Course Description

Minor Specialization – 1 (Cement Technology)

Title: Introduction to Cement **Code: 18B11CL911**
L-T-P scheme:3-0-0 **Credit: 3**

Prerequisite: No prerequisite are required.
Objective: This course will provide an introduction to cement with respect to its manufacturing and Cement types.

Learning Outcomes: After completion of this course, a student will be familiar with the historical development of cement, technological advancements in the process of cement manufacture during last 150 years, various types of cement being manufactured in the country and overview of cement industry.

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help the students in learning the significance of cement in construction.
CO2	Describe the real world problems, challenges with application of different type of cements.
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems of cement.
CO4	Identify and use of various techniques for solving problems arising out of cement manufacture.
CO5	Apply experimental demonstration and validation by using various analytical techniques.
CO6	Demonstrate students with the knowledge and skill base that would enable them to undertake further studies in the field of cement manufacture and quality control and help to develop a range of generic skills that are relevant to wage employment, self employment and entrepreneurship.

Course Content:

Unit-1:Introduction:
What is cement? Importance of cement in construction.
Unit-2: Cement Manufacture:
History of cement manufacture, Historical development of cement manufacturing process, Rotary kiln revolution and its conversion from wet to dry process. Better cement through chemistry and research. Various unit operations of cement manufacture.
Unit-3: Cement Raw Materials:

Limestone, Clay, Laterite, Bauxite, Marl and Shale. Their composition and properties. Raw material selection. Assessment of limestone deposites.

Unit-4: Types of Cement:

Ordinary Portland Cement, Portland pozzolana Cement, Portland slag Cement, Sulphate registing Portland Cement, Hydrobhobic Cement, Oil well Cement, White Portland Cement, Low heat Cement, Composite Cement, Super sulphated Cement and Masonry Cement.

Unit-5: **Dimensions of Cement Industry:**

Indian Cement Industry, Basic data on number of cement companies and plants in India, World Cement scenario and future cement prospects.

Unit-6: Emerging Trends in Cement Industry:

Conservation of raw materials and use of alternative raw materials/ byproducts/industrial wastes, Alternative fuels, Captive power plants, Energy economy in cement production and environmental protection.

Teaching Methodology:

This course is introduced to help the students to understand how cement was produced during pre-industrial times and how it has transformed to a better product for construction? Students will learn about various types of cement being produced in the country and technology transformation to produce better cement economically. Emerging trends in the manufacture of cement will also be learned by students.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Cement Manufacture and types of Cement (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] LEA'S, Chemistry of Cement and Concrete.
[2] Cement Industry data book, Cement Manufacturer Association, New Delhi.
[3] World Cement Directory, CEMBUREAU

[4] Innovation in Portland Cement Manufacturing, J I Bhatty, F M Miller and S H Kosmatka, Portland Cement Association, USA.
.**[5]** Advances in Cement Technology – S N Ghosh – Tech Book International, New Delhi
.**Web References:**

[1] Cement Data Book – Walter H Duda
[2] Cement Engineers' Handbook, Labahn and Kohlhaas, Bauverlag GMBH, Berlin

Title: Mining, Raw Materials and Raw Mix Design **Code: 18B11CL912**
L-T-P scheme: 3-0-0 **Credit:3**

Prerequisite: Students must have already studied courses, "*Introduction to Cement*" and "*Quality Control in cement*".

Objective:
The emphasis of the course will be on the various raw materials used in manufacture of cement and design of raw mix for cement manufacture

Learning Outcomes:
After completion of this course, a student will be familiar with the raw materials for manufacture of cement, their mining and effects of the raw materials on the process.

Course Outcome	Description
CO1	Outline various raw materials used for cement manufacture.
CO2	Understand different mining methodologies to mine cement raw materials.
CO3	Describe methods to pre-blend the limestone to minimise quality variations.
CO4	Develop equations to calculate the influence of coal ash on clinker composition.
CO5	Apply formulae to calculate two, three and four component based raw mix design.
CO6	Demonstrate the change in composition of different cement types by varying chemical composition of raw mix and coal ash influence.

Course Content:**COURSE CONTENT**

Unit 1: CALCARIOUS MATERIALS
Sources of lime, limestone, chalk, marl, carbonate sludge from industrial wastes,influence of minor components.Assessment of limestone deposits. Use of limestone as sweetner.
Unit 2: ARGILLACIOUS MATERIALS
Sources of silica, alumina and iron oxide, clays, shales and effects of coal ash.Additives used as corrective materials.
Unit 3: INDUSTRIAL WASTES USED AS RAW MATERIALS
Use of industrial wastes in cement manufacture, as raw materials and corrective materials, as additives in the manufacture of composite cements,viz. fly ash, slag, sludge, their characteristics and properties,
Unit 4: MINING OF LIMESTONE

Limestone mines, mining equipment, excavation and formation of benches, blasting techniques,latest techniques of limestone mining and transportation. Safety in mining operations.

Unit 5: RAW MIX DESIGN

Sampling, pre-blending of raw materials, methods of proportioning, 2-, 3-, and 4- component mixes,

Unit 6: COAL ASH

Ash absorption in clinker, effects of coal ash in clinker.

Teaching Methodology:

This course is introduced to help students to learn different aspects of raw materials, Their mining and raw mix design to manufacture cement through class room lectures, conducting quizzes and tutorials, preparing the assignments.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1,& Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5& Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Pyro-processing (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1]F. M. Lea, Chemistry of Cement and Concrete, Arnold, London.

