addison Wesley Publishing Company, New Jersey, 1998.

COURSE TITLE	PRINCIPLES OF SUSTAINABLE DEVELOPMENT			CREDITS	3
COURSE CODE	CEB4733	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the values of Environment, Ecosystem and sustainability theory	1,2,3,6,11
2	Identify various environmental issues and current treatment/ disposal methods	1,2,3,4,6,7,10
3	Describe the impacts caused by humans on environment and their measurement tools	1,2,3,4,5,6
4	Identify the changes in material resources and sustainable traps	1,2,3,4,6,10
5	Make use of the sustainable strategies and policies for practical applications	1,2,3,4,6,7,10

MODULE 1 SUSTAINABILITY AND DEVELOPMENT CHALLENGES 15

Definition of sustainability – Environmental, Economical and Social dimensions of sustainability - Sustainable Development Models – Strong and Weak Sustainability – Defining Development- Millennium Development Goals – Mindsets for Sustainability : Earthly, Analytical, Precautionery, Action and Collaborative– Syndromes of Global Change: Utilisation Syndromes, Development Syndromes, and Sink Syndromes – Core problems and Cross Cutting Issues of the 21 Century - Global, Regional and Local environmental issues – Social insecurity - Resource Degradation – Climate Change – Desertification

MODULE 2 ENVIRONMENTAL CONCERNS – PRESENT AND FUTURE 8

Climate Change – Air Issues (Ozone depletion, smog, other air pollutants) – Water issues (Eutrophication, water quality/access, Pollution) – Land use changes – Waste (quantity generated, Treatment/ disposal methods, E-waste – Human health – Diversity of life on the plant (population stresses and ecology, Failure at large scale.

MODULE 3 ASSESSING PROGRESS AND WAY FORWARD 7

Sustainability in global, regional and national context - Change in materials used (history) & critical materials - Energy and fossil fuel consumption - Buildings - Food systems - Transportation - Businesses and service organizations - ISO and other standards - Systems engineering – material flow analysis; lean/6S (certification potential) - Environmental Product Declarations - Carbon Footprinting - Life Cycle Assessment – certification potential Handprints - Trade-offs in Impacts and Decision-Making from Data

MODULE 4 CROSS – DISCIPLINE CONSIDERATIONS 8

Issues in developing countries: sanitation and public health, changes in material resources without corresponding changes in treatment options - Ethical issues: links between environmental emissions and poverty - Sustainability traps: failed policies to address consumption (one-child, forced sterilization, etc.)

MODULE 5 SUSTAINABLE SOCIO-ECONOMIC SYSTEMS 7

Corporate / Organizational responsibility (Sustainability strategy development, Management tools, Sustainable/ethical investment accounts, Silos and open access, Product development and design) - Policies for Sustainability (COP commitments, UK and other national directives, US approaches to sustainability policies) - Sustainability in Individual Lives (Behavioral changes, Activism and group networking) - Future of the planet - Careers in sustainability - Course recap.

REFERENCE BOOKS	
1	F. Douglas Muschett, Principles of Sustainable Development, CRC Press, 2019
2	Kauffman, Joanne, LEE, Kun Mo, Handbook of Sustainable Engineering, Springer 2013.
3	Bhavik R. Bakshi, Sustainable Engineering Principles and Practice, Cambridge University Press, 2019.
	Catherine Mulligan, Sustainable Engineering: Principles and Implementation, CRC Press, 2019

COURSE TITLE	INDUSTRIAL WASTEWATER MANAGEMENT			CREDITS	3
COURSE CODE	CEB4734	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Categorize the various types of industrial waste	1,2,3,4,5,7,9,11
2	Apply the source reduction techniques, carryout waste audit and prepare Environmental statement to enable the industries to apply for consent renewals.	1,2,3,4,5,7,9,11
3	Select appropriate treatment techniques or combination of techniques knowing the wastewater characteristics.	1,2,3,4,5,7,9,11
4	Apply the CETP concepts wherever required and manage the sludge produced while treating the wastewater.	1,2,3,4,5,7,9,11
5	Prepare a report for specific industry starting from process description. Wastewater Source identification, characterisation and treatment methods including source reduction technique application.	1,2,3,4,5,7,9,11

MODULE 1 INTRODUCTION **6**

Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests

MODULE 2 INDUSTRIAL POLLUTION PREVENTION **8**

Prevention vs Control of Industrial Pollution - Benefits and Barriers - Source reduction techniques - Waste Audit - Evaluation of Pollution prevention options - Environmental statement as a tool for pollution prevention - Waste minimization Circles

MODULE 3 INDUSTRIAL WASTEWATER TREATMENT **12**

Equalisation - Neutralization - Oil separation - Flotation - Precipitation - Heavy metal Removal - Refractory organics separation by adsorption - Aerobic and anaerobic biological treatment - Sequencing batch reactors - High Rate reactors - Chemical oxidation Ozonation - Photocatalysis - Wet Air Oxidation - Evaporation - Ion Exchange - Membrane Technologies - Nutrient removal.

