Indian Institute of Technology Bhubaneswar
Curriculum

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Compliance Report

Components	Subjects	Credit Recommended	Credit Approved
1. Common Core	(i) English	4	4
	(ii) Basic Science and Mathematics	20	20
	(iii) General Sciences	6	6
	(iv) Engineering Sciences	27	27
2. Breadth Basket	(i) Breadth-1 (ii) Breadth-2 (iii) Breadth-3 (iv) Breadth-4	12-14	3/4 3 3/4 3/4
3. Miscellaneous	(i) Seminar (ii) Internship (iii) Project	14	2 2 10
4. Laterals	(i) Lateral-1 (ii) Lateral-2 (iii) Lateral-3	9-12	3 3/4 3/4
5. Verticals	Theory	58-68	2nd year - 20 3rd year –23/24 4th year – 19/25
	Laboratory	18-24	18
TOTAL		**168-189**	**172/184**

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1st Semester and 2nd Semester (Common to All Disciplines of Study)

SEMESTER – I					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Mathematics-1	MA1L001	3-1-0	4	4	4
Physics/ Chemistry	PH1L001/ CY1L001	3-1-0	4	4	5-6
Mechanics / English for Communications or Learning English	ME1L001/ HS1L001 or HS1L002	3-1-0/ 3-0-2 or 3-1-0	4	4/ 5 or 4	6-9
Electrical Technology / Introduction to Programing and Data Structures	EE1L001/ CS1L001	3-1-0	4	4	10-11
Introduction to Manufacturing Processes / Engineering Drawing and Graphics	ME1P001/ CE1P001	0-0-3/ 1-0-3	2/3	3/4	11-12
Physics Laboratory/ Chemistry Laboratory	PH1P001/ CY1P001	0-0-3	2	3	12-13
Electrical Technology Laboratory / Introduction to Programing and Data Structures Laboratory	EE1P001/ CS1P001	0-0-3	2	3	13
Extra Academic Activity-1	ID1T001	0-0-3	1	3	
		Total	22/23+1	25/27 or 26+3	
SEMESTER – II					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Mathematics-2	MA1L002	3-1-0	4	4	14
Chemistry/ Physics	CY1L001/ PH1L001	3-1-0	4	4	5-6
English for Communication or Learning English / Mechanics	HS1L001 or HS 1L002/ ME1L001	3-0-2 or 3-1-0/ 3-1-0	4	5 or 4/ 4	6-9
Introduction to Programming and Data Structures/ Electrical Technology	CS1L001/ EE1L001	3-1-0	4	4	10-11
Engineering Drawing and Graphics / Introduction to Manufacturing Processes	CE1P001/ ME1P001	1-0-3/ 0-0-3	3/2	4/3	12-13
Chemistry Laboratory/ Physics Laboratory	CY1P001/ PH1P001	0-0-3	2	3	11-12
Electrical Technology Laboratory / Introduction to Programing and Data Structures Laboratory	EE1P001/ CS1P001	0-0-3	2	3	13
Extra Academic Activity -2	ID1T002	0-0-3	1	3	
		Total	23/22+1	27 or 26/ 25+3	

Syllabus for each course is given in the following pages.

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Syllabus for First Year Courses (Common to All Disciplines of Study)

SEMESTER – I

Subject Code: MA1L001	Subject Name: Mathematics-1	L-T-P: 3-1-0	Credit: 4
Pre-requisite(s): Nil			

Calculus: Rolle's theorem, Lagranges theorem, Cauchy's mean value theorem (Taylor's and Maclaurin theorems with remainders), Indeterminate forms, Concavity and convexity of a curve, points of inflexion, maximum, minimum of a function, 2nd derivative test for max min, Asymptotes and curvature, Cartesian curve tracing, polar curve tracing.
Calculus of Several Variables: Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, differentials, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Euler's theorem on homogeneous functions, harmonic functions, Taylor's expansion of functions of several variables, maxima and minima of functions of several variables, Lagrange's method of multipliers.
Vector Calculus: Double and triple integrals, Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, line and surface integrals, theorems of Green, Gauss and Stokes. Beta and Gamma functions.
Ordinary Differential Equations: First order differential equations, exact, linear and Bernoulli's form, second order differential equations with constant coefficients, Euler's equations, particular integrals by: variation of parameters, undetermined coefficients, operator method, system of differential equations.

Text Books:
1. Narayan S. and Mittal P. K. *Differential Calculus and Integral Calculus*, S. Chand & Company Ltd.
2. Thomas G. B. and Finney R. L. *Calculus and Analytic Geometry*, Pearson
3. Kreyszig E. *Advanced Engineering Mathematics*, John Wiley & Sons
5. Simmons G. F. and Robertson J. S. *Differential Equations with applications and Historical notes*, Tata McGraw-Hill Publishing Company Limited, New Delhi, India

Reference Books:
1. Bartle R. G. and Sherbert D. R. *Introduction to Real Analysis*, Wiley India
2. Jain R. K. and Iyengar S. R. K. *Advanced Engineering Mathematics,* Narosa
3. Apostol T. M. *Calculus - Vol.2*, Wiley India
4. Ross S. L. *Differential Equations*, Wiley India
5. Coddington E. A. *An Introduction to Ordinary Differential Equations*, Prentice Hall

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Subject Code: PH1L001	Subject Name: Physics	L-T-P: 3-1-0	Credit: 4

Pre-requisite(s): Nil

Classical Physics: Review of Newtonian mechanics, Lagrangian mechanics, constraints, principle of virtual work, D'Alembert's principle, Action Principle and Lagrange's equations, Velocity dependent potentials, Legendre Transformation and Hamiltonian equations, Central forces, Kepler's problem, Waves and Oscillations, Damped and Forced Oscillations, normal modes, Basics of Special Relativity, Galilean and Lorentz transformations, Time dilation and length contraction, relativistic kinematics and mass-energy equivalence. Electromagnetic Waves and Optics: Maxwell's equations, wave equation, plane electromagnetic waves, longitudinal and transverse waves, superposition, wave packets, two and three dimensional waves, energy- momentum, Poynting's theorem, electromagnetic boundary conditions, Laser, Young's experiment, interferometers, diffraction, Fraunhofer diffraction (single slit), dispersion. Wave Mechanics: Failure of classical physics, qualitative review of relevant experiments, de Broglie waves, uncertainty principle, wave function and Schrodinger equation, probability interpretation, particle on a chain, potential barrier and quantum tunneling, potential well, Harmonic oscillator, operator algebra, Hydrogen atom and angular momentum algebra.

Text/ Reference Books:

1. Crawford F.S. Waves, *Vol. 3, Berkely Physics Series*.
2. Goldstein, *Classical Mechanics*, Pole and Safko, Pearson Education Inc.
3. Saleh and Teich. *Fundamentals of Photonics*, Wiley-Interscience.
4. Ghatak A. *Optics*, McGraw-Hill.
5. Griffiths D.J. *Introduction to Quantum Mechanics*, Pearson Education Inc.
6. Pain H. J. *The Physics of Vibrations and Waves*, Wiley.
7. Resnick R. *Introduction to Special Relativity*, John Wiley (Asia).
8. Landau L. and Lifshitz E. *Mechanics*, Oxford
9. Zweibach B. *A First Course in String Theory*, Cambridge University Press
10. Hecht E. *Introduction to Optics*, Addison-Wesley.
11. Feynmann Lecture series on Physics.
12. Sakurai J. J. *Modern Quantum Mechanics*, Benjamin-Cummings.

Subject Code: CY1L001	Subject Name: Chemistry	L-T-P: 3-1-0	Credit: 4

Pre-requisite(s): Nil

Energetics & Kinetics: (a) Basic Concepts and Laws of Thermodynamics; Entropy; Engineering Devices: Efficiency & Conversion; Thermochemistry; Bioenergetics. (b) Basic Rate Laws; Multistep Reactions; Activation Energy. (c) Transport of Ions and Gases in biofluids and across biomembranes; Equilibrium: Proton Equilibrium (aqueous & non-aqueous) including Buffers. Phase Equilibrium. Redox & Electrochemistry: Basic Concepts & Laws; Battery (Automobile to Ni-Cd and beyond); Fuel Cells; Latimer, Frost, and Pourbaix diagram; Corrosion. Bonding Models & Properties: (a) In Molecules, Supramolecules, Metals and Metal Complexes; (b) Implications on electrical, magnetic, and optical properties, (c) Absorption and Emission Spectroscopy. Functional Materials - *Design & Application:* (a) Synthetic Polymers (carbon framework,

silicon framework, fluorinated polymer), Bio & biodegradable polymers. (b) Surfactants. (c) Nanostructures, Soft materials and Thin Films. (b) Emerging applications in Energy harvesting, Memory Storage and Micro-fabrication. Industrial & Bio-inspired Chemistry: (a) Case studies on Industrial organics with emphasis to Drugs (b) Oxidation, Reduction, Catalytic hydrogenation and Electron transfer. Molecules in Daily Life: A short tour on molecules behind taste, smell, pain, colour and sex.

Text/Reference Books:
1. Brown L. and Holme, T. *Chemistry for Engineering Students*, Thomson Brooks.
2. Atkins P. and Paula J. D. Atkins' *Physical Chemistry*, Oxford.
3. Shriver, D. F. and Atkins, P. W. Atkins' *Inorganic Chemistry*, Oxford.
4. Morrison R. T. and Boyd R. N. *Organic Chemistry*, Prentice Hall.
5. Steed J. W. and Atwood J. L. *Supramolecular Chemistry*, John-Wiley.
6. Caruther W. *Reagents in Organic Chemistry*, Cambridge University Press.
7. Wiseman P. *An Introduction to Industrial Organic Chemistry*, Applied Science.
8. Hall N. *The New Chemistry*, Cambridge University Press.
9. Atkins P. Atkins' *Molecules* Cambridge University Press.
10. Cengel Y. A. and Boles M. A. *Thermodynamics-An Engineering Approach*, Tata McGraw- Hill

Subject Code: ME1L001	Subject Name: Mechanics	L-T-P: 3-1-0	Credit: 4

Pre-requisite(s): Nil

Force systems: Moment of a force about a point and about an axis; couple moment; reduction of a force system to a force and a couple. Equilibrium: Free body diagram; equations of equilibrium; problems in two and three dimensions; plane frames and trusses. Friction: Laws of Coulomb friction, problems involving large and small contact surfaces; square threaded screws; belt friction; rolling resistance. Kinematics and Kinetics of particles: Particle dynamics in rectangular coordinates cylindrical coordinates and in terms of path variables; central force motion. Properties of areas: Moments of inertia and product of inertia of areas, polar moment of inertia, principal axes and principal moments of inertia. Concept of stress and strain: Normal stress, shear stress, state of stress at a point, ultimate strength, allowable stress, factor of safety; normal strain, shear strain, Hooke's law, Poisson's ratio, generalized Hooke's law; analysis of axially loaded members. Torsion: Torsion of cylindrical bars, torsional stress, modulus of rigidity and deformation. Flexural loading: Shear and moment in beams; load, shear and moment relationship; shear and moment diagrams; flexure formula; shear stress in beams; differential equation of the elastic curve, deflection of beams. Transformation of stress and strain: Transformation of stress and strain, principal stresses, principal strains, Mohr's circle for stress and strain. Combined loading: Axial and torsional; axial and bending; axial, torsional and bending. Column: Buckling of slender columns, Euler bucking load for different end conditions.

Text/Reference Books:
1. Vector Mechanics for Engineers: *Statics and Dynamics* - Ferdinand P. Beer, E. Russell Johnston, Jr. (TMH)
2. Engineering Mechanics: *Statics and Dynamics* - I.H. Shames (Pearson)
3. Engineering Mechanics - S. Timoshenko, D. H. Young (TMH)
4. Mechanics of Materials - Ferdinand Beer, E. Russell Johnston, Jr., J. DeWolf (TMH)

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5. Elements of Strength of Materials - S. Timoshenko, D. H. Young (East West Press)
6. Mechanics of Materials - James M. Gere, Barry J. Goodno (CL Engg)
7. Engineering Mechanics - Stephan Timoshenko, D. Young (TMH)
8. Strength of Materials (Part 1) – S P Timoshenko (CBS)

Subject Code: HS1L001	Subject Name: English for Communication	L-T-P: 3-1-0	Credit: 4

Pre-requisite(s): Nil

English for Communication is an amalgamation of Literature, Language and Communication. The Literature component of the course comprises of Prose and Poetry.
Poetry:
A selection of poetry pieces spanning from 16th century to the Post-Modern Period in English, American and Indian Literature are chosen to introduce to the students to the different poets from different ages and countries and also to acquaint them with the various poetic forms like Sonnet, Ballad, Elegy, Didactic, Dramatic, Nature, Lyric, Romantic, etc. The list is an indicative one. 16th century- 17th century- Geoffrey Chaucer, William Shakespeare, Edmund Spenser, Ben Johnson, Thomas Wyatt. 17th century- 18th century- John Milton, John Donne, George Herbert, John Dryden, Oliver Goldsmith. 18th century- 19th century- Alexander Pope, Thomas Gray, Robert Burns, William Blake, William Wordsworth, Samuel Taylor Coleridge, Lord Byron, P.B. Shelley, John Keats, Robert Bridges, Robert Southey, Samuel Johnson. 19th century- 20th century- Alfred Tennyson, Robert Browning, Walter de la Mare, Thomas Hardy, A.E. Housman, Rudyard Kipling, D.H. Lawrence, Wilfred Owen, D.G. Rossetti, Christina Rossetti, Emily Dickinson, Gerald Manley Hopkins, Charlotte Bronte, Lewis Caroll, Edward Fitzgerald, Walt Whitman. 20th century- Present- Ted Hughes, Louis MacNeice, W.B. Yeats, Stephen Spender, W.H. Auden, Nissim Ezekiel, Sarojini Naidu, Jayanta Mahapatra, Robert Frost, , Ezra Pound, E.E. Cummings, T.S. Eliot, Walt Whitman, A.K. Ramanujan, Kamala Das, Rabindranath Tagore, Jack Prelutsky, Chinua Achebe, Maya Angelou, Margaret Atwood, Leonard Cohen, Louise Erdrich, Leslie Marmon Silko.
Prose:
A selection of fictional and non-fictional prose pieces spanning from 17th century to the Post-Modern Period. Fiction and non-fictional pieces from English, American, Russian and Indian Literature are chosen to introduce the students to different writings from different ages and countries. The list is an inclusive one consisting of short stories, essays, excerpts, extracts from novels, biographies and memoirs, history, travel and other forms. 17th century-18th century: Charles Dickens, William Makepeace Thackeray, George Eliot, Thomas Hardy, Lewis Carroll, Arthur Conan Doyle, John Bunyan, Rudyard Kipling, H.G. Wells, R.L, Stevenson, Jane Austen, Emily Bronte, Charles Lamb, F.M. Dostoyevsky, Nikolai Gogol, Daniel Dafoe, Jonathan Swift, Lewis Carroll; 19th century- 20th century: Oscar Wilde, O Henry, H.H. Munro, Mark Twain, Somerset Maughaum, Nathaniel Hawthorne, G.B. Shaw, G.K. Chesterton, Agatha Christie, Gerald Durrell, Will Durant, E.M. Forster, Aldous Huxley, Henry David Thoreau, Anton Chekov, Maxim Gorky, Leo Tolstoy, George Orwell, Rabindranath Tagore, M.K. Gandhi, J. Nehru, Virginia Woolf, Guy De Maupassant, Washington Irving, Margaret Fuller, Charles Darwin, Arthur Conan Doyle, F. Scott Fitzgerald, Ernest Hemingway, Edgar Allan Poe. 20th century- Present: J.M. Coetzee, R.K. Narayan, R.K. Laxman, A.P.J. Abdul Kalam, Khushwant Singh, Anita Desai, Yann Martel, Ken Kesey, Stephen King, Thomas King, Richard Wright, N Scott Momaday, Chetan Bhagat, J. Krishnamurthy, Virginia Woolf, Gerald Vizenor, Alice Walker, Chinua Achebe, Jeffrey Archer, Issac Asimov, Roald Dahl, J.R.R. Tolkien, D.H. Lawrence, James Joyce, Oran Pamuk, Salman Rushdie, Bertrand Russell, Ruskin Bond, A.G. Gardiner, John Steinbeck.

Communication:
Because communication is so important in business, businesses want and need people with good communication skills. Business communication is a blend of skills like writing and speaking well, displaying proper etiquettes and listening attentively. Communications through technology greatly enhances one's ability to communicate effectively and articulately. For example, E-mails often result in a sender's language skills being placed in front of different people simultaneously; while audio and video will reveal the calibre of one's verbal and diplomatic strengths. The communication aspect of the English for Communication Course includes:

1. The Basics of Business Communication
2. Importance of Listening
3. Barriers in the Communication Process
4. Business Letters (Letter of Inquiry, Complaint, Cover Letter)
5. Resume Writing
6. Memo and Memo Reports
7. Report Writing
8. Fax and E Mail

English Laboratory:
Objective: The laboratory component included in the course provides an ideal platform for students to prepare themselves into confident and self-assured individuals. The Lab course is designed to inculcate confidence and clarity in presentation and expression of thought, views and ideas through practice and exercises. It constitutes six basic components to improve listening, reading and writing skill of the students.
Lessons:
1. Pronunciation (Basic sounds of English like Long/Short Vowels; All consonants)
2. Stress Intonation (Rising and Falling)
3. Speaking- Oral Presentations, Group Discussions, Story Telling, Role Plays
4. Listening – Importance and Practice
5. Reading- Practice
6. Writing (Paragraph writing, good writing and bad writing with samples, Indianism), Grammar (Basic- Articles, Prepositions, Verbs, Common Errors , etc)

Text/Reference Books:
1. John Seely, *The Oxford Guide to Writing and Speaking*, OUP
2. Krishna Mohan and Meenakshi Raman, *Effective English Communication*, TMH
3. R.W.Lesikar and John.D. Pettit, *Business Communication: Theory and Application*, All India Traveller Bookseller
4. Francis Soundaraj, *Speaking and Writing for Effective Business Communication*, Macmillan.
5. Herta A. Murphy, et al., *Effective Business Communication*, Tata Mc-Graw Hill: New Delhi
6. Ronald B. Adler and George Rodman, *Understanding Human Communication*, Oxford University Press: New York

Subject Code: HS1L002	Subject Name: Learning English	L-T-P: 3-1-0	Credit: 4
Pre-requisite(s): Nil			

The Learning English Course is designed to improve the English Listening, Speaking, Reading and Speaking skills of students.

I. Prose

A selection of fictional and non-fictional prose pieces spanning from 17th century to the Post-Modern Period. Fiction and non-fictional pieces from English, American, Russian and Indian Literature are chosen to introduce the students to different writings from different ages and countries. The list is an inclusive one consisting of short stories, essays, excerpts, extracts from novels, biographies and memoirs, history, travel and other forms.

17th century- 18th century- Charles Dickens, William Makepeace Thackeray, George Eliot, Thomas Hardy, Lewis Carroll, Arthur Conan Doyle, John Bunyan, Rudyard Kipling, H.G. Wells, R.L, Stevenson, Jane Austen, Emily Bronte, Charles Lamb, F.M. Dostoyevsky, Nikolai Gogol, Daniel Dafoe, Jonathan Swift, Lewis Carroll.

19th century- 20th century- Oscar Wilde, O Henry, H.H. Munro, Mark Twain, Somerset Maughaum, Nathaniel Hawthorne, G.B. Shaw, G.K. Chesterton, Agatha Christie, Gerald Durrell, Will Durant, E.M. Forster, Aldous Huxley, Henry David Thoreau, Anton Chekov, Maxim Gorky, Leo Tolstoy, George Orwell, Rabindranath Tagore, M.K. Gandhi, J. Nehru, Virginia Woolf, Guy De Maupassant, Washington Irving, Margaret Fuller, Charles Darwin, Arthur Conan Doyle, F. Scott Fitzgerald, Ernest Hemingway, Edgar Allan Poe.

20th century- Present- J.M. Coetzee, R.K. Narayan, R.K. Laxman, A.P.J. Abdul Kalam, Khushwant Singh, Anita Desai, Yann Martel, Ken Kesey, Stephen King, Thomas King, Richard Wright, N Scott Momaday, Chetan Bhagat, J. Krishnamurthy, Virginia Woolf, Gerald Vizenor, Alice Walker, Chinua Achebe, Jeffrey Archer, Issac Asimov, Roald Dahl, J.R.R. Tolkien, D.H. Lawrence, James Joyce, Oran Pamuk, Salman Rushdie, Bertrand Russell, Ruskin Bond, A.G. Gardiner, John Steinbeck.

II. Writing- Paragraph, Essay, Précis, Dictation, Comprehension, Letter Writing

III. English Tutorial- Practice Listening and Speaking English

IV. English Practice- Grammar Assignments and Workbook (Everyday English Level I/II)

Text/Reference Books:

1. John Seely, *The Oxford Guide to Writing and Speaking*, OUP
2. Krishna Mohan and Meenakshi Raman*, Effective English Communication*, TMH
3. R.W.Lesikar and John.D. Pettit, *Business Communication: Theory and Application*, All India Traveller Bookseller
4. Francis Soundaraj, *Speaking and Writing for Effective Business Communication*, Macmillan.
5. Herta A. Murphy, et al., *Effective Business Communication*, Tata Mc-Graw Hill: New Delhi
6. Ronald B. Adler and George Rodman, *Understanding Human Communication*, Oxford University Press: New York

Subject Code: EE1L001	Subject Name: Electrical Technology	L–T–P: 3-1-0	Credit: 4
Pre-requisite(s): Nil			

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Introduction: Sources of energy; General structure of electrical power systems, Power transmission and distribution via overhead lines and underground cables, Steam, Hydel, and Nuclear power generation; DC Networks: Kirchhoff's laws, node voltage and mesh current methods, Delta-star and star-delta conversion, Superposition principle, Thevenin's, Norton's theorems and Maximum power transfer theorem; Single phase AC Circuits: Single phase EMF generation, average and effective values of sinusoids, solution of R,L,C series circuits, the j operator, complex representation of impedances, phasor diagram, power factor, power in complex notation, solution of parallel and series – parallel circuits; Three phase AC Circuits: Three phase EMF generation, delta and Y – connections, line and phase quantities, solution of three phase circuits, balanced supply voltage and balanced load, phasor diagram, measurement of power in three phase circuits, Three phase four wire circuits; Magnetic Circuits: Ampere's circuital law, B – H curve, solution of magnetic circuits, hysteresis and eddy current losses; Transformers: Construction, EMF equation, ratings, phasor diagram on no load and full load, equivalent circuit, regulation and efficiency calculations, open and short circuit tests, auto-transformers; DC Machines: Construction, EMF and Torque equations, Characteristics of DC generators and motors, speed control of DC motors and DC motor starters; Electrical Measuring Instruments: DC PMMC instruments, shunt and multipliers, multimeters, Moving iron ammeters and voltmeters, dynamometer, wattmeter, AC watthour meter, extension of instrument ranges.

Text/Reference Books:

1. E. Hughes*, "Electrical Technology,"* Pearson Education, 2010.
2. V. Del Toro, *"Electrical Engg Fundamentals,"* PHI Learning, 2009.
3. I. J. Nagrath and D. P. Kothari, '*Basic Electrical Engineering'* TATA Mc Graw Hill Education, 2009.
4. D. A. Bell, *"Electric Circuits,"* 7th Ed., Oxford Higher Education, 2009.

Subject Code: CS1L001	Name: Introduction to Programming and Data Structure	L-T-P: 3-1-0	Credit: 4
Pre-requisite(s): Nil			

Digital computer fundamentals, concepts of algorithms and introduction to programming – examples; Constants and variables – data types, operators and expressions - type conversions, types of expressions; Assignment statements, input-output statements - concepts of data formats; Control statements: branching – if-else statements; iteration – while, do-while, for statements. nested control structures, switch, break and continue statements; Functions and recursion – examples; concepts of parameter passing by values and by reference; Arrays – single and multidimensional, examples – searching and sorting; Introduction to pointers, character strings and arrays, pointers and arrays; Structures, linked lists, dynamic allocation, stacks and queues, binary trees and tree traversals; Data files – creating, opening, closing and operating data files; (The programming language C to be used as the basis language).

Text Books:
1. B. Gottfried, *"Schaum's Programming with C,"* Tata McGraw-Hill.
2. E. Balaguruswamy, *"Programming in ANSI C,"* Tata McGraw-Hill.
3. Y. Kanetkar, *"Let us C,"* BPB Publications.
4. S. Lipschutz, *"Data Structures, Schaum's Outlines Series,"* Tata McGraw-Hill.

Reference Books:
1. Brian W. Kernighan and Dennis M. Ritchie, "*The C Programming Language*," Prentice Hall of India.
2. Ellis Horowitz, Satraj Sahni and Susan Anderson-Freed, "*Fundamentals of Data Structures in C*," W. H. Freeman and Company.

Subject Code: ME1P001	Name: Introduction to Manufacturing Processes	L-T-P: 0-0-3	Credit: 2
Pre-requisite(s): Nil			

Machining:
- Introducing to various machine tools and demonstration on machining
- Making a steel pin as per drawing by machining in centre lathe
- External screw thread on lathe
- Making a cast iron Vee block by shaping
- Making a regular polygon prism (MS)/ hexagon by milling machine
- Slot fitting by milling machine
- Study of machining in machining in machining centre (CNC)
- Study of Electro discharge machining (EDM)

Foundry Practice:
- Orientation, demonstration and practice on metal casting
- Practicing sand moulding using split and uneven parting line pattern
- Practice on CO2 moulding and machine moulding
- Mechanised sand preparation and melting practice

Welding Practice:
- Practice on electric arc welding
- Practice on oxy-acetylene gas welding
- Introduction and demonstration on submerged arc welding

Metal Forming:
Demonstration of deep drawing and other forming process

Text/Reference Books:
1. Chapman W.A.J., *Workshop Technology - Part I*, CBS Publishers.
2. Chapman W.A.J., *Workshop Technology - Part II*, CBS Publishers.
3. Hajra Choudhury S.K., *Elements of workshop Technology Vol. I*, Media Promoters.
4. Hajra Choudhury S.K., *Elements of workshop Technology Vol. II*, Media Promoters.

Subject Code: CE1P001	Subject Name: Engineering Drawing and Graphics	L-T-P: 1-0-3	Credit: 3
Pre-requisite(s): Nil			

Introduction to IS code of drawing; Conics and Engineering Curves – ellipse, parabola, hyperbola, cycloid, trochoid, involute; Projection of lines – traces, true length; Projection of planes and solids; sold objects – cube, prism, pyramid, cylinder, cone and sphere; Projection on Auxiliary planes; Isometric projection, isometric scale; Section of solids – true shape of section; Introduction to CAD tools – basics; Introduction of Development and Intersection of surfaces.

Text/Reference Books:
Bhatt N.D.*Elementary Engineering Drawing*, Charotar Publishing House.
Gill P.S.*Engineering Drawing & Engg. Graphics*, S. K. Kataria & Sons.
Lakshminarayan L.V. and Vaish R.S.*Engineering Graphics*, Jain Brothers.

Subject Code: PH1P001	Subject Name: Physics Laboratory	L-T-P: 0-0-3	Credit: 2

Pre-Requisite(s): Nil

To determine the damping constant of the pendulum for different eddy damping current.
To verify Malus's Law of polarization of light.
To determine the wave length of the prominent lines of mercury source by a plane transmission diffraction grating and to calculate the resolving power and dispersive power of the grating.
To study the intensity distribution of Fraunhofer diffraction pattern by a single slit and measure the width of the slit for a given wavelength of laser light.
To determine the wavelength of the given source using the Michelson interferometer.
To determine the wave length of the given source using Fresnel's biprism.
To find out the resonance and beat time period of the coupled pendulum and find out the spring constant.
To study the interference pattern and determine the radius of curvature of the plano convex lens using Newton's rings apparatus.

Text/Reference Books:
1. Ghatak *A. Optics*, McGraw-Hill.
2. Pain H. J. *The Physics of Vibrations and Waves*, Wiley.

Subject Code: CY1P001	Subject Name: Chemistry Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite(s): Nil

Experiment-1: Determination of the surface tension and parachor of a homologous series.
Experiment -2: Measurement of the coefficient of viscosity of ethanol & ethanol -water system.
Experiment -3: Studies on acid-base conductometric titration.
Experiment- 4: Studies on PH metric titration of strong base with strong acid.
Experiment -5: Estimation of sulphate ion in tap water by nepheloturbidimetric analysis.
Experiment - 6: Spectrophotometric determination of acid dissociation constant (pka) of methyl red (MR) an acid base indicator.
Experiment -7: Determination of solubility and solubility product of a sparingly soluble salt at room temperature by conductometric method.

Experiment- 8: Potentiometric titration of a given sodium carbonate solution with aquesous hydrochloric acid solution.
Experiment -9: kinetics of ester hydrolysis.
Experiment -10: Detection of functional groups in an organic compound for solid sample.
Experiment-11: Detection of functional groups in an organic compound for liquid sample.
Experiment -12: Thin layer chromatography (TLC).