[2]R. H. Bouge, Chemistry of Portland Cement, Reinhold, New York

[3]Inventory of Cement Grade Limestone in India, National Council for cement and Building Materials, New Delhi,

[4]H. F. W. Taylor, Cement Chemistry, Academic Press, London.

[5]Innovation in Portland Cement Manufacturing, J I Bhatty, F M Miller and S H Kosmatka, Portland Cement Association, USA.

[6] Advances in Cement Technology – S N Ghosh – Tech Book International, New Delhi

JournalsReferences:

[1]Cement Data Book – Walter H Duda

[2]Cement Engineers' Handbook, Labahn and Kohlhaas, Bauverlag GMBH, Berlin

Title: Size Reduction and Material Handling in Cement Industries Code: 18B11CL913
L-T-P scheme: 3-0-0 Credit: 3

Prerequisite: For studying this course a student should be familiar with cement manufacturing process and types of cement.
Objective: The purpose of this course is to familiarize with unit operations and practices related to size reduction, homogenization, blending and controls in a cement plant.
Learning Outcomes: After completion of this course, a student will be familiar with these unit operations in a cement plant.

Course Outcome	Description
CO1	The outline, outcome and attribute provide students with learning experiences that help in learning the significance and importance of size reduction and material handling during cement manufacture.
CO2	Describe the real world problems, challenges with suitable case studies while size reduction and material handling in cement industry.
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in size reduction and material handling.
CO4	Identify and use of various techniques for solving problems related to size reduction and material handling.
CO5	Apply experimental demonstration and validation by using analytical techniques for size reduction and material handling.
CO6	Demonstrate the students with the knowledge and skill base that would enable them to undertake further studies in the field of cement manufacture and help to develop a range of generic skills that are relevant to wage employment, self employment and entrepreunership.

Course Content:

Unit 1:Particle Size Analysis:

Sieve analysis, cumulative and fractional plot, size distribution, size averaging and equivalence, size estimation in sub-micron range. Optimum sizes at various stages from extraction from mines. Influence of size fraction on reactivity of lime stone.
Screening equipments such as grizzlies, stationary, vibrating, curved and DSM screens & screen capacity.

Unit 2:Size Reduction:
Laws of size reduction (Bond's, Rittinger's & Kick's); energy requirement in size reduction; work index. Theory of crushing & grinding; crushing efficiency; size reduction machinery crushers such as Jaw crusher, gyratory crushers, impact crushers, roll crushers and cone crushers; Grinders such as hammer mills, roller mills and ball mills & tube mills.

Unit 3:Coal:
Grinding & drying of coals; blending of coals; storage and handling of coals.

Unit 4:Material Handling:
Various systems of material handling; haulage and transportation from mines, trucks, dumpers etc

Unit 5:Conveying of Solids:
Conveyor selection, classification of conveyors, conveyors such as belt, screw, chain, vibratory, apron. Pneumatic and hydraulic transportation of solids; pneumatic conveying systems

Unit 6:Storage of Solids:
Bins, silos, hoppers & feeders; storage of raw materials in piles

Unit 7:Blending & Homogenization:

Preparation of cement raw meal as per raw mix design, combined & segregated pre-homogenization,
Blending bed theory; batch & continuous homogenization; Fuller's one-eight blending method. Stacking of blending beds namely in longitudinal & circular stockpiles system & their comparison. Equipments used for reclaiming material from stockpiles such as scraper, bucket wheel, bucket wheel with slewing boom and drum re-claimers.

Unit 8:Size Classification and Air Separators:
Methods of size classification, principles of air separators, and different types of air separators used in cement manufacturing. Wet classification; hydro-cyclones; cyclone material balances in open circuit and closed circuit operations & separating efficiency.

Teaching Methodology:

This course is introduced to help the students to understand size reduction laws, Various material handling and blending equipments, storage of solid, air separators & classifiers used during cement manufacture.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2& Unit 3
Test-2	25 Marks	Based on Unit-4& Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Total	100 Marks

Learning Resources:

Tutorials and lecture slides on size reduction, pre-blending, homogenization and material handling (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] W. H. Duda, Cement Data Book, All volumes, Verlag GmBH, Berlin,
[**2**] VDZ Congress 2002, Process Technology of Cement Manufacturing, Dusseldorf,
[3] Cement Engineers' Handbook, Labahn and Kohlhaas, Bauverlag GMBH, Berlin
[4] Innovation in Portland Cement Manufacturing, J I Bhatty, F M Miller and S H Kosmatka, Portland Cement Association, USA.

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"**Web References:**

[1] Cement Data Book, Vol - 1 – Walter H Duda
[2] Cement Engineers' Handbook, Labahn and Kohlhaas, Bauverlag GMBH, Berlin

Title: Fuel Testing Lab **Code: 18B17CL971**
L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Students must have already studied the courses, "Introduction to Cement".

Objective:

1. To learn various fuels used for cement manufacture.
2. To develop the abilities to calculate the effect of ash absorption on the quality of cement.

Learning Outcomes:

Course Outcome	Description
CO1	Outline of different fuels used in cement manufacture.
CO2	Understand fuel quality, its preparation for usage in cement kilns.
CO3	Describe proximate and ultimate analyses of various solid fuels.
CO4	Develop the role of coal ash on the properties of cement.
CO5	Apply the calculations for knowing the changes occurred in cement quality due to fuel usage.
CO6	Demonstrate the role of fuel quality on cement and usage of alternative fuels to conserve virgin fuels.

