CURRICULUM FOR 5-YEAR
B.Tech. (ENVIRONMENTAL ENGINEERING) and
M.Tech. (ENVIRONMENTAL TECHNOLOGY & MANAGEMENT)
PROGRAMME

Centre for Environmental Science and Engineering
IIT Bombay

CREDIT STRUCTURE FOR 5-YEAR
B.Tech. (ENVIRONMENTAL ENGINEERING) and
M.Tech. (ENVIRONMENTAL TECHNOLOGY & MANAGEMENT) PROGRAMME

Semester	Credits Required										Total Credits
	Basic Sciences and Mathematics		Engineering Sciences		HSS	Institute Electives	Departmental Credits				
	Theory	Lab	Theory	Lab			Core Theory	Labs	Electives	Supervised Learning	
I	22 (28)	3	6 (0)	4	0	0	0	0	0	0	35
II	26 (20)	3	0 (6)	5	0	0	0	0	0	0	34
III	0	0	14	0	6	0	12	4	0	0	36
IV	6	0	0	0	0	0	24+6*	3	0	0	39
V	0	0	0	0	6	0	24+6*	6	0	0	42
VI	0	0	0	0	0	6	18+6*	3	6	3 (Seminar)	42
VII	0	0	0	0	0	6	18+6*	3	6	0	39
VIII	0	0	0	0	0	0	24	5	12	0	41
Subtotal (B. Tech.)	**60**		**29**		**12**	**12**	**120+24***	**24**	**24**	**3**	**308**
IX	0	0	0	0	0	0	6	0	0	36 (Project)	42
X	0	0	0	0	0	0	0	0	0	36 (Project)	36
Subtotal (M. Tech.)	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**72**	**78**
TOTAL	**60**		**29**		**12**	**12**	**126+24***	**24**	**24**	**75**	**386**

* Honors level course

First Year : First Semester

		HOURS PER WEEK			**1**
Code	**Name of the Course**	**Lectures**	**Tutorials**	**Practicals**	**Credits**
MA 105	Calculus	3	1	0	8
CH 105	Organic & Inorganic Chemistry	2	0	0	4
CS 101/ BB 101	Computer Programming and Utilization / Biology	2	0	2	6
PH 107	Quantum Physics & Applications	2	1	0	6
PH 117/ CH 117	Physics Laboratory / Chemistry Laboratory	0	0	3	3
ME 113	Workshop Practice	0	0	4	4
CH 107	Physical Chemistry	2	0	0	4
NC 101	NCC	PP/NP			
NO 101	NSO	PP/NP			
NS 101	NSS	PP/NP			
		11	**2**	**9**	**35**

First Year : Second Semester

		HOURS PER WEEK			**2**
Code	**Name of the Course**	**Lectures**	**Tutorials**	**Practicals**	**Credits**
MA 106	Linear Algebra	2	0	0	4
MA 108	Ordinary Differential Equations-1	2	0	0	4
PH 108	Electricity & Magnetism	2	1	0	6
ES 102	Water Quality Management	2	1	0	6
CS 101/ BB 101	Computer Programming and Utilization / Biology	2	0	2	6
PH 117/ CH 117	Physics Laboratory / Chemistry Laboratory	0	0	3	3
ME 119	Engineering Graphics and Drawing	0	1	3	5
NC 102	NCC	PP/NP			
NO 102	NSO	PP/NP			
NS 102	NSS	PP/NP			
		10	**3**	**8**	**34**

Second Year : First Semester

	HOURS PER WEEK	3

Code	Name of the Course	Lectures	Tutorials	Practicals	Credits
EE 101	Introduction to Electrical and Electronics Circuits	3	1	0	8
HS 101	Economics	2	1	0	6
ES 2XX	Data Analysis & Interpretation	2	1	0	6
ES 2XX	Environmental Chemistry	3	0	0	6
ES 205	Environmental Microbiology and Ecology	3	0	0	6
ES 2XX	Environmental Microbiology Lab	0	0	4	4
		13	**3**	**4**	**36**

Second Year : Second Semester

	HOURS PER WEEK	4

Code	Name of the Course	Lectures	Tutorials	Practicals	Credits
ES 2XX	Introduction to Solid Mechanics	3	0	0	6
ES 206	Water Resources and Open Channel Flow	3	0	0	6
ES 208	Mass Transfer Processes in Environmental Systems	3	0	0	6
ES 2XX	Environmental Geodesy	3	0	0	6
ES 200 + HS 200	Environmental Studies	3	0	0	6
ES 252	Environmental Chemistry Laboratory	0	0	3	3
ES 2XX	GIS for Environmental Planning and Management	1	1	2	6
		16	**1**	**5**	**39**

Third Year : First Semester

	HOURS PER WEEK	**5**

Code	Name of the Course	Lectures	Tutorials	Practicals	Credits
HS 301 HS 303 HS 305 HS 307	Philosophy Psychology Reading Literature Sociology	3	0	0	6
ES 3XX	Wastewater Engineering	3	0	0	6
ES 3XX	Municipal Solid and Biomedical Waste Management	3	0	0	6
ES 305	Air Pollution Science and Engineering	3	0	0	6
ES 3XX	Introduction to Fluid Mechanics	3	0	0	6
ES 351	Air Pollution Monitoring Lab	0	0	3	3
ES 3XX	Environmental Computation Laboratory	0	0	3	3
ES 3XX	Energy Conversion and Environment	3	0	0	6
		18	**0**	**6**	**42**

Third Year : Second Semester

	HOURS PER WEEK	**6**

Code	Name of the Course	Lectures	Tutorials	Practicals	Credits
ES 3XX	Environmental Biotechnology	3	0	0	6
ES 3XX	Biological Treatment Technologies	3	0	0	6
ES 3XX	Solid and Hazardous Waste Laboratory	0	0	3	3
ES 3XX	Numerical Methods for Environmental Engineers	2	0	2	6
ES 3XX	Aerosol Science and Engineering	3	0	0	6
	Department Elective-I	3	0	0	6
	Institute Elective-I	2 (3)	1 (0)	0	6
ES 3XX	Seminar				3
		16 (17)	**1 (0)**	**5**	**42**

Fourth Year : First Semester

		HOURS PER WEEK			7
Code	**Name of the Course**	**Lectures**	**Tutorials**	**Practicals**	**Credits**
ES 655	Environmental Management	3	0	0	6
ES 4XX	Physico-chemical Treatment Technologies	3	0	0	6
ES 4XX	Environmental Impact Assessment	3	0	0	6
ES 4XX	Environmental Field Studies	0	0	3	3
ES 4XX	Simulation & Optimization Techniques in Environmental Systems	3	0	0	6
	Department Elective-II / R&D Project	3	0	0	6
	Institute Elective-II	2 (3)	1 (0)	0	6
		17 (18)	**1 (0)**	**3**	**39**

Fourth Year : Second Semester

		HOURS PER WEEK			8
Code	**Name of the Course**	**Lectures**	**Tutorials**	**Practicals**	**Credits**
ES 672	Air Pollution Control Technologies	3	0	0	6
ES 624	Hazardous Waste Management	3	0	0	6
ES 4XX	Environmental Systems Modelling	3	0	0	6
ES 4XX	Planning and Design of Environmental Engineering Facilities	1	0	3	5
ES 4XX	Industrial Wastewater Management and Reuse	3	0	0	6
	Department Elective-III / R&D Project	3	0	0	6
	Department Elective-IV	3	0	0	6
		19	**0**	**3**	**41**

Fifth Year : First Semester

		HOURS PER WEEK			9
Code	**Name of the Course**	Lectures	Tutorials	Practicals	Credits
ES 645	Environmental Law and Policy	3	0	0	6
ES 5XX	Dual Degree Project Stage I	0	0	0	36
		3	**0**	**0**	**42**

Fifth Year : Second Semester

		HOURS PER WEEK			10
Code	**Name of the Course**	Lectures	Tutorials	Practicals	Credits
ES 5XX	Dual Degree Project II Stage	0	0	0	36
		0	**0**	**0**	**36**

List of Departmental Electives

ES 6XX	Health Safety and Environment	3 0 0 6
ES 644	Industrial Pollution Prevention and Clean Technologies	3 0 0 6
ES 658	Environmental Change and Sustainable Development	3 0 0 6
ES 649	Atmospheric Process and Climate Change	3 0 0 6
ES 654	Groundwater Flow and Contaminant Transport through Porous Media	3 0 0 6
ES 656	Bioremediation - Principles and Applications	3 0 0 6
ES 643	Environmental Statistics and Experiment Design	3 0 0 6
ES 676	Membrane Processes	3 0 0 6
ES 678	Soil Science	3 0 0 6

Up to two R&D projects may be taken in lieu of two Departmental Electives.