Text/Reference Books:
1. Nad, A. K.; Mahapatra, B. and Ghoshal A. *An advanced course in practical chemistry*, New Central Book Agency (P) Ltd.
2. Elias A. J. *A collection of general chemistry experiments*, University Press.
3. Maity S. and Ghosh N. *Physical Chemistry Practical*, New Central Book Agency (P) Ltd.

Subject Code: EE1P001	Subject Name: Electrical Technology Laboratory	L-T-P: 0-0-3	Credits: 2
Prerequisite(s): Electrical Technology			
Experiments as per the topics in the syllabus for the course `Electrical Technology' (EE1L001) will be conducted in the laboratory class.			
Text Books: 1. E. Hughes, *"Electrical Technology,"* Pearson Education, 2010. 2. V. Del Toro, "Electrical Engg Fundamentals," PHI Learning, 2009.			
Reference Books: 1. I. J. Nagrath and D. P. Kothari, `*Basic Electrical Engineering'* TATA McGraw Hill Education, 2009. 2. D. A. Bell, *"Electric Circuits,"* 7th Ed., Oxford Higher Education, 2009.			

Subject Code: CS1P001	Subject Name: Introduction to Programming and Data Structures Laboratory	L-T-P: 0-0-3	Credit: 2
Prerequisite(s): Introduction to Programing and Data Structures			
Familiarization of a computer and the environment; Execution of sample programs related to Expression evaluation, Conditionals and branching, Iteration, Functions, Recursion, Tail-recursion, Arrays, String manipulation, Structures, Linked lists, Doubly-linked lists and Binary Trees. Execution of programs involving abstract data types like Stacks and Queues.			

Semester-II

Subject Code: MA1L002	Subject Name: Mathematics-II	L-T-P: 3-1-0	Credit: 4

Pre-requisite(s): Nil

Linear Algebra: Vector spaces, subspaces, span, Linear dependence, independence of vectors, basis, dimension, linear transformations, range, kernel, rank, nullity of linear transformation, space of all linear transformations, Operator equations, matrix associated with a linear map, linear map associated with a matrix, elementary row operations, solution of algebraic equations, consistency conditions. Matrix inversion by row operations, Eigenvalues and eigenvectors, Hermitian and skew Hermitian matrices, orthogonal and unitary matrices, application to reduction of quadrics.

Complex Analysis: Limit, continuity, differentiability and analyticity of functions Cauchy-Riemann equations (cartesian and polar), Harmonic functions, Elementary complex functions, Line integrals, upper bounds for moduli of contour integrals, Cauchy's integral theorem, Cauchy's integral formula, derivatives of analytic functions, Power series, Taylor's series, Laurent's series, Zeros and singularities, Residue theorem, evaluation of improper integrals by residue theorem.

Text books:
1. Strang G. *Linear Algebra and its applications, Cengage Learning*
2. Churchill R.V. and Brown J.W. *Complex Variables and Applications*, Mc-Graw Hill
3. Kreyszig E. *Advanced Engineering Mathematics*, John Wiley & Sons

Reference Books:
J1. ain R. K. and Iyengar S. R. K. *Advanced Engineering Mathematics*, Narosa
2. Krishnamurthy V., Mainra V. P. and Arora J.L. *An Introduction to Linear Algebra*, Affiliated East-West Press Pvt Ltd New Delhi
3. Axler S. *Linear Algebra Done Right*, UTM, Springer
4. Poole D. *Linear Algebra*: *A Modern Introduction*, Brooks/Cole

All other courses are same as Semester-I Courses.

Indian Institute of Technology Bhubaneswar
Curriculum

B. Tech (Civil Engineering) and Dual Degree (B.Tech. Civil Engineering and M.Tech. Structural/Transportation/Environmental Engineering)

Curriculum (3rd Semester – 6th Semester)

SEMESTER - III					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Introduction to Material Science and Engineering	**ID2L001**	2-0-0	2	2	
Introduction to Bioscience and Technology	**ID2L002**	2-0-0	2	2	
Basic Electronics		3-1-0	4	4	
Probability, Statistics & Stochastic Processes (Mathematics – 3)	**MA2L003**	3-1-0	4	4	
Solid Mechanics	**CE2L001**	3-1-0	4	4	17
Surveying	**CE2L002**	3-0-0	3	3	17
Basic Electronics Laboratory		0-0-3	2	3	
Surveying Practice	**CE2P002**	0-0-3	2	3	17
Project Seminar	**CE2S001**	0-0-0	2	0	
		Total	**25**	**25**	

SEMESTER – IV					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Lateral 1			3/4	3/4	
Breadth-1			3/4	3/4	
Environmental Science, Technology and Management	**ID2L003**	2-0-0	2	2	
Introduction to Civil Engineering and Construction Materials	**CE2L003**	3-0-0	3	3	18
Structural Analysis	**CE2L004**	3-1-0	4	4	18
Hydraulics	**CE2L005**	3-1-0	4	4	18
Transportation Engineering	**CE2L006**	3-0-0	3	3	19
Transportation Engineering Laboratory	**CE2P001**	0-0-3	2	3	19
		Total	**24/26**	**25/27**	

SEMESTER - V					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Lateral 2			3/4	3/4	
Breadth-2			3	3	
Design of Reinforced Concrete Structures	**CE3L001**	3-1-0	4	4	19
Soil Mechanics	**CE3L002**	3-1-0	4	4	19-20
Water Resources Engineering	**CE3L003**	3-0-0	3	3	20
Structural Engineering Laboratory	**CE3P001**	0-0-3	2	3	20
Soil Mechanics Laboratory	**CE3P002**	0-0-3	2	3	20
Water Resources Engineering Laboratory	**CE3P003**	0-0-3	2	3	21
		Total	**23/24**	**26/27**	

Indian Institute of Technology Bhubaneswar
Curriculum

SEMESTER - VI					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Lateral 3			3	3	
Breadth - 3			3	3	
Design of Steel Structures	**CE3L004**	3-0-0	3	3	21
Foundation Engineering	**CE3L005**	3-0-0	3	3	21
Water and Wastewater Engineering	**CE3L006**	3-1-0	4	4	21-22
Civil Engineering Drawing and Estimation	**CE3P004**	0-0-3	2	3	22
Structural Design and Detailing	**CE3P005**	0-0-6	4	6	22
Water and Wastewater Engineering Laboratory	**CE3P006**	0-0-3	2	3	22
		Total	**24**	**28**	
INDUSTRIAL SUMMER TRAINING AFTER 6th SEMESTER					

Indian Institute of Technology Bhubaneswar
Curriculum

B. Tech (Civil Engineering) and Dual Degree (B.Tech. Civil Engineering and M.Tech. Structural/Transportation/Environmental Engineering)

Syllabus (3rd Semester – 6th Semester)

SEMESTER – III

Subject Code: CE2L001	Name: Solid Mechanics	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Stress analysis: forces and moments, theory of stress, principal stresses and stress invariants, compatibility equations, equilibrium equations; Strain analysis: deformation and velocity gradients, Lagrangian and Eulerian description andfinite strain, small deformation theory, principal strains and strain invariants, compatibility conditions; Bending of Symmetric and non-symmetric sections; Thick cylinders and pressure vessels; Introduction of theory of elasticity Simple problems (semi-inverse method);Theories of failure; Stress concentration; Fatigue; Creep and relaxation.

Text/Reference Books:

1. Kazioni, S.M.A., Solid Mechanics, Tata McGraw Hill,
2. Popoo, E.P., Introduction to Mechanics of Solids, Prentice Hill of India
3. Crandall, S.H., Dahl, N.C., Lardner, T.J. and Sivakumar, M.S., An Introduction to Mechanics of Solids, Tata McGraw Hill
4. Jindal, U. C., Strength of Materials, Pearson
5. Timoshenko, Strength of Materials, CBS

Subject Code: CE2L002	Name: Surveying	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction and basic principles of surveying; elements of surveying and mapping, concept of triangulation; measurement of horizontal distances (chain surveying) and correction; plane table surveying; compass surveying; traversing; measurement of vertical distances (levelling); contouring; theodolite surveying; computation of area and volume; curve setting; Basics of total station, global positioning system (GPS), introduction to remote sensing (RS) and Geographical Information System (GIS).

Text/Reference Books:

1. Punmia, B.C., Jain, A.K. and Jain, A.K. Surveying Vol. I, II and III, Laxmi Publication Pvt. Ltd.
2. Arora, K. R., Surveying Vol. I, II and III, Standard Book House.
3. Gopi, S., Sathikumar, R. and Madu, N., Advanced Surveying: Total Station, GIS and Remote Sensing, Pearson Education India.
4. Subramanian, R.S. Surveying and levelling, Second Edition, Oxford Univ. Press.

Subject Code: CE2P002	Name: Surveying Practice	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Chaining, offsets, field book entry, triangulation/traversing, plane table surveying, compass surveying, levelling using auto/dumpy-level instrument, level book entry, preparation of contour map, theodolite surveying for angular and linear measurements, surveying through total station equipment, setting out simple works.

Text/Reference Books:
1. Punmia, B.C., Jain, A.K. and Jain, A.K. Surveying Vol. I, II and III, Laxmi Publication Pvt. Ltd.
2. Arora, K. R., Surveying Vol. I, II and III, Standard Book House.

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Curriculum

SEMESTER – IV

Subject Code: CE2L003	Name: Introduction to Civil Engineering and Construction Materials	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to Civil Engineering; Major Divisions; Civil Engineering Infrastructures; Ethics in Civil Engineering; Properties of construction material and their evaluation; test methods and specifications; Cement – chemical composition, properties such as setting, strength, fineness, hydration; Aggregates – sources, properties, chemical reactivity; Concrete - constituents, proportioning, properties in fresh and hardened state, characteristic strength, quality control, transportation and placing, testing, porosity; Admixtures – chemical, mineral; Steel – properties, types of steel, steel in civil engineering; Bricks – manufacture, properties and classification; masonry bonds; Wood - Structure, defects & preservation; Paints, New materials – Fibre reinforced plastics (FRPs), epoxy-coated bars, Geo-synthetics etc., Construction methodologies and equipment.

Text/Reference Books:

1. Taylor, G.D., Materials of Construction, Prentice Hall
2. Mehta P.K. and Montiero, P.M.J., Concrete – Material, Microstructure and Properties, Tata Mcgraw Hill
3. Gambhir, M.L., Concrete Technology, Tata Mcgraw Hill
4. Neville, A.M. and Brooks, J.J., Concrete Technology, ELBS/Longman
5. Neville, A.M., Properties of Concrete, 4th Edition, ELBS/Longman
6. Dayaratnam, P. Brick and Reinforced Brick Structures, Oxford and IBH
7. Ghose, D.N., Construction Materials, Tata Mcgraw Hill
8. Relevant IS codes for testing and specifications

Subject Code: CE2L004	Name: Structural Analysis	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Stability and Determinacy of Structures; Analysis of Statically Determinate Structures; Review of shear force and bending moment diagrams in beams and frames; Plane trusses: Deflection of trusses; Deflection of beams and frames; Influence line diagrams and moving loads; Analysis of Statically Indeterminate Structures; Force and stiffness methods of analysis; Plane trusses by using method of consistent deformations, Beams and frames: Plane trusses by using direct stiffness method; Curved beams, arches and rings;

Text/Reference Books:

1. Wang, C.K., Intermediate Structural Analysis, McGraw Hill
2. Vazirani, V.N. and Ratwani, M.M., Analysis of Structures Vol-1, Vol-2, Khanna Publishers
3. Ramamrutham, S. and Narayan, R., Theory of Structures, Dhanpat Rai

Subject Code: CE2L005	Name: Hydraulics	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Basic properties of water; Determination of hydrostatic forces; Kinematics of flow; Potential flow; Continuity, Energy and Momentum principles; Open channel flow; Uniform and gradually varied flows; Dimensional analysis; Hydraulic similitude and Modelling; Flow in pipes and Pipe networks; Hydraulics machines; Pumps and Turbines.

Text/Reference Books:

1. Subramanya, K., Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill
2. Kundu, P.K., Cohen, I.M. and Dowling, D.R., Fluid Mechanics, Academic Press, Elsevier
3. White, F.M., Fluid Mechanics, Tata McGraw Hill
4. Streeter, V.L., Fluid Mechanics, Tata McGraw Hill

Indian Institute of Technology Bhubaneswar
Curriculum

Subject Code: CE2L006	Name: Transportation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Different Modes of Transportation; Highway Development in India; Highway Alignment, Survey and Detailed Project Report; Geometric Design of Highways: cross-sectional elements, horizontal and vertical alignments; Elements of Traffic Engineering; Pavement Materials: subgrade soil, aggregates, bituminous binders; Pavement Design: design of flexible and rigid pavements, Elements of Highway Construction: embankment, subgrade, subbase and base courses, bituminous surface courses, concrete pavements, soil stabilization; Drainage; Evaluation and Maintenance of highways.

Text/Reference Books:

1. Khanna, S. K. and Justo, C.E.G., Highway Engineering, Nem Chand & Bros
2. Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers
3. Chakraborthy, P. and Das, A., Principles of Transportation Engineering, Prentice Hall of India

Subject Code: CE2P001	Name: Transportation Engineering Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Tests on Bitumen: Penetration Test, Viscosity Test, Ductility Test, Softening Point Test; Tests on Aggregates: Crushing test, Abrasion Test, Impact Test, Shape Test; CBR test on Soil, Dynamic Cone penetrometer Test, Roughness measurement of road surface, Traffic Studies: Classified Traffic Volume Count, Speed Studies etc.

Text/Reference Books:

1. Khanna, S. K. and Justo, C.E.G., Highway Material Testing, Nem Chand & Bros.
2. Khanna, S.K, Justo, A and Veeraragavan, A, Highway Materials and Pavement Testing, Nem Chand & Bros.
3. Kadiyali, L. R., Traffic Engineering and Transportation Planning, Khanna Publishers

SEMESTER – V

Subject Code: CE3L001	Name: Design of Reinforced Concrete Structures	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Introduction to the design of Concrete structures: Structural Systems, Materials, Loadings and Structural Analysis, Working Stress Design, Ultimate Load Design, Limit State Design; Working Stress Design: Beams for Bending Moment and Shear Force; Limit State Design: Beams for Bending Moment, Shear Force, Bond and Torsion. Axially and eccentrically loaded Columns. Beam-Columns for combined compression and flexure. One and two-way Slabs, Structural Components: Isolated and Combined Footings; Lintels, Stair Cases, Retaining Walls.

Text/Reference Books:

1. Gambhir, M.L., Design of Reinforced Concrete Structures, PHI Learning
2. Varghese, P.C., Limit State Design of Reinforced Concrete, PHI Learning
3. Pillai, S.U. and Menon, D., Reinforced Concrete Design, Tata McGraw Hill
4. Punmia, B.C., Jain A.K. and Jain A.K., Reinforced Concrete Structures Vol-I and II, Laxmi Publications
5. Park, R. and Pauley, T., Reinforced Concrete Structures, Willey International

Subject Code: CE3L002	Name: Soil Mechanics	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Introduction, formation of soils, index properties and classification of soils, soil compaction, proctor and modified compaction, field control of compaction, effective stress, stress point and stress path, soil-water-system - surface tension and capillarity, Darcy's law, permeability

of soils, methods of determining coefficient of permeability, seepage analysis, flow nets, piping, quick sand condition, compressibility and consolidation of soils, normally and over consolidated soil, time rate of consolidation, determination of coefficient of consolidation, shear strength of soils, direct shear and triaxial tests, Mohr-Coulomb strength criterion, CU, CD and UU tests, pore pressures, Skempton's pore pressure coefficients.

Text/Reference Books:

1. Murthy, V.N.S., Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering by Marcel Dekkar, Inc., USA
2. Das, B.M., Principles of Geotechnical Engineering, PWS Publishing Company, Boston, USA.
3. Terzaghi, K., Ralph B.P. and Mesri, G., Soil Mechanics in Engineering Practice, John Wiely and Sons, Inc.
4. Muniram, B., Soil Mechanics and Foundations, John Wiely and Sons, Inc.
5. Lambe, T.W., Whitman, R.V., Soil Mechanics, John Wiely and Sons, Inc. Canada.
6. Parry, R.H.G., Mohr Circles, Stress Paths and Geotechnics, E & FN SPON publishers.

Subject Code: CE3L003	Name: Water Resources Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concepts of hydrologic cycle; Measurement and analysis of precipitation and runoff; Hydrograph analysis; Irrigation requirement of crops; Design of canals; Design and drawing of weirs and barrages; cross drainage works; Classification; analysis; design and drawing of Gravity and Earth dams; Design and drawing of spillways and energy dissipators.

Text/Reference Books:

1. Subramanya, K., Engineering Hydrology, Tata McGraw-Hill
2. Garg, S.K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers
3. Chow, V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology, Tata McGraw-Hill

Subject Code: CE3P001	Name: Structural Engineering Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Casting and load-deformation test of reinforced concrete and post tensioned beams; Cement test: Standard consistency, setting times, compressive strength, fineness and soundness; Aggregate Tests: Sieve analysis, Bulking of sand, Aggregate crushing value, Absorption, Unit weights; Tension test of MS, HYSD, HT bars: Yield/Proof stress, Ultimate Strength, Young's modulus, percentage elongation; Compressive strength of bricks and Pre-conditioning; Load deformation testing of steel beam; Concrete mix design and slump test; Demonstration of flow table, compacting factor and V.B. tests; Compressive strength of cubes by Non-Destructive Testing; Dynamics of SDOF, MDOF systems; Indirect tensile strength of cylinders.

Subject Code: CE3P002	Name: Soil Mechanics Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Specific gravity test, sieve analysis, hydrometer analysis, Atterberg's limits tests, Proctor compaction test, relative density of sand, in-situ density test, permeability tests, direct shear test, unconfined compression test, vane shear test, triaxial tests, consolidation test.

Text/Reference Books:

1. Lambe, T.W., Soil Testing for Engineers John Wiley & Sons Inc.
2. Murthy, V.N.S., Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, Marcel Dekkar, Inc., USA.
3. Robert W.D., Soil Testing Manual: Procedures, Classification Data, and Sampling Practices, McGraw-Hill Professional.

Indian Institute of Technology Bhubaneswar
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Subject Code: CE3P003	Name: Water Resources Engineering Laboratory	L-T-P: 0-0-3	Credit: 2
Prerequisite: CE2L005: Hydraulics			
Experiments on flow measurements in open channels and pipes; verification of momentum and energy equations; hydraulic jump; measurement of hydrostatic and hydrodynamic forces; flow in open channels; specific energy			

SEMESTER – VI

Subject Code: CE3L004	Name: Design of Steel Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to Steel Structure Design: Structural Systems, Design Loads and Load Combinations, Rolled Sections and Built-up sections; Working Stress Design; Plastic Design; Limit State Design Methods; Design of structural fasteners: rivets, bolts and welds. Simple and Eccentric Connections; Design of tension members; Design of compression members; Design of Built-up column using lacing and battening; Design of flexure members; Design of Beam-Column; Design of Column Bases; Design of Plate Girder and Gantry Girder.

Text/Reference Books:

1. Subramanian, N., Design of Steel Structures, Oxford University Press
2. Duggal, S.K., Limit State Design of Steel Structures, McGraw Hill
3. Ram, K S, Design of Steel Structures, Pearson Education

Subject Code: CE3L005	Name: Foundation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, examples of foundation problems, site characterization, soil exploration, site investigation methods, in-situ tests, Bearing capacity: general, local and punching shear failure, effect of size, shape, depth and water table, Settlement of foundations: elastic, consolidation and total settlement, Types of foundation: shallow and deep foundations, isolated, combined, mat etc., contact pressure distribution, basics of design of shallow foundation, deep foundation type, load transfer mechanism in piles, pile capacity, laterally loaded pile, test pile and pile load test, efficiency of pile group, settlement of pile, earth pressure theories: Rankine's theory, Coulomb's theory, Stability analysis of earth retaining structures - gravity, cantilever, counterfort, Slope stability: finite slopes and infinite slopes, Bishop's simplified method, method of slices.

Text/Reference Books:

1. Bowles, E., Foundation Analysis and Design by Joseph, McGraw Hill Higher, USA.
2. Das, B. M., Principles of Foundation Engineering, Cengage Learning.
3. Das, B. M., Principles of Geotechnical Engineering, Cengage Learning.
4. Budhu, M., Soil mechanics and foundations, Wiley Publishers, New Delhi.
5. Murthy, V. N. S., Principles of Soil Mechanics and Foundation Engg, UBSPD.
6. Khan, I.H., A text book of Geotechnical Engg, Prentice Hall India.
7. Gopal Ranjan & Rao, A. S. R. Basic and Applied Soil Mechanics, Wiley Eastern Ltd.
8. Bowles, Joseph E. Foundation analysis and design, McGraw-Hill Publishers

Subject Code: CE3L006	Name: Water and Wastewater Engineering	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

General requirement for water supply, population forecasting and water demand, sources, intake, pumping and transportation of water; Physical, chemical and biological characteristics of water and their significance, Water quality criteria, Water borne diseases, Natural purification of water sources. Engineered systems for water treatment: aeration, sedimentation, softening, coagulation, filtration, adsorption, ion exchange, and disinfection. Generation and collection of wastewater, quantities of sanitary wastes and storm water.

Design of sewerage system Primary, secondary and tertiary treatment of wastewater; Wastewater disposal standards. Basics of microbiology. Biological wastewater treatment systems: Aerobic processes - activated sludge process and its modifications, trickling filter, RBC, Anaerobic Processes- conventional anaerobic digester, High rate and hybrid anaerobic reactors. Sludge digestion and handling. Disposal of effluent and sludge Design problems on water and wastewater treatment units and sludge digestion.

Text/Reference Books:

1. Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed.
2. McGhee, T. J, Water Supply and Sewerage, McGraw-Hill Inc.
3. Davis, M. L and Cornwell, D. A, Introduction to Environmental Engineering, McGraw-Hill, Inc.
4. Metcalf & Eddy, Wastewater Engineering- Treatment and Reuse (Revised by G. Tchobanoglous, F. L. Burton and H. D. Stensel), Tata McGraw Hill.
5. Sawyer, C. N, McCarty, P. L and Parkin, G. F., Chemistry for Environmental Engineers, McGraw- Hill.
6. APHA, Standard Methods Examination of Water and Wastewater, American Public Health Association, Washington DC.
7. Manual for Sewer and Sewerage, Central Public Health & Environmental Engineering Organisation, Ministry of Housing and Urban Development, Govt. of India.
8. Manual for water supply and treatment, Central Public Health & Environmental Engineering Organisation, Ministry of Housing and Urban Development, Govt. of India.

Subject Code: CE3P004	Name: Civil Engineering Drawing and Estimation	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Building drawing: Components of buildings - Plan, elevation and section of buildings; Hands on Practice using AutoCAD or Solid Works, Estimation: Central line method, short wall - long wall method, units of measurement, Rate analysis, Cost estimation for buildings and other structures.

Text/Reference Books:

1. Malik, R.S. and Meo, G.S. Civil Engineering Drawing, Computech Publications Limited
2. Dutta, B.N., Estimating and Costing in Civil Engineering: Theory and Practice including Specification and Valuation, Sangam Books
3. Chakraborti, M., Estimating, Costing, Specification, Valuation in Civil Engineering, Chakraborti

Subject Code: CE3P005	Name: Structural Design and Detailing	L-T-P: 0-0-6	Credit: 4

Prerequisite: CE3L001: Design of Reinforced Concrete Structures

Detailed Design of Multistoried RC Building and Detailing of RC Slabs, Beams, columns and footings; Design of Industrial Steel Building with Truss Roof and Detailing of Trusses, Gusseted Joints, Eccentric Connections Riveted/Welded, Beam End Connections, Built-up Column; Design and detailing of Special Structures: Pile foundation, Water tank and Retaining wall.

Subject Code: CE3P006	Name: Water and Wastewater Engineering Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Physical characteristics of water - Turbidity, Taste, Odor, Colour, Electrical conductivity; Analysis of solids content of water - Dissolved, settleable, suspended, total, volatile, inorganic;; Alkalinity and acidity; Hardness - Total, calcium and magnesium; Analysis of ions - Fluoride, copper, arsenic; Optimum coagulant dose; Break point chlorination; Settling column analysis for sedimentation tank design; BOD and BOD rate constant determination; COD; DO and re-aeration constant determination; Bacteriological quality measurement: MPN, plate count

Indian Institute of Technology Bhubaneswar
Curriculum

B. Tech (Civil Engineering)

Curriculum (7th Semester – 8th Semester)

SEMESTER - VII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Breadth - 4			3/4	3/4	
Elective – 1	**CE4LXXX**		3	3	
Elective – 2	**CE4LXXX**		3	3	
Elective – 3	**CE4LXXX**		3	3	
CAD Laboratory	**CE4P001**	0-0-3	2	3	25
Summer Training	**CE4T001**	0-0-3	2	3	
Project – Part 1 (CE)	**CE4D001**	0-0-6	4	6	
		Total	**20/21**	**24/25**	
SEMESTER - VIII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Elective – 4	**CE4LXXX**		3	3	
Elective – 5	**CE4LXXX**		3	3	
Elective – 6	**CE4LXXX**		3	3	
Elective – 7	**CE4LXXX**		3/4	3/4	
Project – Part 2 (CE)	**CE4D002**	0-0-9	6	9	
		Total	**18/19**	**21/22**	

List of Elective Courses

Subject Name	Code	L-T-P	Credit	Contact Hour	Syllabus Page No.
Elective – I and VII					
Construction Management	**CE4L001**	3-0-0	3	3	25
Air Pollution and Solid Waste Management	**CE4L002**	3-0-0	3	3	25
Advanced Transportation Engineering	**CE4L003**	3-0-0	3	3	26
Rock Mechanics and Tunnelling	**CE4L004**	3-0-0	3	3	26
Maintenance and Rehabilitation of Concrete Structures	**CE4L005**	3-0-0	3	3	26
Computational Hydraulics	**CE4L006**	3-0-0	3	3	27
Water Resources Management	**CE4L007**	3-0-0	3	3	27
Hydraulic and Hydrologic Analysis and Design	**CE4L008**	3-0-0	3	3	27
Hydropower Engineering	**CE4L009**	3-0-0	3	3	28
Elective – II					
Structural Dynamics	**CE4L021**	3-0-0	3	3	28
Bridge Engineering	**CE4L022**	3-0-0	3	3	29
Pre-stressed Concrete	**CE4L023**	3-0-0	3	3	29
Earthquake Engineering	**CE4L024**	3-0-0	3	3	29

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Subject Name	Code	L-T-P	Credit	Contact Hour	Syllabus Page No.
Elective – III					
Environmental Engineering	**CE4L031**	3-0-0	3	3	29
Environmental Impact Assessment	**CE4L032**	3-0-0	3	3	30
Sustainable Water and Sanitation System	**CE4L033**	3-0-0	3	3	31
Environmental System Management	**CE4L034**	3-0-0	3	3	32
Industrial Pollution Prevention	**CE4L035**	3-0-0	3	3	31
Elective – IV					
Soil Dynamics	**CE4L041**	3-0-0	3	3	32
Advanced Foundation Engineering	**CE4L042**	3-0-0	3	3	32
Numerical Methods in Geotechnical Engineering	**CE4L043**	3-0-0	3	3	32
Soil Engineering	**CE4L044**	3-0-0	3	3	33
Earth Retaining Structures	**CE4L045**	3-0-0	3	3	33
Elective – V					
Remote Sensing and GIS	**CE4L051**	3-0-0	3	3	34
River Engineering	**CE4L052**	3-0-0	3	3	34
Open Channel Hydraulics	**CE4L053**	3-0-0	3	3	34
Water Resources Systems	**CE4L054**	3-0-0	3	3	35
Design of Hydraulic Structures	**CE4L055**	3-0-0	3	3	35
Elective – VI					
Transportation Planning	**CE4L061**	3-0-0	3	3	35
Pavement Design	**CE4L062**	3-0-0	3	3	36
Traffic Engineering	**CE4L063**	3-0-0	3	3	36

Indian Institute of Technology Bhubaneswar
Curriculum

Syllabus (7ᵗʰ Semester – 8ᵗʰ Semester)

SEMESTER - VII

Subject Code: CE4P001	Name: CAD Laboratory	L-T-P: 0-0-3	Credit: 2
Prerequisite: None			
Exposure to commercial software tools for analysis, design and research in civil engineering.			

Elective Courses

SEMESTER – VII & VIII

Elective I & VII

Subject Code: CE4L001	Name: Construction Management	L-T-P: 3-0-0	Credit: 3
Prerequisite: None			
Construction Management Overview; Construction Industry; Construction Projects Management; Scheduling Techniques for Construction Projects; Construction Estimating; Construction Cost Control; Construction Contracts Administration; Construction Practice			

Text/Reference Books:

1. Jha, Neeraj Kumar, Construction Project Management, Pearson Education India
2. Williams, Trefor, Construction Management, Pearson Education India
3. Chitkara, Krishnan, Construction Project Management Techniques And Practice, Tata McGraw Hill
4. Purifoy R.L., Construction Planning, equipments and Methods, Mc Graw Hill, Tokyo, Japan.