Course Content:

Unit-1;Solid, liquid and gaseous fuels used in cement manufacture.

Unit-2: Preparation of fuels for usage in cement kilns.
Unit-3: Proximate and ultimate analysis of coal.
Unit-4: Role of coal properties on the quality of cement.
Unit-5: Calculations pertaining to ash absorption and its influence on cement quality.
Unit-6: Calorific value determinations

Teaching Methodology:

Evaluation Scheme:

Exams	Marks	Coverage
P-1	15 Marks	**Based on Lab Exercises: 1-3**
P-2	15 Marks	**Based on Lab Exercises: 4-6**

Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Fuel Testing Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Laboratory Manuals available in Lab
[2] Study material available in related folder of Server
[3] Fuels and Combustion- Samir Sarkar- Universities Press(I) Private Ltd.

Title: Pyro-processing and clinker formation **Code: 18B11CL914**
L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: Students must have already studied courses, "*Introduction to Cement*" and "*Quality Control in cement*".

Objective:

The emphasis of the course will be on description of operations in a cement kiln and manufacture of cement.

Learning Outcomes:

After completion of this course, a student will be familiar with the operation in a cement kiln and controls.

Course Outcome	Description
CO1	Outline the clinker manufacturing process in modern pre-calciner kilns.
CO2	Understand various reactions which result into transformation into clinker phases.
CO3	Describe all the endothermic and exothermic reactions occuring during pyro-processing.
CO4	Develop flow sheets of different clinker manufacturing technologies with advantages and disadvantages of each process.
CO5	Apply the influence of cooling rate on quality of clinker.
CO6	Demonstrate the functioning of modern kilns and coolers aiming for energy conservation.

Course Content:**COURSE CONTENT**

Unit 1: THE CEMENT KILN OPERATION
Types of kilns,different types of clinkerization process, wet process, semi-wet process, dry process, advantages- disadvantages of each process, chain type system in wet process, Lepol grate kiln,heat requirement in each process, L/D ratio. Thermal calculations, sizing of kiln. Heat balance of kiln,air balance of kiln, inlet seal, methods used to feed raw meal to kiln, different types of preheaters, their advantages and disadvantages, selection of preheators, affect of leakages on kiln operation, optimization of kiln output, factors affecting kiln output and determination of litre weight of clinker. Firing system-different types of firing systems, their advantages and disadvantages, conveying of pulverized coal to kiln,calcinations and its control, process parameters like velocity, temperature and draught at various stages.

Unit 2: COAL GRINDING PLANT
Preparation of fuel burning, sampling of coal, proximate and ultimate analyses of coal, calorific value of coal and its determination, crushing and grinding of coal, different types of mills, ball

mills, vertical roller mills, advantages and disadvantages of each operation, L/D ratio of mills , residue and moisture determination and their control, removal of fine coal from dust-laden gases, different equipments used, cyclones, bag filters and ESPS.

Unit 3: CEMENT CLINKER
Clinker minerals, absorption of various constituents in phases . Bouge's calculation, phase diagrams.

Unit 4: FORMATION OF CLINKER MINERALS
Chemical reactions during clinkerization, role of minor constituents in clinkerization, thermochemistry of clinker formation.

Unit 5: MINERALISERS AND FLUXES
Role of additives in controlling temperature of clinker formation, various mineralisers and fluxes and their role in clinkerization process.

Unit 6: COOLING OF CLINKER
Different types of coolers used, their operation and control, planetory coolers; grate coolers, cooling efficiency, air requirement for cooling operation, hammer mill, drag chain, different methods of clinker cooling and their advantages, methods of clinker storage-silo and gantry.

Unit 7: REFRACTORIES
Temperature profile inside kilns, functions of refractories, different types of refractories, ceramic phase diagrams, coating and ring formation.

Teaching Methodology:

This course is introduced to help students to learn different aspects of clinker manufacturing process through class room lectures, conducting quizzes and tutorials, preparing the assignments.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2& Unit-3
Test-2	25 Marks	Based on Unit-4& Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6& Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Total	100 Marks

Learning Resources:

Tutorials and lecture slides on Pyro-processing (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1]F. M. Lea, Chemistry of Cement and Concrete, Arnold, London.
[2]R. H. Bouge, Chemistry of Portland Cement, Reinhold, New York
[3]Inventory of Cement Grade Limestone in India, National Council for cement and Building Materials, New Delhi,
[4]H. F. W. Taylor, Cement Chemistry, Academic Press, London.
[5]Innovation in Portland Cement Manufacturing, J I Bhatty, F M Miller and S H Kosmatka, Portland Cement Association, USA.
[6] Advances in Cement Technology – S N Ghosh – Tech Book International, New Delhi

JournalsReferences:

[1]Cement Data Book – Walter H Duda
[2]Cement Engineers' Handbook, Labahn and Kohlhaas, Bauverlag GMBH, Berlin

Title: Chemical Testing of cement Lab **Code: 18B17CL972**
L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Students must have already studied the courses, "*Introduction to Cement*" and "*Quality control in Cement*".