List of PG Level Courses

ES 655	Environmental Management	3 0 0 6
ES 672	Air Pollution Control Technologies	3 0 0 6
ES 624	Hazardous Waste Management	3 0 0 6
ES 645	Environmental Law and Policy	3 0 0 6

List of Honors Level Courses

ES 2XX	GIS for Environmental Planning and Management	3 0 0 6
ES 3XX	Energy Conversion and Environment	3 0 0 6
ES 3XX	Aerosol Science and Engineering	3 0 0 6
ES 4XX	Simulation & Optimization Techniques in Environmental Systems	3 0 0 6

COURSE CONTENTS

Name of Academic Unit (Department) : CESE
Level : 100
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	WATER QUALITY MANAGEMENT
II.	Credit Structure (L-T-P-C)	2 1 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Water Demand and Quality: Historical introduction to the water and wastewater environment; water quality standards and parameters; assessment of water quality; types of water demand; estimating quantity of water; forecasting population, design period and factors affecting it. Collection and Conveyance of Water: Selecting source(s), various kinds of intake; design of intake structure; design of pumping main; economic sizing of pumping mains. Water Treatment Processes: Clarification - principles of sedimentation; types of settling; discrete particle settling; design of primary sedimentation tank; flocculent type; design of secondary settling tank. Coagulation and flocculation - purpose and action of coagulants. Filtration - theory of granular media filtration; types of filters; slow sand filter and rapid sand filter; mechanism of filtration; modes of operation and operational problems; negative head and air binding phenomena; dual and multimedia filtration. Disinfection - chlorine dioxide; chloramines; ozonation; UV radiation; chlorination. Treatment of groundwater - iron and manganese removal; fluoride removal. Water Distribution Systems: Methods of distribution; design of water distribution systems.
VIII.	Text/Reference**	Nathanson, J.A., Basic Environmental Technology, Prentice Hall of India, New Delhi, 2002. Masters, G.M., Introduction to Environmental Engineering and Science, Prentice Hall, India, 1995. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., Environmental Engineering, McGraw Hill, Singapore, 1985. Gray, N.F., Water Technology – An Introduction for Environmental Scientists and Engineers, Elsevier, A division of Reed Elsevier India Private Limited, New Delhi, 2006.
IX.	Name(S) of Instructor(S)***	Anurag Garg, Munish Chandel, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	