Subject Code: CE4L002	Name: Air Pollution and Solid Waste Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Air pollution: Pollutants, their sources, harmful effects on environment, metrology and atmospheric diffusion of pollutants, dispersion modeling, air sampling and pollutant measurement methods, ambient air quality and emission standards, control, removal of gaseous pollutants, particulate emission control, control of automobile pollution.
Solid waste management: Engineering principles; Sources, Composition and Properties of Municipal Solid Waste, Onsite handling, storage and processing, Collection, Transfer and transport, Recovery of resources, Conversion products and energy, Disposal of solid waste including sanitary landfill. Introduction to biomedical and hazardous waste management.

Text/Reference Books:
1. Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed.
2. Rao, M N, Air Pollution, Tata McGraw Hill, New Delhi.
3. Garg, S. K., Sewage Disposal and Air Pollution Engineering, Khanna Publication.
4. Nevers, N. D. Air Pollution Control Engineering, Mc. Graw Hill International Ed.
5. Tchobanoglous, G., Theisen, H., and Vigil, S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company.
6. LaGrega, M.D., Buckingham, P.L., and Evans, J.C., Hazardous Waste Management, McGraw-Hill International Editions.
7. Martin, E.J. and Johnson, J.H., Hazardous Waste Manage Bhment Engineering, van Nostrand-Reinhold.
8. Wentz, C.A., Hazardous Waste Management, McGraw Hill.

9. Wark K, Warner, C F and Davis, W. Air Pollution Its Origin and Control, Harper and Row
10. Griffin, R D, Principles of Air Quality Management, CRC Press.

Subject Code: CE4L003	Name: Advanced Transportation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Airports: introduction; characteristics of aircrafts related to airport design; obstruction clearance criteria; design of airside facilities: runway orientation, length, capacity, configuration and number, taxiway layout, design of fillets, high-speed exit taxiway, apron gate and circulation areas, hanger; design of landside facilities: terminal building functional areas and facilities, centralized and de-centralized concepts, vertical distribution; airport planning and site selection; pavement design; visual aids; demand estimation of air travel, drainage. Railways:- Introduction, classification of routes; railway gauge, coning of wheels and canting of rails, train resistance and hauling power; track components: rails, sleepers, fastenings, ballast and formation; track stresses; turnouts and crossings, signals and control systems, welded rails. Elements of water and pipeline transportation. Economic Analysis of Transportation Projects

Book:

1. Horonjeff, Robert, Planning and Design of Airports, McGraw Hill
2. Chandra, Satish and Agarwal, M.M., Railway Engineering, Oxford University Press India
3. Garber, NJ and Hoel, LA, Principles of Traffic and Highway Engineering, Cengage Learning

Subject Code: CE4L004	Name: Rock Mechanics and Tunnelling	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction - objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration - rock coring, geophysical methods. Laboratory testing of rocks - all types of compressive strength, tensile strength and flexural strength tests. Strength and failure of rocks, Griffith's theory, Coulombs theory, rheological methods. In-situ tests on rock mass. Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics - interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties. Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence. Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting. Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

Text/Reference Books:

1. Goodman, R. E., Introduction to Rock Mechanics, John Wiley and Sons.
2. Hudson, J.A. and Harrison, J.P. Engineering rock Mechanics: an introduction to the principles, Pergamon publishers.
3. Chapman, David, Metje, Nicole and Stärk, Alfred, Introduction to Tunnel Construction. Spon Publishers, Taylor and Francis Group.
4. Brady, B. H. G. and Brown, E. T. Rock Mechanics: for underground mining, Kluwer Academic Publishers.

Subject Code: CE4L005	Name: Maintenance and Rehabilitation of Concrete Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Maintenance and Repair strategies - Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Serviceability and Durability of

Concrete - Quality assurance for concrete construction concrete properties- strength, permeability, thermal properties and cracking. - Effects due to climate, temperature, chemicals, corrosion - design and construction errors - Effects of cover thickness and cracking; Materials and Techniques for Repair - Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferrocement and polymers coating for rebars loadings from concrete, mortar and dry pack, vacuum concrete, Gunite and Shotcrete, Epoxy injection, Mortar repair for cracks shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels and cathodic protection.; Repairs to Structures - Repair of structures distressed due to earthquake – Strengthening using FRP Strengthening and stabilization techniques for repair.

Text/Reference Books:

1. Denison Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK.
2. Allen R.T and Edwards S.C, Repair of Concrete Structures, Blakie and Sons, UK.
3. Raikar, R.N., Learning from failures - Deficiencies in Design, Construction and Service - R&D Centre (SDCPL), Raikar Bhavan, Bombay.
4. Santhakumar A.R., Concrete Technology, Oxford University Press, Printed in India by Radha Press, New Delhi.
5. Emmons, Peter H., Concrete Repair and Maintenance Illustrated Galgotia Publications pvt. Ltd.

Subject Code: CE4L006	Name: Computational Hydraulics	L-T-P: 3-0-0	Credit: 3
Prerequisite: None			

General numerical methods; Introduction to FEM, FDM and BEM; Perturbation method; Methods of characteristics; Hydroinformatics; Applications to water resources engineering

Text/Reference Books:

1. Michael B. Abbott, Anthony W. Minns, Computational Hydraulics.
2. Cornelis B. Vreugdenhil, Computational Hydraulics.
3. Ioana Popescu, Computational Hydraulics.

Subject Code: CE4L007	Name: Water Resources Management	L-T-P: 3-0-0	Credit: 3
Prerequisite: None			

Water resources economics; Water resources conservation techniques; Optimization in water resources engineering; Irrigation management; Reservoir management; Sustainable water resources development; Environmental impact assessment of water resources projects.

Text/Reference Books:

1. Feldman, Dave Water Resources Management.
2. Nageswara Rao, K., Water Resources Management.
3. Lenton, Roberto L., Muller, Mike, Integrated Water Resources Management in Practice.

Subject Code: CE4L008	Name: Hydraulic and Hydrologic Analysis and Design	L-T-P: 3-0-0	Credit: 3
Prerequisite: None			

Synthetic design storms & Estimation of peak discharge, Urban storm drainage design, Culvert design, Detention storage design, Flood frequency analysis; Design of water distribution network, Analysis and design of mobile and rigid boundary channels, Tractive force concepts in channel design, Design of canal headworks, distribution works, and cross-drainage works, Design of gravity dams, spillways, and energy dissipators.

Text/Reference Books:

1. Ben C. Yen, Yeou-Koung Tung, Reliability and Uncertainty Analyses in Hydraulic Design: A Report, American Society of Civil Engineers
2. Bruce E. Larock, Roland W. Jeppson, Gary Z. Watters, Hydraulics of Pipeline Systems, CRC

Press
3. Ghosh, Karunamoy, Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Pvt. Ltd
4. Chow, Ven Te, Maidment, David R. and Mays, Larry W., Applied Hydrology, Tata McGraw-Hill Education

Subject Code: CE4L009	Name: Hydropower Engineering	L–T–P: 3-0-0	Credit: 3

Prerequisite: None

Power generation through storage (dams) and diversion (barrages); run-of the river schemes with and without pondage; integrated powerhouse with barrage / on diversion channel; pumped storage schemes; tidal power plants; hydroelectric plant layouts for open flow diversion schemes and pressure diversion system or their combinations; underground projects with pressure diversion systems; position of power house (surface, underground or semi-underground); hydropower conveyance structures intakes, conveyance structures and outflow structures; intakes to canals and tunnels (with corresponding de-silting arrangements); intakes for in-stream powerhouses; reservoir type intakes, trash rack and its design; intakes for embankment dams; water conducting systems open channels, fore-bays, tunnels, surge tanks, penstocks, valves and anchor blocks; layout and sections of tunnels; tunnel deign basics; construction methods for tunnels; penstock components (bends, reducer, branches, manifolds); turbine foundations and overhead traveling crane frame; underground powerhouse cavern; types of turbines and their selection.

Text/Reference Books:

1. Subramanya, K., Flow in open channels, Tata McGraw-Hill Education
2. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers
3. Subramanya, K., Fluid Mechanics and Hydraulic Machines, Tata McGraw-Hill Education
4. Daugherty, Robert Long, Hydraulic Turbines, McGraw-Hill

Elective II

Subject Code: CE4L021	Name: Structural Dynamics	L–T–P: 3-0-0	Credit: 3

Prerequisite: None

Single-degree-freedom systems: undamped and damped free vibration; Response to harmonic and periodic excitations; Response to non-periodic excitations; Numerical evaluation of dynamic response; Generalized single-degree-freedom systems. Elements of analytical dynamics: The principle of virtual work; Principle of D Alembert; Hamiltons principle; Lagrange's equation. Multi-degree-freedom systems: Equation of motion; undamped free vibration; Intepretation of modal orthogonality; Decomposition of response in terms of modal co-ordinates; Modal analysis; Response to external excitations; Rayleigh's quotient and its properties; Systems with proportional damping; Systems with arbitrary viscous damping. Distributed parameter systems: axial and bending vibration of beams; orthogonality of modes; Response to external excitations; Rayleigh s quotient; Approximate methods. Earthquake response of linear systems: Earthquake excitations; Equations of motion; Response spectrum concept; Response spectrum characteristics; Design response spectrum; Modal analysis; Displacement response; Element forces; Modal response contribution; Response history analysis; Response spectrum analysis.

Text/Reference Books:

1. Paz, M, Structural Dynamics, CBS Publisher
2. Clough, R.W. and Penzin, J., Dynamics of Structures, Printice-Hall & Tata McGraw Hill
3. Chopra, A K, Dynamics of Structures, Pearson Education

Subject Code: CE4L022	Name: Bridge Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Bridges and loading standards. Hydraulic Design of Bridges, Foundation for piers and abutments, Open Foundation, Pile Foundation, Well Foundation, Bridge Substructure: Piers and Abutments. Bridge Superstructure: Design aspects, RC slab deck, Tee Beam and Slab deck. Composite Bridges. Pre-stressed concrete bridges, Steel trussed bridges; Bridge Construction, Inspection and Maintenance.

Text/Reference Books:

1. Ponnuswamy, S, Bridge Engineering, McGraw Hill
2. Jagadeesh and Jayaram, Design of Bridge Structure, PHI Learning
3. Victor, D. J., Essentials of Bridge Engineering, Oxford and IBH Publishing

Subject Code: CE4L023	Name: Pre-stressed Concrete	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept on Mechanics; Materials; Properties of sections; Stress analysis - three methods; Prestressing and Post stressing; Beam design - no tension and ultimate; Poles and slab panels; Loss assessment; Composite beams; Design for shear. Large span structures; Structural forms and design principles; Special materials, open web and built-up structures.

Text/Reference Books:

1. Lin and Burns, Design Of Prestressed Concrete Structures, Wiley India
2. Dayaratnam, P Prestressed Concrete Structures, Oxford and IBH
3. Raju, K., Prestressed Concrete Bridges, CBS

Subject Code: CE4L024	Name: Earthquake Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Characteristics of earthquakes; Seismic Hazards, Earthquake response of structures; Mechanisms of earthquake generation and propagation, Magnitude and Intensity of an earthquake. Response of SDOF and MDOF systems to Earthquake Loading. Geotechnical Failures Due to Earthquakes, Faulting, Liquefaction; Wave Propagation. Concept of Earthquake Resistant Design, Code provisions.

Text/Reference Books:

1. Duggal, S K, Earthquake Resistant Design of Structures, Oxford University Press
2. Chopra, A K, Dynamics of Structures, Pearson
3. Paulay and Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, Wiley International Publication
4. Bolt, B A, Earthquakes, WH Freeman & Company, New York
5. Kramer, S L, Geotechnical Earthquake Engineering, Pearson
6. Dutta, S C and Mukhopadhyay, P S, Improving Earthquake and Cyclone Resistance of Structures, TERI Delhi

Elective III

Subject Code: CE4L031	Name: Environmental Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Components of water supply systems, Water use and demand estimation, Design period, population data and flow rates for water supply systems, Factors affecting water consumption and variation in demand, Intakes, Transportation of water, Pumping of water, Design of water distribution systems, methods of analysis for optimal distribution network design, Types of reservoirs and design parameters and methods, Water supply plumbing systems in buildings, Rural Water supply.

Design principles of wastewater collection systems, quantities of sanitary wastes and storm water, Estimation of dry weather flows, separate, combined and semi-combined sewers, Sewer pipe hydraulics, construction, maintenance and appurtenances for sewers, Pumping stations, sewage collection from buildings.

Estimation, Handling, Storage, Collection, Transfer, Transport and Disposal of Solid waste

Text/Reference Books:

1. Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International.
2. Garg, S. K., Water Supply Engineering, Khanna Publication.
3. Garg, S. K., Sewage Disposal and Air Pollution Engineering, Khanna Publication.
4. McGhee, T. J., Water Supply and Sewerage, McGraw Hill International.
5. Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, Ministry of Urban Development, New Delhi.
6. Central Public Health and Environmental Engineering Organization, Manual on Sewerage and Sewage Treatment, Ministry of Urban Development, New Delhi.
7. Quasim, S. R., Motley, E. M. and Zhu, G., Water Works Engineering- Planning, Design and Operation, Prentice Hall.
8. Bhave, P. R. and Gupta, R., Analysis of Water Distribution Networks, Narosa publishing house, New Delhi.
9. Bhave, P. R., Optimal Design Of Water Distribution Networks, Narosa publishing house, New Delhi., 2003

Subject Code: CE4L032	Name: Environmental Impact Assessment	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA; EIA process; Screening and scoping criteria; Rapid and comprehensive EIA. 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. Specialised areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties. EMP.

Text/Reference Books:

1. Canter, L., Environmental Impact Assessment, McGraw Hill.
2. Kiely, G., Environmental Engineering, Tata McGraw Hill.
3. Rau, G. J. and Wooten, C. D., Environmental Impact Analysis Handbook, McGraw Hill.
4. Munn, R. E., Environmental Impact Assessment, John Wiley & Sons.
5. Dhameja, S. K., Environmental Engineering and Management, S. K. Kataria & Sons.

Subject Code: CE4L033	Name: Sustainable Water and Sanitation Systems	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept of sustainability in water and waste management, Water Conservation, Rainwater Harvesting: Roof water harvesting, technology, quality, health issues, Groundwater recharge, techniques, case studies, Water tariff, sustainable water management. Decentralised wastewater treatment systems, Reliability and cost effectiveness of wastewater systems, Tertiary treatment, process selection, granular- medium filtration, micro screening, removal of toxic compounds and refractory organics, removal of dissolved inorganic substances, Natural Wastewater Treatment Systems, Natural and constructed wetlands, different types, Mechanisms, performance, design, case studies. Land treatment systems. Wastewater reuse and reclamation. Rural water supply and sanitation, Low-cost sanitation, Dry sanitation methods, Pit latrines, VIP latrines, Aquaprivy, septic tank, Organic solid waste management techniques, Composting/vermicomposting, biogas technology, plasma technology,

Text/Reference Books:

1. Ahluwalia, P. and Nema, A. K., Water and Wastewater Systems: Source, Treatment, Conveyance and Disposal, S. K. Kataria & Sons.
2. Arceivala, S. J. and Asolekar, S. R., Wastewater Treatment for Pollution Control and Reuse, Tata McGraw Hill.
3. Cites, R. W., Middlebrooks, E. J., and Reed, S. C., Natural Wastewater Treatment Systems, CRC Taylor and Francis.
4. Cairncross, S. and Feachem, R., Environmental Health Engineering in the Tropics, John Wiley & Sons.
5. Metcalf & Eddy, Wastewater Engineering- Treatment and Reuse (Revised by Tchobanoglous, G., Burton, F. L. and Stensel, H. D.), Tata McGraw Hill.

Subject Code: CE4L034	Name: Environmental System Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Human - environment relationship, normative criteria, descriptive and prescriptive models, limits of growth; Environmental and natural resources economics, pollution control policy, growth in a finite environment; Environmental protection laws; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes; Planning and management of environmental systems: optimization techniques, stochastic modelling, statistical inferences; Large scale systems; Optimal monitoring network design, identification of sources; Risk reliability and uncertainty in environmental systems; Topics in groundwater and surface water quality management.

Text/Reference Books:

1. Schnoor, J. L., Environmental Modelling, Wiley-interscience.
2. Boubel, R. W., Fox, D. L., Turner, D. B. and. Stern, A. C., Fundamentals of Air Pollution, Academic Press, New York.
3. Thomann, R. V., and Muller, J. A., Principles of Surface Water Quality Modelling and Control, Harper International Edition.
4. Tchobanoglous, G., Schroeder, E. D., Water Quality, Addison – Wesley Publishing Company, Reading, Massachusetts.
5. Welford, R., Corporate Environmental Management, Earthscan Publications Limited, London.
6. Rosencranz, A., Divan, S. and Noble, M. L., Environmental Law and Policy in India : Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay.
7. Asolekar, S. R. and Gopichandran, R., Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (The Indian Association of Cambridge University Press, UK).

Subject Code: CE4L035	Name: Industrial Pollution Prevention	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Unit operations in separation technology; Separation technologies as tools for waste minimization. Process optimization for cleaner industrial processes; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; 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.

Text/Reference Books:

1. Bishop, P. E., Pollution Prevention : Fundamentals And Practice, McGraw Hill.
2. Freeman, H. M., Industrial Pollution Prevention Handbook, McGraw Hill, 1995.
3. Allen, D. T., and Rosselot, K. S., Pollution Prevention for Chemical Processes, John Wiley.
4. Allen, D. T., Bakshani, N., and Rosselot, K. S., Pollution Prevention: Homework and Design Problems for Engineering Curricula, American Institute for Pollution Prevention.
5. Johansson, A., Clean Technology, Lewis Publishers.
6. Theodore, L. and McGuinn, Y. C., Pollution Prevention, Van Nostrand Reinhold, NewYork.
7. Asolekar, S. R. and Gopichandran, R., Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (The Indian Association of Cambridge University Press, UK).

Elective IV

Subject Code: CE4L041	Name: Soil Dynamics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, Fundamental of vibrations, dynamic properties of geomaterials, transient vibrations, analysis of free and forced vibrations using spring dashpot model, single degree of freedom system, multidegrees of freedom system, application of single and multidegree of freedom systems, wave propagation in elastic media, laboratory and field evaluation of soil properties, analysis of earthquake loadings, liquefaction analysis.

Text/Reference Books:

1. Saran, S., Soil Dynamics and Machine Foundations, Galgotia Publications.
2. Das, B. M. and Ramana, G. V., Principles of Soil Dynamics, CL-Engineering.
3. Richart, F. E., Woods, R. D., and Hall, J. R., Vibrations of Soils and Foundations, Prentice Hall.
4. Kramer, S. L., Geotechnical Earthquake Engineering, Prentice Hall.

Subject Code: CE4L042	Name: Advanced Foundation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Bearing capacity of shallow foundations: Prandtl, Terzaghi and Meyerhof s method of analysis, safe and allowable bearing pressures, selection of type and depth of foundations, combined footings, mat foundations including floating raft, settlement calculations, Skempton - Bjerrum modification, and Martin s method, bearing capacity of layered soils, bearing capacity of footings on slopes, Deep foundations: mechanics of load transfer in piles, load carrying capacity, pile load test, lateral loaded piles, design of pile groups including settlement calculations, design of block foundation, well foundations, coffer dams, pier foundations, earth pressure computations on retaining walls and their design, earthquake response of foundations.

Text/Reference Books:

1. Das, B. M., Principles of Foundation Engineering, Cengage Learning.
2. Budhu, M., Soil Mechanics and Foundations, Wiley Publishers, New Delhi.
3. Coduto, D. P., Foundation Design: Principles and Practices, Prentice Hill Publishers.
4. Holts, R. D. and Kovacs, W. D., An Introduction to Geotechnical Engineering, Prentice Hall.
5. Das, B. M., Shallow Foundations: Bearing Capacity and Settlement, CRC Press.
6. Tomilson, M. J., Foundation Design and Construction, Pearson Publishers.

Subject Code: CE4L043	Name: Numerical Methods in Geotechnical Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to numerical modeling in Geotechnical Engineering, constitutive modeling, review of basic concepts, solution of nonlinear systems of equations, finite difference method, finite element method, constitutive modeling of soil response, large deformation – large strain analysis, applications: flow and consolidation, groundwater and seepage, slopes and cuts,

embankments, shallow and deep foundations, retaining walls, tunnels and caverns and rock Mechanics

Text/Reference Books:

1. Desai, C. S. and Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.
2. Potts, D. M. and Zdravkovic, L., Finite Element Analysis in Geotechnical Engineering: Theory and Application, Thomas Telford Publishing.
3. Benz, T. and Nordal, S., Numerical Methods in Geotechnical Engineering: NUMGE 2010, CRC Press.
4. Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.

Subject Code: CE4L044	Name: Soil Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Shear strength of cohesionless and cohesive soils, physico-chemical aspects, experimental determination of shear strength, failure theories, Yield criteria, influence on failure conditions of inter-mediate principal stress, history, drainage, rate of stress applications etc.; Plastic equilibrium in soils, Mohr diagram, active and passive states, theories of earth pressure on retaining walls, effect of wall friction on the shape of sliding surface, theories of arching, bearing capacity, concepts of general and local shear failure, critical height of vertical banks, various methods of computation of slope stability, earth pressure on timbering of cuts and on free and anchored bulkheads.

Text/Reference Books:

1. Lambe, T. W. and Whitman, R. V., Soil Mechanics in SI Version, Wiley, New Delhi.
2. Scott, R. F., Principles of Soil Mechanics, Addison Wesley, World Student Edition.
3. Leonards, G. A., Foundation Engineering, McGraw-Hill.
4. Bowles, J. E., Foundations Analysis and Design, McGraw-Hill.
5. Peck, R. B., Hanson, W. E., and Thornburn, T. H., Foundation Engineering, John Wiley and Sons.

Subject Code: CE4L045	Name: Earth Retaining Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Earth Pressure: Fundamental relationships between the lateral pressures and the strain with a back fill. Rankine's and Coulomb's theories, Active, passive and earth pressure at-rest; Backfill with broken surface, wall with broken back, concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Passive earth pressure in engineering practice. Assumption and conditions, point of application of passive earth pressures; Bulkheads: Definition and assumptions, conditions of end supports and distribution of active earth pressure and bulkheads, bulkheads with free and fixed earth supports, equivalent beam method, Improvements suggested by Rowe, Tschebotarioff's method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates, Consideration of effects of ground water, seepage, surcharge loading together with possibility of shallow and deep sliding failures on retaining structure; Sheet Pile wall: Free earth system, fixed earth system, Dead man; Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations, Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays; Reinforced earth retaining structures-Design of earth embankments and slopes; Recent advances in Earth retaining structures.

Text/Reference Books:

1. Das, B. M., Principles of Foundation Engineering, Thomson, Indian Edition.
2. Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth-retaining Structures, Chapman and Hall Publishers.
3. Bowel, J., Foundation Engineering, Analysis and Design, McGraw Hill.

4. Raj, P., Geotechnical Engineering, Tata McGraw Hill.
5. Craig, R. F., Soil Mechanics, Chapman and Hall (ELBS).

Elective V

Subject Code: CE4L051	Name: Remote Sensing and GIS	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Physics of remote sensing: Electromagnetic spectrum, atmospheric effects, energy interaction with earth surface features. Platforms and remote sensing sensors: Photographic camera, scanners, earth resources satellites, active and passive microwave sensors. Digital image processing: Image rectification, image enhancement, image classification and accuracy. Image interpretation. Geographical Information System (GIS): Map data representation, geographic database concepts and analysis. Application of remote sensing and GIS in land and water resources system and evaluation.

Text/Reference Books:

1. Bhatta, B., Remote Sensing and GIS, Oxford University Press.
2. Mesev, V., Integration of GIS and Remote Sensing, John Wiley & Sons Ltd.
3. Nayak, S., and Zlatanova, S., Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters, Springer.

Subject Code: CE4L052	Name: River Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

River basins; erosion from river catchments and its transportation by rivers; classification of streams, delta, alluvial fans, point bars, etc.; hydraulic geometry and plan form of alluvial rivers; features of gravel bed rivers; bed level changes in streams sedimentation on the upstream and degradation on the downstream of dams and barrages; morphology of some Indian rivers; river flow measurement techniques; stream gauging and analysis of rating curves (hydrometry); dynamics of tidal rivers and estuarine flows; mathematical models for sediment transport and pollutant transport in rivers; introduction to software packages for river flow, sediment and pollutant transport; riverbank erosion mechanisms; direct bank erosion protection methods (use of fascine mattresses; geosynthetics; other [hard] options); indirect bank erosion protection methods (flow deflection using spurs, groynes, etc. and their possible ill effects); foundations for bridges across rivers; river training works (guide bunds) for bridges and barrages.

Text/Reference Books:

1. Julien, P. Y., River Mechanics, Cambridge University Press.
2. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
3. U. S. Army Corps of Engineers, River Hydraulics.

Subject Code: CE4L053	Name: Open Channel Hydraulics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Basic concepts; Energy and Momentum equations and their applications; Critical flow, channel control ad transitions; Uniform flow and flow resistance; Sheet flow; Concepts of boundary layer and surface roughness; Theoretical uniform flow equations; Instability of uniform flow; Gradually varied flow, flow profile classification and computation methods; Flow profiles in natural channels; Spatially varied flow; Hydraulic jump; Unsteady flow, continuity equation, dynamic equation, wave propagation; Method of characteristics; Rapidly varied unsteady flow, surges; Dam break problems.

Text/Reference Books:

1. Subramanya, K., Flow in Open Channels, Tata McGraw-Hill.

2. Chanson, H., Hydraulics of Open Channel Flow, Elsevier.
3. Chow, V. T., Open Channel Hydraulics, McGraw Hill.
4. French, R., Open Channel Hydraulics, McGraw-Hill.
5. Sturm, T.W., Open Channel Hydraulics, Tata McGraw-Hill.

Subject Code: CE4L054	Name: Water Resources Systems	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to systems concept in water resources engineering: its role in planning and management; data acquisition and processing; descriptive and prescriptive models; economics of water resources systems; social, economical, technical and environmental issues; decision making under uncertainty and/or risk; evaluation of project alternatives; application to surface and subsurface water resources systems planning and management.

Text/Reference Books:

1. Vedula, S. and Mujumdar, P. P., Water Resources Systems, McGraw-Hill.
2. Jain, S. K., and Singh, V. P., Water Resources Systems Planning and Management, Elsevier.
3. Purcell, P., Design of Water Resources Systems, Thomas Telford Publishing.

Subject Code: CE4L055	Name: Design of Hydraulic Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concrete dams, force and stress analysis for components like piers, bridges and trash rack and their reinforcement detailing; stress analysis around galleries, adits and shafts and reinforcement provisions; integrated stability analysis of concrete dams considering foundation rock; construction methods for concrete dams. Embankment dams, seepage analysis (finding the phreatic line) for different types of embankment dams; seepage control measures for embankment dams; construction methods for embankment dams. Spillways and energy dissipators design of ogee spillways; calculations for chute spillway profiles; flow characteristics of shaft and syphon spillways; types of energy dissipators, their selection and dimensioning; flow characteristics of radial gates; introduction to relevant BIS codes and guidelines. Barrages - design of barrage structure and canal head regulator; construction methods for barrages. Irrigation structures, Canals, cross drainage works, falls and energy dissipators.

Text/Reference Books:

1. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
2. Ghosh, K., Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Private Limited.
3. Novak, P., Moffat, A. I. B., Nalluri, C., and Narayanan, R. Hydraulic Structures, Taylor & Fransis.

Elective VI

Subject Code: CE4L061	Name: Transportation Planning	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Transportation planning Process, Demand-supply interaction of a transportation system, four-step-travel demand modeling- such as trip generation, trip distribution, modal split and traffic assignment, discussion of case study on travel demand model, land-use transport model, household travel survey, public transportation, traffic forecasting techniques on highway, Demand analysis for air transportation

Book:

1. Kadiyali, L. R., Traffic Engineering and Transport Planning, Khanna Publishers.
2. Ortuzar, J. D. and Williumsen, L. G., Modeling Transport, John Wiley & Sons Ltd.

Subject Code: CE4L062	Name: Pavement Design	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Pavement, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, pavement evaluation and overlay design.

Text/Reference Books:

1. Huang, Y. H., Pavement Analysis and Design, Pearson Education.
2. Yoder, E. J. and Witczak, M. W., Principles of Pavement Design, John Wiley & Sons Ltd.
3. Mallick, R. B. and El-Korchi, T., Pavement Engineering: Principles and Practice, CRC Press.

Subject Code: CE4L063	Name: Traffic Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Driver behaviour, visual angle modelling, traffic information and control systems, traffic studies- volume, speed and delay studies, elements of traffic flow theory, Greenshields' model and Greenberg's model, PCU concept, characteristics of uninterrupted traffic, gap acceptance-Raff's method, queuing theory, shock wave, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic, IRC method of roundabout design, traffic characteristics at unsignalised intersections, queue discharge characteristics at signalised intersections, Trial Cycle method and Webster's method of signal design, dilemma zone, actuated signal control, signal coordination.