Objective:

3. To learn chemical testing of cement.
4. To develop the abilities to test the cement chemically.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the role of chemical testing of cement.
CO2	Understand cement testing procedure.
CO3	Describe cement chemical testing methods.
CO4	Develop testing of SiO_2, $Al2O_3$, Fe_2O_3, CaO, MgO, SO_3 and Insoluble residue chemically by wet method.
CO5	Apply the methods described in IS 4032 for cement chemical testing.
CO6	Demonstrate different chemical tests carried out for cement.

Course Content:

Unit-1;Determination of L O I in cement

Unit-2: Determination of insoluble residue in cement
Unit-3: Determination of Silica in cement
Unit-4: Determination of Al2O3 in cement
Unit-5: Determination of Fe2O3 in cement
Unit-6 : Determination of CaO and MgO in cement
Unit – 7: Determination of SO3 in cement
Unit – 8: Determination of Alkalies in cement

Teaching Methodology:

This course is introduced to help students to carry out chemical testing of cement.

Evaluation Scheme:
All the chemical tests will be carried out by the students.

Exams	Marks	Coverage
P-1	15 Marks	**Based on Lab Exercises: 1-4**

P-2		15 Marks	**Based on Lab Exercises: 5-8**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Web Technology Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Laboratory Manual available in Lab
[2] Study material available in related folder of Server

Reference Books/Material:

[1] IS - 4032

Title: Quality Control in Cement **Code: 18B11CL915**
L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: For studying this course a student should be familiar with cement manufacturing process and types of cement.
Objective: The purpose is to familiarize with various techniques of sampling and quality control in a cement plant.

Learning Outcomes: After completion of this course, a student will be familiar with the quality control measures and able to implement them.

Course Outcome	Description
CO1	Outline the role of quality control in cement manufacture.
CO2	Understand various types of cement produced in the country.
CO3	Describe the procedure followed for cement quality control.
CO4	Develop concept to convert raw materials into cement type through changes in chemical composition of raw mix.
CO5	Apply different equations to calculate the phase composition of cement.
CO6	Demonstrate the cement manufacturing process to conserve energy and raw materials.

Course Content:

Unit 1: STATISTICAL CONCEPTS:
Treatment of variability, histograms, means, standard deviation, co-efficient of variation, normal distribution, control charts,
Unit 2: INPUT CONTROL
Control of input at various stages of production, control of raw materials, raw meal and kiln feed, chemical composition and physical characteristics, norms of control,

Unit 3:SPECIFICATIONS
Quality and specification requirements, minimum value specified, average values expected in production, acceptance criteria,
Unit 4: PHYSICAL TESTING OF CEMENT
Normal Consistency, specific surface, initial and final setting time, Le-Chtelier and Autoclave soundness, Compressive strength of cement. Lime reactivity of pozzolanic materials. Drying shrinkage of PPC.
Unit 5:NATIONAL AND INTERNATIONAL SPECIFICATIONS
BIS, ASTM and EN standards, differences in test methods, comparison of requirements,
Unit 6:SCHEME OF TESTING AND INSPECTION
Detailed requirements of STI issued by Bureau of Indian Standards.

Teaching Methodology:

This course is introduced to help the students to understand raw material collection procedures, Quality control norms to be followed during cement manufacture.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 & Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on raw material collection, specification requirements, physical tests, quality control norms (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] IS: 4031(All Parts) - Bureau of Indian Standards

[2] M. R. Spiegel, Statistics, Schaum Series.

[3] Neville and Kennedy, Basic Statistical Methods for Engineers and Scientists, International Textbook Co., Scranton, Pennsylvania.

[4] National Council for Cement and Building Materials, Norms for Quality Control in Cement Manufacture, New Delhi.

[5]IS:397 (Parts I,II and III)

"**Web References:**

[1] Cement Data Book, Vol - 1 – Walter H Duda

[2] Cement Engineers' Handbook, Labahn and Kohlhaas, Bauverlag GMBH, Berlin

Title: Physical Testing of Cement Lab **Code: 18B17CL973**
L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite: Students must have already studied the courses, "Quality Control in Cement".

Objective:

1.To learn various physical tests of cement.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the role of physical testing of cement
CO2	Understand various physical tests carried out to judge the cement quality.
CO3	Describe the procedures followed for different physical tests.
CO4	Demonstrate physical tests carried out for cement.
CO5	Apply the calculations for determination of water quantity for all cement physical tests.
CO6	Demonstrate different cement physical tests.

Course Content:

Unit-1; Determination of normal consistency of cement

Unit-2: Determination of specific surface of cement.
Unit-3: Determination of initial and final setting time of cement.
Unit-4: Determination of Le-Chetelier soundness of cement.
Unit-5: Determination of Autoclave soundness of cement.
Unit-6: Determination of compressive strength of cement.
Unit-7: Determination of specific gravity of cement.
Unit 8: Determination of lime reactivity of pozzolanic materials.
Unit 9. Determination of drying shrinkage of cement.

Teaching Methodology:

Evaluation Scheme:

Exams	Marks	Coverage
P-1	15 Marks	**Based on Lab Exercises: 1-4**

P-2		15 Marks	**Based on Lab Exercises: 5-9**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of cement Testing Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Laboratory Manuals available in Lab
[2] Study material available in related folder of Server
[3] Indian Standard IS: 4031(All parts)- Bureau of Indian Standard, New Delhi

Minor Specialization – II (Industrial Pollution Abatement)

Title: Environmental ChemistryCode: 18B11CL916
L-T-P Scheme: 3-1-0 **Credit: 4**

Prerequisite:

This is an advanced undergraduate level course in environmental chemistry, and thus, students are required to have: (1) taken at least one undergraduate course in general chemistry (2) taken at least one undergraduate course in physics; (3) comfort with doing some math. It is strongly recommended that advanced undergraduates that register for this course have had at least one undergraduate course in organic chemistry. This course also serves as an introduction (or "refresher") for first year graduate students pursuing research projects in fields related to environmental chemistry

Objective:

The course explains the concepts of the Environmental Chemistry. It helps student to learn various chemical reaction occurring atmosphere, water and soil. It helps student to resolve various environmental problems. It is micro-specialization course for the Chemical Engineering students.