XII.	Justification/ Need for introducing the course	This course aims to provide a basic introduction to water quality, distribution system, treatment concepts. This is a core course.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	DATA ANALYSIS AND INTERPRETATION
II.	Credit Structure (L-T-P-C)	2 1 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Engg Skills
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Sources of data, data representation, measurement of data, gathering of data and design of experiments, errors in measurement bias and random error); multivariate data and regression; posing statistical hypothesis. Elementary probability and statistics (random variables, distribution, central limit theorem), population sampling, confidence intervals; elementary hypothesis testing; exposure to standard models of physical processes, parameter estimation using least squares.
VIII.	Text/Reference**	Montgomery, D.C. and Runger, G.C., Applied Statistics and Probability for Engineers, John Wiley and Sons, 2003. Mendenhall, W., Beaver, R.J. and Beaver, B.M. Introduction to Probability and Statistics, 14th Ed., Brooks/Cole, Cengage Learning, 2012.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Subhankar Karmakar, Harish Phuleria
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course aims to provide basic foundation for data analysis and their interpretation with special applications related to the field of environmental science and engineering. This is a core course.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL CHEMISTRY
II.	Credit Structure (L-T-P-C)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Fundamentals of chemistry for Environmental Engineers—covalent and ionic bonding, chemical equations, concentration and activity, structure and chemistry of organic molecules, radioactivity of elements, order of chemical reactions. Atmospheric chemistry: composition of the atmosphere; reactivity of trace substances in the atmosphere; Urban atmosphere—smog and particulate pollution; Chemistry of stratosphere—destruction of ozone by halogenated species; Chemistry of acid rain. Water Chemistry: Fundamentals of chemical equilibria and kinetics; acid-base equilibrium; buffer solutions; Complexation, precipitation and redox reactions; Analysis of water and wastewater. Soil Chemistry: weathering reactions; structure and surface reactions of clays and oxides, soil-water interfaces. Ocean Chemistry: Estuarine processes; major ion chemistry and minor chemical components in sea water; Anthropogenic effects on ocean chemistry.
VIII.	Text/Reference**	Swayer, C.N., McCarty, C.N. and Parkin, G.F., Chemistry for Environmental Engineering; 4th Ed., Tata McGraw-Hill, New Delhi, 2000. Manahan, S.E., Fundamentals of Environmental Chemistry, Lewis Publishers, Inc. Boca Raton, 1993. Snoeyink, V.L. and Jenkins, D., Water Chemistry, John Wiley, New York, 1980. Sposito, G., Surface Chemistry of soils, Oxford University Press, NY, 1984. Andrews, J. E., Brimblecombe, P., Jickells, T.D., Liss, P.S. and Reid, B.J., An Introduction to Environmental Chemistry, Blackwell Publishing, 2004.
IX.	Name(S) of Instructor(S)***	Harish Phuleria, Suparna Mukherji, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course is aimed to provide fundamentals of environmental chemistry which are required to understand the fate and removal of pollutants from environment.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL MICROBIOLOGY AND ECOLOGY
II.	Credit Structure (L-T-P-C)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Definition of ecology; Structure (components) of an ecosystem; Function of ecosystems (energy flow and material cycling); Role of microorganisms in biogeochemical cycles; Types of ecosystems; Biodiversity and conservation of wild genetic resources; Structural organization of prokaryotic and eukaryotic cells; Metabolic classification of organisms; Types of biomolecules present in living cells and their functions; Structure and function of enzymes; Energy generation (respiration) in cells; Microbial growth; Structure and function of genes; Genetic regulation in microorganisms; Principles of recombinant DNA technology and its application for environment management; Microbiology of aerobic wastewater treatment plants (activated sludge process); Typical biochemical reactions in biological treatment systems (carbon oxidation, nitrification, denitrification and biological phosphorus uptake); Anaerobic biodegradation processes.
VIII.	Text/Reference**	Madigan M.M., Bender K. S., Buckley, D.H., Sattley, W.M., Stahl, D.A. Brock's Biology of Microorganisms, 15th Ed, ASM Press, 2018. Maier, R.M., Pepper, I.L., Gerba C.P., Environmental Microbiology, 2nd Ed. Academic Press, 2009 Bitton, G., Wastewater Microbiology, 3rd Ed., Wiley-Liss Inc., New York, 2005 Jackson, A.R.W. and Jackson, J.M., Environmental Science: The Natural Environment and Human Impact, 2nd Ed., Pearson Education, 2000 Odum E. P. and Saunders, W. B., Fundamentals of Ecology, Philadelphia, USA, 1971.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is fundamental core course to provide insights into ecology, and microbiology aspects required for environmental engineering.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL MICROBIOLOGY LABORATORY
II.	Credit Structure (L-T-P-C-)	0 0 4 4
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Microscopy; Staining and detection of microbes; Methods of enumerating microbes; Multiple tube fermentation technique; Membrane filter technique.
VIII.	Text/Reference**	Pepper, I. L., Gerba, C. P. and Brendecke, J. W., Environmental Microbiology- A Laboratory Manual, Academic Press Inc., San Diego, USA, 1995. Csuros, M. and Csuros, C., Microbiological Examination of Water and Wastewater, Lewis Publishers, CRC Press, Boca Raton, Florida, USA, 1999. CESE Lab Manuals.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This lab course is to provide hands-on training on methods of identification and enumeration of microbes, and practices for microbiology laboratory.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	INTRODUCTION TO SOLID MECHANICS
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Rigid and deformable solids; Method of sections for evaluating internal forces in bodies - review of free body diagrams; Concept of stress - normal and shear stresses; State of stress; Concept of strain - normal and shear strains; State of strain; Hookes law; Constitutive relations; Axially loaded members, force and deflections; Indeterminate systems and compatibility conditions; Simple indeterminate systems and lack of fit problems; Generalized Hookes law; Stress in cylindrical and spherical shells; Thin-Walled Pressure Vessels; Torsion of circular shafts - determinate and simple indeterminate systems. Elastic theory of bending of beams; Shear force and bending moment diagrams; Bending and shearing stresses in beams of symmetrical cross-section; Concept of shear flow and shear centre; Principle of superposition and its limitations. Transformation of plane stress and strain; Principal stresses and strains; Mohrs circle. Bending deflection of beams by direct integration method; Application of direct integration method to simple indeterminate systems. Elastic buckling of compression members.
VIII.	Text/Reference**	Beer, F.P., Johnston, E.R. and DeWolf, J.T., Mechanics of Materials, 3rd Ed., Tata McGraw Hill, New Delhi, 2004. Popov, E.P., Engineering Mechanics of Solids, 2nd Ed., Prentice Hill, New Delhi, 1999. Shames, I.H. and Pitarresi, J.M., Introduction to the Solid Mechanics, 3rd Ed., Prentice Hill, New Delhi, 1989. Gere, J.M., Mechanics of Materials, 5th Ed., Brooks/Cole, Chennai, 2001. Crandall, S.H., Dhal, N.C. and Lardner, T.J., Mechanics of Solids: An Introduction, McGraw Hill, Tokyo, 1994. Kazimi, S.M.A., Solid Mechanics, Tata McGraw-Hill, New Delhi, 1981.
IX.	Name(S) of Instructor(S)***	Anurag Garg, Amritanshu Shriwastav, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This core course is needed to understand the concepts of internal forces in bodies and structures.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	WATER RESOURCES AND OPEN CHANNEL FLOW
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Precipitation; Streamflow measurement; Runoff; Hydrographs; Floods and flood routing; Basic classification and design of open channels; Concepts of specific energy, specific force and critical depth; Gradually varied flow; Hydraulic jump; Control channel and transitions; Dispersion in open channels; Groundwater
VIII.	Text/Reference**	French, R.H., Open Channel Hydraulics, McGraw Hill Book Co., New York, 1986. Chaudhry, M. H., Open Channel Flow, Englewood Cliffs : Prentice Hall, 1993. Chanson, H., Hydraulics of open channel flow: an introduction, Oxford : Butterworth-Heinemann, 1999. Subramanya, K., Engineering hydrology, New Delhi: Tata McGraw Hill Co, 1994. Brebbia, C.A. and Pinder, G.F., Advances in water resources, CML Pub., 1980. Linsley, R.K. and Paulhus, J.L.H., Water Resources Engineering, McGraw Hill Book Co., 1992.
IX.	Name(S) of Instructor(S)***	Subhankar Karmakar, Anurag Garg
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course is required to get familiar with various aspects such as methods used for flow measurement in open channels, design of open channels (like water supply canals and sewers), and groundwater.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	MASS TRANSFER PROCESSES IN ENVIRONMENTAL SYSTEMS
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Environmental Systems and Processes: Natural and Engineered Systems of Environmental Significance, Character and Scale, Quantification, Reactions, Reactors, Material Balance Relationship, Initial and Boundary Conditions, Mass Balance based Process Models. Macro Transport and Micro Transport Processes: Advective and Dispersive Transport Mass & Momentum Balance, Reynolds Number, Prandtl Hypothesis, Dispersion Coefficient and Flux Expressions, Diffusive Mass Transfer, Ficks Law, Diffusivity Estimation, Interphase Mass Transfer, Boundary Layers, Mass Transfer Coefficients, Film Model, Penetration and Surface Renewal Model, Development of Mass Transfer Correlations. Energetics in Homogeneous and Heterogenous System: Reaction Concepts, Equilibrium vs Steady-state, Thermodynamic Relationships and Functions, Reaction Feasibility, Fugacity and Chemical Potential , Henry's Law, Raoult's Law, Phase Exchange Equilibria, Absorption and Adsorption Processes, Isotherm models, Species Distribution among Phases in Environmental Systems. Rate Concepts in Homogenous System: Mass law relationship, reaction order, rate data analysis and choice of rate expression, Activation Energy, Complex Reaction kinetics, Reactor Engineering in Steady state Homogenous Systems: Ideal Reactions, CMBR, CMFR, PFR, PFDR, Nonideal reactors, Residence time distribution analysis.
VIII.	Text/Reference**	Weber, W. J. Jr., Environmental Systems and Processes: Principles, Modeling and Design, John Wiley and Sons Inc., New York, 2001. Weber, W.J. Jr., Process Dynamics in Environmental Systems, John Wiley & Sons Inc., 1996. Fogler, H.S., Elements of Chemical Reaction Engg., 2nd Ed., Prentice-Hall India, 2001.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar, Suparna Mukherji, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course is to introduce the mass transfer concepts of chemical engineering with a focus on applications in environmental science and engineering.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL GEODESY
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Fundamentals of Surveying, Levelling and Levelling Instruments, Traversing compass, theodolite and plane table, Tachometry triangulation, Contouring, Errors and adjustments, Area and volumes measurements.
VIII.	Text/Reference**	Punmia, B.C., Surveying, 11th edition, Vol. I and II, Laxmi Publishers, New Delhi, 1988. Davis, R.E., Foote, F.S. and Kelly, J.W., Surveying; Theory and Practice, 7th edition, McGraw-Hill Book Co., NY, 1980. Clark, D., Plane and Geodetic Surveying, Constable, London, Vol. I and III.
IX.	Name(S) of Instructor(S)***	Anurag Garg, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course is to understand the surveying concepts, area and volume measurements leveling which are required during the construction of sewer/water supply lines and treatment plants.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL STUDIES
II.	Credit Structure (L-T-P-C-)	3 0 0 3 (alongwith HS 200)
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Institute Basic Sciences
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Half (alongwith HS 200)
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Multidisciplinary nature of environmental studies; Natural Resources: Forest, Water, Mineral, Energy, Land; Sustainable development; Ecosystems; Biodiversity and its conservation. Environmental Pollution: Air, Water, Soil, Solid and Hazardous Waste Management; Environment and human health; Environmental Legislation. Global Issues: Climate change, global warming, acid rain, ozone layer depletion. Social Issues and the Environment: Environmental ethics and economics; Resettlement and rehabilitation of people.
VIII.	Text/Reference**	Cunningham W.P. and Cunningham M.A., Principles of Environmental Science, Tata McGraw-Hill Publishing Company, New Delhi, 2002. Dasgupta, P. and Maler, G. (eds.), The Environment and Emerging Development Issues, Vol. I, Oxford University Press, New Delhi, 1997. Jackson, A.R.W. and Jackson, J.M. Environmental Sciences: The Environment and Human Impact, Longman Publishers, 1996. Nathanson, J.A., Basic Environmental Technology, Prentice Hall of India, New Delhi, 2002. Redclift, M. and Woodgate, G. (eds.), International Handbook of Environmental Sociology, Edward Edgar, 1997. Srivastava, K.P., An Introduction to Environmental Study, Kalyani Publishers, Ludhiana, 2002.
IX.	Name(S) of Instructor(S)***	Amritanshu Shriwastav, Anurag Garg, Harish Phuleria, Munish Chandel, Sanjeev Chaudhari, Suparna Mukherji, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is an existing course which is offered to all undergraduates.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL CHEMISTRY LABORATORY
II.	Credit Structure (L-T-P-C-)	0 0 3 3
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Water quality monitoring, Cation/anion analysis; BOD; COD; Residual chlorine analysis; Metal analysis; Instrumental methods of pollutant analysis; Characterization of sludge sample.
VIII.	Text/Reference**	Standard Methods for the Examination of Water and Wastewater, 19th Edition, APHA/AWWA/WPCF Publishing, Washington, D.C., 1995.
IX.	Name(S) of Instructor(S)***	Harish Phuleria, Suparna Mukherji, Anurag Garg, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	In this course, the students will learn experimental methods for determination of water and wastewater characteristics.