Text/Reference Books:

1. Mannering, F. L., Kilareski, W. P. and Washburn, S. S., Principles of Highway Engineering and Traffic Analysis, Wiley India Edition.
2. Drew, D. R., Traffic Flow Theory and Control, MaGraw-Hill.
3. May, A. D. Traffic Flow Fundamentals, Prentice Hall.
4. Slinn, M., Guest, P. and Mathews, P., Traffic Engineering Design, Elsevier.
5. Roess, R. P., Prassas, E. S., McShane, W. R. Traffic Engineering, Pearson.
6. Kadiyali, L. R., Traffic Engineering and Transport Planning, Khanna Publishers.
7. Pignatro, L. J., Traffic Engineering-Theory and Practice, Prentice-Hall, Englewood Cliffs, New Jersey.
8. Khanna, S. K. and Justo, C. E. G., Highway Engineering, Nem Chand & Bros, Roorkee.
9. Khisty, C. J. and Lal, B. K., Transportation Engineering, Prentice Hall India.
10. Papacostas, C. S. and Prevedouros, P. D., Transportation Engineering & Planning, Prentice-Hall.

Indian Institute of Technology Bhubaneswar
Curriculum

Dual Degree (B.Tech. Civil Engineering and M.Tech. Environmental Engineering)

Curriculum (7th Semester – 10th Semester)

SEMESTER - VII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Breadth - 4		3-0/1-0	3/4	3/4	
Water Treatment and Supply	**CE6L101**	3-1-0	4	4	39
Wastewater Treatment	**CE6L102**	3-1-0	4	4	39
Elective - 1		3-0-0	3	3	
CAD Laboratory	**CE4P001**	0-0-3	2	3	40
Industrial Training Defence	**CE4T001**	0-0-0	2	0	
Project – Part 1 (CE)	**CE4D001**	0-0-0	4	0	
Environmental Monitoring Laboratory	**CE6P101**	0-0-3	2	3	40
		Total	**24/25**	**17/18**	
SEMESTER - VIII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Air Pollution Control	**CE6L103**	3-1-0	4	4	40
Environmental Impact Assessment	**CE6L104**	3-1-0	4	4	40
Elective - 2		3-0/1-0	4	3/4	
Elective – 3		3-1-0	4	3	
Advanced Environmental Engineering Laboratory	**CE6P102**	0-0-3	2	3	41
Project – Part 2 (CE)	**CE4D002**	0-0-0	6	0	
		Total	**23/24**	**18**	
SEMESTER - IX					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Elective - 4		3-0/1-0	3/4	3/4	
Thesis : Part-I (CE)	**CE6D001**	0-0-0	12	0	
		Total	**15/16**	**4**	
SEMESTER - X					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Seminar	**CE6S001**	0-0-0	2	0	
Environmental Design Sessional	**CE6P103**	0-0-3	2	2	41
Thesis : Part-II (CE)	**CE6D003**	0-0-0	12	0	
		Total	**16**	**2**	
	Grand Total	**Total**	**220/225**		

Indian Institute of Technology Bhubaneswar
Curriculum

Elective-1					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Computational Hydraulics	CE4L032	3-0-0	3	3	42
Water Resources Management	CE4L033	3-0-0	3	3	42
Hydraulic and Hydrologic Analysis and Design	CE4L034	3-0-0	3	3	42
Hydropower Engineering	CE4L035	3-0-0	3	3	43
Sustainable Water and Sanitation System	CE4L042	3-0-0	3	3	43
Environmental System Management	CE4L043	3-0-0	3	3	44
River Engineering	CE4L051	3-0-0	3	3	44
Open Channel Hydraulics	CE4L052	3-0-0	3	3	44
Design of Hydraulic Structures	CE4L054	3-0-0	3	3	45
Construction Management	CE4L027	3-0-0	3	3	45
Advanced Transportation Engineering	CE4L029	3-0-0	3	3	45
Soil Dynamics	CE4L045	3-0-0	3	3	46
Advanced Foundation Engineering	CE4L046	3-0-0	3	3	46
Transportation Planning	CE4L055	3-0-0	3	3	46
Pavement Design	CE4L056	3-0-0	3	3	47
Traffic Engineering	CE4L057	3-0-0	3	3	47
NB: Any other subjects of same or higher level floated by any other specialisations of School of Infrastructure and/or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators					

Elective - 1 to 4					
Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Advanced Water and Wastewater Treatment	CE6L105	3-1-0	4		47
Environmental Economics	CE6L106	3-0-0	3		48
Environmental Hydraulics	CE6L107	3-1-0	4		49
Solid Waste Management	CE6L108	3-1-0	4		49
Industrial Pollution Prevention	CE6L109	3-0-0	3		50
Environmental Chemistry and Microbiology	CE6L110	3-1-0	4		51
Highway Environment and Noise Pollution Control	CE6L111	3-0-0	3		51
Environmental Nanotechnology and Applications	CE6L112	3-1-0	4		52
Water Quality Modeling and Management	CE6L113	3-0-0	3		52
Water Resources Planning and Management	CE6L513	3-1-0	4		53
Design of Pipe Networks	CE6L514	3-1-0	4		53
GIS & Remote Sensing Applications in Civil Engineering	CE6L515	3-0-0	3		54
Non-Point Source Pollution of Water Resources	CE6L516	3-0-0	3		54
Integrated Watershed Management	CE6L518	3-0-0	3		55
Geotechnics of Polluted Sites	CE6L216	3-0-0	3		55
Geotechnics of Waste and Waste Containment	CE6L217	3-0-0	3		56
Groundwater Modeling & Simulation	ES6L104	3-0-0	3		57
Mathematical Methods	MA6L001	3-1-0	4		57
Advanced Techniques in Operation Research	MA6L002	3-1-0	4		57
NB: Any other subjects of same or higher level floated by any other specialisations of SIF or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators					

Indian Institute of Technology Bhubaneswar
Curriculum

Syllabus

Subject Code: CE6L101	Name: Water Treatment and Supply	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Water requirements, Types of water demands, Water demand forecasting,Surface water and ground water sources, Water quality and drinking water standards, Water treatment systems, Physico-chemical processes, Sedimentation, Coagulation, Flocculation, Granular media filtration, Disinfection, Water softening, Adsorption and ion exchange processes,Desalination, Membrane filtration, Treatment of specific contaminants: Fluoride, Nitra and Arsenic, Water supply schemes, Determination of reservoir capacity, Gravitational, pumping and combined water supply schemes, Water-lifting arrangements, Distribution reservoirs and service storage, Pumping and design considerations for pumps, Design and hydraulic analysis of water distribution system, Distribution system components, Aqueducts, Hydraulics of conduits, Appurtenances and valves, water pipes, Storage tanks, Optimization of pipe network systems, Planning of urban and metropolitan water supply project and its implementation

Text/Reference Books:

- Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Ed.
- Bhave P. R. and Gupta R., Analysis of Water Distribution Networks, Narosa publishing house, New Delhi.
- Qasim S. R., Motley E. M. and Zhu G., Water Works Engineering- Planning, Design and Operation, Prentice Hall.
- Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, 2nd Ed, Ministry of Urban Development, New Delhi December.1999 (Check)
- Hammer M. J., Water and Waste water Technology, PHI Learning.
- McGhee T. J., Water Supply and Sewerage, McGraw Hill International.
- Relevant BIS Codes

Subject Code: CE6L102	Name: Wastewater Treatment	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Wastewater- Sources, nature and characteristics, Population equivalent, Municipal wastewater collection, Systems of sanitation and water carriage, Estimation of wastewater flows and variation in wastewater flow, Estimation of storm water runoff, Process Flow sheets, Reactor Analysis, Unit operations and processes, Theory and Design of biological treatment processes, Aerobic treatment such as activated sludge process, Extended Aeration, oxidation ditches, Biofilm Processes: trickling filters, biotowers, MBBR and Natural Processes: waste stabilization ponds, aerated lagoon, Anaerobic treatment: upflow anaerobic sludge blanket reactor, Anaerobic Filters, sludge treatment and disposal, Design of a wastewater treatment plant,
On Site collection and Disposal, pit latrines, Compositing privy, Septic Tanks and Aqua privy.

Text/Reference Books:

1. Metcalf & Eddy., Wastewater Engineering- Treatment and Reuse (Revised by G. Tchobanoglous, F. L. Burton and H. D. Stensel), Tata McGraw Hill.
2. Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, 2nd Ed, Ministry of Urban Development, New Delhi December.
3. Hammer M. J., Water and Waste water Technology, PHI Learning.
4. McGhee T. J., Water Supply and Sewerage, McGraw Hill International.
5. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill

International Ed.

6. Quasim S. R., Motley E. M. and Zhu G., Water Works Engineering- Planning, Design and Operation, Prentice Hall.
7. Eckenfelder, W. W., Jr. (2000) Industrial Water Pollution Control, 3d ed., McGraw-Hill

Subject Code: CE4P001	Name: CAD Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Exposure to commercial software tools for analysis, design and research in civil engineering.

Subject Code: CE6P101	Name: Environmental Monitoring laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Physical and chemical characteristics of water and wastewater, Optimum coagulant dose, Break point Chlorination, DO, BOD and COD, Microbial characteristics of water – total and fecal coliforms, Settling Column Analysis, Ambient air quality Analysis - Determination of SPM, PM_{10}, $PM_{2.5}$, CO, NOx and SOx, detection of environmental noise.

Text/Reference Books:

1. Standard methods for the examination of water and wastewater, APHA, 20th Edition, Washington, 1998
2. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineers, 4th Edn. McGraw Hill, New Delhi, 1994.
3. Garg, S.K., "Environmental Engineering Vol. I & II", Khanna Publishers, New Delhi
4. Modi, P.N., "Environmental Engineering Vol. I & II", Standard Book House, Delhi-6

Subject Code: CE6L103	Name: Air Pollution Control	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Air pollution, Sources of air pollution, Types of pollutant, Gases and particulate; Atmospheric sources, sinks, transport; Effects on health and environment; Criteria pollutants, ambient and source standards. Characterization of aerosols, size distributions, Gaseous Pollutants, Control systems, Air quality management, dispersion modeling. Industrial and Vehicular sources of air pollution, Behaviour of pollutants in atmosphere, Emission factors, regulations, control strategies and policies; Monitoring of air pollutants, Particulate and Gaseous Pollutant Control, Control technologies for removal of SO_2, NOx, VOC, Control technologies for motor vehicles.

Text/Reference Books:

1. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Edition.
2. Nevers N. D., Air Pollution Control Engineering, Mc. Graw Hill International Edition.
3. Buonicore A.J., and Davis W.T., Air Pollution Engineering Manual, van Nostrand-Reinhold, New York.
4. Flagan R.C., and Seinfeld J.H., Fundamentals of Air Pollution Engineering, Prentice Hall, New Jersey.
5. Wark K., Warner C. F. and Davis W., Air Pollution Its Origin and Control, 3rd edition, Harper and Row, New York.
6. Rao M. N., Air Pollution, Tata McGraw Hill, New Delhi.
7. Griffin R. D., Principles of Air Quality Management, CRC Press, Boca Raton, USA.

Subject Code: CE6L104	Name: Environmental Impact Assessment	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept of environmental impact, Introduction to Environmental impact assessment (EIA) – definitions, terminology and concepts, Evolution of EIA in the USA, Key features of the National Environmental Policy Act and its implementation and the Council on Environmental Quality (CEQ) guidelines, Role of the USEPA, Evolution of
EIA in India, Sustainable development, Generalised EIA process flow chart, Screening, Initial environmental examination (IEE), Scoping, Public participation.
Environment Risk assessment, Pollution prevention and Waste minimization, sustainable development (SD), Life cycle assessment. Global Environmental Issues.
EIA - Screening and scoping criteria, Rapid and comprehensive EIA, Impact assessment methods, checklists, matrices, quantitative methods, networks, overlay mapping, Impact prediction and evaluation, 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, initial environmental examination (IEE), environmental impact statement (EIS), environmental appraisal, environmental audit (EA), Environmental impact factors and areas of consideration, measurement of environmental impact, organisation, scope and methodologies of EIA, case studies stressing physical aspects of environment, Evolution of EIA, EIA at project, Regional and policy levels, Strategic EIA, EIA process.

Text/Reference Books:

1. Canter L., Environmental Impact Assessment, McGraw Hill.
2. Asolekar S. R. and Gopichandran R. Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK).
3. Rau G.J. and Wooten, C.D., Environmental Impact Analysis Handbook, McGraw Hill.
4. Dhameja S. K., Environmental Engineering and Management, S. K. Kataria& Sons
5. Anjaneyulu Y. , Environmental impact assessment methodologies, B.S. Publications
6. World Bank 'Environmental Assessment Source Book', Environment Dept., Washington D.C.
7. Welford R., Corporate Environmental Management, Earthscan Publications Limited, London.
8. Sayre D., Inside ISO 14000: Competitive Advantage of Environmental Management, St. Louis Press, Florida.

Subject Code: CE6P102	Name: Advanced Environmental Engineering laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Use of analytical instruments such as AAS, GC, LC for gas and micropollutant analysis, heavy metal detection, use of microscope, isolation and analysis of microbes, Tracer Studies for Reactors, Adsorption Kinetics

Text/Reference Books:

1. Standard methods for the examination of water and wastewater, APHA, 20th Edition, Washington, 1998
2. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineers, 4th Edn. McGraw Hill, New Delhi, 1994.

Subject Code: CE6P103	Name: Environmental Design Sessional	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Environmental engineering hydraulic design: design of distribution systems, design of urban sanitary and storm water sewers, design of water and wastewater pumping systems. Design of intake structure, detailed design of water treatment plant, Design of wastewater treatment and disposal systems, use of ANOVA, statistical analysis of case studies, use of

software in environmental design.

Text/Reference Books:

1. Bhave P R , Optimal Design Of Water Distribution Networks, Narosa publishing house, New Delhi., 2003
2. Bhave P R and Gupta R., Analysis of Water Distribution Networks, Narosa publishing house, New Delhi, 2006.
3. Montgomery, J.M., Water Treatment Principles and Design, John Wiley and Sons.
4. Check for R. Qasim Books for Design of Water Treatment Plant and Wastewater treatment Plant
5. Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, 2nd Ed, Ministry of Urban Development, New Delhi December 1999.- Check its date
6. Central Public Health and Environmental Engineering Organization, Manual on Sewerage and Sewage Treatment, 2nd Ed, Ministry of Urban Development, New Delhi, December 2014- Check 2014
7. Quasim, S. R., Motley E. M. and Zhu, G., Water Works Engineering- Planning, Design and Operation, Prentice Hall, 2000.

Subject Code: CE4L032	Name: Computational Hydraulics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

General numerical methods; Introduction to FEM, FDM and BEM; Perturbation method; Methods of characteristics; Hydroinformatics; Applications to water resources engineering

Books:

1. Michael B. Abbott, Anthony W. Minns, Computational Hydraulics.
2. Cornelis B. Vreugdenhil, Computational Hydraulics.
3. Ioana Popescu, Computational Hydraulics.

Subject Code: CE4L033	Name: Water Resources Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Water resources economics; Water resources conservation techniques; Optimization in water resources engineering; Irrigation management; Reservoir management; Sustainable water resources development; Environmental impact assessment of water resources projects.

Text/Reference Books:

1. Feldman, Dave Water Resources Management.
2. Nageswara Rao, K., Water Resources Management.
3. Lenton, Roberto L., Muller, Mike, Integrated Water Resources Management in Practice.

Subject Code: CE4L034	Name: Hydraulic and Hydrologic Analysis and Design	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Synthetic design storms & Estimation of peak discharge, Urban storm drainage design, Culvert design, Detention storage design, Flood frequency analysis; Design of water distribution network, Analysis and design of mobile and rigid boundary channels, Tractive force concepts in channel design, Design of canal headworks, distribution works, and cross-drainage works, Design of gravity dams, spillways, and energy dissipators.

Text/Reference Books:

1. Ben C. Yen, Yeou-Koung Tung, Reliability and Uncertainty Analyses in Hydraulic Design: A Report, American Society of Civil Engineers
2. Bruce E. Larock, Roland W. Jeppson, Gary Z. Watters, Hydraulics of Pipeline Systems, CRC Press
3. Ghosh, Karunamoy, Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Pvt. Ltd
4. Chow, Ven Te, Maidment, David R. and Mays, Larry W., Applied Hydrology, Tata McGraw-Hill Education

Subject Code: CE4L035	Name: Hydropower Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Power generation through storage (dams) and diversion (barrages); run-of the river schemes with and without pondage; integrated powerhouse with barrage / on diversion channel; pumped storage schemes; tidal power plants; hydroelectric plant layouts for open flow diversion schemes and pressure diversion system or their combinations; underground projects with pressure diversion systems; position of power house (surface, underground or semi- underground); hydropower conveyance structures intakes, conveyance structures and outflow structures; intakes to canals and tunnels (with corresponding de-silting arrangements); intakes for in-stream powerhouses; reservoir type intakes, trash rack and its design; intakes for embankment dams; water conducting systems open channels, fore-bays, tunnels, surge tanks, penstocks, valves and anchor blocks; layout and sections of tunnels; tunnel deign basics; construction methods for tunnels; penstock components (bends, reducer, branches, manifolds); turbine foundations and overhead traveling crane frame; underground powerhouse cavern; types of turbines and their selection.

Text/Reference Books:

1. Subramanya, K., Flow in open channels, Tata McGraw-Hill Education
2. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers
3. Subramanya, K., Fluid Mechanics and Hydraulic Machines, Tata McGraw-Hill Education
4. Daugherty, Robert Long, Hydraulic Turbines, McGraw-Hill

Subject Code: CE4L042	Name: Sustainable Water and Sanitation Systems	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept of sustainability in water and waste management, Water Conservation, Rainwater Harvesting: Roof water harvesting, technology, quality, health issues, Groundwater recharge, techniques, case studies, Water tariff, sustainable water management. Decentralised wastewater treatment systems, Reliability and cost effectiveness of wastewater systems, Tertiary treatment, process selection, granular- medium filtration, micro screening, removal of toxic compounds and refractory organics, removal of dissolved inorganic substances, Natural Wastewater Treatment Systems, Natural and constructed wetlands, different types, Mechanisms, performance, design, case studies. Land treatment systems. Wastewater reuse and reclamation. Rural water supply and sanitation, Low-cost sanitation, Dry sanitation methods, Pit latrines, VIP latrines, Aquaprivy, septic tank, Organic solid waste management techniques, Composting/vermicomposting, biogas technology, plasma technology,

Text/Reference Books:

1. Ahluwalia, P. and Nema, A. K., Water and Wastewater Systems: Source, Treatment, Conveyance and Disposal, S. K. Kataria & Sons.
2. Arceivala, S. J. and Asolekar, S. R., Wastewater Treatment for Pollution Control and Reuse, Tata McGraw Hill.
3. Cites, R. W., Middlebrooks, E. J., and Reed, S. C., Natural Wastewater Treatment

Systems, CRC Taylor and Francis.
4. Cairncross, S. and Feachem, R., Environmental Health Engineering in the Tropics, John Wiley & Sons.
5. Metcalf & Eddy, Wastewater Engineering- Treatment and Reuse (Revised by Tchobanoglous, G., Burton, F. L. and Stensel, H. D.), Tata McGraw Hill.

Subject Code: CE4L043	Name: Environmental System Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Human - environment relationship, normative criteria, descriptive and prescriptive models, limits of growth; Environmental and natural resources economics, pollution control policy, growth in a finite environment; Environmental protection laws; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes; Planning and management of environmental systems: optimization techniques, stochastic modelling, statistical inferences; Large scale systems; Optimal monitoring network design, identification of sources; Risk reliability and uncertainty in environmental systems; Topics in groundwater and surface water quality management.

Text/Reference Books:

1. Schnoor, J. L., Environmental Modelling, Wiley-interscience.
2. Boubel, R. W., Fox, D. L., Turner, D. B. and. Stern, A. C., Fundamentals of Air Pollution, Academic Press, New York.
3. Thomann, R. V., and Muller, J. A., Principles of Surface Water Quality Modelling and Control, Harper International Edition.
4. Tchobanoglous, G., Schroeder, E. D., Water Quality, Addison – Wesley Publishing Company, Reading, Massachusetts.
5. Welford, R., Corporate Environmental Management, Earthscan Publications Limited, London.
6. Rosencranz, A., Divan, S. and Noble, M. L., Environmental Law and Policy in India : Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay.
7. Asolekar, S. R. and Gopichandran, R., Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (The Indian Association of Cambridge University Press, UK).

Subject Code: CE4L051	Name: River Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

River basins; erosion from river catchments and its transportation by rivers; classification of streams, delta, alluvial fans, point bars, etc.; hydraulic geometry and plan form of alluvial rivers; features of gravel bed rivers; bed level changes in streams sedimentation on the upstream and degradation on the downstream of dams and barrages; morphology of some Indian rivers; river flow measurement techniques; stream gauging and analysis of rating curves (hydrometry); dynamics of tidal rivers and estuarine flows; mathematical models for sediment transport and pollutant transport in rivers; introduction to software packages for river flow, sediment and pollutant transport; riverbank erosion mechanisms; direct bank erosion protection methods (use of fascine mattresses; geosynthetics; other [hard] options); indirect bank erosion protection methods (flow deflection using spurs, groynes, etc. and their possible ill effects); foundations for bridges across rivers; river training works (guide bunds) for bridges and barrages.

Text/Reference Books:

1. Julien, P. Y., River Mechanics, Cambridge University Press.
2. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
3. U. S. Army Corps of Engineers, River Hydraulics.

Subject Code: CE4L052	Name: Open Channel Hydraulics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Basic concepts; Energy and Momentum equations and their applications; Critical flow, channel control ad transitions; Uniform flow and flow resistance; Sheet flow; Concepts of boundary layer and surface roughness; Theoretical uniform flow equations; Instability of uniform flow; Gradually varied flow, flow profile classification and computation methods; Flow profiles in natural channels; Spatially varied flow; Hydraulic jump; Unsteady flow, continuity equation, dynamic equation, wave propagation; Method of characteristics; Rapidly varied unsteady flow, surges; Dam break problems.

Text/Reference Books:

1. Subramanya, K., Flow in Open Channels, Tata McGraw-Hill.
2. Chanson, H., Hydraulics of Open Channel Flow, Elsevier.
3. Chow, V. T., Open Channel Hydraulics, McGraw Hill.
4. French, R., Open Channel Hydraulics, McGraw-Hill.
5. Sturm, T.W., Open Channel Hydraulics, Tata McGraw-Hill.

Subject Code: CE4L054	Name: Design of Hydraulic Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concrete dams, force and stress analysis for components like piers, bridges and trash rack and their reinforcement detailing; stress analysis around galleries, adits and shafts and reinforcement provisions; integrated stability analysis of concrete dams considering foundation rock; construction methods for concrete dams. Embankment dams, seepage analysis (finding the phreatic line) for different types of embankment dams; seepage control measures for embankment dams; construction methods for embankment dams. Spillways and energy dissipators design of ogee spillways; calculations for chute spillway profiles; flow characteristics of shaft and syphon spillways; types of energy dissipators, their selection and dimensioning; flow characteristics of radial gates; introduction to relevant BIS codes and guidelines. Barrages - design of barrage structure and canal head regulator; construction methods for barrages. Irrigation structures, Canals, cross drainage works, falls and energy dissipators.

Text/Reference Books:

1. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
2. Ghosh, K., Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Private Limited.
3. Novak, P., Moffat, A. I. B., Nalluri, C., and Narayanan, R. Hydraulic Structures, Taylor & Fransis.

Subject Code: CE4L027	Name: Construction Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Construction Management Overview; Construction Industry; Construction Projects Management; Scheduling Techniques for Construction Projects; Construction Estimating; Construction Cost Control; Construction Contracts Administration; Construction Practice

Text/Reference Books:

1. Jha, Neeraj Kumar, Construction Project Management, Pearson Education India
2. Williams, Trefor, Construction Management, Pearson Education India
3. Chitkara, Krishnan, Construction Project Management Techniques And Practice, Tata McGraw Hill
4. Purifoy R.L., Construction Planning, equipments and Methods, Mc Graw Hill, Tokyo, Japan.

Subject Code: CE4L029	Name: Advanced Transportation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Airports: introduction; characteristics of aircrafts related to airport design; obstruction clearance criteria; design of airside facilities: runway orientation, length, capacity, configuration and number, taxiway layout, design of fillets, high-speed exit taxiway, apron gate and circulation areas, hanger; design of landside facilities: terminal building functional areas and facilities, centralized and de-centralized concepts, vertical distribution; airport planning and site selection; pavement design; visual aids; demand estimation of air travel, drainage. Railways:- Introduction, classification of routes; railway gauge, coning of wheels and canting of rails, train resistance and hauling power; track components: rails, sleepers, fastenings, ballast and formation; track stresses; turnouts and crossings, signals and control systems, welded rails. Elements of water and pipeline transportation. Economic Analysis of Transportation Projects

Text/Reference Books:

1. Horonjeff, Robert, Planning and Design of Airports, McGraw Hill
2. Chandra, Satish and Agarwal, M.M., Railway Engineering, Oxford University Press India
3. Garber, NJ and Hoel, LA, Principles of Traffic and Highway Engineering, Cengage Learning

Subject Code: CE4L045	Name: Soil Dynamics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, Fundamental of vibrations, dynamic properties of geomaterials, transient vibrations, analysis of free and forced vibrations using spring dashpot model, single degree of freedom system, multidegrees of freedom system, application of single and multidegree of freedom systems, wave propagation in elastic media, laboratory and field evaluation of soil properties, analysis of earthquake loadings, liquefaction analysis.

Text/Reference Books:

1. Saran, S., Soil Dynamics and Machine Foundations, Galgotia Publications.
2. Das, B. M. and Ramana, G. V., Principles of Soil Dynamics, CL-Engineering.
3. Richart, F. E., Woods, R. D., and Hall, J. R., Vibrations of Soils and Foundations, Prentice Hall.
4. Kramer, S. L., Geotechnical Earthquake Engineering, Prentice Hall.

Subject Code: CE4L046	Name: Advanced Foundation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Bearing capacity of shallow foundations: Prandtl, Terzaghi and Meyerhof s method of analysis, safe and allowable bearing pressures, selection of type and depth of foundations, combined footings, mat foundations including floating raft, settlement calculations, Skempton - Bjerrum modification, and Martin s method, bearing capacity of layered soils, bearing capacity of footings on slopes, Deep foundations: mechanics of load transfer in piles, load carrying capacity, pile load test, lateral loaded piles, design of pile groups including settlement calculations, design of block foundation, well foundations, coffer dams, pier foundations, earth pressure computations on retaining walls and their design, earthquake response of foundations.

Text/Reference Books:

1. Das, B. M., Principles of Foundation Engineering, Cengage Learning.
2. Budhu, M., Soil Mechanics and Foundations, Wiley Publishers, New Delhi.
3. Coduto, D. P., Foundation Design: Principles and Practices, Prentice Hill Publishers.
4. Holts, R. D. and Kovacs, W. D., An Introduction to Geotechnical Engineering, Prentice

Hall.

5. Das, B. M., Shallow Foundations: Bearing Capacity and Settlement, CRC Press.
6. Tomilson, M. J., Foundation Design and Construction, Pearson Publishers.

Subject Code: CE4L055	Name: Transportation Planning	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Transportation planning Process, Demand-supply interaction of a transportation system, four-step-travel demand modeling- such as trip generation, trip distribution, modal split and traffic assignment, discussion of case study on travel demand model, land-use transport model, household travel survey, public transportation, traffic forecasting techniques on highway, Demand analysis for air transportation

Text/Reference Books:

1. Kadiyali, L. R., Traffic Engineering and Transport Planning, Khanna Publishers.
2. Ortuzar, J. D. and Williumsen, L. G., Modeling Transport, John Wiley & Sons Ltd.

Subject Code: CE4L056	Name: Pavement Design	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Pavement, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, pavement evaluation and overlay design.

Text/Reference Books:

1. Huang, Y. H., Pavement Analysis and Design, Pearson Education.
2. Yoder, E. J. and Witczak, M. W., Principles of Pavement Design, John Wiley & Sons Ltd.
3. Mallick, R. B. and El-Korchi, T., Pavement Engineering: Principles and Practice, CRC Press.

Subject Code: CE4L057	Name: Traffic Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Driver behaviour, visual angle modelling, traffic information and control systems, traffic studies- volume, speed and delay studies, elements of traffic flow theory, Greenshields' model and Greenberg's model, PCU concept, characteristics of uninterrupted traffic, gap acceptance-Raff's method, queuing theory, shock wave, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic, IRC method of roundabout design, traffic characteristics at unsignalised intersections, queue discharge characteristics at signalised intersections, Trial Cycle method and Webster's method of signal design, dilemma zone, actuated signal control, signal coordination.

Text/Reference Books:

1. Mannering, F. L., Kilareski, W. P. and Washburn, S. S., Principles of Highway Engineering and Traffic Analysis, Wiley India Edition.
2. Drew, D. R., Traffic Flow Theory and Control, MaGraw-Hill.
3. May, A. D. Traffic Flow Fundamentals, Prentice Hall.
4. Slinn, M., Guest, P. and Mathews, P., Traffic Engineering Design, Elsevier.
5. Roess, R. P., Prassas, E. S., McShane, W. R. Traffic Engineering, Pearson.
6. Kadiyali, L. R., Traffic Engineering and Transport Planning, Khanna Publishers.
7. Pignatro, L. J., Traffic Engineering-Theory and Practice, Prentice-Hall, Englewood Cliffs, New Jersey.
8. Khanna, S. K. and Justo, C. E. G., Highway Engineering, Nem Chand & Bros, Roorkee.
9. Khisty, C. J. and Lal, B. K., Transportation Engineering, Prentice Hall India.