Course LearningOutcomes:

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help in still deep interests in learning of Environmental Chemistry. It develops broad and balanced knowledge and understanding of key chemical concepts, principles, and theories related to atmosphere, water and soil.
CO2	Describe the real world problems, challenges in current scenario. It is micro-specialization paper for the Chemical Engineering students.
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in the Environment.
CO4	Identify and use of various analytical techniques for resolving the environmental problem and in project management.
CO5	Apply experimental demonstration and validation by using various analytical techniques given in theorem, principles as explained in lectures.
CO6	Demonstrate students with the knowledge and skill base that would enable them to

	undertake further studies in the Environmental Chemistry and related areas or in multidisciplinary areas that involve Environmental Chemistry and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

COURSE CONTENT

Unit 1

Basic Principles, Chemical Kinetics, Reaction Rates, Oxidation-Reduction reactions, Redox Stoichiometry,Applications of redox Chemistry.

Unit 2 Chemical Equilibria, Basic concepts from Equilibrium Chemistry, Solubility Product, Common Ion Effect,Solubility Equilibria, Precipitation-Dissolution, Acid-Base Equilibria, Strong and Weak Acids, Carbonate System,pH, Buffers and Buffer Intensity.

Unit 3

Complex Formation, Log Concentration Diagrams, Metal Hydroxide Precipitation, Metal Speciation, Waterstabilization, Langlier Saturation Index, Cadwell-Lawrence Diagram.

Unit 4

Organic Chemistry, Aquatic chemistry, Atmospheric chemistry, Toxic Compounds, Organic Solvents, Pesticides,Dioxins, PCBs and PAHs, Surfactants,Laboratory practice for determination of ions and solids.

Teaching Methodology:

This course planned in 3 lectures each week. The course content divided in two 42 lectures. The lectures will be conducted in both manner white board and PowerPoint presentation. At the end of this course student will be able to understand the concept of Environmental Chemistry and able to apply in further study and research.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2(70 %) and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit 3, Unit-4 to Unit-5 and around 30% from coverage of Test-1 and Text-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Total	100 Marks

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book

[1] Colin Baird and Michael Cann, Environmental Chemistry, 5th Edition, 2012.

[2] Barbara J. Finlayson-Pitts and James N. Pitts, Jr., Chemistry of the Upper and Lower Atmosphere, 1999, Academic Press.

[3] Environmental Chemistry : Anil Kumar De

[4] Brezonik, P.L.; Arnold, W.A. Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Systems, Oxford University Press. 2011.

Reference Book:

[1] Water Quality and Treatment, 5th edition, R. Letterman, Editor, American Water Works Association, Denver, CO, 1999

[2] Sawyer C, McCarty P and Parkin G, "Chemistry for Environmental Engineering and Science", Tata McGraw Hill Edition.

[3] Larry D Benefield, "Process Chemistry for water and wastewater Treatment", Prentice Hall Publications

[4] Colin Baired and Michael Cann, "Environmental Chemistry" W.H. Freeman& Co Ltd. U.S.A.

Title: Air pollution control and monitoring **Code: 18B11CL917**

L-T-P scheme: 3-1-0 **Credit: 4**

Prerequisite: NIL

Objective: To educate the students on various methods of particulate and gaseous air pollutants.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various air pollutants present in the atmosphere.
CO2	Understand the causes of air pollution and their harmful effects.
CO3	Describe various air pollution control equipments.
CO4	Develop expressions for the estimating the efficiency of various air pollution control equipments.
CO5	Apply appropriate equations for the design of air pollution control equipments.
CO6	Demonstrate the working of various equipments related to air pollution control and monitoring.

Course Content:

UNIT -1 : Sources and classification of air pollutants

Classification, Sources and Effects of air pollutants, Sampling methods and measurements of air pollutants, Measurement and analysis of primary air pollutants SO_2, NO_x and SPM using high volume sampler, Ambient air quality standards, Emission standards.

UNIT -2 : Meterology and dispersion of pollutants

Basic Meterology, Transport dispersion and transformation of pollutants in air, Adiabatic lapse rate, Atmospheric stability, Dispersion of pollutants, Air pollution dispersion models, Point, Line and Area source models, Inversions, Plume behavior, Mixing height, Plume rise, Stack emissions and design.

UNIT -3 : Particulate control methods

Air pollution control techniques, Control of particulate matter, Theory and description of control devices and their applications, Equipment's and their design, selection of control equipments, Engineering control concepts: gravity settling chamber, cyclone, fabric filter, electrostatic precipitator.

UNIT – 4: Gaseous and Noise control methods

Control of gaseous pollutants – Oxides of nitrogen and sulfur, Sources and effects of noise pollution, Kinetics of noise, Measurement and control of noise pollution, Climate change, Odur removal, Atmospheric chemistry, Photochemical smog, Global change – Greenhouse effect and global warming, ozone layer depletion, acid rain, Air emissions from wastewater treatment facilities and their control.