Name of Academic Unit (Department) : CESE
Level : 200
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	GIS FOR ENVIRONMENTAL PLANNING AND MANAGEMENT
II.	Credit Structure (L-T-P-C-)	1 1 2 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Introduction to GIS, Data input, verification, storage and output, Data structures in GIS, Data analysis and spatial modeling, DEMS, DTMS, Surfaces, TINS and Networks in GIS. Introduction to remote sensing particularly for getting Input data from remote sensing. Introduction to GIS software and hardware. Laboratory sessions with hands on practice on GIS software say ArcGIS. Case studies on various applications of GIS for environmental planning and management.
VIII.	Text/Reference**	Goodchild, M.F., Parks, B.O. and Steyaert, L.T. Environmental modeling with GIS, Oxford University Press, New York, 1993. Maguire, D.J., Goodchild, M.F. and Rhind, D.W., Geographical information systems, Longman Scientific and Technical, Essex, 1991. Burrough, P.A. and McDonnell, R.A., Principles of geographical information systems, Oxford University Press, Oxford, 1998. Delaney, J., Geographical information systems: an introduction, Oxford University Press, Oxford, 1999. DeMers, M.N., Fundamentals of geographic information systems, John Wiley, New York, 1997.
IX.	Name(S) of Instructor(S)***	Anil Dikshit, Subhankar Karmakar
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is an introductory hands-on computer laboratory course in GIS for students to start using software for spatial databases.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENERGY CONVERSION AND ENVIRONMENT
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Principles of energy conversion methods: Thermal, nuclear, hydro, solar. An introduction to fuels, combustion fundamentals, thermodynamics, kinetics and properties of combustion products; Combustion principles for gases, liquids and solids. Formation of pollutants, measurements and control. Automobile engines, operation and design, emissions. Power production and emissions from waste incineration. Alternative energy sources, economics, sustainability.
VIII.	Text/Reference**	Flagan, R.C., and Seinfeld, J.H., Fundamentals of Air Pollution Engineering, Prentice Hall, New Jersey, 1988. Fowler, J.M., Energy and the Environment, McGraw Hill, New York, 1975. Kanury, A.M., Introduction to Combustion Phenomena, Gordon and Breach Science Publishers, New York, 1992.
IX.	Name(S) of Instructor(S)***	Munish Chandel, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Energy conversion has a direct bearing on air pollution. This course is for the interface of energy and environment.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	INTRODUCTION TO FLUID MECHANICS
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Definition and Properties of fluids; Fluid pressure and its measurement; Hydrostatic force on plane, inclined and curved submerged surfaces; Buoyancy and Floatation; Kinematics of fluid flow:; Fluid dynamics: Flow through orifices; weir and notches; Flow through pipes; Flow of compressible Fluids; Continuity, Momentum and Energy Equations; Hydraulic machines.
VIII.	Text/Reference**	Streeter, V.L. and Wylie, E. B., Fluid Mechanics, McGraw Hill Book Co.,1983. Subramanya, K., Open Channel Hydraulics, Tata McGraw Hill Co., 1998. Giles, R. V., Schaum's outline of theory and problems of fluid mechanics and hydraulics, Schaum publication, New York, 1994.
IX.	Name(S) of Instructor(S)***	Subhankar Karmakar, Anurag Garg, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is a basic engineering course to understand fundamentals of fluid flow. This is a core course.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	WASTEWATER ENGINEERING
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Wastewater Generation, Wastewater Collection in Urban Areas: Design of Sanitary Sewer, Design of Storm Water Sewers, Construction of Wastewater Conveyance System, Sewer material and Joints, Sewer Appurtenances, Sewage Pumping Station, Construction of Sewers, Operation and Maintenance of Municipal Sewer System, Municipal Wastewater Treatment Plant: Screening, Grit Chambers, Sedimentation, Activated Sludge Process, Trickling Filters, Sludge Disposal, Disposal of Effluent, Few Typical Examples
VIII.	Text/Reference**	Masters, G.M., Introduction to Environmental Engineering and Science, Prentice Hall, India, 1995. McGhee, T.J., Water Supply and Sewerage, McGraw Hill, Singapore, 1995. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., Environmental Engineering, McGraw Hill, Singapore, 1985. Davis, M.L. and Cornwell, D.A., Introduction to Environmental Engineering, McGraw Hill, Singapore, 1991. Metcalf & Eddy, Inc, Tchobanoglous G. and Burton, F.L., Wastewater Engineering: Treatment, Disposal and Reuse, 4th ed., Tata McGraw Hill, New Delhi, 2003.
IX.	Name(S) of Instructor(S)***	Anurag Garg, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	The core course is included to cover various aspects related to wastewater generation, conveyance and treatment.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	MUNICIPAL SOLID AND BIOMEDICAL WASTE MANAGEMENT
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Solid waste management: Sources, Composition and Properties of Municipal Solid Waste, Engineering principles; Generation of solid waste; Onsite handling, storage and processing including segregation; Collection of solid waste; Transfer and transport; Processing technique and equipment; Recovery of resources; Conversion products and energy; Composting; Recycling; Incineration and pyrolysis; Disposal of solid waste including sanitary landfill, planning, siting, design, closure and post-closure monitoring; Regional/Integrated solid waste management related issues. Biomedical waste: Regulatory framework, categorization; generation, collection, transport, treatment and disposal.
VIII.	Text/Reference**	Tchobanoglous, G., Theisen, H., and Vigil, S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company, Singapore, 1993. Powes, P.W., How to Dispose of Toxic Substances and Industrial Waste, Noyes Data Corporation, England, 1976. Pavoni, J.L., Handbook of Solid Waste Disposal, Solid Waste Management, Van Nostrand-Reinhold Co., 1975. Mantell, C.L., Solid Waste Management, John Wiley, New York, 1975.
IX.	Name(S) of Instructor(S)***	Anil Dikshit, Anurag Garg, Munish Chandel
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	In this course, solid waste management fundamentals like generation, composition and treatment are covered.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	AIR POLLUTION SCIENCE AND ENGINEERING
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Department Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Air Pollutants and their Effects: The air pollution system; Gases and particulate; Atmospheric sources, sinks, transport; Effects of health and environment; Criterial pollutants, ambient and source standards. Aerosols: Characterization of aerosols, size distributions, measurement methods; Transport behaviour: diffusion, sedimentation, inertial, electrical and thermal; Aerosol Dynamics: nucleation, condensation and coagulation, Radiation properties – visibility, climate effects degradation; principles of particulate control systems. Gaseous Pollutants: Measurement methods; Vapour-liquid and vapour-solid equilibria; Diffusion and Interfacial mass-transfer; Control systems. Air quality management: dispersion modeling, source apportionment methods.
VIII.	Text/Reference**	Friedlander, S. K., Smoke Dust and Haze, Oxford University Press, New York, 2000. Hinds, W.C., Aerosol Technology: Principles, Behaviour and Measurements of Airborne Particles, Wiley: NY, 1982. N. de Nevers, Air Pollution Control Engineering, McGraw Hill, New Delhi, 1995. Seinfeld, J. H. and Pandis, S N., Atmospheric Chemistry and Physics: from Air Pollution to Climate Change, John Wiley, New York, 1998.
IX.	Name(S) of Instructor(S)***	Harish Phuleria, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Effects, monitoring and principles of control of gaseous and particulate pollutants will be introduced.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	AIR POLLUTION MONITORING LABORATORY
II.	Credit Structure (L-T-P-C-)	0 0 3 3
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Department Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Air pollution measurements: Measurement design and methods; Principles and instruments for particulate and gaseous pollutant measurements; Meteorological measurements.
VIII.	Text/Reference**	I.S. Codes: IS 5182, IS 11255, IS 8829, IS 3028. Cohen, B.S., and Hering, S.V. (Eds), Air Sampling Instruments for Evaluation of Atmospheric Contaminants, 8th Ed., ACGIH, 1995. Hinds, W.C., Aerosol Technology: Properties, Behaviour and Measurements of Air borne Particles, Wiley-Interscience, New York. Kenneth, E., Noll and Terry L. Miller, Air Monitoring Survey Design, Ann Arbor Science, 1977.
IX.	Name(S) of Instructor(S)***	Harish Phuleria, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is a companion laboratory course with the air pollution science and engineering theory course to provide hands-on experience with instruments and field measurements.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL COMPUTATION LABORATORY
II.	Credit Structure (L-T-P-C-)	0 0 3 3
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Introduction to Computers and Computing, Introduction to a programming language, Applications of spreadsheet and management of software for solving environmental problem; Hands-on practice on statistical software/tools; hands-on practice on standard software in environmental science and engineering field.
VIII.	Text/Reference**	Ghezzi C. and Jazayeri, M., Programming Language Concepts, John Wiley & Sons, 1999. Pratap, R., Getting Started with MATLAB 7, A Quick Introduction for Scientists and Engineers, Oxford University Press, 2005. Palm III, W.J., Introduction to Matlab 7.4, Tata Mcgraw Hill Publishing Company Limited, 2008. Supplementary Reading Materials (Selected Book Chapters and Papers)
IX.	Name(S) of Instructor(S)***	Subhankar Karmakar, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Students will get introduced to basics in programming as applied for environmental science and engineering(ESE) and also to software packages routinely used in ESE.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL BIOTECHNOLOGY
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Nature of biological processes and their application to industries such as fermentation technology; enzyme technology and their environmental applications: Bioprocesses for cleaner production, sustainable development and economic benefits: biobleaching in pulp and paper industries; bioleaching (biomining) of ores for recovery of precious metals; cleaner biotechnologies in oil agro industries Biological fuel generation: Biohydrogen, biomethanation and alcohol production Biotechnology for enhancing agricultural productivity: Bioinsecticides- structure, function and mode of action Cleaner production activities in Asia: Case studies on demonstration projects, Pollution control biotechnology: Application of microorganisms, enzymes and plants (phytoremediation) for treatment of domestic and industrial wastewater and soil; immobilized microorganisms in waste treatment; use of immobilized cells and enzymes as biosensors; Genetic engineering: Introduction to recombinant DNA technology, safety, social, moral and ethical considerations; applications of recombinant technology for enhanced biodegradation and engineer organism with novel catabolic capabilities; detection of pathogens and parasites in wastewater and environmental samples using nucleic acid probes and polymerase chain reaction (PCR). Public perception of biotechnology, protection of biotechnological inventions, looking to the future of biotechnology.
VIII.	Text/Reference**	Bhattacharya, B. C. and Banerjee R., (2007) Environmental Biotechnology, Oxford University Press, India Vallero, D.A.V., (2010) Environmental Biotechnology: A Biosystems Approach, 2nd Ed., Elsevier. Smith, J. E. (2004) Biotechnology, 3rd Edition, Cambridge University Press, UK
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course(s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	In this course, fundamentals of biotechnology and its application in environmental problems will be covered.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	BIOLOGICAL TREATMENT TECHNOLOGIES
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	Environmental Microbiology and Ecology
VII.	Course Content*	Classification of biochemical operations; Stoichiometry and kinetics of biochemical operations; Modelling of suspended growth systems (basic model for CSTRs; Extensions of the basic model; Methods of biomass recycle and retainment; Techniques for evaluation of kinetic and stoichiometric parameters; Multiple microbial activities in reactors); Design and evaluation of suspended growth processes (guiding principles; Iterative nature of process design and evaluation; Basic decisions during design; Levels of design; Factors to be considered during design); Biological nutrient removal (carbon, nitrogen and phosphorous removal); Anaerobic treatment (process options, components of anaerobic reactions that influence process design); Attached growth reactors (process description and applications); Biodegradation of xenobiotic organic chemicals.
VIII.	Text/Reference**	Arceivala, S.J. and Asolekar, S.R., Wastewater Treatment for Pollution Control and Reuse, 3rd Edition, Tata McGraw Publishing Co. Ltd., New Delhi, 2006. Rittmann, B.E. and McCarty, P.L. (2001) Environmental Biotechnology: Principles and Applications, McGraw Hill Education, Pvt. Ltd., New Delhi. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, 4thEdition, McGraw-Hill Book Company, Singapore, 2003. Gray, N.F., Biology of Wastewater Treatment, Oxford University Press, London, 1989.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Anurag Garg, Amritanshu Shriwastav, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	In this course, the fundamentals of biological treatment of wastewater will be covered. These will include stoichiometry, modelling of suspended and fixed film reactors, aerobic and anaerobic processes.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	SOLID AND HAZARDOUS WASTE LABORATORY
II.	Credit Structure (L-T-P-C-)	0 0 3 3
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Characterization and testing of solid wastes. Characterization and testing of hazardous waste
VIII.	Text/Reference**	CPHEEO Manual on Municipal Solid Waste Management, 2000.
IX.	Name(S) of Instructor(S)***	Anil Dikshit, Anurag Garg, Munish Chandel
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	In the laboratory course, the students will learn the solid waste sampling and analysis methods.