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10. Papacostas, C. S. and Prevedouros, P. D., Transportation Engineering & Planning, Prentice-Hall.			
Subject Code: CE6L105	**Name: Advanced Water and Wastewater Treatment**	**L-T-P: 3-1-0**	**Credit: 4**

Prerequisite: None

Capabilities and limitations of conventional water and waste water treatment methods, Need for advanced treatment of water and waste water, Advanced water treatment- Iron and manganese removal, colour and odour removal, activated carbon treatment, carbonate balance for corrosion control, ion exchange, electro-dialysis, reverse osmosis and modern methods and flouride management.

Nitrogen and phosphorus removal methods including biological methods, Methods for the removal of heavy metals, oil and refractory organics, Micro-screening, ultra-filtration, centrifugation and other advanced physical methods- aerobic/anaerobic digestion, anaerobic filtration, novel methods of aeration etc.,

Combined physico-chemical and biological processes, Pure oxygen systems, Filtration for high quality effluents, Multistage treatment systems, Land treatment and other resources recovery systems. Decentralised wastewater treatment systems; Reliability and cost effectiveness of wastewater systems. Natural treatment systems- floating aquatic plant treatment systems, constructed wetlands. Industrial Wastewater management and reuse, removal of industry specific pollutants

Text/Reference Books:

1. Metcalf & Eddy., Wastewater Engineering- Treatment and Reuse (Revised by G. Tchobanoglous, F. L. Burton and H. D. Stensel), Tata McGraw Hill.
2. PeavyH. S.,Rowe D. R.,and Tchobanoglous G., Environmental Engineering, McGraw-Hill InternationalEdition.
3. Nemerow N. L and Dasgupta A., Industrial and Hazardous Waste Treatment, Van Nostarnd Reinhold (New York).
4. Arceivala S.J. and Asolekar S.R., Wastewater Treatment for Pollution Control and Reuse, Tata McGraw Hill.
5. Eckenfelder, W. W., Industrial Water Pollution Control, McGraw-Hill.
6. Nemerow, N. L., Zero Pollution for Industry: Waste Minimization through Industrial Complexes, John Wiley & Sons.
7. Cites R W., Middlebrooks E J., Reed S C., Natural wastewater Treatment Systems, CRC Taylor and Francis.
8. Patwardhan A.D., Industrial Wastewater Treatment, PHI Learning
9. S.R. Qasim, Edward and Motley and Zhu, H., "Water Works Engineering – Planning, Design and Operation", Prentice Hall, India.
10. S. Vigneswaran and C. Visvanathan, "Water Treatment Processes: Simple Options", CRC Press.

Subject Code: CE6L106	**Name: Environmental Economics**	**L-T-P: 3-0-0**	**Credit: 3**

Prerequisite: None

Introduction to Environmental Economics: Scope of the problem, Interaction between economy and environment, Economist's perspectives on environmental problems. Brief idea about Quality of natural Environment and Environmental problems (Air Pollution, Water Pollution, Toxic Emission, ecosystem health).Introduction to Environmental Policy Instruments: Choice of policy instrument, command and control instruments, taxation, tradable permits, Environmental performance bonds
Public and environmental goods, negative externality and market failure, Internalization Environmental Valuation: Contingent valuation methods, travel cost method, hedonic price

method

Economics of natural resources: Natural Resources (renewable and non-renewable), Population dynamics, extraction of non-renewable resources, depletion, resource modeling, Green and Natural resource accounting: GDP, NDP and sustainable development, Environmental accounting

Social efficiency and benefit-cost analysis: Efficiency and competitive markets, supply, demand and efficiency, benefit and cost analysis

Sustainable development and irreversibility in environmental policy: definition, economical efficiency, economic growth and environment

Global Environmental Issues and policies: Climate Change: Causes; possible effects; costs of mitigating green house gas emissions; Carbon Trading, adaptation measures, Design of international agreements, Environmental conflict, bargaining and cooperation, Environmental issues and policies in India

Text/Reference Books:

1. KolstadC.D., Environmental Economics, Oxford University Press.
2. Conrad J. M., Resource Economics. Cambridge University Press
3. Bhattacharya R.N., Environmental economics: an Indian perspective, Oxford University Press, New Delhi.
4. Hanley N., Shogren, J. F., and White, B., Environmental economics in theory and practice. Oxford university press, New York.
5. CommonM. and Stagi, S., Ecological Economics an introduction, Cambridge University Press.
6. GraftonR. Q. andAdamowicz W., The economics of the environment and natural resources, Wiley Blackwell Publication.
7. Baumol W.J. and OatesE.E., The Theory of Environmental Policy, Cambridge University Press
8. TitenbergT., Environmental Economics and Policy, Addision-Wesley

Subject Code: CE6L107	Name: Environmental Hydraulics	L–T–P: 3-1-0	Credit: 4

Prerequisite: None

Introduction to the principles of fluid dynamics, continuity, momentum and energy equations, Basic concepts in friction and flow in pipes, Flow formulation, turbulent and viscous flow, Hardy-Cross, Tong O Conner and other methods of analysis of pipe networks, Basic concepts in open channel hydraulics, Energy and momentum equations, critical flow, channel control and transitions, uniform flow, gradually varied flow, flow profiles and their computation, unsteady flow, hydraulic jumps, Design of drainage systems, Ground water hydraulics, estimation of aquifer parameters, confined and unconfined aquifers, steady and unsteady flow into wells, Dupuit approximations, single and multi-well system, well losses, recharging, well developments etc., movement of pollutants in ground water and wastewater treatment plants hydraulics. Different Flow measurement devices in channels and pipes

Text/Reference Books:

1. Chow V T, Flow through open channel, McGraw-Hill, 1973.
2. Ranga Raju K. G., Flow through Open Channels, Second edition, TATA McGraw-Hill, 1997.
3. Garde R. J. and Ranga Raju K. G., Mechanics of sediment transportation and alluvial stream problems, Third edition, New Age International (P) Limited, New Delhi, 2000.
4. Bhave P. R., Analysis of Flow in Water Distribution Network, Technomic Publishing Co., Lancaster, USA, 1996.
5. Todd D. K. Groundwater Hydrology , John Wiley publishers , 2004
6. Jacob and Bear, Hydraulics of Groundwater, McGraw Hill, 1997
7. Raghunath, Groundwater & Well Hydraulics, Wiley Eastern Ltd, New Delhi, 1992

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Subject Code: CE6L108	Name: Solid Waste Management	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Solid waste management: Sources, Composition and Properties of Municipal Solid Waste, Engineering principles; Generation, Onsite handling, storage and processing including segregation; Collection, Recycling, Transfer and transport,Waste processing, Recovery of resources, Waste processing technologies, Biological, chemical and thermal technologies – Composting, Anaerobic digestion, 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. Principles of E-waste Management.

Biomedical waste: Regulatory framework, categorization; generation, collection, transport, treatment and disposal.

Hazardous Waste Fundamentals, Definition, Classification, Generation, Regulatory process, Current Management Practices, Treatment and Disposal Methods, Physicochemical processes, Biological processes, Stabilization and solidification; Thermal methods; Land disposal, Remediation of Contaminated Sites.

Text/Reference Books:

1. Tchobanoglous G., Theisen H., and Vigil S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company, 1993.
2. Peavy H. S., Rowe D. R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill International Edition.
3. LaGrega, M.D., Buckingham P.L., and Evans J.C., Hazardous Waste Management, McGraw-Hill International Editions, 1994.
4. Martin E.J. and Johnson J.H., Hazardous Waste Management Engineering, van Nostrand-Reinhold, 1987.
5. Wentz C.A., Hazardous Waste Management, 2nd Edition, McGraw Hill, 1995
6. VesilindP.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.
7. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2000.
8. Bhatia, S. Solid and Hazardous Waste Management, Atlantic Publishers & Distributors

Subject Code: CE6L109	Name: Industrial Pollution Prevention	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

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: Flow sheet 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. Presently used wastewater treatment systems such as MBR, MBBR, SBR, UASB reactor, Anammox, etc

Text/Reference Books:

1. Freeman H. M. Industrial Pollution Prevention Handbook, McGraw Hill.
2. Shen T. T., Industrial Pollution Prevention, Springer
3. Bishop P.E. Pollution Prevention: Fundamentals and Practice, McGraw Hill.
4. Allen D.T. and Rosselot, K.S. Pollution Prevention for Chemical Processes, John Wiley.
5. Allen D.T., Bakshani, N. and Rosselot, K.S., Pollution Prevention: Homework and Design Problems for Engineering Curricula, American Institute for Pollution Prevention, and Center for Waste Reduction Technologies.
6. Johansson A., Clean Technology, Lewis Publishers, Boca Raton.
7. Theodore, L. and McGuinn, Y. C.Pollution prevention, Van Nostrand Reinhold, NewYork.
8. Eckenfelder, W. W., Industrial Water Pollution Control, McGraw-Hill.
9. Nemerow, N. L., Zero Pollution for Industry: Waste Minimization through Industrial Complexes, John Wiley & Sons.

Subject Code: CE6L110	Name: Environmental Chemistry and Microbiology	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Environmental chemistry-basic concepts from general chemistry, Chemical equations, chemical reactions, calculation from chemical reactions, solutions, activity and activity coefficients, Chemical Equilibria and Kinetics Fundamentals, Acid-Base equilibria – fundamentals, equilibrium diagrams, Acidity, Alkalinity, Buffers and Buffer Intensity, Chemical equilibrium calculations, pC-pH diagram, Langelier index, Solubility diagram, Oxidation and Reduction equilibria.

Water and wastewater quality parameters and their analysis, Basic concepts of quantitative analytical chemistry, instrumental methods of analysis.

Types of microorganisms found in the environment, Metabolic classification of organisms, Enzyme and enzyme kinetics, indicator organisms, coliforms - fecal coliforms - E.coli, Streptococcus fecalis differentiation of coliforms - significance - MPN index, M.F. technique, standards, Microbiological Parameter Analysis, Measurements and Isolation of Microorganism, Different Cultures, Media and Techniques of Staining and Enumeration of microorganism, Staining and detection of microbes, Methods of enumerating microbes, Multiple tube fermentation technique, Membrane filter technique.

Text/Reference Books:

1. Sawyer, C.N. and McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineers, 4th Edition, McGraw Hill, New Delhi, 1994.
2. Benefield, Judkins and Weand – Process Chemistry for Water and Wastewater Treatment, Prentice Hall
3. Maier R. M., Pepper I. L., and Gerba C. P., Environmental Microbiology, Second Edition, Elsevier- AP, 2009.
4. Pelczar, Jr, M.J., Chan, E.C.S., Krieg, R.N., and Pelczar M. F, Microbiology, 5thEdn., Tata McGraw-Hill Publishing Company Limited, New Delhi, 1996.
5. Rittman B, McCarty P L McCarty P, Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000

Subject Code: CE6L111	Name: Highway Environment and Noise Pollution Control	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Sources and Classification of Noise, Effects of Noise, Noise Measuring Instruments and Survey: Sound level meter, audiometer, dose meter, octave band analyzer; Noise Indices:

Leq, Ldn, TNI, NII, Noise Control Measures: noise control at source, path and receiver, acoustic barriers, enclosures, control of machinery noise, community and industrial noise control strategies; Noise Standards in India and Abroad; Noise Impact Assessment and Prediction Techniques.

Human factors in road user behaviour, vehicle characteristics, driver, road and environment. Environmental Factors: impacts and mitigation measures of air quality, noise, severance, visual intrusion, impact on water quality, use of limited resources, impact on flora & fauna, vibration, dust ; Transport related pollution. Urban and non urban traffic noise sources, Noise pollution. Traffic calming, Measures, Road transport related air pollution, sources of air pollution, effects of weather conditions, Vehicular emission parameters, pollution standards, measurement and analysis of vehicular emission; control measures; EIA requirements of Highways projects.

Text/Reference Books:

1. Tripathy D.P., Noise Pollution, APH Pub., New Delhi.
2. Sengupta M., Environmental Engineering (Vol. 2), CRC Press, Boca Raton.
3. Pandey G.N. and Carney G.C., Environmental Engineering, Tata McGrawHill, New Delhi.
4. Beranek L., Noise and Vibration Control, McGrawHill Co, NY.
5. Trivedy P.R. Int. Encyclopedia of Ecology & Environment, Noise Pollution (Vol. 13), IIEE, New Delhi.
6. Wark K., Warner C.F. and Davi, W.T., Air Pollution: Its Origin and Control, Prentice Hall.
7. Boubel R.W. Fundamentals of Air Pollution, Academic Press.
8. Vallero D., Fundamentals of Air Pollution, Academic Press.
9. Canter L., Environmental Impact Assessment, McGraw-Hill International.

Subject Code: CE6L112	Name: Environmental Nanotechnology and Applications	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Introduction to nanotechnology, Nanotechnology for reduced wasteand improved energy efficiency, Nanotechnology based water treatment strategies, nanomaterials-microporous materials, carbon nanotubes, photocatalystsetc, synthesis of nanocrystals and membranes, properties, environmental application, Development of carbon nanotubes (CNTs), structure and properties of fullerene, C60, carbon nanotube and fibre, CNT synthesis – mechanism and commercial techniques, organized assembly of CNTs, possible applications of CNTs, Environmental applications – adsorption, hydrogen storage, photocatalysts preparation and characterizationUV induced hydrophobicity, modified photocatalysts, application of photocatalysts in environmental treatment, nanoscale biometal for subsurface remediation, Sensing materials, introduction to novel sensing materials, operation principle, sensors – mass and optical sensors, nano-sensing systems and applications.

Text/Reference Books:

1. Wiesner M., Bottero J-Y., Environmental Nanotechnology : Applications and Impacts of Nanomaterials Applications and Impacts of Nanomaterials, McGraw Hill Professional.
2. Pradeep T., Textbook of Nanoscience and Nanotechnology, McGraw Hill Education (India) Private Limited
3. Mittal V., Nanocomposites with Biodegradable Polymers: Synthesis, Properties, and Future perspectives., Oxford University Press

Subject Code: CE6L113	Name: Water Quality Modeling and Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant

transport, transport mechanism-advection, diffusion, dispersion; River and streams, convective diffusion equation and its application. Estuaries, Estuarine hydraulics, Estuarine water quality models; Lakes and reservoirs, eutrophication; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes Contaminant transport in unsaturated flows, solute transport models for conservative species, solute transport in spatially variable soils; Contaminant transports in ground water advection, dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, bio degradation reaction; Water quality management, socio-economic aspects of water quality management, management alternatives for water quality control, waste load allocation process, lake quality management, ground water remediation.

Text/Reference Books:

1. Ramaswami A., Milford J. B., Small M. J., Integrated Environmental Modeling - Pollutant Transport, Fate, and Risk in the Environment John Wiley & Sons, 2005.
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems, Oxford University Press, 1998.
3. Snape J.B., Dunn I.J.,Ingham J., and Prenosil J., Dynamics of environmental bioprocesses, modelling and simulation Weinheim: VCH, 1995.
4. International Water Association - Activated sludge modelling ASM1 and ASM2
5. Chapra S. C., Surface Water Quality Modeling, McGraw-Hil, Inc., New York, 1997.
6. Garde R. J., and Ranga Raju K. G., Mechanics of sediment transportation and alluvial stream problems, Third edition, New Age International (P) Limited, New Delhi
7. Thomann, R.V. and Mueller, J.A. Principles of surface water quality modeling and control, Pearson, 1987
8. Chapra, S.C. Surface water quality modelling, Waveland Press, INC., 1997
9. Schnoor, J.L., Environmental Modeling Wiley, John & Sons, 1997
10. Thomann, R.V., Systems Analysis and Water Quality Management, McGraw Hill, 1972

Subject Code: CE6L513	Name: Water Resources Planning and Management	L-T-P: 3-1-0	Credit: 4

Pre-requisites: None

Introduction to issues in planning and management; Role of water resources systems modelling; Decision support systems (DSS); Simulation models; Optimization methods; Dynamic programming; Application in reservoir operation, etc.; Linear programming; Multi-objective optimization; Modelling uncertainty; Sensitivity and uncertainty analyses; Advances in modelling; Fuzzy optimization-applications in reservoir storage, water quality studies, etc.; Artificial neural networks; Genetic algorithms; Data mining; Flood management; Flood plain modelling; Managing risk; Risk reduction; Decision support and prediction; Reliability-resilience-vulnerability (RRV) analysis; Drought management; Causes, types and impacts; Impact of climate change; Drought monitoring; Drought triggers; S-D-F analysis of droughts using copulas.

Text/Reference Books:

1. Loucks, D. P., and Van Beek, E., Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications, the UNESCO, Paris, 2005.
2. Loucks, D. P., Stedinger, J.R., and Haith, D. A., Water Resources Systems Planning and Analysis, Prentice-Hall, NJ, 1981.
3. Vedula, S., and Mujumdar, P. P., Water Resources Systems: Modelling Techniques and Analysis, Tata McGraw Hill, New Delhi, 2007.
4. Jain, S.K., and Singh, V. P., Water Resources Systems Planning and Management, Developments in Water Science, Vol. 51, Elsevier Science, New York, 2003.
5. Govindaraju, R. S., and Rao, A. R., Artificial Neural Networks in Hydrology, Water Science and Technology Library, Volume 36, Springer Netherlands, 2000.
6. Raju, K. S., and Kumar D. N., Multicriterion Analysis in Engineering and Management,

Prentice-Hall, India, 2014.

Subject Code: CE6L514	Name: Design of Pipe Networks	L-T-P: 3-1-0	Credit: 4

Pre-requisites: None

Introduction to flow hydraulics and network analysis; Basic principles of pipe flow; Fittings and valves; Pipe network analysis, pipe network geometry, branched and looped networks; Multi-Input source water network analysis; Cost considerations, Life cycle costing, Relative cost factor; General principles of network synthesis, constraints, parameters for network sizing, reliability considerations; Water transmission lines, gravity mains, pumping mains; Water distribution mains; Single-input source branched systems; Single-input source looped systems; Multi-input source branched systems; Multi-input source looped systems; Decomposition of a large multi-input, looped network; Optimal water supply zone size.

Text/Reference Books:

1. Swamee, P. K., and Sharma, A. K.,Design of Water Supply Pipe Networks, John Wiley & Sons, Inc., New Jersey, 2008.
2. Bhave, P. R., Analysis of Flow in Water Distribution Networks, Technomic Publishing; Lancaster, 1991.
3. Surhone, L. M., Tennoe, M. T., Henssonow, S. F.,Pipe Network Analysis, VDM Publishing, Germany, 2010.
4. Jeppson, R. W., Analysis of flow in pipe networks, Ann Arbor Science Publishers, Inc., Ann Arbor, 1976.
5. Mays, L. W., Water Distribution Systems Handbook, McGraw-Hill Education, New York, 1999.

Subject Code: CE6L515	Name: GIS and Remote Sensing Applications in Civil Engineering	L-T-P: 3-0-0	Credit: 3

Pre-requisites: None

Remote sensing; Energy source; Spectral signatures; Remote sensing satellites and sensors; Radar image interpretation; Digital image processing; Image classification; Principal component transformation; Applications in watershed management, flood management, groundwater quality, reservoir sedimentation, irrigation management. Geographic information systems (GIS); Raster and vector data; GIS for Surface-Water Hydrology; Digital elevation models; Hydrographic vector data; Arc-hydro model; GIS for groundwater modeling; GIS for flood plain management; HEC-RAS and HEC-GeoRAS; Case studies.

Text/Reference Books:

1. Lillesand, T., Kiefer, R. W., and Chipman, J., Remote Sensing and Image Interpretation, Seventh Edition, John Wiley & Sons, New York, 2015.
2. Burrough, P. A., and McDonnell, R. A., Principles of Geographical Information Systems, Second Edition,Oxford University Press, Oxford, 1998.
3. Richards, J. A., Remote Sensing Digital Image Analysis: An Introduction, Fifth Edition, Springer-Verlag Berlin Heidelberg, 2013.
4. Johnson, L. E., Geographic Information Systems in Water Resources Engineering, CRC Press, Boca Raton, 2008.

Subject Code: CE6L516	Name: Non-Point Source Pollution of Water Resources	L-T-P: 3-0-0	Credit: 3

Pre-requisites: None

Basic concept of water pollution; Water quality standards pertaining to drinking, irrigation and aquatic life; Water quality analysis methods and instruments used; Concept and

behaviour of point and nonpoint source pollution (NPS); Sources of NPS pollution; Pathways and assessment of NPS pollutants; linkage between water pollution and hydrology; Application of hydrologic models in NPS pollution assessment at watershed scale; Quantification and control of NPS pollution from agricultural watersheds; Nitrogen, Phosphorus, pesticides and water quality impacts; Impacts of mining and forestry; Watershed-scale NPS pollution models; Optimum management strategy; Best management practices for NPS pollution control.

Text/Reference Books:

1. Novotny, V., Water Quality: Diffuse Pollution and Watershed Management, Second Edition, John Wiley and Sons, New York, 2003.
2. Ritter, W. F., Shirmohammadi, A., Agricultural Nonpoint Source Pollution: Watershed Management and Hydrology, CRC Press, Boca Raton, 2001.
3. Brooks, K. N., Ffolliott, P., F., and Magner, J. A., Hydrology and the Management of Watersheds, Fourth Edition, Wiley-Blackwell, New York, 2012.
4. Das, M. M., Saikia, M., Watershed Management, PHI Learning, Delhi, 2012.

Subject Code: CE6L518	Name: Integrated Watershed Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to integrated approach for the management of watersheds; Watershed hydrology: runoff and sediment load estimation; Instrumentation, and monitoring of hydro-meteorological variables at watershed-scale; Discharge measurement, sediment (suspended and bed load) measurement; Control of soil erosion; GIS for integration of different aspects of watersheds; Rainwater management: rainwater harvesting, artificial recharge, types and design of water harvesting and recharge structures; Irrigation management: use of conserved water; Land degradation, soil quality and water quality aspects, soil conservation strategies, water conveyance structures-spillways, culverts, etc.; Droughts: causes, types, drought indices, control and adaptation strategies; Drainage: estimation of drainage coefficient, design of surface and subsurface drainage systems, control of soil salinity; Climate change: general circulation models (GCMs), IPCC climate change scenarios, impacts of climate change and land use change on watersheds; Case studies

Text/Reference Books:

1. Brooks, K. N., Ffolliott, P., F., and Magner, J. A., Hydrology and the Management of Watersheds, Fourth Edition, Wiley-Blackwell, New York, 2012.
2. Das, M. M., Saikia, M., Watershed Management, PHI Learning, Delhi, 2012.
3. Ven Te Chow, Maidment, D. and Mays, L.W., Applied Hydrology, Second Edition, McGraw-Hill Inc., New York, 2013.
4. Heathcote, I. W., Integrated Watershed Management: Principles and Practice, Second Edition, John Wiley and Sons, Inc., NJ, 2009.
5. Gregersen, H. M., Ffolliott, P. F., Brooks, K. N., Integrated Watershed Management: Connecting People to Their Land and Water, CAB International, UK, 2007.
6. Climate Change 2014: Impacts, Adaptation and Vulnerability, Working Group Report II, IPCC Fifth Assessment Report of the IPCC.
7. Climate Change 2014: Mitigation of Climate Change, Working Group Report III, IPCC Fifth Assessment Report of the IPCC.
8. Mujumdar, P. P., and Kumar D. N., Floods in a Changing Climate: Hydrologic Modeling, International Hydrology Series, Cambridge University Press, Cambridge, U.K., 2012.

Subject Code: CE6L216	Name: Geotechnics of Polluted Sites	L-T-P: 3-0-0	Credit: 3

Pre-requisites: None

Basic concepts related to soil pollution; Sources of pollution: industrial areas, agricultural,

municipal, nuclear; types of contaminants; Role of physical and chemical properties of soil in contamination; Factors effecting retention and transport of contaminants; Soil sampling collection and characterization: sampling of contaminated soil, site investigation and monitoring parameters, exploratory site investigation, methods of analysis/identification, sample handling, preservation, transportation and storage; Non-destructive techniques of site characterization: electrical and thermal properties, GPR; Soil and ground water remediation: conceptual approach to soil and ground water remediation, risk assessment, methodologies and selection of treatment models; Soil remediation: excavation, soil washing, stabilization/solidification; Soil vapor extraction, electrokinetic remediation, thermal desorption, vitrification; Bioremediation, phytoremediation, soil fracturing; Groundwater Remediation: selection of technique, pump and treat, in-situ flushing; Groundwater Remediation: permeable reactive barriers, in-situ air sparging, monitored natural attenuation, bioremediation; Green and sustainable remediation; Case studies on polluted sites and issues related to environment.

Text/Reference Books:

1. Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004, 992p. (ISBN: 0-471-21599-6).
2. Reddy, K.R., and Cameselle, C. Editors, Electrochemical Remediation Technologies for Polluted Soils, Sediments and Groundwater, John Wiley & Sons, Inc., Hoboken, New Jersey, 2009, 760p. (ISBN: 0-470-38343-7).
3. Reddy, K.R., and Adams, J.A., Sustainable Remediation of Contaminated Sites, Momentum Press, New York, December 2014 (ISBN: 9781606505205).
4. Rowe R.K.,"Geotechnical and Geoenvironmental Engineering Handbook" Kluwer Academic Publications, London, 2000.

Subject Code: CE6L217	Name: Geotechnics of Waste and waste Containment	L-T-P: 3-0-0	Credits: 3

Pre-requisites: None

Sources and types of wastes; Environmental and engineering properties of wastes; New and developing government policies; Beneficial re-use of wastes; Fundamentals of waste-soil interaction; Containment systems and basic principles; Lining and capping systems; Leachate and gas collection systems; Compacted soi liners; Admixed soil liners; Geosynhtetic clay liners; Geomembranes; Drainage layers; Geosynhtetic composites; Seepage flow; Contaminant transport; Landfill settlement; Landfill slope stability; Conventional caps, ET caps; Ground water monitoring; Landfill gas; Post-closure monitoring; Bioreactor landfills; Landfill mining; End-use of closed landfills; Impoundments; Integrated waste management and alternative landfills.

Text/Reference Books:

1. H.D. Sharma and K.R. Reddy Geo-environmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, John Wiley, New Jersey, 2004.
2. R.N. Yong, Geoenvironmental Engineering: Contaminated Ground: Fate of Pollutions and Remediation, Thomson Telford, 2000.
3. L.N. Reddy & H.I. Inyang, Geoenvironmental Engineering: Principles and Applications, Marcel Dek, 2000.
4. Raju, V.S., Datta, M., Seshadri, V., and Agarwal, V.K. (1996) (Eds.), "Ash Ponds and Ash Disposal Systems", Narosa Publishers, Delhi,424 pages.
5. Datta, M. (1997) (Ed.), "Waste Disposal in Engineered Landfills", Narosa Publishers, Delhi, 231 pages.
6. Datta, M., Parida, B.P., Guha, B.K. and Sreekrishnan, T., (1999) (Eds.), "Industrial Solid Waste Management and Landfilling Practice", Narosa Publishers, Delhi, 204 pages.

7. David E. Daniel, Geotechnical Practice for Waste Disposal, Published by Chapman & Hall, London, 1993.
8. Bagchi,A.,"Design of landfills and integrated solid waste management" John Wiley & Sons, Inc., USA, 2004.
9. Qian, X., R. M. Koerner, and D. H. Gray. Geotechnical Aspects of Landfill Design and Construction. New Jersey: Prentice Hall, Upper Saddle River, 2002.

Subject Code: ES6L104	Name: Groundwater Modeling and Simulation	L-T-P: 3-1-0	Credit: 4

Pre-requisites: None

Data requirement; Aquifer configuration and hydraulic parameters; Subsurface Groundwater flow equation; Conceptual modelling; Aquifer geometry; Model boundary; Model design; Model calibration; Simulation techniques; Solute transport modelling; Groundwater modelling examples from India.

Text/Reference Books:

1. Damena, T, Mathematical Modelling and Simulation on Groundwater Flow: The study of groundwater flow with computer aided mathematical methods, LAP LAMBERT Academic Publishing.
2. Refsgaard, J.C., Kovar, K. Haarder, E. and Nygaard, E., Calibration and Reliability in Groundwater Modelling: Credibility of Modelling (IAHS Proceedings & Reports), International Association of Hydrological Sciences.
3. Rushton, K.R., Groundwater Hydrology: Conceptual and Computational Models, Wiley.

Subject Code: MA6L001	Name: Mathematical Methods	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Probability and Statistics : Random variables (rv) and their properties, some standard discrete and continuous rv, Expectation, Variance, moments, moment generating functions, functions of a rv, their distribution and moments, joint, marginal and conditional distribution and independence of rvs, Hypothesis testing.
Numerical solutions of systems of linear equations: Gauss elimination, LU decomposition, Gauss-Jacobi and Gauss-Seidel methods.
Numerical methods of ODE and PDE: Runge-Kutta and finite difference methods for ODE, Finite difference methods for solving 2-D Laplace's equation, Poisson's equation, 1-D heat equation : Bender Schmidt, Crank Nicholson method and Du Fort Frankel methods, 1-D wave equation using Explicit method. Consistency and stability analysis.