MODULE 4 WASTEWATER REUSE AND RESIDUAL MANAGEMENT **7**

Individual and Common Effluent Treatment Plants - Joint treatment of industrial wastewater - Zero effluent discharge systems - Quality requirements for Wastewater reuse - Industrial reuse - Disposal on water and land - Residuals of industrial wastewater treatment - Quantification and characteristics of Sludge - Thickening, digestion, conditioning, dewatering and disposal of sludge - Management of RO rejects.

MODULE 5 CASE STUDIES **12**

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles - Tanneries - Pulp and paper - metal finishing - Petroleum Refining - Pharmaceuticals - Sugar and Distilleries - Food Processing - fertilizers - Thermal Power Plants and Industrial Estates

TEXT BOOKS

1. Patwardhan A.D. Industrial Wastewater Treatment, Prentice Hall of India Ltd, New Delhi,

	2008.
2	Eckenfelder, W.W., "Industrial Water Pollution Control", McGraw-Hill, 1999.
REFERENCE BOOKS	
1	Arceivala, S.J., "Wastewater Treatment for Pollution Control", Tata McGraw-Hill, 1998.
2	Frank Woodard Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001.
3	World Bank Group "Pollution Prevention and Abatement Handbook - Towards Cleaner Production', World Bank and UNEP, Washington D.C.1998.
4	Paul L. Bishop "Pollution Prevention:- Fundamentals and Practice", McGraw-Hill International, 2000.

COURSE TITLE	INDOOR AIR QUALITY			CREDITS	3
COURSE CODE	CEB4735	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Assess the levels of indoor air pollution	1,2,3,4,6,7,11
2	Design the air circulation and ventilation of various buildings prior to ambient air quality standards	1,2,3,4,6,7,8,9
3	Use the air pollution control measures of arresting air pollutants in various buildings.	1,2,3,4,7,10,11
4	Use the concepts and tools in designing the ambient air pollutant control measures.	1,2,3,4,5,6,7,11
5	Implement pollution control technologies while designing the buildings.	1,2,3,4,6,7,8,11

MODULE 1 INTRODUCTION **7**

Indoor activities of inhabitants - residence time. Levels of many pollutants in indoor and outdoor air. Design and operation of buildings for improvements of public health. IAQ policy issues; sustainability; indoor air quality as a basic human right.

MODULE 2 INDOOR AIR POLLUTANTS **10**

Air pollutants in indoor environments, private residences, offices, schools, sand public buildings, factors that govern pollutant indoors concentrations, including ventilation. Characteristics, Consequences.

MODULE 3 CONTROL OF POLLUTANTS **10**

Control of several pollutant classes, such as radon, toxic organic gases, combustion byproducts, and microorganisms such as molds and infectious bacteria. Case study by an exploration of public policy related to indoor air.

MODULE 4 CONCEPTS AND TOOLS **10**

Concepts and tools; exposure, material-balance models, statistical models Ventilation

MODULE 5 INDOOR AIR POLLUTION FROM OUTDOOR SOURCES **8**

Indoor air pollution from outdoor sources; particulate matter and ozone; Combustion byproducts; Radon and its decay products. Volatile organic components: odours and sick-building syndrome, Humidity Bio-aerosols: infectious disease transmission. Special indoor environments; A/C units in indoor, museums-labs; museums-labs, Measurement methods, Control technologies, Control strategies

TEXT BOOKS

1. Thaddes Godish, Indoor air and Environmental Quality, CRC Press, 2000

REFERENCE BOOKS

1. Nazaroff W.W and L Alvarez-Cohen, Environmental Engineering Science Wiley sons, New York, 2001.
2. Moroni Marco, Seifet Bernd and Lindrall Thomas, Indoor Air Quality: A Comprehensive Reference Book, Elsvier Science, Vol. 3, 1995.

COURSE TITLE	INSTRUMENTAL MONITORING OF ENVIRONMENT			CREDITS	3
COURSE CODE	CEB4736	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Perform the experiments individually for various environmental parameters	1,2,3,4,7,8,9,11
2	Work on the various spectrographic instruments used for environmental quality monitoring.	1,2,3,4,6,9
3	Work with various chromatographs in environmental quality monitoring areas.	1,2,3,4,6,9
4	Use and access various electro and radio instruments in various environmental quality monitoring area.	1,2,3,4,6
5	Adopt principles behind continuous monitoring, for analyzing the various gaseous emissions and water.	1,2,3,4,6

MODULE 1 INTRODUCTION **7**

Instrumental Methods, Selection of method, Precision and Accuracy, Errors in measuring signals, Noise/signal ratio, base line drift, Indicator tubes.

MODULE 2 SPECTROSCOPIC METHODS **11**

Electromagnetic radiation, matter radiation interactions, Colorimetry and spectrophotometry, fluorimetry, nephelometry and turbidimetry, flame photometry Atomic Absorption Spectrometry (AAS), Atomic Emission Spectrometry (AES) - Inductively coupled plasma (ICP) and Direct Current Plasma (DCP) spectrometry. ICP - MS (Mass spectrometry).

MODULE 3 CHROMATOGRAPHIC METHODS **10**

Classical methods, Column, Paper and thin layer chromatography (TLC), Gas Chromatrography (GC), GC-MS, High performance liquid chromatography (HPLC) and Ion chromatrography (IC).