Name of Academic Unit (Department) : CESE
Level : 300
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	NUMERICAL METHODS FOR ENVIRONMENTAL ENGINEERS
II.	Credit Structure (L-T-P-C-)	2 0 2 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Numerical differentiation and Integration, Numerical methods and techniques for solving ordinary, partial differential equations, nonlinear equations; Matrices Eigenvalues and Eigenvectors, Finite difference method: schemes – implicit and explicit types. Accuracy, convergence and stability, method of characteristics, Finite element method- variational and weighted residual formulations; Introduction and hands-on practice on popular / available numerical tools and software; Applications to Environmental systems viz. water, air, wastewater and groundwater systems.
VIII.	Text/Reference**	Guha, S. and Srivastava, R. Numerical methods for engineering and science, Oxford University Press, New Delhi, 2010. Salvadori, M.G. and Baron, M.C. Numerical methods in engineering, Prentice-Hall of India, New Delhi, 1993. Bathe, K.J. and Wilson, E.L., Numerical methods in finite element analysis, Prentice Hall, New Jersey, 1999. Bajpai, A.C., Numerical methods for engineers and scientists, Wiley Interscience, New York, 1977. Rozsa P., Numerical methods, North-Holland Pub., Amsterdam, 1980. Noble, B., Numerical methods, Oliver and Boyd, Edinburgh, 1964. Buchanan, J.L. and Turner, P.R., Numerical methods and analysis, McGraw-Hill, New York, 1992. Reddy, J.N., Introduction to the finite element method, McGraw-Hill, New York, 1985. Desai, C.S. and Abel, J.F., Introduction to the finite element method: a numerical method for engineering analysis, Van Nostrand Reinhold, New York, 1972.
IX.	Name(S) of Instructor(S)***	Subhankar Karmakar, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This core course is designed to introduce the concepts of various numerical methods which are relevant to analyze complex environmental systems.

Name of Academic Unit (Department) : CESE
Level :300 (ES 674)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	AEROSOL SCIENCE AND ENGINEERING
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	ES 305 AIR POLLUTION SCIENCE AND ENGINEERING
VII.	Course Content*	Physics of aerosols: size and size distributions, mechanics of motion, agglomeration, diffusion, electrical effects and light scattering. Applications to sampling, deposition, and visibility. Particle formation and growth dynamics, aerosol reactor design engineering, and applications to environmental aerosols, catalysis, combustion, instrumentation, pharmaceuticals and powder production.
VIII.	Text/Reference**	Friedlander, S.K., Smoke Dust and Haze, Oxford University Press, New York, 2000. Hinds, W C., Aerosol Technology: Properties, Behavior and Measurement of Airborne Particles, Wiley-Interscience, New York, 1999. Seinfeld, J H and Pandis, S N., Atmospheric Chemistry and Physics: from Air Pollution to Climate Change, John Wiley, New York, 1998.
IX.	Name(S) of Instructor(S)***	Harish Phuleria, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course will focus on fundamentals of aerosol characteristics and processes in the atmosphere (pollution), and combustion and nano-particles synthesis processes.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 655)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL MANAGEMENT
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Introduction to Environmental Management; Corporate and international charters and protocols; Environment Risk assessment; Industrial ecology, Pollution prevention and Waste minimization; Sustainable development; Life cycle assessment; Environmental Management Systems, Environmental Design; Environmental auditing; Eco-labelling of products; Performance indicators. Spatial Environmental Planning, Environmental Planning and Management at various levels of government ranging from Federal to State to Regional to Municipal levels. Planning principles, co-ordination, tools, decision making and execution. Information management instruments, planning instruments, co-ordination instruments, Nature protection and conservation. Case studies from India and other parts of the world. Environmental management systems particularly ISO 14000 series.
VIII.	Text/Reference**	Welford, R., Corporate Environmental Management, Earthscan Publications Limited, London, 1996. Sayre, D., Inside ISO 14000: Competitive Advantage of Environmental Management, St. Louis Press, Florida, 1996. Graedel, T.E. and Allenby, B.R., Industrial Ecology, Englewood Cliffs: Prentice Hall, New Jersey, 1995. Rosencranz, A., Divan, S. and Noble, M.L., Environmental Law and Policy in India: Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay, 1992.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar, Anurag Garg, Munish Chandel
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is an existing course covering various tools of environmental management (such as LCA, environmental audit etc)

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	PHYSICO-CHEMICAL TREATMENT TECHNOLOGIES
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Particle separation processes; Coagulation and flocculation processes, Particle surface charge, surface potential and stability of colloidal dispersions; Sedimentation and flotation processes, Gravity thickeners, clarifiers and flotation systems; Filtration and Ultrafiltration Processes, Modeling approaches for rapid sand filters. Solute separation processes; Gas transfer processes, Diffused and surface Aeration and Air stripping of volatile contaminants in packed tower; Adsorption and ion exchange processes, sorption isotherm models and rates considerations, Sorption in completely mixed and packed bed reactors; Precipitation processes; Reverse osmosis and electrodialysis. Species transformation processes; Chemical oxidation / reduction processes, disinfection using chlorine and UV.
VIII.	Text/Reference**	Weber, W.J. Jr., Environmental Systems and Processes: Principles, Modeling and Design, John Wiley and Sons Inc., New York, 2001. Weber, W.J. Jr., and DiGiano, F.A., Process Dynamics in Environmental Systems, John Wiley and Sons Inc., New York, 1996. Weber, W.J. Jr., Physicochemical Processes for Water Quality Control, John Wiley and Sons Inc., New York, 1972. Metcalf & Eddy, Inc, Tchobanoglous G. and Burton, F.L., Wastewater Engineering: Treatment, Disposal and Reuse, 4th ed., Tata McGraw Hill, New Delhi, 2003.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Shyam Asolekar
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is course covering fundamentals of physico-chemical treatment processes used in environmental engineering.

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL IMPACT ASSESSMENT
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA; EIA process; Screening and scoping criteria; Rapid and comprehensive EIA; Specialised areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties. Legislative and environmental clearance procedures in India and other countries, Siting criteria; CRZ; Public participation; Resettlement and rehabilitation. Practical applications of EIA; EIA methodologies; Baseline data collection; Prediction and assessment of impacts on physical, biological and socio-economic environment; Environmental management plan; Post project monitoring, EIA report and EIS; Review process. Case studies on project, regional and sectoral EIA.
VIII.	Text/Reference**	World Bank, Environmental Assessment Source Book, Environment Dept., Washington D.C., 1991. Rau, G.J. and Wooten, C.D., Environmental Impact Analysis Handbook, McGraw Hill, New York, 1980. Canter, L., Environmental Impact Assessment, McGraw Hill, New York, 1996.
IX.	Name(S) of Instructor(S)***	Anil Dikshit
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is a core course to introduce the important concepts of environmental impact assessment, and is highly relevant towards environmental science and engineering education.