Teaching Methodology:

This course is introduced to help students understand various types of air pollutants present in the atmosphere along with their control techniques. The entire course is broken down into following separate units: Sources and classification of air pollutants,

meteorology and dispersion of pollutants, Particulate control methods, gaseous and noise control methods. Each section includes multiple topics to help a student gain deeper understanding of the subject. This theory course is well complemented by a laboratory course under the name Air pollution control and monitoring Lab in the same semester that helps a student learn with hand-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and study material (will be added from time to time): Digital copy will be available on the JUET server.

TEXT BOOKS:

1. Richard W. Boubel et al., " Fundamentals of air pollution", Academical Press, New York, 2004.
2. M.N. Rao et al., "Air Pollution", Tata McGraw Hill, 2009.

REFERENCES BOOKS:

1. Noel de Nevers, " Air Pollution Control Engg." McGraw Hill, New York, 2005

Title: Air pollution control and Monitoring Lab **Code: 18B17CL974**

L-T-P scheme: 0-0-2 **Credit: 1**

Prerequisite:NIL

Objective: To educate the students on various methods of particulate and gaseous air pollutants.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various air pollutants present in the atmosphere.
CO2	Understand the causes of air pollution and their harmful effects.
CO3	Describe various air pollution control equipments.
CO4	Develop expressions for the estimating the efficiency of various air pollution control equipments.
CO5	Apply appropriate equations for the design of air pollution control equipments.
CO6	Demonstrate the working of various equipments related to air pollution control and monitoring.

Course Content:

LIST OF EXPERIMENTS:

1. Demonstration of air pollution monitoring instruments.
2. Determination of SPM; PM10
3. Determination of SO_2 in ambient air.
4. Determination of NOx and CO in ambient air.
5. Respirable dust monitoring by GDS.
6. Demonstration of stack monitoring kits; Wind rose diagram.
7. Sampling and analysis of inorganic and organic particulates, Sox, NOx, NH_3.

Teaching Methodology:

This course is introduced to help students understand various types of air pollutants present in the atmosphere along with their control techniques. The entire course is broken down into following separate units: Sources and classification of air pollutants, meteorology and dispersion of pollutants, Particulate control methods, gaseous and noise control methods. Each section includes multiple topics to help a student gain deeper understanding of the subject. This lab course is well complemented by a theory course under the name Air pollution control and monitoring in the same semester that helps a student learn and discuss the technical details of the underlying technologies.

Evaluation Scheme:

Exams	Marks	Coverage

P-1		15 Marks	**Based on Lab Exercises: 1-5**
P-2		15 Marks	**Based on Lab Exercises: 6-8**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Air pollution control and monitoring Lab (will be added time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Laboratory Manual available in Lab
[2] Study material available in related folder of Server
[3] Richard W. Boubel et al., " Fundamentals of air pollution", Academical Press, New York, 2004.
[4] M.N. Rao et al., "Air Pollution", Tata McGraw Hill, 2009.

Reference Books/Material:

1. Noel de Nevers, " Air Pollution Control Engg." McGraw Hill, New York, 2005

Title: Waste Water Treatment Processes **Code: 18B11CL918**

L-T-P scheme:3-1-0 **Credit: 4**

Prerequisite: NIL

Objective: To impart knowledge on various chemical treatment methods used in waste water treatment industry.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various types of water pollutants.
CO2	Understand the causes of water pollution along with their harmful effects.
CO3	Describe various equipments related water pollution control.
CO4	Develop rate expressions for different types of processes used in waste water treatment.
CO5	Apply appropriate equations for the design of water pollution control equipments.
CO6	Demonstrate the working of various equipments related to waste water treatment.

COURSE CONTENT:

UNIT -1

Waste Water Treatment An Overview : Terminology, Regulations, Health and Environment concerns in waste water management, Constituents in waste water inorganic, organic and metallic constituents.

UNIT -2

Process Analysis and Selection: Components of waste water flow, Analysis of data, Reactors used in waste water treatment, Mass balance analysis, Modeling of ideal and non-ideal flow in reactors, Process selection.

UNIT – 3

Chemical Unit Processes: Role of unit processes in waste water treatment, coagulation, Chemical precipitation for improved plant performance, chemical oxidation, Neutralization, chemical storage.

UNIT -4

Biological Treatment: Overview of biological treatment, Microbial metabolism, bacterial growth and energetic, aerobic biological oxidation, Anaerobic fermentation and oxidation, Trickling filters, Rotating biological contractors, Combined aerobic processes, Activated sludge film packing.

UNIT – 5

Asdvance wastewater treatment: Technologies used in advanced treatment, classification of technologies, Removal of colloids and suspended particles, depth filtration, surface filtration, membrane filtration, adsorption and ion exchange, advanced oxidation processes

Teaching Methodology:

This course is introduced to help students understand basic principles of application of wastewater treatment technolgoies in process industries. The entire course is broken down into following separate units: wastewater treatment – an overview, Process analysis and selection, Chemical unit processes, Biological treatment, Advanced treatment processes. Each section includes multiple topics to help a student gain deeper understanding of the subject. This theory course is well complemented by a laboratory course under the name Environmental Engineering Lab in the same semester that helps a student learn with hand-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 &Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4, and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and study material (will be added from time to time): Digital copy will be available on the JUET server.