MODULE 4 ELECTRO AND RADIO ANALYTICAL METHODS **10**

Conductometry, potentiometry, coulometry, amperometry polarography, Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods

MODULE 5 CONTINUOUS MONITORING INSTRUMENTS **7**

Non-dispersive infra-red (NDIR) analyzer for CO, chemiluminescent analyzer for NOx, Fluorescent analyzer for SO2, Auto analyzer for water quality using flow injection analysis; permeation devices

TEXT BOOKS

1 Ewing "Instrumental Methods of Chemical Analysis", 5th Edn., McGraw-Hill, New York, 1995.

REFERENCE BOOKS

1 Willard, H., Merritt, L., Dean, D.A. and Settle. F.A. "Instrumental methods of analysis, 7th Edition, Worlds Worth, New York, 2004.

COURSE TITLE	ENVIRONMENTAL POLICIES AND LEGISLATION			CREDITS	3
COURSE CODE	CEB4737	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the importance of civil and criminal law related to environmental legislation	1,2,3,4,6,7,11
2	Take decisions based on fundamental rights and directive principles of our constitution	1,2,3,4,6,7,8,9
3	Manage various environmental issues and handle the real time problems in industries.	1,2,3,4,7,10,11
4	Adopt pollution control laws and implement it in working sectors.	1,2,3,4,5,6,7,11
5	Manage biomedical, hazardous waste, Ecolabelling, and EIA.	1,2,3,4,6,7,8,11

MODULE 1 INTRODUCTION **8**

Basics of jurisprudence - Environmental law relation with other disciplines - Criminal law - Common Law - Relevant sections of the Code of Civil Procedure, Criminal Procedure Code - Indian Penal Code.

MODULE 2 INDIAN CONSTITUTION AND ENVIRONMENT **9**

Introduction - Fundamental Rights - Directive Principles of State Policy - Article 48 (A) and 51-A(g) Judicial enforceability - Constitution and Resources management and pollution control - Indian Forest Policy (1990) - Indian Environmental Policy (1992).

MODULE 3 ADMINISTRATIVE REGIME & LEGAL REGIME **10**

Administrative regulations - constitution of Pollution Control Boards Powers, functions, Accounts, Audit etc. - Formal Justice Delivery mechanism Higher and Lower of judiciary - Constitutional remedies writ jurisdiction Article 32, 226 136 special reference to Mandamus and Certiorari for pollution abatement - Equitable remedies for pollution control.

MODULE 4 POLLUTION CONTROL LAWS **9**

Administrative regulation under recent legislations in wear pollution control. Water (prevention & control of pollution) Act 1974 as amended by Amendment Act 1988. Water (prevention and control of pollution) Rules 1975 Water (prevention & Control or Pollution) Cess Act. 1977 as amended by Amendment Act 1987 and relevant notifications.

MODULE 5 ENVIRONMENTAL (PROTECTION) ACT 1986 **9**

Relevant notifications in connection with Hazardous Wastes (management and handling) Biomedical wastes (management and handling), Noise pollution, Eco-labeling, and E.I.A.

TEXT BOOKS

1. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001.

2	CPCB, “Pollution Control acts, Rules and Notifications issued there under “Pollution Control 22 Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
REFERENCE BOOKS	
1	Constitution of India Eastern Book Company Lucknow 12th Edn. 1997.
2	Administrative Law U.P.D. Kesari Universal Book Trade, Delhi, 1998.
3	Environmental Law H.N. Tiwari, Allahabad Law Agency 1997.
4	Environmental Policy. Forest Policy, Bare Acts - Government Gazette Notification. 1986.

COURSE TITLE	SAFETY AND HAZARD CONTROL MANAGEMENT			CREDITS	3
COURSE CODE	CEB4738	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Identify hazards using basic principles.	1,2,3,4,7
2	Analyze the consequence of accidents in industries/workplace.	1,2,3,4,6,7,11
3	Assess risk in the workplace.	1,2,3,4
4	Complete a Job Hazard Analysis for a typical worker task.	1,2,3,4,7,11
5	Suggest methods to overcome Disasters and mitigation measures.	1,2,3,4,7,11

MODULE 1 INTRODUCTION **9**

Conventional and modern concepts of safety, Basic Principles and concepts in hazard identification, Chemical hazards, Process and operation hazard, Hazards from utilities like air, water, steam etc., Occupational health hazards, Hazard and operability Studies, Safety Audits.

MODULE 2 ACCIDENTAL ANALYSIS **9**

Past Accident Analysis, Consequence Analysis of fire, gas/vapour, Dispersions and explosion, Vulnerability models, Fault and Event Tree Analysis

MODULE 3 SAFETY AND RISK ASSESSMENT **9**

Safety in plant design and layout. Risk Assessment.

MODULE 4 SAFETY IN HANDLING **9**

Safety measures in handling and storage of chemicals, Process plant, personnel Protection, First Aid

MODULE 5 DISASTER MANAGEMENT **9**

Disaster mitigation, Emergency Preparedness plans.

REFERENCE BOOKS

1	
2	Coulson J.M and Richardson J.F., Chemical Engineering, Vol. 1 (Chapter 4) Asian Book House Pvt. Ltd., New Delhi. 1998.