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL FIELD STUDIES
II.	Credit Structure (L-T-P-C-)	0 0 3 3
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Study of natural setting: description of the location with drawing; recording temperature, light, sound & rainfall; description of soil properties (physical, chemical and biological) and soil profiling; extraction, isolation and enumeration of bacteria, fungi, protozoans, nematodes, micro-arthropods; description of number and kinds of plants and animals; identification of organisms into genus and species; recording and measuring emergence and growth of plants ; analysis of vegetation data, frequency; descriptions of animals found at ground level as compared to 12 inches above or 3 inches below ground; measurement and calculation of biodiversity indices based on plants and animals. Observations of interactions (interdependence) among organisms: prey-predator relationship; pollination and seed dispersal; social interactions and structures; symbiotic relationships (such as plants and fungi) Field trips, movie screening, photography, audio-video recordings of plants, animals and microorganisms; backyard bird watching, design of bird feeders to attract birds, observations of bird behaviour, factors that affect them, inter and intra species behaviour, habitats and niche; presentation of findings: posterboard, graphicwork, artwork, photographs, audio-video recordings, personal thoughts and comments during the field work. Methods for sampling of population, determining population size, distribution of organisms. Ecological methods and Analyses: basic ecological research protocols; ecological informatics using state-of-the-art data management tools (GPS and GIS use); introduction to measures of energy flux, nutrient and carbon cycling in forest ecosystems Soil and water ecotoxicology and pollution
VIII.	Text/Reference**	Begon M., Ecology: From individuals to ecosystems, 4th edition, Malden, MA : Blackwell Publishers, 2006. Quinn, G.P. and Keough, M.J., Experimental design and data analysis for biologists, Cambridge University Press, 2002. Smith, R.L. and Smith, T.M., Ecology & field biology, San Francisco, USA, Benjamin Cummings, 2001. Krebs C.J., Ecological methodology, 2nd edition, Menlo Park, California, USA, Benjamin Cummings, 1999. Smith, R.L., Study guide to accompany ecology and field biology, 5th edition, Menlo Park, California, USA, B Benjamin Cummings, 1996. Smith, R.L., Ecology and field biology, 5th edition, New York, USA, HarperCollins College Publishers, 1996.
IX.	Name(S) of Instructor(S)***	Amritanshu Shriwastav, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This core course is designed to expose the students to the realistic implications of important concepts in environmental science and engineering through extensive field/site visits/surveys/sampling.

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	SIMULATION AND OPTIMIZATION TECHNIQUES IN ENVIRONMENTAL SYSTEMS
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Constrained and unconstrained optimization; Kuhn-Tucker conditions; Linear programming; Dynamic programming; Review of probability theory-random variables, probability distributions; Stochastic optimization-chance constrained linear programming, stochastic dynamic programming; Applications in environmental and water resources engineering-storage yield analysis, water allocation, multipurpose reservoir operation for hydropower, flood control and irrigation, river water quality management, solid waste management; Use of advanced optimization techniques in Environmental systems-Fuzzy optimization, Interval optimization, Nonlinear search algorithms-Genetic Algorithms and Probabilistic Global Search Laussane.
VIII.	Text/Reference**	Hillier, F.S. and Lieberman, G.J., Introduction to Operations Research, 7th edition, McGraw-Hill Science/Engineering/Math, 2002. Kieffer, J.L.M., Didrit, O. and Walter, E., Applied Interval Analysis, Springer-Verlag, London, 2001. Loucks, D.P., Stedinger, J.R. and Haith, D.A., Water Resources Systems Planning and Analysis, Prentice Hall, 1981. Mays, L.W. and Tung, Y-K., Hydrosystems Engineering and Management, Intl. editions,1992. Ross, S.M., Introduction to Probability Models, 8th edition, Elsevier, 2004. Ross, T.J., Fuzzy Logic with Engineering Applications, 2nd edition, Wiley, 2004. Taha, H.A., Operations Research an Introduction, 8th edition, Pearson Prentice Hall, 2006.
IX.	Name(S) of Instructor(S)***	Subhankar Karmakar, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This core course is designed to introduce the concepts of simulations and optimization during the design and decision making of various environmental systems.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 672)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	AIR POLLUTION CONTROL TECHNOLOGIES
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	ES305 AIR POLLUTION SCIENCE AND ENGINEERING
VII.	Course Content*	Industrial sources of air pollution; Behaviour of pollutants in atmosphere; Emission factors, regulations, control strategies and policies; Choosing appropriate APC technology. Particulate Pollutant Control: Settling chambers – laminar and turbulent flow; Filtration – interception; Impaction; Convective diffusion; Collection of particles by cylindrical fibres and granular beds; Electrostatic precipitation – field and diffusion charging; Electrical migration velocity; Cyclones – laminar and turbulent flow; Wet collectors; Design and drawing of various particle control devices. Gaseous Pollutant Control : Gas absorption in tray and packed towers; Stage efficiency; Liquid/gas rates; Equilibrium number of stages/packed height; Absorption with/without chemical reaction; Adsorption in fixed beds; Breakthrough; Wet scrubbers; Condensation and combustion; Design and drawing of various pollutant control devices. Control of specific pollutants: Control technologies for removal of SO2, NOx, VOC. Control technologies for motor vehicles.
VIII.	Text/Reference**	de Nevers, N., Air Pollution Control Engineering, McGraw Hill Book Company, Singapore, 2000. McCabe, W.L., Smith, J.C., and Harriott, P.W.L., Unit Operations of Chemical Engineering, McGraw Hill, New York, 1993. Buonicore, A.J., and Davis, W.T., Air Pollution Engineering Manual, van Nostrand-Reinhold, New York, 1992. Cheremisinoff, P., Encyclopaedia of Environmental Control Systems, Gulf Publishing Company, Houston, 1989. Flagan, R.C., and Seinfeld, J.H., Fundamentals of Air Pollution Engineering, Prentice Hall, New Jersey, 1988. Compilation of Air Pollutant Emission Factors, AP-42, USEPA, Washington D.C., 1984.
IX.	Name(S) of Instructor(S)***	Anurag Garg, Harish Phuleria, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course(s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing Course: This is the design course for air pollution control equipment.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 624)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	HAZARDOUS WASTE MANAGEMENT
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Hazardous Waste Fundamentals: Definition; Landmark episodes; Classification; Generation. Regulatory process: Hazardous Waste (Management and Handling) Rules and Amendments, Guidelines for HWM from MoEF, New Delhi, Regulatory framework in the USA and EU, Basal Convention and other international statutes. Process: Physicochemical properties; Energy and mass balances; Fate and transport of contaminants; Toxicology Current Management Practices: Environmental audit; Pollution prevention; Facility development and operations. Treatment and Disposal Methods: Physicochemical processes; Biological processes; Stabilization and solidification; Thermal methods; Land disposal. Remediation of Contaminated Sites: Quantitative risk assessment; Site and subsurface characterization; Containment, Remedial alternatives.
VIII.	Text/Reference**	LaGrega, M.D., Buckingham, P.L., and Evans, J.C., Hazardous Waste Management, McGraw-Hill International Editions, New York, 1994. Freeman, H.W., Standard Handbook of Hazardous Waste Treatment and Disposal, McGraw Hill, New York, 1989. Martin, E.J. and Johnson, J.H., Hazardous Waste Management Engineering, van Nostrand-Reinhold, New York, 1987. Wentz, C.A., Hazardous Waste Management, 2nd Edition, McGraw Hill, New York, 1995.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar, Munish Chandel, Anurag Garg
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This PG level course is an existing course.

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL SYSTEMS MODELLING
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Definition; Classification; Examples of models for environmental systems. Introduction to air quality models; Meteorology; Atmospheric stability and turbulence; Gaussian plume model and modifications; Numerical models, Urban diffusion models, Calibration and sensitivity analysis; Applications of public domain models and software, Global radiation balance and climatic changes. Transport and fate of pollutant in aquatic systems; Introduction to river, estuarine and lake hydrodynamics; Stratification and eutrophication of lakes; Dissolved oxygen model for streams; Temperature models. Transport and fate of pollutants in soils and ground water; Utility of environmental models for forecasting. Computational methods in environmental modelling.
VIII.	Text/Reference**	Seinfeld, J.H., and Pandis, S.N., Atmospheric Chemistry and Physics, John Wiley and Sons, Inc., New York, 1998. Schnoor, J.L., Environmental Modelling, Inter Sc. Publ., 1996. Boubel, R.W., Fox, D.L., Turner, D.B., and. Stern, A.C., Fundamentals of Air Pollution, Academic Press, New York, 1994. Thomann, R.V., and Muller, J.A., Principles of Surface Water Quality Modelling and Control, Harper International Edition, N.D., 1987. Tchobanoglous, G., and Schroeder, E.D., Water Quality, Addison – Wesley Publishing Company, Reading, Massachusetts, 1987.
IX.	Name(S) of Instructor(S)***	Anil Dikshit, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is a core course to introduce students towards various modeling approaches relevant to environmental systems, both at macro and microscales.