TEXT BOOKS:

1. Wastewater Engineering Treatment and Reuse: McGraw Hill, G. Tchobanoglous, FI Biston, 2002
2. Industrial Waste water management treatment and disposal by Waste Water Mc Graw Hill III Edition 2008.

REFERENCE BOOKS:

1. Metcalf et. al., “Waste Water Treatment, Disposal & Teuse”, 3/e, Tata McGraw Hill.
2. Chandalia S.B., Rajgopal D., “Environmental Perspectives of Chemical Industries”

Title: Wastewater Treatment Processes Lab **Code: 18B17CL975**
L-T-P scheme:0-0-2 **Credit: 1**

Prerequisite:NIL

Objective: To impart knowledge on various chemical treatment methods used in waste water treatment industry.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various types of water pollutants.
CO2	Understand the causes of water pollution along with their harmful effects.
CO3	Describe various equipments related water pollution control.
CO4	Develop rate expressions for different types of processes used in waste water treatment.
CO5	Apply appropriate equations for the design of water pollution control equipments.
CO6	Demonstrate the working of various equipments related to waste water treatment.

COURSE CONTENT:

1. pH, Turbidity, Electrical Conductivity
2. Acidity and Alkalinity
3. Total Hardness, Calcium and Magnesium
4. Solids (total, suspended and dissolved)
5. Settleable solids (by Imhoff Cone)
6. Optimum coagulant dose (Jar Test)
7. Dissolved oxygen
8. Biochemical oxygen demand
9. Chemical oxygen demand (COD)
10. Gas liquid mass transfer characteristics (aeration apparatus)
11. Softening or demineralization of water (ion exchange column)

Teaching Methodology:

This course is introduced to help students understand basic principles of application of wastewater treatment technolgoies in process industries. The entire course is broken down into following separate units: wastewater treatment – an overview, Process analysis and selection, Chemical unit processes, Biological treatment, Advanced treatment processes. Each section includes multiple topics to help a student gain deeper understanding of the subject. This lab course is well complemented by a theory course under the name Wastewater treatment processes in the same semester that helps a student learn and discuss the technical details of the underlying technologies.

Evaluation Scheme:

Exams		Marks	Coverage
P-1		15 Marks	**Based on Lab Exercises: 1-7**
P-2		15 Marks	**Based on Lab Exercises: 8-11**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Environmental Engineering Lab (will be added time to time): Digital copy will be available on the JUET server.

TEXT BOOKS

1.Laboratory Manual available in Lab

2.Study material available in related folder of Server

3. Wastewater Engineering Treatment and Reuse: McGraw Hill, G. Tchobanoglous, FI Biston, 2002

4.Industrial Waste water management treatment and disposal by Waste Water Mc Graw Hill III Edition 2008.

REFERENCE BOOKS / Material:

1. Metcalf et. al., “Waste Water Treatment, Disposal & Teuse”, 3/e, Tata McGraw Hill.
2. Chandalia S.B., Rajgopal D., “Environmental Perspectives of Chemical Industries”

Title: Treatment and Management of Hazardous WasteCode: 18B11CL919

L-T-P Scheme: 3-0-0 Credit: 3

Prerequisite: The students must be aware of the basic Environmental Science upto graduation level. Basic knowledge of Environmental Science helps them to understand the basic concept behind management of solidwaste

OBJECTIVE:

The purpose behind this course is to make the students familiar with the concepts of solid and hazardous waste, their classification, origin and risk management.

Course LearningOutcomes:

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help in understanding the significance and importance of solid and Hazardous waste management.
CO2	Describe the real world problems, challenges raised due to industrial and domestic solid waste. It also emphasis the dangerous effect of the Hazardous waste for current and future generation.
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in their surrounding case study.
CO4	Identify and use of various statistical and managerial techniques for solving the problems rise due to hazardous, domestic and industrial waste.
CO5	Apply various statistical and managerial techniques for case study in the surrounding localities.
CO6	Demonstrate students with the knowledge and skill base that would enable them to undertake further studies in the solidwaste and hazardous waste management and related multidisciplinary areas that help to develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

COURSE CONTENT

Unit 1: Introduction:

Environment and development, Solid, liquid and gaseous emissions, Environmental standards and legal framework, Hazardous wastes.

Unit 2: Solid Waste Management:

Terminology, Solid waste characteristics, Sources, Collection and transportation, solid waste processing and recovery, Solid waste disposal, Land fill, Environmental issues.

Unit 3: Hazardous Waste Management:

Definition, Types of hazardous wastes, Ignitability, Corrosiveness, Reactivity, Toxicity, Radioactivity, Health Effects, Cradle to grave management. Treatment Methods –

Physiochemical processes, Neutralization, Oxidation-reduction, Precipitation, Biological mehods, Solidification and Stabilization, Incineration, Final Disposal, Risk Assessment – Carcinogens, Dose- response assessment, Risk exposure assessment.

Unit 4: Site Remediation:

Quantitative risk assessment, Site and sub surface characterization, Remedial Technologies, Remedial actions and corrective measures.

Unit 5: Solid Waste Utilization Options:

Concept of waste to wealth, Case studies of solid waste utilization, Byproducts, Land fill management, Ash management, Incineration, Biological sludge disposal.