Text/Reference Books:

1. Grawel B.S. Numerical Methods
2. Jain M.K., Iyengar S.R.K. and Jain R.K., Numerical Methods-problem and solutions, Wiley Eastern Limited, 2001.
3. Ross S. Introduction to Probability Models, Wiley India
4. Gun A.M., Gupta M.K. and Gupta B.S. Fundamentals of Statistics
5. Hayter A.J., Probability and Statistics, Duxbury, 2002
6. Scarborough J.B., Numerical mathematical analysis, Oxford & IBH Publishing Co.Pvt.,2000
7. Hamming R.W., Numerical Methods for Scientist and Engineers, McGraw Hill, 1998
8. Mathews J.H. and Fink, K.D., Numerical Methods using MATLAB, Pearson Education, 2004.

Subject Code: MA6L002	Name: Advanced Techniques in Operation Research	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

One variable unconstrained optimization, multivariable unconstrained optimisation, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization, quadratic programming, separable programming, convex and non convex programming, steepest and Quasi-Newton method.

Dynamic Programming: Characteristics of dynamic problems, deterministic dynamic programming and probabilitistic dynamic programming, Network analysis, Shortest path problems, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, network simplex, interior point methods, stochastic programming, Nonlinear goal programming applications, Geometric Programming.

Multi-objective Optimization Problems: Linear and non linear programming problems, Weighting and Epsilon method, P-norm methods, Gradient Projection Method, STEM method, Convex Optimization.

Text/Reference Books:

1. Rao S.S., Engineering Optimization Theory and Practices, John Wiley and Sons, 2009
2. Ehrgott., M. Multi-criteria Optimization, Springer 2006
3. Miettien K.M., Non-linear multi-objective optimization, Kluwers International Series, 2004
4. Deb K., Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

Indian Institute of Technology Bhubaneswar
Curriculum

Dual Degree (B.Tech. Civil Engineering and M.Tech. Structural Engineering)

Curriculum (7th Semester – 8th Semester)

SEMESTER - VII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Breadth - 4			3/4	3/4	
Dynamics of Structures	**CE6L301**	3-1-0	4	4	61
Advanced Structural Analysis	**CE6L302**	3-1-0	4	4	61
Elective-1		3-0-0	3	3	
CAD Laboratory	**CE4P001**	0-0-3	2	3	62
Industrial Training Defence	**CE4T001**	0-0-0	2	0	
Project – Part 1 (CE)	**CE4D001**	0-0-0	4	0	
		Total	**22/23**	**17/18**	

SEMESTER – VIII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Advanced Solid Mechanics	**CE6L303**	3-1-0	4	4	62
Elective – 2		3-0-0	3	3	
Elective – 3		3-0-0	3	3	
Elective – 4		3-1-0	4	4	
Design of Special Structures	**CE6P303**	0-0-6	4	6	62
Project – Part 2 (CE)	**CE4D002**	0-0-0	6	0	
		Total	**24**	**20**	

SEMESTER – IX					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Elective-5		3-0-0	3	3	
Advanced Structural Laboratory	**CE6P301**	0-0-3	2	3	62
Thesis : Part-I (CE)	**CE6D001**	0-0-0	12	0	
		Total	**17**	**6**	

SEMESTER – X					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Seminar		0-0-0	2	0	
Computational Laboratory	**CE6P302**	0-0-3	2	3	63
Thesis : Part-I (CE)	**CE6D002**	0-0-0	12	0	
		Total	**16**	**3**	

Elective-1					
Subject Name	**Subject Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Advanced Transportation Engineering	**CE4L003**	3-0-0	3	3	63
Rock Mechanics and Tunnelling	**CE4L004**	3-0-0	3	3	63
Maintenance and Rehabilitation of Concrete Structures	**CE4L005**	3-0-0	3	3	64

Computational Hydraulics	**CE4L006**	3-0-0	3	3	64
Hydraulic and Hydrologic Analysis and Design	**CE4L008**	3-0-0	3	3	64
Bridge Engineering	**CE4L022**	3-0-0	3	3	65
Prestressed Concrete	**CE4L023**	3-0-0	3	3	65
Advanced Foundation Engineering	**CE4L042**	3-0-0	3	3	65
Numerical Methods in Geotechnical Engineering	**CE4L043**	3-0-0	3	3	66
Soil Engineering	**CE4L044**	3-0-0	3	3	66
Earth Retaining Structures	**CE4L045**	3-0-0	3	3	66
Open Channel Hydraulics	**CE4L053**	3-0-0	3	3	67
Water Resources Systems	**CE4L054**	3-0-0	3	3	67
Design of Hydraulic Structures	**CE4L055**	3-0-0	3	3	67
Pavement Design	**CE4L062**	3-0-0	3	3	68
NB: Any other subjects of same or higher level floated by any other specialisations of SIF or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinator					

Elective - 1 to 5					
Name	**Subject Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Advanced Concrete Technology	**CE6L304**	3-0-0	3	3	68
Theory of Plates & Shells	**CE6L305**	3-1-0	4	4	69
Seismic Design of Structures	**CE6L306**	3-1-0	4	4	69
Bridge Engineering	**CE6L307**	3-0-0	3	3	69
Infrastructure Maintenance and Rehabilitation	**CE6L308**	3-0-0	3	3	70
Modern Construction Materials	**CE6L309**	3-0-0	3	3	70
Advanced construction Techniques	**CE6L310**	3-0-0	3	3	71
Construction Project Management	**CE6L311**	3-0-0	3	3	71
Advanced Design of RC Structures	**CE6L312**	3-1-0	4	4	72
Mathematical Methods	**MA6L001**	3-1-0	4	4	72
Advanced Techniques in Operation Research	**MA6L002**	3-1-0	4	4	73
Nonlinear Functional Analysis	**MA7L020**	3-1-0	4	4	73
Hydraulics of Sediment Transport	**CE6L008**	3-0-0	3	3	74
Advanced Transportation Systems Analysis	**CE6L017**	3-0-0	3	3	74
Analysis and Design of Pavements	**CE6L018**	3-0-0	3	3	74
Pavement Evaluation, Maintenance and Rehabilitation	**CE6L019**	3-0-0	3	3	75
Dynamics of Soil and Foundations	**CE6L020**	3-0-0	3	3	75
Soil-Structure Interaction	**CE6L021**	3-0-0	3	3	75
Ground Improvement	**CE6L022**	3-0-0	3	3	76
Computational Geomechanics	**CE6L023**	3-0-0	3	3	76
Geotechnical Earthquake Engineering	**CE6L024**	3-0-0	3	3	76
Geotechnical Risk and Reliability	**CE6L025**	3-0-0	3	3	77
Advanced Soil Mechanics	**CE6L026**	3-0-0	3	3	77
Free Surface Flows	**CE6L027**	3-0-0	3	3	78
Applied Elasticity	**CE6L028**	3-0-0	3	3	78
Structural Health Monitoring	**CE6L029**	3-0-0	3	3	78
NB: Any other subjects of same level floated by any other specialisations of SIF or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators					

Indian Institute of Technology Bhubaneswar
Curriculum

Syllabus

Subject Code: CE6L301	Name: Dynamics of Structures	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Single-degree-freedom systems: undamped and damped free vibration; Response to harmonic and periodic excitations; Response to non-periodic excitations; Numerical evaluation of dynamic response; Generalized single-degree-freedom systems. Elements of analytical dynamics: The principle of virtual work; Principle of D Alembert; Hamiltons principle; Lagrange's equation. Multi-degree-freedom systems: Equation of motion; undamped free vibration; Interpretation of modal orthogonality; Decomposition of response in terms of modal co-ordinates; Modal analysis; Response to external excitations; Rayleigh s quotient and its properties; Systems with proportional damping; Systems with arbitrary viscous damping. Distributed parameter systems: axial and bending vibration of beams; orthogonality of modes; Response to external excitations; Rayleigh s quotient; Approximate methods. Earthquake response of linear systems: Earthquake excitations; Equations of motion; Response spectrum concept; Response spectrum characteristics; Design response spectrum; Modal analysis; Displacement response; Element forces; Modal response contribution; Response history analysis; Response spectrum analysis. Introduction to Random Vibration; Stationary and non-stationery random processes; Ergodic random processes. Narrow band and wide band random processes; Properties of Autocorrelation and Power spectral density functions; Response to arbitrary excitation by Fourier transform method.

Text/Reference Books:

1. Chopra, A.K., Dynamics of Structures: Theory and Applications to Earthquake Engineering, Prentice Hall/Pearson Education
2. Clough, R.W. and Penzien, J., Dynamics of structures, McGraw Hill, Inc., New York
3. Craig, R.R., Structural Dynamics: An Introduction to Computer Methods, Wiley New York
4. Meriovitch, L., Elements of vibration analysis, McGraw-Hill
5. Rao, S.S., Mechanical Vibrations, Pearson
6. Thomson, W.T., Theory of Vibration with Application, CRC Press
7. Newland, D.E., An Introduction to Random Vibrations, Spectral and Wavelet Analysis, Courier Dover Publications

Subject Code: CE6L302	Name: Advanced Structural Analysis	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Basics of structural analysis: static & dynamic loading, linear & nonlinear structural behaviour, geometric & material nonlinearity, hysteretic behaviour; Classical linear analysis of frames and trusses: displacement method, slope deflection equations & matrix displacement method, effect of foundation settlement and temperature; Geometric nonlinear analysis of frames and trusses: displacement method, nonlinear slope-deflection equations & nonlinear behaviour, linearized iterative matrix displacement method, geometric stiffness matrix, tangent stiffness matrix, P-Δ effect, buckling of frames, tension structures; Material nonlinear analysis of frames: basics of plasticity, distributed plasticity & lumped plasticity, incremental nonlinear analysis.

Text/Reference Books:

1. Thandavamoorthy, T.S., Structural Analysis, Oxford University Press
2. Weaver, W. and Gere, J.M., Matrix Analysis of Framed Bstructures, CBS Publisher
3. Wang, C.K., Intermediate Structural Analysis, McGraw Hill
4. Kanchi, M.B., Matrix Methods of Structural Analysis, Wiley Eastern Limited

5. Hibbeler, R.C., Structural Analysis, Pearson

Subject Code: CE4P001	Name: CAD Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Exposure to commercial software tools for analysis, design and research in civil engineering.

Subject Code: CE6L303	Name: Advanced Solid Mechanics	L-T-P: 3-1-0	Credit:4

Prerequisite: None

Introduction to elasticity theory; Stress analysis: forces and moments, theory of stress, principal stresses and stress invariants, compatibility equations, equilibrium equations; Strain: deformation and velocity gradients, Lagrangian and Eulerian description and finite strain, small deformation theory, principal strains and strain invariants, compatibility conditions; Fundamental physical principles: conservation of mass, linear momentum, angular momentum, and energy, second law of thermodynamics; Constitutive theory: St. Venant's principal, linear elasticity and generalized Hook's law, Stokesian and Newtonian fluids, Navier-Stokes equations, Bernoulli equation, linear viscoelasticity, yield criteria; Applications: Airy stress function, two-dimensional elastostatics problems, torsion.

Text/Reference Books:

1. Srinath, L.S., Advanced Mechanics of Solids, Tata McGraw Hill
2. Timoshenko, S., Strength of Materials, CBS
3. Bruhns, O.T., Advanced Mechanics of Solids, Springer
4. Timoshenko, S., and Goodier, J.N., Theory of Elasticity, Tata McGraw Hill
5. Chakrabarty, J. Theory of Plasticity , Butterworth-Heinemann

Subject Code: CE6P303	Name: Design of Special Structures	L-T-P: 0-0-6	Credit: 4

Prerequisite: Advanced Design of RC Structure

Design of overhead, underground, ground supported water tanks, dams; Design of industrial structures; Design of bunkers and silos; Design of special RC elements: Design of slender columns, RC walls, ordinary and shear walls, Corbels, Deep beams, RCC chimney; Design of simple cylindrical shell roof by beam theory.

Text/Reference Books:

1. Fintel, M., Handbook of Concrete Engineering, CBS Publishers Delhi
2. Naeim, F., Handbook on Seismic Analysis and Design of Structures, Kluwer Academic Publisher
3. IS 4326, Earthquake Resistant Design and Construction of Buildings - Code of Practice, Bureau of Indian Standard; New Delhi
4. Jain, S.K. and Jaiswal, O.R., Guidelines for Seismic Design of Liquid Storage Tanks, NICEE, IIT Kanpur

Subject Code: CE6P301	Name: Advanced Structural Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Vibration analysis of SDOF system, Modal study, Natural Period determination using free and forced vibration, Stress-strain behaviour of MS steel and high strength steel bars. 1g shake table test.

Indian Institute of Technology Bhubaneswar
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Subject Code: CE6P302	Name: Computational Laboratory	L-T-P: 0-0-3	Credit: 2
Prerequisite: None			
Finite element modelling of structures, Seismic analysis of structures, Pushover analysis, seismic ground response analysis.			

Subject Code: CE4L003	Name: Advanced Transportation Engineering	L-T-P: 3-0-0	Credit: 3
Prerequisite: None			

Airports: introduction; characteristics of aircrafts related to airport design; obstruction clearance criteria; design of airside facilities: runway orientation, length, capacity, configuration and number, taxiway layout, design of fillets, high-speed exit taxiway, apron gate and circulation areas, hanger; design of landside facilities: terminal building functional areas and facilities, centralized and de-centralized concepts, vertical distribution; airport planning and site selection; pavement design; visual aids; demand estimation of air travel, drainage. Railways:- Introduction, classification of routes; railway gauge, coning of wheels and canting of rails, train resistance and hauling power; track components: rails, sleepers, fastenings, ballast and formation; track stresses; turnouts and crossings, signals and control systems, welded rails. Elements of water and pipeline transportation. Economic Analysis of Transportation Projects

Book:

1. Horonjeff, Robert, Planning and Design of Airports, McGraw Hill
2. Chandra, Satish and Agarwal, M.M., Railway Engineering, Oxford University Press India
3. Garber, NJ and Hoel, LA, Principles of Traffic and Highway Engineering, Cengage Learning

Subject Code: CE4L004	Name: Rock Mechanics and Tunnelling	L-T-P: 3-0-0	Credit: 3
Prerequisite: None			

Introduction - objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration - rock coring, geophysical methods. Laboratory testing of rocks - all types of compressive strength, tensile strength and flexural strength tests. Strength and failure of rocks, Griffith's theory, Coulombs theory, rheological methods. In-situ tests on rock mass. Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics - interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties. Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence. Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting. Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

Text/Reference Books:

1. Goodman, R. E., Introduction to Rock Mechanics, John Wiley and Sons.
2. Hudson, J.A. and Harrison, J.P. Engineering rock Mechanics: an introduction to the

principles, Pergamon publishers.
3. Chapman, David, Metje, Nicole and Stärk, Alfred, Introduction to Tunnel Construction. Spon Publishers, Taylor and Francis Group.
4. Brady, B. H. G. and Brown, E. T. Rock Mechanics: for underground mining, Kluwer Academic Publishers.

Subject Code: CE4L005	Name: Maintenance and Rehabilitation of Concrete Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Maintenance and Repair strategies - Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Serviceability and Durability of Concrete - Quality assurance for concrete construction concrete properties- strength, permeability, thermal properties and cracking. - Effects due to climate, temperature, chemicals, corrosion - design and construction errors - Effects of cover thickness and cracking; Materials and Techniques for Repair - Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferrocement and polymers coating for rebars loadings from concrete, mortar and dry pack, vacuum concrete, Gunite and Shotcrete, Epoxy injection, Mortar repair for cracks shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels and cathodic protection.; Repairs to Structures - Repair of structures distressed due to earthquake – Strengthening using FRP Strengthening and stabilization techniques for repair.

Text/Reference Books:

1. Denison Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK.
2. Allen R.T and Edwards S.C, Repair of Concrete Structures, Blakie and Sons, UK.
3. Raikar, R.N., Learning from failures - Deficiencies in Design, Construction and Service - R&D Centre (SDCPL), Raikar Bhavan, Bombay.
4. Santhakumar A.R., Concrete Technology, Oxford University Press, Printed in India by Radha Press, New Delhi.
5. Emmons, Peter H., Concrete Repair and Maintenance Illustrated Galgotia Publications pvt. Ltd.

Subject Code: CE4L006	Name: Computational Hydraulics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

General numerical methods; Introduction to FEM, FDM and BEM; Perturbation method; Methods of characteristics; Hydroinformatics; Applications to water resources engineering

Text/Reference Books:

1. Michael B. Abbott, Anthony W. Minns, Computational Hydraulics.
2. Cornelis B. Vreugdenhil, Computational Hydraulics.
3. Ioana Popescu, Computational Hydraulics.

Subject Code: CE4L008	Name: Hydraulic and Hydrologic Analysis and Design	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Synthetic design storms & Estimation of peak discharge, Urban storm drainage design, Culvert design, Detention storage design, Flood frequency analysis; Design of water distribution network, Analysis and design of mobile and rigid boundary channels, Tractive force concepts in channel design, Design of canal headworks, distribution works, and cross-drainage works, Design of gravity dams, spillways, and energy dissipators.

Text/Reference Books:

1. Ben C. Yen, Yeou-Koung Tung, Reliability and Uncertainty Analyses in Hydraulic Design: A Report, American Society of Civil Engineers
2. Bruce E. Larock, Roland W. Jeppson, Gary Z. Watters, Hydraulics of Pipeline Systems, CRC Press
3. Ghosh, Karunamoy, Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Pvt. Ltd
4. Chow, Ven Te, Maidment, David R. and Mays, Larry W., Applied Hydrology, Tata McGraw-Hill Education

Subject Code: CE4L022	Name: Bridge Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Bridges and loading standards. Hydraulic Design of Bridges, Foundation for piers and abutments, Open Foundation, Pile Foundation, Well Foundation, Bridge Substructure: Piers and Abutments. Bridge Superstructure: Design aspects, RC slab deck, Tee Beam and Slab deck. Composite Bridges. Pre-stressed concrete bridges, Steel trussed bridges; Bridge Construction, Inspection and Maintenance.

Text/Reference Books:

1. Ponnuswamy, S, Bridge Engineering, McGraw Hill
2. Jagadeesh and Jayaram, Design of Bridge Structure, PHI Learning
3. Victor, D. J., Essentials of Bridge Engineering, Oxford and IBH Publishing

Subject Code: CE4L023	Name: Pre-stressed Concrete	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept on Mechanics; Materials; Properties of sections; Stress analysis - three methods; Prestressing and Post stressing; Beam design - no tension and ultimate; Poles and slab panels; Loss assessment; Composite beams; Design for shear. Large span structures; Structural forms and design principles; Special materials, open web and built-up structures.

Text/Reference Books:

1. Lin and Burns, Design Of Prestressed Concrete Structures, Wiley India
2. Dayaratnam, P Prestressed Concrete Structures, Oxford and IBH
3. Raju, K., Prestressed Concrete Bridges, CBS

Subject Code: CE4L042	Name: Advanced Foundation Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Bearing capacity of shallow foundations: Prandtl, Terzaghi and Meyerhof s method of analysis, safe and allowable bearing pressures, selection of type and depth of foundations, combined footings, mat foundations including floating raft, settlement calculations, Skempton - Bjerrum modification, and Martin s method, bearing capacity of layered soils, bearing capacity of footings on slopes, Deep foundations: mechanics of load transfer in piles, load carrying capacity, pile load test, lateral loaded piles, design of pile groups including settlement calculations, design of block foundation, well foundations, coffer dams, pier foundations, earth pressure computations on retaining walls and their design, earthquake response of foundations.

Text/Reference Books:

1. Das, B. M., Principles of Foundation Engineering, Cengage Learning.
2. Budhu, M., Soil Mechanics and Foundations, Wiley Publishers, New Delhi.
3. Coduto, D. P., Foundation Design: Principles and Practices, Prentice Hill Publishers.

4. Holts, R. D. and Kovacs, W. D., An Introduction to Geotechnical Engineering, Prentice Hall.
5. Das, B. M., Shallow Foundations: Bearing Capacity and Settlement, CRC Press.
6. Tomilson, M. J., Foundation Design and Construction, Pearson Publishers.

Subject Code: CE4L043	Name: Numerical Methods in Geotechnical Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to numerical modeling in Geotechnical Engineering, constitutive modeling, review of basic concepts, solution of nonlinear systems of equations, finite difference method, finite element method, constitutive modeling of soil response, large deformation – large strain analysis, applications: flow and consolidation, groundwater and seepage, slopes and cuts, embankments, shallow and deep foundations, retaining walls, tunnels and caverns and rock Mechanics

Text/Reference Books:

1. Desai, C. S. and Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.
2. Potts, D. M. and Zdravkovic, L., Finite Element Analysis in Geotechnical Engineering: Theory and Application, Thomas Telford Publishing.
3. Benz, T. and Nordal, S., Numerical Methods in Geotechnical Engineering: NUMGE 2010, CRC Press.
4. Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.

Subject Code: CE4L044	Name: Soil Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Shear strength of cohesionless and cohesive soils, physico-chemical aspects, experimental determination of shear strength, failure theories, Yield criteria, influence on failure conditions of inter-mediate principal stress, history, drainage, rate of stress applications etc.; Plastic equilibrium in soils, Mohr diagram, active and passive states, theories of earth pressure on retaining walls, effect of wall friction on the shape of sliding surface, theories of arching, bearing capacity, concepts of general and local shear failure, critical height of vertical banks, various methods of computation of slope stability, earth pressure on timbering of cuts and on free and anchored bulkheads.

Text/Reference Books:

1. Lambe, T. W. and Whitman, R. V., Soil Mechanics in SI Version, Wiley, New Delhi.
2. Scott, R. F., Principles of Soil Mechanics, Addison Wesley, World Student Edition.
3. Leonards, G. A., Foundation Engineering, McGraw-Hill.
4. Bowles, J. E., Foundations Analysis and Design, McGraw-Hill.
5. Peck, R. B., Hanson, W. E., and Thornburn, T. H., Foundation Engineering, John Wiley and Sons.

Subject Code: CE4L045	Name: Earth Retaining Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Earth Pressure: Fundamental relationships between the lateral pressures and the strain with a back fill. Rankine's and Coulomb's theories, Active, passive and earth pressure at-rest; Backfill with broken surface, wall with broken back, concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Passive earth pressure in engineering practice. Assumption and conditions, point of application of passive earth pressures; Bulkheads: Definition and assumptions, conditions of end supports and distribution of active earth pressure and bulkheads, bulkheads with free and fixed earth supports, equivalent beam

method, Improvements suggested by Rowe, Tschebotarioff's method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates, Consideration of effects of ground water, seepage, surcharge loading together with possibility of shallow and deep sliding failures on retaining structure; Sheet Pile wall: Free earth system, fixed earth system, Dead man; Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations, Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays; Reinforced earth retaining structures-Design of earth embankments and slopes; Recent advances in Earth retaining structures.

Text/Reference Books:

1. Das, B. M., Principles of Foundation Engineering, Thomson, Indian Edition.
2. Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth-retaining Structures, Chapman and Hall Publishers.
3. Bowel, J., Foundation Engineering, Analysis and Design, McGraw Hill.
4. Raj, P., Geotechnical Engineering, Tata McGraw Hill.
5. Craig, R. F., Soil Mechanics, Chapman and Hall (ELBS).

Subject Code: CE4L053	Name: Open Channel Hydraulics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Basic concepts; Energy and Momentum equations and their applications; Critical flow, channel control ad transitions; Uniform flow and flow resistance; Sheet flow; Concepts of boundary layer and surface roughness; Theoretical uniform flow equations; Instability of uniform flow; Gradually varied flow, flow profile classification and computation methods; Flow profiles in natural channels; Spatially varied flow; Hydraulic jump; Unsteady flow, continuity equation, dynamic equation, wave propagation; Method of characteristics; Rapidly varied unsteady flow, surges; Dam break problems.

Text/Reference Books:

1. Subramanya, K., Flow in Open Channels, Tata McGraw-Hill.
2. Chanson, H., Hydraulics of Open Channel Flow, Elsevier.
3. Chow, V. T., Open Channel Hydraulics, McGraw Hill.
4. French, R., Open Channel Hydraulics, McGraw-Hill.
5. Sturm, T.W., Open Channel Hydraulics, Tata McGraw-Hill

Subject Code: CE4L054	Name: Water Resources Systems	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to systems concept in water resources engineering: its role in planning and management; data acquisition and processing; descriptive and prescriptive models; economics of water resources systems; social, economical, technical and environmental issues; decision making under uncertainty and/or risk; evaluation of project alternatives; application to surface and subsurface water resources systems planning and management.

Text/Reference Books:

1. Vedula, S. and Mujumdar, P. P., Water Resources Systems, McGraw-Hill.
2. Jain, S. K., and Singh, V. P., Water Resources Systems Planning and Management, Elsevier.
3. Purcell, P., Design of Water Resources Systems, Thomas Telford Publishing.

Subject Code: CE4L055	Name: Design of Hydraulic Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concrete dams, force and stress analysis for components like piers, bridges and trash rack

and their reinforcement detailing; stress analysis around galleries, adits and shafts and reinforcement provisions; integrated stability analysis of concrete dams considering foundation rock; construction methods for concrete dams. Embankment dams, seepage analysis (finding the phreatic line) for different types of embankment dams; seepage control measures for embankment dams; construction methods for embankment dams. Spillways and energy dissipators design of ogee spillways; calculations for chute spillway profiles; flow characteristics of shaft and syphon spillways; types of energy dissipators, their selection and dimensioning; flow characteristics of radial gates; introduction to relevant BIS codes and guidelines. Barrages - design of barrage structure and canal head regulator; construction methods for barrages. Irrigation structures, Canals, cross drainage works, falls and energy dissipators.

Text/Reference Books:

1. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
2. Ghosh, K., Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Private Limited.
3. Novak, P., Moffat, A. I. B., Nalluri, C., and Narayanan, R. Hydraulic Structures, Taylor & Fransis.

Subject Code: CE4L062	Name: Pavement Design	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Pavement, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, pavement evaluation and overlay design.

Text/Reference Books:

1. Huang, Y. H., Pavement Analysis and Design, Pearson Education.
2. Yoder, E. J. and Witczak, M. W., Principles of Pavement Design, John Wiley & Sons Ltd.
3. Mallick, R. B. and El-Korchi, T., Pavement Engineering: Principles and Practice, CRC Press.

Subject Code: CE6L304	Name: Advanced Concrete Technology	L-T-P: 3-0-0	Credit:3

Prerequisite: None

Fundamental of concrete - constituents, proportioning, mixing, transportation, placing and curing., Properties of fresh and hardened concrete., Quality control in concrete construction, Concrete mix design, Durability of concrete - alkali aggregate reaction, reinforcement corrosion, freezing and thawing, etc., Special concretes - high strength, low heat of hydration, high early strength, self-compacting, etc., Construction methods – shot-crete, roller compacted concrete, etc., Reinforcing materials - epoxy coated bars, fibre-reinforced plastics, Introduction to 'maintenance' of concrete structures - use of non-destructive testing, evaluation criteria.

Text/Reference Books:

1. Gambhir, M,L., Concrete Technology, Tata Mcgraw Hill

2. Neville, A.M. and Brooks, J.J., Concrete Technology, Neville, ELBS/Longman
3. Neville, A.M., Properties of Concrete, ELBS/Longman
4. Ghose, D.N., Construction Materials, Tata Mcgraw Hill
5. Mehta, P.K. and Montiero, P.M.J., Concrete Material, Microstructure and Properties, Tata Mcgraw Hill

Subject Code: CE6L305	Name: Theory of Plates & Shells	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Pure bending of plates; Symmetric bending of circular plates; Small deflection of laterally loaded plates; Rectangular plates with various edge conditions; Continuous rectangular plates; Plates of various shapes; Shells as space enclosure, geometry, classification, principal and Gauss curvature; General theory of thin elastic shells; Shallow and high rise shells; Circular long and short cylindrical shells, beam-arch approximation for long shells; Shells of double curvature, surfaces of revolution and translation; Circular, elliptic and hyperbolic paraboloids, conoids and funicular shells - membrane and approximate bending theories; Closed form and numerical methods of analysis of synclastic and anticlastic shells.

Text/Reference Books:

1. Timoshenko, S.L., Theory of Plates and Shells, McGraw Hill
2. Reddy, J.N., Theory and Analysis of Elastic Plates and Shells, Taylor & Francis
3. Ugural, A.C., Stresses in plates and shells, WCB/McGraw Hill
4. Ventsel, E. and Krauthammer, T., Thin Plates and Shells: Theory: Analysis, and Applications, CRC Press

Subject Code: CE6L306	Name: Seismic Design of Structures	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Characteristics of earthquakes; Earthquake response of structures; Concept of earthquake resistant design; Response of SDOF and MDOF systems to random excitations. Code provisions of design of buildings; Design for Liquefaction; Non-engineered construction; Special topics: bridges, dams, strengthening of existing buildings.