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	PLANNING AND DESIGN OF ENVIRONMENTAL ENGINEERING FACILITIES
II.	Credit Structure (L-T-P-C-)	1 0 3 5
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	Wastewater Engineering
VII.	Course Content*	Planning, design and drawing of water supply systems, water treatment units and sludge treatment units. Planning, design and drawing of wastewater collection system, wastewater treatment units and sludge treatment units.
VIII.	Text/Reference**	CPHEEO Manual on Water Supply and Treatment, 1999. Bhole, A.G., Design of water treatment plants, IWWA, Nagpur Centre, 2003. CPHEEO Manual on Sewarage and Sewage Treatment, 1993. Metcalf & Eddy, Inc, Tchobanoglous G. and Burton, F.L., Wastewater Engineering: Treatment, Disposal and Reuse, 4th ed., Tata McGraw Hill, New Delhi, 2003. Qasim, S.R., Wastewater treatment Plants – Planning, design and operation, CRC Press, 2nd Edition, 1999.
IX.	Name(S) of Instructor(S)***	Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	In this course, the students will work on the detailed planning and design of water and wastewater conveyance and treatment systems.

Name of Academic Unit (Department) : CESE
Level : 400
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	INDUSTRIAL WASTEWATER MANAGEMENT AND REUSE
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Tertiary treatment of industrial wastewater including removal of nitrate, sulfate, phosphorous, pathogens, color, odor, TDS, COD and residual BOD; Sector specific issues in management of industrial wastewater including petrochemical, textile, food processing, pharmaceutical, fertilizer, pesticides etc.; Policy and legislation including challenges posed by various sectors of industries and legislation framework and regulation in India; Case studies.
VIII.	Text/Reference**	Eckenfelder, W.W. Jr., Industrial Water Pollution Control, 3rd Edition, McGraw Hill International Edition, Singapore, 2000. Arceivala, S.J. and Asolekar, S.R., Wastewater Treatment for Pollution Control and Reuse, 3rd Edition, Tata McGraw Publishing Co. Ltd., New Delhi, 2006. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse. 3rd Edition, McGraw-Hill Book Company, Singapore, 1991.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This course is to teach industrial wastewater treatment strategies for encouraging its reuse.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 645)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL LAW AND POLICY
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Core
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Environmental regulations and policies; Environmental protection laws and acts; Models of environmental management; Incentives; Context; Theories of corporate strategy and environmental policy; Environmental guidelines and charters; Auditing, Monitoring; Reporting, economics and accounting; Local economic development and environmental management; Role of government; Law and policies beyond environmentalism; Sustainability issues; Role of government and non-government organizations and citizens.
VIII.	Text/Reference**	Hawken, P., Ecology and Commerce, Harper Business, New York, 1993. Welford, R., Corporate Environmental Management, Earthscan Publications Ltd., London, 1988.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	The existing course provides information on the existing law and policies in the field of environment.

Name of Academic Unit (Department) : CESE
Level : 600
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	Environmental Health and Safety
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Regulations for Environment, Health and Safety: Factories Act and Rules, Environmental Pollution Act, Oil Industry Safety Directorate (OISD), Indian Electricity Acts and Rules, Mines Acts and Rules, Workmen Compensation Act, OSHA Standards, IS & BS Standards Occupational Health and Hygiene: Physical hazards - Noise and vibration, Ionizing and non-ionizing radiations, Health effects, surveying methods, Control measures and protective equipment Chemical Hazards – Hazard identification, TLV for air, gas and chemical contaminants, Assessment of physical and chemical hazards; Occupational Health - Workplace health hazards, Industrial toxicology, and Risk assessment. Safety performance: Indian and International standards; Hazard analysis - Cost effectiveness in hazard elimination, logical analysis – HAZOP; Probabilistic reliability considerations. Safety management techniques: Safety inspection – safety action, safety survey disaster control, Fire hazard and firefighting, Case study in construction, chemical and oil/gas industry. Environmental Monitoring and Pollution Control: Environmental exposure standards, Human exposure and dose assessment, Study designs, Environmental monitoring of air, water, food, soil and microorganisms, Personal monitoring. Air, Water and Solid waste pollutants' classification, major sources, control and mitigation and transport in the environment.
VIII.	Text/Reference**	Tillman C., Principles of Occupational Health and Hygiene, Allen & Unwin, NSW, Australia, 2008 Berglund M., Elinder C.-G., Jarup L. Human Exposure Assessment, World Health Organization (WHO), Geneva, 2001 Leelakrishnan P., Environmental Law in India, LexisNexis, Gurgaon, India, 2016 Panda B., Industrial Safety, Health Environment and Security, University Sciences Press, New Delhi, 2013 Henrich, H.W., Industrial Accident Prevention, McGraw Hill, 1980. Encyclopedia of Occupational Health and Safety, Vol. I and II. International Labour Organisation, Geneva, 1985.
IX.	Name(S) of Instructor(S)***	Harish Phuleria
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	This is an industry relevant course which will cater to the needs of graduate students in CESE. It will provide an overview of the current legislations, standards and practices related to environmental health and safety in the workplaces.

Name of Academic Unit (Department) : CESE

Level : 600 (ES 644)

Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	INDUSTRIAL POLLUTION PREVENTION AND CLEAN TECHNOLOGIES
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Principles and techniques for industrial pollution prevention and waste minimization; Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Source reduction tools and techniques: raw material substitution, toxic use reduction and elimination, process modification and procedural changes; Recycling and reuse; Opportunities and barriers to cleaner technologies; Pollution prevention economics. Waste audits, emission inventories and waste management hierarchy for process industries; Material balance approach; Material and process mapping approach; Emission sources; Estimation of fugitive emissions; Environmental impact of VOCs; Energy and resource (material and water) audits for efficient usage and conservation. Unit operations in separation technology; Pollution prevention for unit operations: Boilers and Heat Exchangers; Storage tanks; Distillation columns; Application of separation technologies for pollution prevention; Process optimization for cleaner industrial processes: Flowsheet analysis—qualitative and quantitative approaches using mass exchange networks; Thermodynamic constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks. Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries.
VIII.	Text/Reference**	Asolekar, S.R. and Gopichandran, R. "Preventive Environmental Management – An Indian Perspective" Foundation Books Pvt. Ltd., New Delhi, 2005. Bishop, P.E., Pollution Prevention: Fundamentals And Practice, McGraw Hill, 2000. Allen, D.T., and Rosselot, K.S., Pollution Prevention for Chemical Processes, John Wiley, 1997. Allen, D.T., Bakshani, N., and Rosselot, K.S., Pollution Prevention: Homework and Design Problems for Engineering Curricula, American Institute for Pollution Prevention. Freeman, H.M., Industrial Pollution Prevention Handbook, McGraw Hill, 1995. Johansson, A., Clean Technology, Lewis Publishers, 1992. Theodore, L., and McGuinn, Y.C., Pollution prevention, Van Nostrand Reinhold, NewYork, 1992.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course: The existing course emphasizes on the prevention of industrial pollution generation.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 658)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL CHANGE AND SUSTAINABLE DEVELOPMENT
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Issues of sustainability : food, materials and energy resources, demands, policies, ethics; Paradigms of agricultural/industrial age, population, limits to growth; Current debates on the issues of sustainability; Relationships of ecological, economic and social systems; Engineering tools for assessment and design for environment and sustainability; Relevance of traditional paradigms for rural India.
VIII.	Text/Reference**	Lee, N., and Kirkpatrick, C., (Eds), Sustainable Development and Integrated Appraisal in a Developing World, Edward, Elgar, UK, 2000. Chopra, K., and Kadekodi, G.K., Operationalisting Sustainable Development, Sage Publication, New Delhi, 1999. Roy, K.C., Sen R.K. and Tisdell, C.A., Environment and Sustainable Agricultural Development (Volumes I and II), New Age International Pvt. Ltd., New Delhi, 1996. Kirkby, J., O'Keefe, P., and Timberlake, L. (Eds.), The Earthscan Reader in Sustainable Development, Earthscan Publications, London, 1995.
IX.	Name(S) of Instructor(S)***	Shyam Asolekar, Munish Chandel
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course: In this course, the issues related to environmental sustainability and concepts related to design for environment are discussed.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 643)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ENVIRONMENTAL STATISTICS AND EXPERIMENT DESIGN
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Overview of statistics and probability; Statistics in the context of environmental analysis; Probability concepts and probability distributions; conditional probability and Bayes' theorem. Fundamentals of data analysis; Measurement uncertainty: Precision and accuracy; Reproducibility/repeatability; Types of Error, Normal error curve; Error propagation; Quality assurance and quality control; Confidence intervals. Hypothesis testing for equality of mean and standard deviation: t-test, chi-square test and F-test; Errors in hypothesis testing. Experiment design and analysis of variance; ANOVA concepts; Completely randomized design; Randomized block design; Two-way factorial design; Variance component analysis; Factorial and fractional factorial design; Significance of interaction between factors. Regression versus correlation; Autocorrelation in data; Linear versus non-linear regression models; Linear least-squares regression; Precision of parameter estimates, coefficient of determination: inherent limitations; Non-parametric statistics; Exercises using the statistical package SYSTAT.
VIII.	Text/Reference**	Berthouex, P.M. and Brown, L.C., Statistics for Environmental Engineers, Lewis Publishers, CRC Press, Boca Raton, 1994. Mendenhall, W., Beaver, R.J. and Beaver, B.M. Introduction to Probability and Statistics, 14th Ed., Brooks/Cole, Cengage Learning, 2012. Ott, W.R. Environmental Statistics and Data Analysis, Lewis Publishers, New Jersey, 1995. Maxwell, S.E. and Delaney, H.D. Designing Experiments and Analysing Data—A Model Comparison Perspective, Wadsworth Publishing Company, California, 1990.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Subhankar Karmakar, Harish Phuleria
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course