COURSE TITLE	ENVIRONMENTAL RISK ASSESSMENT			CREDITS	3
COURSE CODE	CEB4739	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Adopt methods and processes employed in environmental health and risk assessment.	1,2,3,4,6,7,11
2	Use different tools to aid the risk assessment analysis.	1,2,3,4,5,7,11
3	Use environmental laws and regulations to develop guidelines, procedures and processes for health and safety issues.	1,2,3,4,7
4	Use models to simulate data	1,2,3,4,5,11
5	Use epidemiological data to analyze the various methods of risk assessment	1,2,3,4,5,7,11

MODULE 1 INTRODUCTION **9**

Risk analysis introduction, quantitative risk assessment, rapid risk analysis –comprehensive risk analysis – identification, evaluation and control of risk.

MODULE 2 RISK ASSESSMENT METHODS **9**

Risk assessment – introduction and available methodologies, Risk assessment steps, Hazard identification, Hazard assessment (consequence analysis), probabilistic hazard assessment (Fault tree analysis).

MODULE 3 EMS MODELS **9**

Overall risk contours for different failure scenarios – disaster management plan –emergency planning – onsite and offsite emergency planning, risk management ISO 14000, EMS models – case studies – marketing terminal, gas processing complex.

MODULE 4 SAFETY AND ACCIDENTAL MODELING **9**

Safety measures design in process operations. Accidents modeling – release modeling, toxic release and dispersion modeling, fire and explosion modeling.

MODULE 5 CASE STUDIES **9**

Past accident analysis: Flux borough – Mexico – Bhopal analysis. Government policies to manage environmental risk.

REFERENCE BOOKS

1	Crowl,D.A and Louvar,J.F., Chemical process saftery; Fundamentals with applications, prentice hall publication Inc., 2002.
2	Houstan,H.B., Process safety analysis, Gulf publishing company, 1997.
3	Khan,F.I and Abbasi,S.A., Risk assessment of chemical process industries; Emerging technologies, Discovery publishing house, New Delhi, 1999.

COURSE TITLE	NANO AND BIOTECHNOLOGY APPLICATIONS IN ENVIRONMENTAL ENGINEERING			CREDITS	3
COURSE CODE	CEB4740	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Apply knowledge on Nano Technology to Environmental issues.	1,3,7,10
2	Suggest the appropriate ways to synthesize nano materials	1,2,3,7,10
3	Apply the basics of nano technology in environmental fields	1,3,6
4	Apply bio-Technology principles for Environmental issues.	1,3,6
5	Suggest Biotechnological techniques to solve societal problems.	1,2,3,6,7,10,11

MODULE 1 GENERAL **9**

Background of nanotechnology, particle size and surface area, quantum dot. Converging science and technology, nanotechnology as a tool for sustainability, health, safety and environmental issues

MODULE 2 SYNTHESIS AND FABRICATION OF NANOMATERIALS **9**

Preparation of nano scale metal oxides, metals, CNT, functionalized nano porous adsorbents, nano composite- Chemical vapour deposition, sol gel, sonochemical, microwave, solvothermal, plasma, pulsed laser abalation, magnetron sputtering, electrospinning, Molecular imoring.

MODULE 3 ENVIRONMENTAL APPLICATIONS **9**

Gas sensors, micro-fludics and lab on chip, catalytic and photo-catalyic applications, Non-materials for ground water remediation, nano-materials as adsorbents, membrane process.

MODULE 4 INTRODUCTION TO BIOTECHNOLOGY **9**

Principles and concepts of environmental biotechnology - usefulness to mankind..

MODULE 5 BIOTECHNOLOGY APPLICATIONS IN ENVIRONMENT **9**

Biotechnological remedies for environmental damages - decontamination of ground water systems – subsurface environment - reclamation concepts - bioremediation. Production of proteins - biofertilizers. Biodegradation of solid wastes - physical, chemical and microbiological factors of composting - health risk - pathogens – odor management - technologies of commercial importance advances in biogas technology - case study.

REFERENCE BOOKS

1	Environmental applications of nanomaterials-Synthesis, Sorbents and Sensors, edited by Glen E Fryxell and Guozhong Cao, worldscibooks, UK, 2012
2	Environmental nanotechnology, Mark Wisener, Jeo Yues Bolteru, McGraw Hill. 2007
3	The Chemistry of Nanomaterials, Synthesis, Properties and applications. Edited by C.N.R.Rao. Mulller, A.K.Cheetham WILEY-VCH Verlag GmbH & Co.KGaA, Weinheim, 2004
4	Fulker M.H. Environmental Biotechnology, CRC Press, 2010.

COURSE TITLE	SUSTAINABLE ENVIRONMENT AND CLIMATE CHANGE			CREDITS	3
COURSE CODE	CEB4741	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the terrestrial eco-system comprising of 3 principal components : Energy, Environment and Climate Change	1,2,3,4,6,7,10
2	Comprehend a global picture of the inter-relatedness of the Energy-Environment-Climate system	1,3,10
3	Describe the global energy balance	1,3,4,10
4	Interlink atmospheric chemistry with climate change	1,2,6,10
5	Assess the effects of human activities on the earth's climate and to predict emerging climate change trends globally as well as within the Indian Subcontinent	1,2,3,8

MODULE 1 INTRODUCTION **9**

Overview on the Earth's energy requirement vis-à-vis Climate Change. Origins of the terrestrial atmosphere. Earth's early atmosphere. Introduction to Climate. Layers of the atmosphere.