Text/Reference Books:

1. Duggal, S.K., Earthquake Resistant Design of Structures, Oxford University Press
2. Chopra, A.K., Dynamics of Structures: Theory and Applications to Earthquake Engineering, Prentice Hall/Pearson Education
3. Paulay, T. and Priestley, M.J.N., Seismic Design of Reinforced Concrete and Masonry Buildings, Wiley International Publication
4. Bolt, B.A., Earthquakes, W.H. Freeman
5. Kramer, S.L., Geotechnical Earthquake Engineering, Pearson

Subject Code: CE6L307	Name: Bridge Engineering	L-T-P: 3-0-0	Credit: 3

Pre-requisite(s): None

Introduction, historical review, engineering and aesthetic requirements in bridge design, introduction to bridge codes of practice, economic evaluation of bridge projects, site investigation and planning, hydraulic calculations for bridges, bridge foundations-open, pile, well and caisson, Piers, abutments and approach structures, superstructures-analysis and design of right, skew and curved slabs, Girder bridges-Types, load distribution, design, orthotropic plate analysis of bridge decks, introduction to long span bridges- cantilever,

arch, cable stayed and suspension bridges.

Text/Reference Books:

1. Victor, D.J., Essentials of bridge engineering, Oxford & IBH Publishing
2. Ponnuswamy, S., Bridge Engineering, Tata Mcgraw Hill
3. Jagadeesh, T.R. and Jayaram, M.A., Design of Bridge Structures, Phi Learning
4. Bindra, S.P., Principles and Practice of Bridge Engineering, Dhanpat Rai Publications

Subject Code: CE6L308	Name: Infrastructure Maintenance and Rehabilitation	L-T-P: 3-0-0	Credit: 3

Pre-requisite(s): None

Quality assurance for concrete construction as built concrete properties strength, permeability, thermal properties and cracking. Influence on servicebility and durability:– Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection; Maintenance and repair strategies:– Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance importance of Maintenance, Preventive measures on various aspects Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration , testing techniques; Materials:-Materials for Repair – Special Mortar and Concretes, Concrete Chemicals, Special Cements and High Grade Concrete, Expansive Cement, Polymer Concrete, Sulphur Infiltrated Concrete, Ferro Cement, Fiber Reinforced Concrete, and Admixtures of latest origin. Techniques for Repair- Surface Repair – Material Selection – Surface Preparation - Rust Eliminators and Polymers Coating For Rebar During Repair – Repair Of Cracks In Concrete and Masonry-Methods of Repair - Epoxy Injection, Mortar Repair For Cracks - Guniting and Shotcreting - Waterproofing Of Concrete Roofs; Strengthening Measures - Flexural Strengthening, Beam Shear Capacity Strengthening, Column Strengthening, Shoring, Under Pinning and Jacketing. Demolition of Buildings – Introduction, Planning, Precautions and protective measures in demolition work, Sequence of operations, demolition of structural elements.

Text/Reference Books:

1. Campbell-Allen, D. and Roper, H., Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical, UK
2. Allen, R.T and Edwards, S.C, Repair of Concrete Structures, Blakie and Sons, UK
3. Santhakumar A.R., Concrete Technology, Oxford University Press
4. Dayaratnam, P. and Rao, R., Maintenance and Durability of Concrete Structures, University Press, India
5. CPWD, Handbook on Repairs and Rehabilitation of RCC Buildings.

Subject Code: CE6L309	Name: Modern Construction Materials	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Basics (Introduction to the course, Science, Engineering and Technology of Materials); Microstructure (Atomic Bonding, Structure of solids, Movement of atoms, Development of microstructure); Material behaviour (Surface properties, Response to stress, Failure theories, Fracture mechanics, Rheology, Thermal properties); Structural Materials (Review of Construction Materials and Criteria for Selection, Wood and Wood Products, Polymers, Fibre Reinforced Polymers, Metals, Bituminous Materials, Concrete, Glass); : Non-structural materials, accessories and finishes (Review of Non-structural Materials and Criteria for Selection, Waterproofing materials, Polymer Floor Finishes, Paints, Tiles, Acoustic

Treatment, Dry walls, Anchors); Environmental Concerns, Social Perception of Construction Materials.

Text/Reference Books:

1. Varghese, P.C., Building Materials, Prentice-Hall India
2. Callister, W.D., Materials Science and Engineering: An introduction, John Wiley
3. Raghavan, V., Materials Science and Engineering, Prentice Hall
4. Higgins, R.A., Properties of Engineering Materials, Industrial Press
5. Construction materials: Their nature and behaviour, Eds. J.M. Illston and P.L.J. Domone, Spon Press
6. Young, J.F., Mindess, S., Gray, R.J. and Bentur, A., The Science and Technology of Civil Engineering Materials, Prentice Hall
7. Neville, A.M., Properties of concrete, Pearson

Subject Code: CE6L310	Name: Advanced construction Techniques	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Sub Structure Construction -Box jacking, Pipe Jacking, Under Water Construction of diaphragm walls and Basement, Tunnelling Techniques, Piling Techniques, Driving Well and Caisson Sinking, Cofferdam, Cable Anchoring and Grouting, Driving Diaphragm Walls, Sheet Piles-Laying Operations For Built Up Offshore System-Shoring For Deep Cutting-Large Reservoir Construction with membranes and Earth system-well points-Dewatering and stand by Plant equipment for underground open excavation ; Super Structure Construction- Vacuum dewatering of concrete flooring-Concrete paving technology, Techniques of construction for continuous concreting operation in Tall buildings of various shapes and Varying sections, Launching Techniques-Suspended formwork-erection techniques of tall structures, Large span structures-Launching techniques for heavy decks-in-situ pre-stressing in high rise structures, aerial transporting ,handling, erecting light weight components on tall structures-erection of lattice towers and rigging of transmission line structures; Construction Sequences- in cooling towers, Silos Chimney, Sky scrapers, bow string bridges, cable stayed bridges; Launching and pushing of box decks, support structure for heavy Equipment and conveyor and machinery in heavy industries, erection of articulated structures, braced domes and space decks;

Repair Construction: Mud Jacking Grout through Slab Foundation, Micro Piling for Strengthening Floor and Shallow Profile, Pipeline Laying, Protecting Sheet Piles, Sub Grade Water Proofing, Underpinning Advanced Techniques and Sequence in Demolition and Dismantling.

Text/Reference Books:

1. Brown, R., Practical foundation engineering hand book, McGraw Hill Publications
2. Powers, J.P., Corwin, A.B., Schmall, P.C. and Kaeck, W.E., Construction Dewatering: New Methods and Applications, John Wiley and Sons
3. Irvine, J., Advanced Construction Techniques, California Rocketry
4. National Building Code of India, Part-IV and VII – 2006
5. Mohan, R. and Jaisingh. M.P., Advances in Building Materials and Construction, CBRI Roorkee
6. Hand Book on concrete Mixes based on Indian standards, SP-23 (S&T)

Subject Code: CE6L311	Name: Construction Project Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Principles of Project Management, Project Planning, Introduction to scheduling - work/project break down structures, Bar-charts; Principles of application of CPM and PERT;

Precedence Method; Updating; Time - cost trade-offs, Resource constrained scheduling; Resource leveling Project control; Performance Measurement, Earned value; Multiple Construction Projects; Other network techniques; Project Management Software Packages.

Text/Reference Books:

1. Jha, N.K., Construction Project Management, Pearson Education India
2. Williams, T., Construction Management, Pearson Education India
3. Chitkara, K., Construction Project Management Techniques And Practice, Tata McGraw Hill
4. Purifoy, R., Schexnayder, C.J., Shapira, A. and Schmitt, R., Construction Planning, equipment and Methods, McGraw Hill, Tokyo, Japan

Subject Code: CE6L312	Name: Advanced Design of RC Structure	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Design of overhead, underground, ground supported water tanks, dams; Design of industrial structures; Design of bunkers and silos, Airy's theory, Janssen's theory; Design of special RC elements: Design of slender columns, RC walls, ordinary and shear walls, Corbels, Deep beams, RCC chimney; Introduction to shell and folded plate roofs, their forms and structural behaviour. Design of simple cylindrical shell roof by beam theory, Yield line analysis of slabs by virtual work, Yield line analysis by equilibrium methods.

Text/Reference Books:

1. Varghese , P.C., Advanced Reinforced Concrete Design, PHI Learning
2. Naeim, F., Handbook on Seismic Analysis and Design of Structures, Kluwer Academic Publisher
3. IS 4326, Earthquake Resistant Design and Construction of Buildings - Code of Practice, Bureau of Indian Standard; New Delhi
4. Jain, S.K. and Jaiswal, O.R., Guidelines for Seismic Design of Liquid Storage Tanks, NICEE, IIT Kanpur
5. Fintel, M., Handbook of Concrete Engineering, CBS Publishers Delhi

Subject Code: MA6L001	Name: Mathematical Methods	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Probability and Statistics : Random variables (rv) and their properties, some standard discrete and continuous rv, Expectation, Variance, moments, moment generating functions, functions of a rv, their distribution and moments, joint, marginal and conditional distribution and independence of rvs, Hypothesis testing.
Numerical solutions of systems of linear equations: Gauss elimination, LU decomposition, Gauss-Jacobi and Gauss-Seidel methods.
Numerical methods of ODE and PDE: Runge-Kutta and finite difference methods for ODE, Finite difference methods for solving 2-D Laplace's equation, Poisson's equation, 1-D heat equation : Bender Schmidt, Crank Nicholson method and Du Fort Frankel methods, 1-D wave equation using Explicit method. Consistency and stability analysis.

Text/Reference Books:

1. Grawel, B.S. Numerical Methods
2. Jain, M.K., Iyengar, S.R.K. and Jain, R.K. Numerical Methods-problem and solutions, Wiley Eastern Limited, 2001.
3. Ross, S. Introduction to Probability Models, Wiley India
4. Gun, A.M., Gupta, M.K. and Gupta, B.S. Fundamentals of Statistics
5. Hayter, A.J., Probability and Statistics, Duxbury, 2002

6. Scarborough, J.B., Numerical mathematical analysis, Oxford & IBH Publishing Co.Pvt.,2000
7. Hamming, R.W., Numerical Methods for Scientist and Engineers, McGraw Hill, 1998
8. Mathews, J.H. and Fink, K.D. Numerical Methods using MATLAB, Pearson Education, 2004.

Subject Code: MA6L002	Name: Advanced Techniques in Operation Research	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

One variable unconstrained optimization, multivariable unconstrained optimisation, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization, quadratic programming, separable programming, convex and non convex programming, steepest and Quasi-Newton method.

Dynamic Programming: Characteristics of dynamic problems, deterministic dynamic programming and probabilitistic dynamic programming, Network analysis, Shortest path problems, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, network simplex, interior point methods, stochastic programming, Nonlinear goal programming applications, Geometric Programming.

Multi-objective Optimization Problems: Linear and non linear programming problems, Weighting and Epsilon method, P-norm methods, Gradient Projection Method, STEM method, Convex Optimization.

Text/Reference Books:

1. Rao, S.S., Engineering Optimization Theory and Practices, John Wiley and Sons, 2009
2. Ehrgott, M. Multi-criteria Optimization, Springer 2006
3. Miettien, K.M, Non-linear multi-objective optimization, Kluwers International Series, 2004
4. Deb, K., Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

Subject Code: MA7L020	Subject Name: Nonlinear Functional Analysis	L-T-P: 3-1-0	Credit: 4

Prerequisite: Mathematics – II (MA1L002)

Fixed point theory, Banach contraction mapping theorem, contractive type mappings, generalization of Banach contraction mapping theorem, fixed point theorem of other types. Nonlinear operators, monotone, strictly monotone and strongly monotone operators, their properties and applications. Variational inequalities and complementarity problem. Approximation theory, theory of best approximation and farthest points. Calculus of Banach Space, Frechet and Gateaux differentiability, strict convexity and uniform convexity of norms, semi inner product space.

Text Books::

1. Zeidler E. Nonlinear Functional Analysis and its applications, Springer
2. Ambrosetti A., Arcoya D., Birkhauser. An Introduction to Nonlinear Functional Analysis and Elleptic Problems,

References Books::

1. Debnath L. and Mikusinski P., Hilbert Spaces with Applications, Academic Press
2. Kinderleherer D., Stampacchia G. An Introduction to Variational Inequalities and their

Applications, Academic Press
3. Tinsley Oden J., Demkowicz L. Applied Functional Analysis, CRC Press

Subject Code: CE6L008	Subject Name: Hydraulics of Sediment Transport	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Sediment properties; Initiation of motion; Bed Load; Bed Forms; Effective bed roughness; Armouring; Suspended Load; Total Load; Transport of Sediment due to unsteady flow; Meandering of rivers; Braided river; Local scour at different structures; Sediment sampling; Mathematical models of sediment transport.

Text/Reference Books:

1. Yang, Sediment Transport: Theory and Practice
2. Graf, Hydraulics of Sediment Transport
3. Fredsoe and Diegaard, Mechanics of Coastal Sediment Transport
4. Garde, History of Fluvial Hydraulics

Subject Code: CE6L017	Subject Name: Advanced Transportation Systems Analysis	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Behavioural aspect of transportation planning: Basics of travel behaviour analysis, stated and revealed preference data, binary logit, multinomial logit, nested logit model, maximum likelihood technique, travel behaviour survey, case study analysis/discussion on travel behaviour analysis- destination choice, mode choice, route choice etc. demand-supply interaction in an urban transport system, urban transportation network analysis, shortest path analysis, formulation of traffic assignment problem, solving traffic assignment problems, equilibrium traffic assignment with link interactions, traffic assignment under travel behaviour, Basics of dynamic traffic assignment

Text/Reference Books:

1. Marvin L. Manheim, Fundamentals Of Transportation Systems Analysis, Volume 1
2. Swait, Louviere and Hensher, Stated Preference Methods
3. Moshe Ben Akiva, Discrete Choice Analysis: Theory and Analysis to Travel Demand
4. YosefSheffi, Urban Transportation Networks
5. Transportation Systems Engineering: Theory and Methods by Ennio Cascetta

Subject Code: CE6L018	Subject Name: Analysis and Design of Pavements	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Pavements, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, comparison of different pavement design approaches, design of overlays and drainage system.

Text/Reference Books:

1. Y. H. Huang, Pavement Analysis and Design
2. E.J. Yoder and M. W. Witczak, Principles of Pavement Design
3. Rajib B. Mallick, Tahar El-Korchi, Pavement Engineering: Principles and Practice

Indian Institute of Technology Bhubaneswar
Curriculum

*The examination for this course may be considered for open book system.

Subject Code: CE6L019	Subject Name: Pavement Evaluation, Maintenance and Rehabilitation	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of pavements, Distresses in flexible and rigid pavements , Techniques for functional and structural evaluation of pavements, pavement rehabilitation techniques, overlay design procedures, recycling of flexible and rigid pavements, Maintenance of paved and unpaved roads, Pavement management systems

Text/Reference Books:

1. Y. H. Huang, Pavement Analysis and Design
2. Rajib B. Mallick, Tahar El-Korchi, Pavement Engineering: Principles and Practice
3. Derek Pearson, Deterioration and Maintenance of Pavements
4. Ralph Haas, W. Ronald Hudson, John P. Zaniewski, Modern pavement management

Subject Code: CE6L020	Subject Name: Dynamics of Soil and Foundations	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, vibration theories, analysis of free and forced vibrations using spring dashpot model, single degree of freedom system, multi-degrees of freedom system, application of single and multi-degree of freedom systems, wave propagation in elastic media, laboratory and field evaluation of dynamic soil properties, seismic bearing capacity of shallow foundations, pile foundation under dynamic load, seismic earth pressures, seismic slope stability.

Text/Reference Books:

1. Swami Saran, Soil Dynamics and Machine Foundations, Galgotia Publications.
2. Braja M. Das and G. V. Ramana, Principles of Soil Dynamics, Publisher: CL-Engineering.
3. Richart, F.E., Woods, R.D., and Hall, J.R., Vibrations of soils and foundations, Prentice Hall, 1970.
4. Steven L. Kramer, Geotechnical Earthquake Engineering, 1996, Prentice Hall.

Subject Code: CE6L021	Subject Name: Soil-Structure Interaction	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to soil foundation interaction problems, soil behaviour, foundation behaviour, interface behaviour, concept of subgrade modulus, effects/parameters influencing subgrade modulus soil foundation interaction analysis, Winkler, elastic continuum, two parameter elastic model, Elastic Plastic behaviour, time dependent behaviour, elastic analysis of single pile, theoretical solutions for settlement and load distributions, analysis of pile group, interaction analysis, Load deflection prediction for laterally loaded piles, other applications.

Text/Reference Books:

1. Selvadurai, A.P.S.,"Elastic analysis of soil foundation interaction. Elsevier Science Ltd.
2. Plasticity and Geomechanics by R. O. Davis, A. P. S. Selvadurai, Cambridge University Press
3. R.O. Davis and A.P.S. Selvadurai, Elasticity and Geomechanics, Cambridge University Press, New York.
4. Poulos, H.G. and Davis E.H. Pile Foundation Analysis and Design.
5. Soil structure interaction: numerical analysis and modelling / edited by John W. Bull. London ; New York : E & FN Spon, 1994.

Subject Code: CE6L022	Subject Name: Ground Improvement	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, ground improvements schemes for cohesive soil sites (preloading, staged construction, accelerated consolidation with prefabricated drains, granular columns, lime columns, electro-osmosis, compaction piles, deep mixing, and vibro-replacement), ground improvement schemes for cohesionless soil sites (deep dynamic compaction, vibro-compaction, blast densification, grouting, and jet grouting), mechanically stabilized earthwork, soil nailing, ground anchors, light weight fill, and monitoring and quality control in ground improvement projects.

Text/Reference Books:

1. P. Puroshothama Raju, Ground Improvement Techniques, Laxmi Publications, New Delhi.
2. M.P. Moseley and K. Kirsch, Ground Improvement, Spon Press, Taylor and Francis Group.
3. B. M. Das, Principles of Foundation Engineering, Cengage Learning.
4. Buddhima Indraratna and Jian J Chu, Ground Improvement: Case Histories, Elsevier.
5. Chris A. Raison, Ground and Soil Improvement, Thomas telford, UK.
6. Robert M. Koerner., Designing with Geosynthetics, Pearson Prentice Hall.

Subject Code: CE6L023	Subject Name: Computational Geomechanics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Numerical modeling, constitutive modeling of soils and rock, continuum and discrete element modeling. Concept of stress and strain, principle stresses and strains. Octahedral stresses and strains, finite element discretization of a continuum, geomechanics problems of plane strain and axisymmetric problem. Failure criteria for soils, associated and non-associated flow rule. Finite elements for non-linear material problems in soil mechanics computational procedures. Finite difference approach. Simulation of soil-structure interaction problems, application in consolidation, bearing capacity and slope stability problems using numerical approaches.

Text/Reference Books:

1. Chandrakant S. Desai and J.T. Christian Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.
2. Plasticity and Geomechanics by R. O. Davis, A. P. S. Selvadurai, Cambridge University Press
3. Finite Element Analysis in Geotechnical Engineering: Theory and Application Author: David M. Potts and Lidija Zdravkovic (January 1, 2001)
4. John T. Christian, Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers
5. Computational Geomechanics with Special Reference to Earthquake Engineering by O. C. Zienkiewicz, A. H. C. Chan, M. Pastor, and B. A. Schrefler (Hardcover - May 11, 1999), Publisher: Wiley

Subject Code: CE6L024	Subject Name: Geotechnical Earthquake Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, engineering seismology, plate tectonics, earthquake magnitude, ground motion characteristics, effect of local soil conditions on ground motion, dynamic behaviour of soils, analysis of seismic site response. Liquefaction analysis of soil, laboratory and in-situ testing for seismic loading, analysis and design of slopes, embankments, foundations

and earth retaining structures for seismic loading, computer-aided analysis.

Text/Reference Books:

1. Kramer, S.L., Geotechnical Earthquake Engineering, Pearson Education.
2. Day, R.W., Geotechnical Earthquake Engineering Handbook, McGraw Hill.

Subject Code: CE6L025	Subject Name: Geotechnical Risk and Reliability	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to probabilistic geotechnical engineering, variability measures, random variables, probability mass and density functions, moments of distribution, modelling of uncertainty, engineering judgment, spatial variability of soil, autocovariance functions, functions of random fields, levels of reliability, loads and resistances, reliability methods, first order second moment (FOSM) method, Hasofer-Lind approach, Response Surface Method, Monte Carlo simulations.

Text/Reference Books:

1. Achintya Haldar and Sankaran Mahadevan, Probability, Reliability, and Statistical Methods in Engineering Design, John Wiley and Sons
2. Gregory Baecher and John Christian, Reliability and Statistics in Geotechnical Engineering, John Wiely and Sons, Inc.
3. Alfredo Hua-Sing Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design: Basic Principles (Vol. I), John Wiely and Sons, Inc.
4. Alfredo Hua-Sing Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design: Decision, Risk, and Reliability (Vol. II), John Wiely and Sons, Inc.
5. Alfredo Hua-sing Ang, Wilson H. Tang, Probability Concepts In Engineering: Emphasis On Applications In Civil & Environmental Engineering, Publisher: Wiley
6. Robert E. Melchers, Structural Reliability Analysis and Prediction, John Wiley and Sons.
7. Andrzej S Nowak and Kevin R. Collins, Reliability of Structures
8. Erik Vanmarcke, Random Fields: Analysis and Synthesis, The MIT Press, Cambridge, Massachusetts.

Subject Code: CE6L026	Subject Name: Advanced Soil Mechanics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction: Origin of soil and its types, mineralogy and structure of clay minerals, Consolidation: Steady State flow, 2D and 3D seepage, transient flow; Compressibility and rate of consolidation, one, two, and three dimensional consolidation theories; Sand drains; Mohr's circles; Critical state soil mechanics: Critical State Line, Hvorslev Surface, Yield Surfaces: Modified Cam-clay and Original Cam-clay; Elastic and plastic analysis of soil: Constitutive relationships of soil; failure theories. Limit analysis-Upper bound theorems, lower bound theorems, limit equilibrium methods; Soil Stabilization: Classification of stabilizing agents and stabilization processes. Strength improvement characteristic of soft and sensitive clays, Marine clay and waste material.

Text/Reference Books:

1. B M Das, Advanced Soil Mechanics, Taylor and Francis
2. R F Scott, Principles of Soil Mechanics, Addison & Wesley.
3. R.O. Davis and A.P.S. Selvadurai, Elasticity and Geomechanics, Cambridge University Press, New York.
4. Mitchell, James K, Fundamentals of Soil Behaviour, John Wiley and Sons.
5. D.M. Wood, Soil Behaviour and Critical State Soil Mechanics, University of Glasgow.
6. Schofield, A. N.; Wroth, C. P., Critical State Soil Mechanics, McGraw-Hill

Indian Institute of Technology Bhubaneswar
Curriculum

Subject Code: CE6L027	Subject Name: Free Surface Flows	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Energy and momentum of flow; critical flow; channel control and transitions; discharge measurement methods; uniform flow and flow resistance; composite roughness and compound channels; gradually varied flow; classifications and computations of free surface profiles; spatially varied flow; supercritical flows and oblique flows; rapidly varied flow; hydraulic jump; continuity and dynamic equations of unsteady flow; wave propagation and surge; method of characteristics; dam-break problem; flow in channel bends; buoyant and submerged jets.

Text/Reference Books:

1. K. Subramanya, Flow in open channels
2. Hubert Chanson, Hydraulics of Open Channel Flow
3. V. T. Chow, Open Channel Hydraulics
4. Richard French, Open Channel Hydraulics
5. Sturm, Open Channel Hydraulics

Subject Code: ME6L052	Subject Name: Applied Elasticity	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

Concepts of states of stress and strain. Analysis of three dimensional stresses and strains, equations of equilibrium, generalized Hookes law, Plane elastic problems in cartesian and polar coordinates, axisymmetric problems, torsion, solutions of problems using elasticity theory, anisotropic elasticity, thermoelasticity, contact problems, energy and variational principles and elastic stability.

Text/Reference Books:

1. Y. C. Fung, "Foundations of Solid Mechanics", Prentice - Hall Publishers.
2. T.G. Sitharam and L.GovindaRaju, "Applied Elasticity", Interline Publishers, Bangalore.
3. S.P.Timoshenko and J.N. Goodier, "Theory of Elasticity", McGraw-Hill Book Company.
4. C.T. Wang, "Applied Elasticity", McGraw-Hill Book Company
5. Elasticity in engineering mechanics- Arthur Peter Boresi, Ken Pin Chong (Wiley)

Subject Code: CE6L029	Subject Name: Structural Health Monitoring	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to structural health monitoring and overview of different techniques. Vibration based damage detection techniques. Sensors for structural health monitoring. Non-destructive techniques (NDT). Noncontact measurement. Numerical modelling, analysis of structures and inverse analysis. Linear and Non-Linear systems. Application of structural health monitoring.

Text/Reference Books:

1. Karvari an Ansari, "Structural health monitoring of civil infrastructure", Elsevior.
2. Adams Douglas E., "Health Monitoring of Structural Materials and Components: Methods with Application" John Wiley and Sons Inc.
3. Ferrar and Worden "Structural Health Monitoring: A Machine Learning Perspective" John Wiley and Sons Inc.
4. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes "Structural Health Monitoring" John Wiley and Sons Inc.
5. Ostachowicz, Wiesław, Güemes, Alfredo, "New Trends in Structural Health Monitoring" Springer

Indian Institute of Technology Bhubaneswar
Curriculum

Dual Degree (B.Tech. Civil Engineering and M.Tech. Transportation Engineering)

Curriculum (7th Semester – 10th Semester)

SEMESTER - VII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Breadth - 4			3/4	3/4	
Urban Transportation Planning	**CE6L401**	3-1-0	4	4	81
Pavement Material Characterization	**CE6L403**	3-1-0	4	4	81
Elective - 1		3-0-0	3	3	
CAD Laboratory	**CE4P001**	0-0-3	2	3	81
Industrial Training Defence	**CE4T001**	0-0-0	2	0	
Project – Part 1 (CE)	**CE4D001**	0-0-0	4	0	
		Total	**22/23**	**17/18**	
SEMESTER - VIII					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Fundamentals of Traffic Flow Theory	**CE6L402**	3-1-0	4	4	82
Elective – 2		3-0-0	3	3	
Elective – 3		3-0-0	3	3	
Elective – 4		3-1-0	4	4	
Traffic Engineering Studies	**CE6P402**	0-0-3	2	2	82
Project – Part 2 (CE)	**CE4D002**	0-0-0	6	0	
		Total	**23**	**17**	
SEMESTER - IX					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Elective - 5		3-1-0	4	4	
Pavement Materials Laboratory	**CE6P401**	0-0-3	2	3	82
Thesis : Part-I (CE)	**CE6D001**	0-0-0	12	0	
		Total	**18**	**7**	
SEMESTER - X					
Subject Name	**Code**	**L-T-P**	**Credit**	**Contact Hour**	**Syllabus Page No.**
Seminar	**CE6S002**	0-0-0	2	0	
Transportation Systems Planning Studio	**CE6P404**	0-0-3	2	3	83
Thesis : Part-I (CE)	**CE6D003**	0-0-0	12	0	
		Total	**16**	**3**	
	Grand Total	**Total**	**220/225**		

Elective-1

Subject Name	Code	L-T-P	Credit	Contact Hour	Syllabus Page No.
Rock Mechanics and Tunnelling	**CE4L004**	3-0-0	3	3	83
Maintenance and Rehabilitation of Concrete Structures	**CE4L005**	3-0-0	3	3	84
Bridge Engineering	**CE4L022**	3-0-0	3	3	84
Prestressed Concrete	**CE4L023**	3-0-0	3	3	84
Soil Engineering	**CE4L044**	3-0-0	3	3	85
Earth Retaining Structures	**CE4L045**	3-0-0	3	3	85
Remote Sensing and GIS	**CE4L051**	3-0-0	3	3	85
NB: Any other subjects of same or higher level floated by any other specialisations of School of Infrastructure and/or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators					

Elective-1 to 5

Subject Name	Code	L-T-P	Credit	Contact Hour	Syllabus Page No.
Analysis and Design of Pavements	**CE6L404**	3-1-0	4	4	86
Design of Transportation Facilities and Safety	**CE6L451**	3-1-0	4	4	86
Economic Evaluation of Transportation System	**CE6L452**	3-0-0	3	3	87
Analysis of Transportation Systems	**CE6L453**	3-0-0	3	3	88
Pavement Evaluation and Management	**CE6L454**	3-1-0	4	4	88
Airport Planning and Design	**CE6L455**	3-0-0	3	3	88
Public Transportation System	**CE6L456**	3-0-0	3	3	89
Construction Project Management	**CE6L006**	3-0-0	3	3	89
Environmental Management & Impact Assessment	**CE6L011**	3-0-0	3	3	89
Ground Improvement	**CE6L022**	3-0-0	3	3	90
Computational Geomechanics	**CE6L023**	3-0-0	3	3	90
Geotechnical Risk and Reliability	**CE6L025**	3-0-0	3	3	91
Advanced Techniques in Operation Research	**MA6L002**	3-1-0	4	4	91
NB: Any other subjects of same level floated by any other specialisations of School of Infrastructure and/or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators					

Indian Institute of Technology Bhubaneswar
Curriculum

Syllabus

Subject Code: CE 6L401	Subject Name: Urban Transportation Planning	L-T-P: 3-1-0	Credit: 04

Pre-requisite(s): None

Fundamentals of transportation system planning, transportation system planning process, Characteristics of Travel and urban transportation system, Demand theory and supply theory of transportation system, Steps of urban travel demand forecasting- trip generation, trip distribution, modal split and trip assignment, basics of urban transportation network, basics of tour-based or activity-based travel demand model, land use transport model, urban mass transportation, urban goods movement, Basics of activity-based model

Text/Reference Books:

1. L.R. Kadiyali, Traffic Engineering and Transport Planning
2. Williumsen and Ortuzar, Modelling Transport
3. Kanafani, Transp. Demand Analysis.
4. B.G. Hutchinson, Principles of Urban Transport System Planning
5. Marvin L. Manheim, Fundamentals Of Transportation Systems Analysis, Volume 1
6. Travel Demand Software for example TRANSCA, CUBE

Subject Code: CE 6L403	Subject Name: Pavement Material Characterization	L-T-P: 3-1-0	Credit: 04

Pre-requisite(s): None

Subgrade Soil: Classification, desirable properties, determination of soil strength characteristics, resilient modulus, Road aggregates: classification, properties of aggregates, design of aggregate gradation, Bituminous road binders: bitumen, emulsions, cut backs and modified binders, Rheology of bituminous binders, modified binders, Hot mix, Warm mix and Cold mix Bituminous constructions, Mix design: Marshall method and Superpave procedure, Visco-elastic and fatigue properties of bituminous mixtures, Requirements of paving concrete, design of mixes for recycling of bituminous and concrete pavement surfaces.