Name of Academic Unit (Department) : CESE
Level : 600 (ES 654)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	GROUNDWATER FLOW AND CONTAMINANT TRANSPORT THROUGH POROUS MEDIA
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Water movement in the subsurface; Groundwater and the hydrologic cycle; The groundwater environment; Types of aquifers; Sources of contamination; Saturated flow: continuity equation; Darcy's Law; Equation of flow; Analytical solutions and numerical modeling; Unsaturated flow; Ground water sampling methods and analyses. Transport of contaminants; Transport equation; Dispersion and diffusion in porous media; Reaction terms; Analytical solutions; Soil chemistry; Groundwater quality; Common soil minerals and components; Forces at soil-water interfaces; Adsorption and surface complexation models; Interaction of non-polar compounds with soils; Soil chemical kinetics; Modelling Groundwater Pollution; Coupling of contaminant-soil interactions with transport; Reaction and transport of trace metals, ligands and nonpolar organic solutes.
VIII.	Text/Reference**	Domenico, P.A., and Schwartz, F.W., Physical and Chemical Hydrogeology, John Wiley and Sons, New York, 1990. Sposito, G., Surface Chemistry of Soils, Oxford University Press, New York, 1984. Stumm, W., and Morgan, J.J., Aquatic chemistry: An Introduction Emphasizing Chemical Equilibria In Natural Waters, 2nd Edition., Wiley Interscience, New York, 1981. Freeze, R.A., and Cherry, J.A., Groundwater, Prentice Hall, Englewood Cliffs, New Jersey, 1979.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course: This elective course consists of the information on groundwater environment, its movement and contaminants transport.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 656)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	BIOREMEDIATION – PRINCIPLES AND APPLICATIONS
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Current bioremediation practice and applications; Microbial systems of bioremediation; Factors influencing bioremediation (environmental factors, physical factors and chemical factors); Genetic responses of microorganisms to the presence of pollutants (plasmid coded inducible degradative enzymes); Application of genetically engineered microorganisms for hazardous waste management; Microbial transformation reactions (aerobic and anaerobic biotransformations); Microbial detoxification of specialty chemicals (insecticides, herbicides, fungicides, polychlorinated biphenyls, heavy metals); Bioremediation systems and processes (solid, liquid and slurry phase bioremediation); Microbial cleaning of gases (biofiltration and bioscrubbing); In situ bioremediation; Laboratory scale biotreatability studies for bioremediation; Management of bioremediation project.
VIII.	Text/Reference**	Baker, K.H., and Herson, D.S., Bioremediation, McGraw-Hill Publishing Company, New York, 1994. Eweis, J.B., Ergas, S.J., Chang D.P.Y., and Schroeder E.D., Bioremediation Principles, McGraw-Hill Publishing Company, Singapore, 1998.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Amritanshu Shriwastav
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course: This course is designed to provide information on current bioremediation practices, its principles and applications in the removal of toxic as well as non-toxic contaminants.

Name of Academic Unit (Department) : CESE

Level : 600 (ES 649)

Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	ATMOSPHERIC PROCESSES AND CLIMATE CHANGE
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Structure of atmosphere, composition, global cycles and lifetimes; Atmospheric chemistry: troposphere and stratospheric; Atmospheric aerosols : properties, chemistry and processes. Meso and macro scale atmospheric and meteorological processes; Global circulation models. Radiation balance, direct and indirect effects of pollutants; climate change implications; policies and international protocols.
VIII.	Text/Reference**	Seinfeld, J. H., and Pandis, S N., Atmospheric Chemistry and Physics : from Air Pollution to Climate Change, John Wiley, New York, 1998. Almeida, G.A., Koepke, P., and Shettle, E.P., Atmospheric Aerosols : Global Climatoloty and Radiative Characteristics, A. Deepak Publishing, Virginia, 1981. Charlson, R.J., and Heintzenberg, O.J. (Eds.), Aerosol Forcing of Climate, John Wiley and Sons, N.Y., 1995.
IX.	Name(S) of Instructor(S)***	Harish Phuleria, Virendra Sethi
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course: In this course, various atmospheric processes and their impact on the climate are described.

Name of Academic Unit (Department) : CESE
Level : 600 (ES 676)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	MEMBRANE PROCESSES
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Introduction to processes and materials, Phenomena governing process operation; driving forces, concentration polarization, hydrodynamics, sealing, fouling, Module configurations, Applications. Reverse Osmosis fundamentals, process design and operation: municipal and industrial applications. Desalination of sea water, pure/ultrapure water production. Fouling and pretreatment, CAD for RO design. Electrodialysis, Definition of process operation conditions from first principles. Water and industrial wastewater applications with reference to recent case studies. Nanofiltration and ultrafiltration applications. NF for surface water treatment. UF in ultrapure and potable water production and in membrane bioreactors. Dead-end cartridge filtration applications in potable and pure water treatment. Choice of media: filtration mechanism, filter media structure.
VIII.	Text/Reference**	Hillis, P., Membrane technology in water and wastewater treatment, Royal Society of Chemistry, Cambridge, 2000. Belfort, G., Synthetic membrane processes: fundamentals and water applications edited by Academic Press, Orlando, 1984.
IX.	Name(S) of Instructor(S)***	Virendra Sethi, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course

Name of Academic Unit (Department) : CESE
Level : 600 (ES 678)
Programme : B. Tech. – M. Tech. Dual Degree

I.	Title of Course	SOIL SCIENCE
II.	Credit Structure (L-T-P-C-)	3 0 0 6
III.	Type of Course (Institute/Departmental) + (Core/Elective/...)	Departmental Elective
IV.	Semester in which normally to be offered(Autumn/Spring)	Autumn/Spring
V.	Whether Full or Half Semester Course	Full
VI.	Pre-requisite(s), if any (For the student) –Specify Course number(s)	None
VII.	Course Content*	Definition of soil and soil properties; Nature and arrangement of soil solids; Measurement of physical properties of the solid phase; Liquid phase characteristics and measurements: potential; capillarity; hysteresis; Prediction of soil moisture characteristics; Composition and properties of the air phase. Fundamentals of unsaturated fluid flow; hydraulic conductivity measurement and prediction; Infiltration of water; Movement of non-aqueous fluids in soils; Two-phase transport properties; Richard's equation; Immiscible displacement. Chemical composition of soils; Soil minerals—structure and surface functional groups; Mineral solubility and weathering; Surface chemistry and electric double layer; Composition and chemistry of soil organic matter; Inorganic and organic contaminant sorption processes.
VIII.	Text/Reference**	Jury, W.A., W.R. Gardner and W.H. Gardner, Soil Physics, 5th Ed. John Wiley, New York, 1991. Essington, M.E., Soil and Water Chemistry—An Integrative Approach, CRC Press, Boca Raton, 2004. Sposito, G., The Chemistry of Soils, Oxford University Press, New York, 1989.
IX.	Name(S) of Instructor(S)***	Suparna Mukherji, Anurag Garg, Munish Chandel, Sanjeev Chaudhari
X	Name(s) of other Departments/ Academic Units to whom the course is relevant	
XI.	Is/Are there any course (s) in the same/other academic unit(s) which is/are equivalent to this course? If so, please give details.	
XII.	Justification/ Need for introducing the course	Existing course