MODULE 2 GLOBAL ATMOSPHERIC ISSUES **9**

Composition of the present day atmosphere. Introduction to Atmospheric chemistry, Green House Gases, and the O3 lepletion problem. Post Industrial Revolution Scenario.

MODULE 3 ENERGY BALANCE **9**

Earth –Atmosphere System. Solar and Terrestrial Radiation. Absorption of Radiation by gases. Energy balance. Solar variability and the Earth's Energy Balance.

MODULE 4 ATMOSPHERIC CHEMISTRY AND CLIMATE **9**

The Global Temperature Record. Possible effects of Global Warming. – Indian Context. Atmospheric Chemistry and Climate Change. Atmospheric Aerosol and Cloud Effects on Climate

MODULE 5 ENVIRONMENTAL VARIABILITY AND SAFEGUARDING FUTURE CLIMATE **9**

Natural (volcanoes, forest fires) and Anthropogenic (Antarctic Ozone Hole, Global Warming). Green House Gas theory. Effects of urbanization, Landscape changes, Influence of Irrigation, Desertification and Deforestation. The role of International Bodies. Kyoto and Montreal Protocol. Intergovernmental Panel on Climate Change (IPCC).

TEXT BOOKS

1	Peter E Hodgson (2010), Energy, the Environment and Climate Change, Publisher: Imperial College Press
2	Richard Wolfson, (2011), Energy, Environment, and Climate, Publisher: W. W. Norton

REFERENCE BOOKS

1	Wilbanks, T., Bilello, D., Schmalzer, D., & Scott, M. (Lead Authors). (2013). 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.
2	Frank T. Princiotta,(2011), Global Climate Change - The Technology Challenge, Publisher: Springer

COURSE TITLE	SUSTAINABLE ENERGY IN BUILT ENVIRONMENT			CREDITS	3
COURSE CODE	CEB4742	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Identify the various energy use and energy processes in building	
2	Point out the interaction of various external parameters influencing building energy requirements	
3	Analyze energy requirements for lighting, air-conditioning, etc.	
4	Conduct energy audit and energy conservation measures in buildings	
5	Manage indoor environmental requirements	

MODULE 1 INTRODUCTION **9**

Indoor activities and environmental control - Internal and external factors on energy use - Characteristics of energy use and its management -Macro aspect of energy use in dwellings and its implications - Thermal comfort - Ventilation and air quality - Air-conditioning requirement -Visual perception - Illumination requirement - Auditory requirement

MODULE 2 SOLAR ENERGY AND DAY – LIGHTING **9**

The sun-earth relationship - Climate, wind, solar radiation and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings – Lighting and daylighting: Characteristics and estimation, methods of day-lighting - Architectural considerations for day-lighting

MODULE 3 HEAT TRANSFER AND THERMAL PERFORMANCE **9**

Steady and unsteady heat transfer through wall and glazed window. Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

MODULE 4 ENERGY REQUIREMENTS IN BUILDINGS AND ENERGY AUDIT **9**

Thermal gain and net heat gain - End-use energy requirements - Status of energy use in buildings - Estimation of energy use in a building - Energy audit and energy targeting - Technological options for energy management - Natural and forced ventilation – Indoor environment and air quality - Airflow and air pressure on buildings - Flow due to stack effect.

MODULE 5 VENTILATION **9**

Passive building architecture – Radiative cooling - Solar cooling techniques - Solar desiccant dehumidification for ventilation - Natural and active cooling with adaptive comfort – Evaporative cooling – Zero energy building concept

TEXT BOOKS

1	Intelligent Buildings: Design, Management and Operations (2010) by Derek Clements-Croome. Thomas Telford, U.K.
2	Green Building: Principles and Practices in Residential Construction (Go Green with Renewable Energy Resources) by Abe Kruger (Author), Carl Seville (Author), Jim Devoe (Editor) Hardcover –

	Import, 21 Apr A.Shaw (1991), Energy Design for Architects, AEE Energy Books.
REFERENCE BOOKS	
1	Heating and Cooling of Buildings: Design for Efficiency, Revised Second Edition (2009) CRC Press USA.

COURSE TITLE	ENVIRONMENTAL MICROBIOLOGY			CREDITS	3
COURSE CODE	CEB4743	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the classification, types and characteristics of microorganisms	1,3,8,9
2	Analyze the various microbial growth factors and metabolism	1,2,3,4,7,10
3	Assess the problems caused and control the microbes in drinking water	1,3,7, 10
4	Describe the mechanism of biological treatment for toxic pollutants	1,2,3
5	Use knowledge on aquatic Microbiology	1,4,10

MODULE 1 INTRODUCTION **9**

.Microorganisms – classification, prokaryotic and eukaryotic cells, structure, characteristics, nucleic acids, DNA and RNA, replication, Recombinant DNA – Genetic Engineering.