Teaching Methodology:

This course planned in 3 lectures each week. The course content divided in two 42 lectures. The lectures will be conducted in both manner white board and PowerPoint presentation. At the end of this course student will be able to: Understand the significance of the domestic and hazardous solidwaste management. They will demonstrate various case studies for solving the hazardous waste management problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3(70 %) and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-1 and Text-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1 Hazardous Waste Management –Weritz A. - McGraw Hill- 1989.

2 Hazardous Waste Management- 2nd Edition – M.D. Lagrega, P.L. Buckingham, J. C. Evans – McGraw Hill – 2001.

Reference Book:

[1] Environmental Engineering – A design Approach – G.A. Sicero and A.P. Sincero – Prentice Hall India Ltd.-1996.

[2] Handbook of Solid Waste Management - 2nd Edition – G. Tcchobanoglous, F. Kreith – McGraw Hill – 2002.
[3] Loss Prevention in Process Industries – 3rd Edition, Editor Sam Mannan, Elsevier - 2000

Title: Environmental Impact Assessment Code: 18B11CL920

L-T-P Scheme: 3-0-0 **Credit: 3**

Perquisites:

The students should complete the Environmental Science course at under graduate level before considering this course for the study.

Course objectives: This course will enable students to identify environmental attributes for the EIA study. To identify methodology and prepare EIA reports. Specify methods for prediction of the impacts. Formulate environmental management plans.

Course Outcome	Description
CO1	The outline, outcomes and attributes provide students with learning experiences that help in still deep interests in learning of Environmental Impact Assessment. It develops broad and balanced knowledge and understanding of key EIA concepts, principles, and theories related to atmosphere, water and soil.
CO2	Describe the real world problems, challenges in current scenario. It is micro-specialization paper for the Chemical Engineering students.
CO3	Develop in students the ability to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in the Environment.
CO4	Identify and use of various EIA techniques for resolving the environmental problem and in project management.
CO5	Apply experimental demonstration and validation by using various EIA techniques given in theorem, principles as explained in lectures.
CO6	Demonstrate students with the knowledge and skill base that would enable them to undertake further studies in the Environmental Impact Assessments and related areas or in multidisciplinary areas that involve Environment and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

COURSE CONTENT

Unit 1

Introduction: The Need for EIA, Indian Policies Requiring EIA, The EIA Cycle and Procedures, Screening, Scoping, BaselineData, Impact Prediction, Assessment of Alternatives,Delineation of Mitigation Measure and EIA Report, PublicHearing, Decision Making, Monitoring the ClearanceConditions, Components of EIA, Roles in the EIA Process.Government of India

Ministry of Environment and ForestNotification (2000), List of projects requiring Environmentalclearance, Application form, Composition of ExpertCommittee, Ecological sensitive places, Internationalagreements.

Unit 2

Identifying The Key Issues: Key Elements of an Initial ProjectDescription and Scoping, Project Location(s), Land UseImpacts, Consideration of Alternatives, Process selection:Construction Phase, Input Requirements, Wastes andEmissions, Air Emissions, Liquid Effluents, Solid Wastes,Risks to Environment and Human, Health, Socio- EconomicImpacts, Ecological Impacts, Global Environmental Issues.

Unit 3

EIA Methodologies: Criteria for the selection of EIAmethodology, impact identification, impact measurement,impact interpretation & Evaluation, impact communication,Methods-Adhoc methods, Checklists methods, Matricesmethods, Networks methods, Overlays methods,Environmental index using factor analysis, Cost/benefitanalysis, Predictive or Simulation methods. Rapid assessment of Pollution sources method, predictive models for impact assessment, Applications for RS and GIS

Unit 4

Reviewing the EIA Report: Scope, Baseline Conditions, Siteand Process alternatives, Public hearing. Construction StageImpacts, Project Resource Requirements and RelatedImpacts, Prediction of Environmental Media Quality, SocioeconomicImpacts, Ecological Impacts, Occupational HealthImpact, Major Hazard/ Risk Assessment, Impact onTransport System, Integrated Impact Assessment.

Unit 5

Review of EMP And Monitoring: Environmental ManagementPlan, Identification of Significant or Unacceptable ImpactsRequiring Mitigation, Mitigation Plans and Relief &Rehabilitation, Stipulating the Conditions, What should bemonitored? Monitoring Methods, Who should monitor? Pre-Appraisal and Appraisal.

Case Studies: Preparation of EIA for developmental projects-Factors to be considered in making assessment decisions,Water Resources Project, Pharmaceutical industry, thermalplant, Nuclear fuel complex, Highway project, Sewagetreatment plant, Municipal Solid waste processing plant, Tannery industry.

Teaching Methodology:

This course planned in 3 lectures each week. The course content divided in two 42 lectures. The lectures will be conducted in both manner white board and Power Point presentation. At the end of this course student will be able to understand the concept of Environmental Impact Assessment and able to apply in further study and research.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit 2
Test-2	25 Marks	Based on Unit-2, Unit 3 and Unit 4 (70 %) and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit 4 and Unit-5 and around 30% from coverage of Test-1 and Text-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] Canter, L.W., Environmental Impact Assessment, McGraw Hill Pub. Co., 1997.

[2] David P. Lawrence, Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, 2003.

[3] Hosetti, B. B., Kumar A, Eds, Environmental Impact Assessment & Management, Daya Publishing House, 1998.

Reference Book:

[1] UNESCO, Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development, UNESCO/UNEP, Paris, 1987.

[2] Anjaneyulu.Y., and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.

[3] Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.