MODULE 2 MICROBIAL GROWTH AND METABOLISM **9**

nvironmental factors, nutrition and metabolism, growth phases, enzymes, carbohydrate, protein, lipids metabolism, respiration, fermentation, Glycolysis, Kreb's cycle, Hexose monophosphate pathway, significance of energetics.

MODULE 3 MICROBIOLOGY OF DRINKING WATER **9**

Distribution of microorganisms, indicator organisms, coliforms – fecal coliforms – E.coli, Streptococcus fecalis and Clostridium welchii, differentiation of coliforms – significance – MPN index, M.F. technique, standards. Virus-concentration techniques. Algae in water supplies – problems and control.

MODULE 4 MICROBIOLOGY OF TOXIC WASTEWATER TREATMENT **9**

Biodegradation of toxic pollutants – alpha oxidation, beta-oxidation, electrons transport system and oxidative phosphorylation mechanism, Microbiology of biological treatment

MODULE9 MICROBIOLOGY **9**

Biotechnological remedies for environmental damages - decontamination of ground water systems – subsurface environment - reclamation concepts - bioremediation. Production of proteins - biofertilizers. Biodegradation of solid wastes - physical, chemical and microbiological factors of composting - health risk - pathogens – odor management - technologies of commercial importance advances in biogas technology - case study.

REFERENCE BOOKS

1	Pelczar, Jr, M.J., Chan E.C.S., Krieg, R.Noel., and Pelczar Merna Foss, Microbiology, 5thEdition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.
2	Stainer, R.Y., Ingrahum, J.L., Wheelis, M.C. and Painter, P.R. General Microbiology, Mac Millan Edition Limited, London, 1989.
3	Pichai, R. and Govindan, V.S., Edition, Biological processes in pollution control Anna University, Madras, 1988.

COURSE TITLE	SUSTAINABLE ALTERNATIVE FUELS			CREDITS	3
COURSE CODE	CEB4744	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the limitations of fossil fuels and need for alternative fuels	1,2,7,10
2	Identify the methods of hydrogen storage, distribution, safety and other clean technologies	1,7,10
3	Assess and adopt various renewable technologies and alternative fuels	1,3,7
4	Identify sustainable gaseous fuels, engine requirements and combustion characteristics	1,3,7,10
5	Describe the suitability of solid fuels	1,3,7,10

MODULE 1 INTRODUCTION **9**

Status of petroleum reserves, economics; Need for alternative fuels; Review of fuel properties.

MODULE 2 HYDROGEN AND CLEAN TECHNOLOGIES **9**

Properties; Production and storage methods; Safety aspects; Use in SI and CI engines; Performance and emissions. Fuel cells - types, working; Hybrid and electric vehicles; Solar power; Challenges; Engine performance.

MODULE 3 BIODIESEL, ALCOHOLS AND ETHERS **9**

Composition and properties; Challenges of use in CI engines, solutions - preheating, blending; Transesterification;Performance and emissions; Oils from algae, waste materials - cooking oil, wood, rubber, plastic etc. Methanol and ethanol; DME and DEE; Properties; Production methods; Use in SI and CI engines - blends and emulsions; Performance and emissions.

MODULE 4 ORGANIC GASEOUS FUELS **9**

Natural Gas, LPG, biogas, producer gas, syngas etc.; Properties; Production and storage methods - CNG and LNG, gasification, digesters; Use in SI and CI engines; Performance and emission characteristics; Dual fuel and HCCI modes.

MODULE 5 SOLID FUELS **9**

Biomass - processing and usage, forms - municipal solid waste, wood

TEXT BOOKS

1. Thipse S. S, (2010), Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.
2. Richard L. Bechtold, (2014), Alternative Fuels Guidebook, Society of Automotive Engineers (SAE).
3. Ganesan V., (2012), Internal Combustion Engines, McGraw-Hill Education India Pvt. Ltd.

REFERENCE BOOKS

1. Michael F. Hordeski, (2013), Alternative Fuels: The Future of Hydrogen, The Fairmont Press, Inc.
2. Larminie J., Lowry J., (2004), Electric Vehicle Technology Explained, Wiley.

COURSE TITLE	ADVANCED WASTEWATER TREATMENT			CREDITS	3
COURSE CODE	CEB4745	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe advanced wastewater treatment process and its importance	1,3,7,10
2	Identify microorganisms in wastewater treatment and Nutrients removal	1,7,10
3	Describe the nitrification and denitrification processes	1,3,7
4	Describe the processes of removal of Refractory Organics and Dissolved Inorganic Substances	1,3,7,10
5	Suggested reuse, recycling and disposal of treated effluents	1,2,6,7,10

MODULE 1 IMPORTANCE OF ADVANCED WASTEWATER TREATMENT 9

Effects of chemical constituents in wastewater / Basis of process selection and development of treatment flow sheets

MODULE 2 BIOLOGICAL AND CHEMICAL NUTRIENT REMOVAL 9

Sources and forms of Nitrogen (N) and Phosphorus (P) / Conventional biological nitrification/ denitrification processes and its process fundamentals. Sequencing Batch Reactor (SBR) and Simultaneous Nitrification – Denitrification (SND) processes for nitrogen removal. Nitrogen removal by physical and chemical methods- Air stripping of ammonia / Breakpoint Chlorination / Ion – exchange. Removal of phosphorus by chemical addition.

MODULE 3 ADVANCED PROCESS FOR NITRIFICATION – DENITRIFICATION 9

New processes for nitrogen removal: ANAMMOX, SHARON, CANON etc. Biological removal of Phosphorus-Process fundamentals and types of processes. Combined removal of N and P by biological methods

MODULE 4 REFRACTORY ORGANICS AND DISSOLVED INORGANIC SUBSTANCES REMOVAL 9

Advanced Oxidation Processes (AOP)/ Adsorption / Chemical precipitation / Ion Exchange / Membrane Processes.

MODULE 5 WASTEWATER RECLAMATION/REUSE/DISPOSAL AND BIODEGRADATION 9

Direct and indirect reuse of wastewater- Municipal reuse/industrial reuse/agricultural reuse/recreational reuse/ground water recharge. Criteria and disposal of effluent in to lakes, rivers and ocean. Membrane Bio-Reactor (MBR) applications. Microbial degradation of biopolymers and Hydrocarbons – Eco-technologies – Wetland process.

TEXT BOOKS

1. Metcalf & Eddy Wastewater Engineering- Treatment, Disposal and Reuse, Second edition, Tata McGraw-Hill, New Delhi (2009)
2. Peavy, Rowe &Tchobanoglous Environmental Engineering, Tata McGraw-Hill, New Delhi. (2010)

REFERENCE BOOKS

1. Syed R. Qasim, Wastewater Treatment Plants: Planning, Design and Operation, CRC Press, 2001

COURSE TITLE	SUSTAINABLE WATER MANAGEMENT			CREDITS	3
COURSE CODE		COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe and assess water problems in the society.	1,3,4,6,9,10
2	Suggest ways for Water Resources and Wetland protection.	3,4,6,7,10
3	Adopt appropriate Irrigation practices based on the availability of water	3,4,6,7,10
4	Adopt best Household sustainable practices to avoid wastage of water	1,3,4,6,7,10
5	Suggest New Techniques of saving water based on the case studies.	1,3,4,6,7,10

MODULE 1 INTRODUCTION **9**

Introduction- Global water problems-The hydrologic cycle-Surface and ground water-Global water shortages-Global water demand- Domestic- Agricultural- Industrial

MODULE 2 WATER RESOURCES & WETLANDS PROTECTION **9**

Impact of Sea level rise, thermal shifts and storm intensity/frequency on water resources. Increased storm water runoff/pollution, increased floodplain areas, loss of drinking water supplies and migration of wetlands. Mitigation, adaptation strategies and protection Techniques

MODULE 3 SUSTAINABLE IRRIGATION PRACTICES **9**

Sprinkler and Drip Irrigation. Reducing transit losses in canals. Reduction in Evaporation losses. Conjunctive use of water. Water Pricing. Optimal Water Use. Participatory Irrigation Management. Water Users Association. National Water Policy 2012.

MODULE 4 SUSTAINABLE HOUSEHOLD PRACTICES **9**

Reuse of Grey Water, wash basins, Bath tubs, Water closets, Car wash, modern home appliances which uses less water. Recycling and Reduction in use.

MODULE 5 SUSTAINABLE WATER PRACTICES – CASE STUDIES **9**

Sustainable Design and manufacturing – Paper, Textile and Food, Integrated Water Management in other countries- Singapore, Israel, Melbourne, Sri Lanka and Challenges and Development

TEXT BOOKS

1. Ken'ichi Nakagami, Jumpei Kubota, Budi Indra Setiawan, Sustainable Water Management: New Perspectives, Design, and Practices, Springer 2016.
2. Tamim Younos, Tammy E. Parece, Sustainable Water Management in Urban Environments Springer 2016.

REFERENCE BOOKS

1. Douglas S. Kenney, In Search of Sustainable Water Management, Edward Elgar Publishing, 2005

COURSE TITLE	ADVANCED ENVIRONMENTAL CHEMISTRY			CREDITS	3
COURSE CODE	CEB4748	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Describe the mechanism of reactions for degradation of pollutant by various processes	1,2,3,4,6,7,10
2	Apply the principles of aquatic and biochemistry.	1,3,4,7,11
3	Analyze the fate of chemical reactions in Environmental processes	1,2,3,4,6,7,10
4	Describe atmospheric chemistry.	1,3,4,8
5	Apply the fundamentals of chemistry in the instrumentation techniques	1,3,4,6,7

MODULE 1 PRINCIPLES OF PHYSICAL CHEMISTRY 7

Reversible reactions, equilibrium constant, Le-Chatelier principle. Reaction rate Order and molecularity, kinetic equations of different orders, reversible and consecutive reactions. Catalysis-type, characteristics , activation energy, mechanism of catalyst action, acid base catalysts. Photo catalysis. Adsorption-classification, adsorption of gases on solids, adsorption from solutions, ion exchange adsorption, applications, Longmuir theory.

MODULE 2 PRINCIPLES OF AQUATIC CHEMISTRY AND BIOCHEMSITRY 12

Water resources, sea water- composition, Ph of sea water. Humic substances.
Aquatic chemical reactions- microbial redox reaction, iron and manganese bacteria, nitrogen transformation bacteria. Enzymes-mechanism and factors influencing enzyme action. Biodegradation- biodegradation of carbohydrates, proteins , fats and oils and detergents. Colloidal state- stability, kinetic, optical and electrical properties

MODULE 3 ENVIRONMENTAL CHEMICALS 10

Chemical speciation – speciation of lead, mercury, arsenic and chromium. Structure and property- activity relationship, fate of organics in the environment – transformation reactions hydrolysis, elimination, oxidation, reduction and photochemical transformation. Risk evaluation of environmental chemicals, Toxic chemicals in the environment, impact on enzymes. Biochemical effects of arsenic, lead, mercury and pesticides

MODULE 4 ATMOSPHERIC CHEMISTRY 10

Structure of atmosphere, chemical and photochemical reactions in the atmosphere. Ozone chemistry-formation and depletion of zone layer, oxides of nitrogen and sulphur. Acid rain mechanism of formation and effects. Photochemical smog, and sulfurous smog. Green house effect/global warming, green house gases, effects

MODULE 5 FUNDAMENTALS OF ANALYTICAL PRINCIPLES 6

Analysis of water and water quality parameters -concept of pH, measurement of acidity, alkalinity, hardness, residual chlorine, chlorides, DO, BOD, COD, fluoride and nitrogen. Introduction to spectral analysis,

colorimetry, fluorimety, nephlometry, turbidimetry, absorption and emission spectral methods	
REFERENCE BOOKS	
1	C.N Sawyer, P.L McCarty and G.F Parkin, Chemistry for Environmental Engineering and Science, 5th ed. Tata McGraw-Hill, 2003
2	B.S Bhal, GD Tuli and Arun Bhal, Essentials of Physical Chemistry, S. Chand & Co Ltd. New Delhi, 2003
3	Arun Kumar De, Environmental Chemistry, 5th ed, New Age International (P) Ltd, New Delhi, 2007

COURSE TITLE	PHYSIO-CHEMICAL AND BIOLOGICAL TREATMENT OF WATER AND WASTEWATER			CREDITS	3
COURSE CODE	CEB4749	COURSE CATEGORY	ELE	L-T-P	3-0-0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

Prerequisites : Nil

CO	COURSE OUTCOMES	PO
Students will be able to :		
1	Characterize the water and wastewater based on the characteristics	1,3,4,6,7,9,10,11
2	Identify the various physical and chemical treatment methods including Nano-filtration and ultra-filtration for treating water and wastewater.	1,3,4,6,7,10
3	Choose the chemical treatment methods to be adopted for treating the industrial wastewater.	1,2,3,4,6,7,10,11
4	Design various units for Aerobic and Anaerobic treatment of wastewater.	1,2,3,4,6,7,10,11
5	Identify the ways of treatment of sludge and its disposal.	1,2,3,4,6,7,10

MODULE 1 INTRODUCTION **3**

Pollutants in water and wastewater - characteristics, Standards for performance - Significance and need for physico-chemical treatment.

MODULE 2 PHYSICAL TREATMENT PRINCIPLES **10**

Principles of Screening - Mixing, Equalisation - Sedimentation - Filtration - modeling - back washing evaporation - Incineration - gas transfer - mass transfer coefficients. Adsorption - Isotherms - Principles, equilibria and kinetics, reactors, regeneration, membrane separation, Reverse Osmosis, nano filtration ultra filtration and hyper filtration - electrodialysis, distillation - stripping and crystallization-Recent Advances.

MODULE 3 CHEMICAL AND CONVENTIONAL TREATMENT PRINCIPLES **15**

Principles of Chemical treatment - Coagulation flocculation - Precipitation - flotation, solidification and stabilization - Disinfection. Ion exchange- advance oxidation / reduction - Recent Advances- S- Design of conventional water treatment plant units - Aerators - chemical feeding - Flocculation - clarifier - filters - Rapid sand filter, slow sand filter, pressure filter – chlorinators - O & M aspects - Residue management - Recent Advances.

MODULE 4 DESIGN OF AEROBIC AND ANAEROBIC TREATMENT OF WASTE WATER **12**

Design of sewage treatment plant units - screen chamber, Grit chamber - sedimentation tank - Trickling filters - activated sludge process - aerated lagoons, waste stabilization ponds - nutrient removal systems - Disinfected disposal options - reclamation and reuse - Flow charts, layout, hydraulic profile - Recent advances. Attached and suspended growth, Design of units - UASB, up flow filters, Fluidised beds - Septic tank and disposal - Nutrient removal systems - Layout and Hydraulic profile - Recent advances.

MODULE 5 SLUDGE TREATMENT AND DISPOSAL **5**

Design of Sludge management facilities, sludge thickening, sludge digestion, Biogas generation, sludge dewatering (mechanical and gravity) - upgrading existing plants - ultimate residue disposal - Recent Advances

TEXT BOOKS

1	Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.
REFERENCE BOOKS	
1	Manual on water supply and Treatment CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999.
2	Lee, CC and Shun dar Lin, Handbook of Environmental Engineering Calculations, McGraw-Hill, New York, 1999.
3	Casey, T.J. Unit treatment processes in water and wastewater Engineering, John Wiley and Sons, London, 1993.