Text/Reference Books:

1. A. T. Papagiannakis and E. A. Masad, Pavement Design and Materials, Wiley Publications
2. J. Read and D. Whiteoak, The Shell Bitumen Handbook, 5th edition, Thomas Telford Ltd
3. Asphalt Institute, Asphalt Binder Handbook, Manual Series No. 2 (MS-26). Asphalt Institute. Lexington, KY
4. Asphalt Institute. Mix Design Methods for Asphalt, Manual Series No. 2 (MS-02). Asphalt Institute. Lexington, KY
5. Rajib B. Mallick, Tahar El-Korchi Pavement Engineering: Principles and Practice, Second Edition, CRC Press
6. Roberts, F.L.; Kandhal, P.S.; Brown, E.R.; Lee, D.Y. and Kennedy, T.W. Hot Mix Asphalt Materials, Mixture Design, and Construction. National Asphalt Pavement Association Education Foundation. Lanham, MD

Subject Code: CE4P001	Name: CAD Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite: None

Exposure to commercial software tools for analysis, design and research in civil engineering.

Subject Code: CE6L402	Subject Name: Fundamentals of Traffic Flow Theory	L-T-P: 3-1-0	Credit: 04

Pre-requisite(s): None

Driver behaviour, traffic information and control systems, traffic studies- volume, speed and delay studies, elements of traffic flow theory, PCU concept, characteristics of uninterrupted traffic, mathematical theories of traffic flow (Poisson arrivals, binomial and negative binomial distributions), headway distributions, gap acceptance, critical gap estimation, queuing theory, shock wave, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic, traffic characteristics at unsignalised intersections, queue discharge characteristics at signalised intersections, dilemma zone.

Text/Reference Books:

1. Fred. L. Mannering, Walter P. Kilareski and Scott S. Washburn, Principles of Highway Engineering and Traffic Analysis, John Wiley & Sons.
2. D. R. Drew, Traffic Flow Theory and Control, MaGraw-Hill Book Company.
3. A. D. May, Traffic Flow Fundamentals, Prentice Hall.
4. Mike Slinn, Peter Guest and Paul Mathews, (2012). Traffic Engineering design, Taylor & Francis.
5. Roess and McShane, Roger P. Roess, Elena S. Prassas, William R. McShane, Traffic Engineering, Pearson.
6. L. R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers.
7. Louis J. Pignatro, Traffic Engineering-Theory and Practice, Prentice-Hall, Englewood Cliffs, New Jersey.
8. Khisty & Lal, Transportation Engineering, Prentice Hall India.
9. C. S. Papacostas and P. D. Prevedouros, Transportation Engineering & Planning.

Subject Code: CE6P402	Subject Name: Traffic Engineering Studies	L-T-P: 0-0-3	Credit: 02

Pre-requisite(s): None

Volume studies: Direction, Duration and Classification of Traffic Volume at Mid-Block Section and Intersections, Headway Distributions
Speed studies: Spot Speed Studies
Journey time and delay studies: Travel Time and Delay Studies by Floating Car Method
Arrival pattern studies of vehicles, Queue discharge characteristics
Gap acceptance studies: Study of Gaps, Lags, Critical Gaps
Intersection delay studies: Delay Measurement at Intersections
Highway Capacity Estimation: Videographic method, Dynamic PCU

Text/Reference Books:

1. Currin, T. R. (2013). Traffic Engineering-A Manual for Data Collection and Analysis, 2nd Edition, Cenage Learning.
2. Slinn, M. Guest, P., Mattehews, P. (2006). raffic Engineering Design-Principles and Practice, 2nd Edition Elseiver.
3. Highway Capacity Manual, 2010
4. Relevant Indian Roads Congress (IRC) Codes

Subject Code: CE6P401	Subject Name: Pavement Materials Laboratory	L-T-P: 0-0-3	Credit: 02

Pre-requisite(s): None

Tests on Soils: Density of soil, CBR, Determination of Field CBR using Dynamic Cone Penetrometer
Tests on Aggregate: gradation, shape tests, specific gravity, water absorption, aggregate crushing value, Los Angeles abrasion value, aggregate impact value.

Tests on Bitumen: penetration, viscosity, flash and fire point, ductility and elastic recovery, softening point, specific gravity, Ageing of Bitumen, Rheology of Bitumen using Dynamic Shear Rheometer

Tests on Bituminous Mixes: Marshall mix design, Bitumen content determination using centrifuge extractor.

Text/Reference Books:

1. Highway Material Testing Laboratory Manual by Khanna S. K., Justo, C.E.G and Veeraraghavan, A., Nem Chand & Bros.
2. Various IRC, ASTM and AASTHO Codes

Subject Code: CE6P404	Subject Name: Transportation Systems Planning Studio	L–T–P: 0-0-3	Credit: 02

Pre-requisite(s): None

Parking study, OD study, travel demand survey, questionnaire development of mode choice, trip generation, trip distribution, mode choice model parametric and non-parametric modelling, dealing with different transportation planning packages and traffic engineering packages, economic analysis and accident analysis

Text/Reference Books:

1. Simon P. Washington, Matthew G. Karlaftis, Fred L. Mannering, Statistical and Econometric Methods for Transportation Data Analysis, CRC Press
2. User Manuals of various packages
3. Relevant Indian Roads Congress (IRC) Codes
4. Williumsen and Ortuzar, Modelling Transport

Subject Code: CE4L004	Name: Rock Mechanics and Tunnelling	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction - objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration - rock coring, geophysical methods. Laboratory testing of rocks - all types of compressive strength, tensile strength and flexural strength tests. Strength and failure of rocks, Griffith's theory, Coulombs theory, rheological methods. In-situ tests on rock mass. Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics - interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties. Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence. Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting. Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

Text/Reference Books:

5. Goodman, R. E., Introduction to Rock Mechanics, John Wiley and Sons.
6. Hudson, J.A. and Harrison, J.P. Engineering rock Mechanics: an introduction to the principles, Pergamon publishers.
7. Chapman, David, Metje, Nicole and Stärk, Alfred, Introduction to Tunnel Construction. Spon Publishers, Taylor and Francis Group.

8. Brady, B. H. G. and Brown, E. T. Rock Mechanics: for underground mining, Kluwer Academic Publishers.

Subject Code: CE4L005	Name: Maintenance and Rehabilitation of Concrete Structures	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Maintenance and Repair strategies - Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Serviceability and Durability of Concrete - Quality assurance for concrete construction concrete properties-strength, permeability, thermal properties and cracking. - Effects due to climate, temperature, chemicals, corrosion - design and construction errors - Effects of cover thickness and cracking; Materials and Techniques for Repair - Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferrocement and polymers coating for rebars loadings from concrete, mortar and dry pack, vacuum concrete, Gunite and Shotcrete, Epoxy injection, Mortar repair for cracks shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels and cathodic protection.; Repairs to Structures - Repair of structures distressed due to earthquake – Strengthening using FRP Strengthening and stabilization techniques for repair.

Text/Reference Books:

6. Denison Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK.
7. Allen R.T and Edwards S.C, Repair of Concrete Structures, Blakie and Sons, UK.
8. Raikar, R.N., Learning from failures - Deficiencies in Design, Construction and Service - R&D Centre (SDCPL), Raikar Bhavan, Bombay.
9. Santhakumar A.R., Concrete Technology, Oxford University Press, Printed in India by Radha Press, New Delhi.
10. Emmons, Peter H., Concrete Repair and Maintenance Illustrated Galgotia Publications pvt. Ltd.

Subject Code: CE4L022	Name: Bridge Engineering	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Types of Bridges and loading standards. Hydraulic Design of Bridges, Foundation for piers and abutments, Open Foundation, Pile Foundation, Well Foundation, Bridge Substructure: Piers and Abutments. Bridge Superstructure: Design aspects, RC slab deck, Tee Beam and Slab deck. Composite Bridges. Pre-stressed concrete bridges, Steel trussed bridges; Bridge Construction, Inspection and Maintenance.

Text/Reference Books:

4. Ponnuswamy, S, Bridge Engineering, McGraw Hill
5. Jagadeesh and Jayaram, Design of Bridge Structure, PHI Learning
6. Victor, D. J., Essentials of Bridge Engineering, Oxford and IBH Publishing

Subject Code: CE4L023	Name: Pre-stressed Concrete	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Concept on Mechanics; Materials; Properties of sections; Stress analysis - three methods; Prestressing and Post stressing; Beam design - no tension and ultimate; Poles and slab panels; Loss assessment; Composite beams; Design for shear. Large span structures; Structural forms and design principles; Special materials, open web and built-up structures.

Text/Reference Books:

4. Lin and Burns, Design Of Prestressed Concrete Structures, Wiley India
5. Dayaratnam, P Prestressed Concrete Structures, Oxford and IBH

6. Raju, K., Prestressed Concrete Bridges, CBS			
Subject Code: **CE4L044**	**Name: Soil Engineering**	**L-T-P:** **3-0-0**	**Credit: 3**

Prerequisite: None

Shear strength of cohesionless and cohesive soils, physico-chemical aspects, experimental determination of shear strength, failure theories, Yield criteria, influence on failure conditions of inter-mediate principal stress, history, drainage, rate of stress applications etc.; Plastic equilibrium in soils, Mohr diagram, active and passive states, theories of earth pressure on retaining walls, effect of wall friction on the shape of sliding surface, theories of arching, bearing capacity, concepts of general and local shear failure, critical height of vertical banks, various methods of computation of slope stability, earth pressure on timbering of cuts and on free and anchored bulkheads.

Text/Reference Books:

6. Lambe, T. W. and Whitman, R. V., Soil Mechanics in SI Version, Wiley, New Delhi.
7. Scott, R. F., Principles of Soil Mechanics, Addison Wesley, World Student Edition.
8. Leonards, G. A., Foundation Engineering, McGraw-Hill.
9. Bowles, J. E., Foundations Analysis and Design, McGraw-Hill.
10. Peck, R. B., Hanson, W. E., and Thornburn, T. H., Foundation Engineering, John Wiley and Sons.

Subject Code: **CE4L045**	**Name: Earth Retaining Structures**	**L-T-P:** **3-0-0**	**Credit: 3**

Prerequisite: None

Earth Pressure: Fundamental relationships between the lateral pressures and the strain with a back fill. Rankine's and Coulomb's theories, Active, passive and earth pressure at-rest; Backfill with broken surface, wall with broken back, concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Passive earth pressure in engineering practice. Assumption and conditions, point of application of passive earth pressures; Bulkheads: Definition and assumptions, conditions of end supports and distribution of active earth pressure and bulkheads, bulkheads with free and fixed earth supports, equivalent beam method, Improvements suggested by Rowe, Tschebotarioff's method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates, Consideration of effects of ground water, seepage, surcharge loading together with possibility of shallow and deep sliding failures on retaining structure; Sheet Pile wall: Free earth system, fixed earth system, Dead man; Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations, Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays; Reinforced earth retaining structures-Design of earth embankments and slopes; Recent advances in Earth retaining structures.

Text/Reference Books:

6. Das, B. M., Principles of Foundation Engineering, Thomson, Indian Edition.
7. Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth-retaining Structures, Chapman and Hall Publishers.
8. Bowel, J., Foundation Engineering, Analysis and Design, McGraw Hill.
9. Raj, P., Geotechnical Engineering, Tata McGraw Hill.
10. Craig, R. F., Soil Mechanics, Chapman and Hall (ELBS).

Subject Code: **CE4L051**	**Name: Remote Sensing and GIS**	**L-T-P:** **3-0-0**	**Credit: 3**

Prerequisite: None

Physics of remote sensing: Electromagnetic spectrum, atmospheric effects, energy interaction with earth surface features. Platforms and remote sensing sensors: Photographic camera, scanners, earth resources satellites, active and passive microwave sensors. Digital image processing: Image rectification, image enhancement, image

classification and accuracy. Image interpretation. Geographical Information System (GIS): Map data representation, geographic database concepts and analysis. Application of remote sensing and GIS in land and water resources system and evaluation.

Text/Reference Books:

4. Bhatta, B., Remote Sensing and GIS, Oxford University Press.
5. Mesev, V., Integration of GIS and Remote Sensing, John Wiley & Sons Ltd.
6. Nayak, S., and Zlatanova, S., Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters, Springer.

Subject Code: CE 6L404	Subject Name: Analysis and Design of Pavements	L-T-P: 3-1-0	Credit: 04

Pre-requisite(s): None

Types of Pavements, Pavement Composition, Philosophy of design of flexible, composite and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible, composite and rigid pavements using different methods (IRC, AASHTO, Austroads etc), comparison of different pavement design approaches, design of overlays.

Text/Reference Books:

1. Y. H. Huang, Pavement Analysis and Design, Pearson Education.
2. E.J. Yoder and M. W. Witczak, Principles of Pavement Design, McGrawPub.
3. Rajib B. Mallick, Tahar El-Korchi, Pavement Engineering: Principles and Practice, Second Edition, CRC Press
4. Animesh Das, Analysis of Pavement Structures, CRC Press
5. Nick Thom, Principles of Pavement Engineering, ICE Publishing

*The examination for this course may be considered for open book examination system.

Subject Code: CE6L451	Subject Name: Design of Transportation Facilities and Safety	L-T-P: 3-1-0	Credit:04

Pre-requisite(s): None

Geometric design provisions for various transportation facilities, Discussion of controls governing geometric design, Route layout and selection, Elements of design - sight distances, horizontal alignment, transition curves, super elevation and side friction. Vertical alignment: - grades, crest and sag curves. Highway cross-sectional elements and their design for rural highways, urban streets and hill roads. At-grade Inter-sections - sight distance consideration and principles of design, channelisation, mini round-abouts, layout and design of round-abouts, Design of signalised intersections, capacity and LOS for signalised intersections, signal design, signal coordination, interchange design templates, entrance and exit ramps, acceleration and deceleration lanes, Bicycle and Pedestrian Facility Design; Parking Layout and Design; Terminal Layout and Design. Accident prevention through better planning, Designing for safety, Highway operation and accident counter measures, Road safety checklists, accident data analysis and its prediction models.

Text/Reference Books:

1. A policy on geometric design of highways and streets, American Association of State Highway Officials.
2. Geometric design standards for urban roads in plains (IRC:86-1983), The Indian Roads Congress.
3. Geometric design standards for rural (non-urban) highways (IRC:73-1980), The

Indian Roads Congress, 1980.
4. Manual of specifications & standards for six laning of highway through public private partnership (IRC: SP: 87-2010), The Indian Roads Congress.
5. Manual of specifications & standards for four laning of highway through public private partnership (IRC:SP:84-2009), The Indian Roads Congress.
6. Hill road manual (IRC:SP:48-1998), The Indian Roads Congress.
7. Guidelines for expressways – Part I, Ministry of Road Transport & Highways.
8. Guidelines for the design of interchanges in urban areas (IRC:92-1985), The Indian Roads Congress.
9. Roadside design guide, American Association of State Highway Officials.
10. Manual of geometric design standards for Canadian roads, Transportation Associations of Canada.
11. Pline, J.L., Traffic Engineering Handbook, Institute of Transportation Engineers.
12. Manual on Uniform Traffic Control Devices, Federal Highway Administration.
13. Highway Capacity Manual 2010, Transportation Research Board.
14. S.K. Khanna and C.E.G. Justo, Highway Engineering, Khanna Publishers, Roorkee, MXRoad Suite and manual for geometric design

Subject Code: CE6L452	Subject Name: Economic Evaluation of Transportation System	L-T-P: 3-0-0	Credit:03

Pre-requisite(s): None

concept of demand and its elasticity, concept of supply-side in transport, demand-supply interaction; appraisal and economic evaluation of transportation projects, Travel demand and value of time, Willingness-to-pay, Willingness-to-accept; valuation of user's benefit and transport pricing policy, economic evaluation of highway projects in India; Road-users' cost study in India-Objectives and Methodology, Using behavioural data for evaluation of transport infrastructure; stated and revealed preference data, binary and multinomial logit, maximum likelihood, case studies on choice modelling and estimation of value of planning attribute, multi-criteria analysis and public Policy

Text/Reference Books:

1. Studies in the economics of transportation by Beckmann et al.
2. Applied Transport Economics by Stuart Cole
3. McCarthy, P. Transportation Economics, Blackwell Publishers
4. Transportation Decision Making: Principles of Project Evaluation and Programming, Wiley, by Kumares C. Sinha, Samuel Labi,
5. C. Jotin Khisty, B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall.
6. Indian Roads Congress, "Manual for Road Investment Decision Model", Special Publication 38, New Delhi.
7. Indian Roads Congress, "Manual on Economic Analysis of Highway Projects", Special Publication 30, New Delhi. Revised version.
8. John Hibbs, Transport Economics & Policy: A Practical Analysis of Performance, Efficiency and Marketing Objectives Kogan Page,.
9. Economics of Urban Transport by Kenneth A Small and Erik T Verhoef
10. Principles of Traffic and Highway Engineering by Garber and Hoel
11. Economic Evaluation of highway projects in India-IRC
12. Road Users cost study in India - IRC

Subject Code: CE6L453	Subject Name: Analysis of Transportation Systems	L-T-P: 3-0-0	Credit:03

Pre-requisite(s): None

Transportation demand theory, supply theory and their interaction, transportation network and its analysis, shortest-path algorithm, concept in minimization problems and convex optimization, mathematical formulation of user equilibrium (UE) and System

optimal (SO) traffic assignment methods, Uniqueness of UE and SO traffic assignment, solution of UE and SO traffic assignment, traffic assignment with variable demand and link-interaction, combined distribution-assignment models, Supernetworks, Stochastic network loading and stochastic user-equilibrium, multi-class assignment, basics of optimal network geometry and non-convex functions, concept of dynamic traffic assignment, brief introduction of probabilistic modelling, Queuing theory and its applications, spatially distributed queues, application of network models, Simulation in the urban context.

Text/Reference Books:

1. Yosef Sheffi, Urban Transportation Networks
2. Transportation Systems Engineering: Theory and Methods by Ennio Cascetta
3. Marvin L. Manheim, Fundamentals Of Transportation Systems Analysis, Volume 1
4. Urban Operations Research by Larson and Odoni
5. Ran, B., and Boyce, D. E., Modeling Dynamic Transportation Network - An Intelligent Transportation System Oriented Approach, Springer-Verlag, Heidelberg
6.

Subject Code: CE6L454	Subject Name Pavement Evaluation and Management	L-T-P: 3-1-0	Credit:04

Pre-requisite(s): None

Types of pavements, Distresses in flexible and rigid pavements , Techniques for functional and structural evaluation of pavements, pavement rehabilitation techniques, overlay design procedures, recycling of flexible and rigid pavements, Maintenance of paved and unpaved roads, Pavement management systems, Introduction to HDM-4

Text/Reference Books:

1. Y. H. Huang, Pavement Analysis and Design, Second ed.,Pearson Education
2. Rajib B. Mallick, Tahar El-Korchi, Pavement Engineering: Principles and Practice, Second Edition, CRC Press
3. Derek Pearson, Deterioration and Maintenance of Pavements, ICE Publishing
4. Ralph Haas, W. Ronald Hudson, John P. Zaniewski, Modern pavement management Modern Pavement Management, Krieger Pub Co
5. Croney, D. and P. Croney, The design and performance of road pavements, McGraw-Hill Book Company, London, UK.

Subject Code: CE6L455	Subject Name Airport Planning and Design	L-T-P: 3-0-0	Credit:03

Pre-requisite(s): None

Air transport and its characteristics, Capacity and configuration, Runway and Taxi way design, Design, maintenance and rehabilitation of airfield pavements, terminal area lay-out, air traffic control, Grading and drainage, Environmental guidelines for airport projects, air-traffic demand estimation.

Text/Reference Books:

1. Khanna,S. K., Arora A. K. and Jain S. S., Airport Planning and Design, Nem Chand & Bros.
2. Ashford, N. and Wright, P.H., Airport Engineering, Third ed, John Wiley & Sons
3. Robert Horonjeff, Francis X. McKelvey, William J. Sproule and Seth B. Young, Planning and Design of Airports, Fifth Ed., McGraw Hill Pub.

Subject Code: CE6L456	Subject Name Public Transportation System	L-T-P: 3-0-0	Credit:03

Pre-requisite(s): None

Urban Passenger Transport Modes Classifications, Role of Mass Transportation System, Transit Modes and Characteristics, System Performance, Capacity, Quality of Service, efficiency and utilization, trip makers' perception analysis to various travel attributes, Willingness-to-pay estimation, demand analysis and user's benefit policy issue with reference to public transportation service improvement, optimal transport pricing policy, planning Issues, Route Determination, Network Design, Service Policy and Schedule development, Life Cycle cost in public transportation, Scheduling, Priority Measures and their Implementations, Issues and Challenges related to development of Mass Transportation System, Para-transits

Text/Reference Books:

1. Public Transit Planning and Operation: Theory, Modelling and Practice by Avishai Ceder
2. Urban Transit Systems and Technology by Vukan R. Vuchik.
3. Urban Transit: Operations, Planning and Economics by Vukan R. Vuchik
4. Studies in the economics of transportation by Beckmann et al.
5. Applied choice analysis: A Primer by David Hensher and Willium Greeene
6. Transportation Decision Making: Principles of Project Evaluation and Programming, Wiley,2007 by Kumares C. Sinha, Samuel Labi
7. Fundamentals of Transportation Engineering by Fricker and Whitford

Subject Code: CE6L006	Subject Name: Construction Project Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Principles of Project Management, Project Planning, Introduction to scheduling - work/project break down structures, Bar-charts; Principles of application of CPM and PERT; Precedence Method; Updating; Time - cost tradeoffs, Resource constrained scheduling;Resource leveling Project control; Performance Measurement, Earned value; Multiple Construction Projects; Other network techniques; Project Management Software Packages.

Books

- Construction Project Management by Neeraj Kumar Jha , (Pearson Education India)
- Construction Management by Trefor Williams (Pearson Education India)
- Construction project managemnet techniques and practice by Krishnan Chitkara (Tata Mcgraw Hill)
- Purifoy, "Construction Planning, equipments and Methods", Mc Graw Hill, Tokyo, Japan.

Subject Code: CE6L011	Subject Name: Environmental Management & Impact Assessment	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Environmental management, problems and strategies; Review of political, ecological and remedial actions; Future strategies; multidisciplinary environmental strategies, the human, planning, descision-making and management dimensions. Environment Risk assessment, Pollution prevention and Waste minimization; sustainable development (SD), Life cycle assessment. Environmental impact assessment (EIA), definitions and concepts, Screening and scoping criteria; Rapid and comprehensive EIA, 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, initial environmental examination (IEE), environmental impact statement (EIS), environmental appraisal, environmental audit (EA); Environmental impact factors and areas of consideration, measurement of environmental impact, organisation, scope and methodologies of EIA, case studies stressing physical aspects of environment. Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA;

EIA process;

Books

- Canter, L., Environmental Impact Assessment, McGraw Hill, 1996.
- Kiely, G., Environmental Engineering, Tata McGraw Hill, 2007
- Rau, G.J. and Wooten, C.D., Environmental Impact Analysis Handbook, McGraw Hill, 1980.
- Dhameja, Suresh K., Environmental Engineering and Management, S. K. Kataria & Sons
- World Bank, 'Environmental Assessment Source Book', Environment Dept., Washington D.C., 1991
- 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.
- Rosencranz, A., Divan, S. and Noble, M.L., Environmental Law and Policy in India : Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay, 1992.

Asolekar, S. R. and Gopichandran, R. Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK), 2005.

Subject Code: CE6L022	Subject Name: Ground Improvement	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, ground improvements schemes for cohesive soil sites (preloading, staged construction, accelerated consolidation with prefabricated drains, granular columns, lime columns, electro-osmosis, compaction piles, deep mixing, and vibro-replacement), ground improvement schemes for cohesionless soil sites (deep dynamic compaction, vibro-compaction, blast densification, grouting, and jet grouting), mechanically stabilized earthwork, soil nailing, ground anchors, light weight fill, and monitoring and quality control in ground improvement projects.

Books

- P. Puroshothama Raju, Ground Improvement Techniques, Laxmi Publications, New Delhi.
- M.P. Moseley and K. Kirsch, Ground Improvement, Spon Press, Taylor and Francis Group.
- B. M. Das, Principles of Foundation Engineering, Cengage Learning.
- Buddhima Indraratna and Jian J Chu, Ground Improvement: Case Histories, Elsevier.
- Chris A. Raison, Ground and Soil Improvement, Thomas telford, UK.
- Robert M. Koerner., Designing with Geosynthetics, Pearson Prentice Hall.

Subject Code: CE6L023	Subject Name: Computational Geomechanics	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Numerical modeling, constitutive modeling of soils and rock, continuum and discrete element modeling. Concept of stress and strain, principle stresses and strains. Octahedral stresses and strains, finite element discretization of a continuum, geomechanics problems of plane strain and axisymmetric problem. Failure criteria for soils, associated and non-associated flow rule. Finite elements for non-linear material problems in soil mechanics computational procedures. Finite difference approach. Simulation of soil-structure interaction problems, application in consolidation, bearing capacity and slope stability problems using numerical approaches.

Books

- Chandrakant S. Desai and J.T. Christian Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.
- Plasticity and Geomechanics by R. O. Davis, A. P. S. Selvadurai, Cambridge University Press
- Finite Element Analysis in Geotechnical Engineering: Theory and Application Author: David M. Potts and Lidija Zdravkovic (January 1, 2001)

- John T. Christian, Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers
- Computational Geomechanics with Special Reference to Earthquake Engineering by O. C. Zienkiewicz, A. H. C. Chan, M. Pastor, and B. A. Schrefler (Hardcover - May 11, 1999), Publisher: Wiley

Subject Code: CE6L025	Subject Name: Geotechnical Risk and Reliability	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to probabilistic geotechnical engineering, variability measures, random variables, probability mass and density functions, moments of distribution, modelling of uncertainty, engineering judgment, spatial variability of soil, autocovariance functions, functions of random fields, levels of reliability, loads and resistances, reliability methods, first order second moment (FOSM) method, Hasofer-Lind approach, Response Surface Method, Monte Carlo simulations.

Books

- Achintya Haldar and Sankaran Mahadevan, Probability, Reliability, and Statistical Methods in Engineering Design, John Wiley and Sons
- Gregory Baecher and John Christian, Reliability and Statistics in Geotechnical Engineering, John Wiely and Sons, Inc.
- Alfredo Hua-Sing Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design: Basic Principles (Vol. I), John Wiely and Sons, Inc.
- Alfredo Hua-Sing Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design: Decision, Risk, and Reliability (Vol. II), John Wiely and Sons, Inc.
- Alfredo Hua-sing Ang, Wilson H. Tang, Probability Concepts In Engineering: Emphasis On Applications In Civil & Environmental Engineering, Publisher: Wiley
- Robert E. Melchers, Structural Reliability Analysis and Prediction, John Wiley and Sons.
- Andrzej S Nowak and Kevin R. Collins, Reliability of Structures
- Erik Vanmarcke, Random Fields: Analysis and Synthesis, The MIT Press, Cambridge, Massachusetts.

Subject Code: MA6L002	Name: Advanced Techniques in Operation Research	L-T-P: 3-1-0	Credit: 4

Prerequisite: None

One variable unconstrained optimization, multivariable unconstrained optimisation, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization, quadratic programming, separable programming, convex and non convex programming, steepest and Quasi-Newton method.

Dynamic Programming: Characteristics of dynamic problems, deterministic dynamic programming and probabilitistic dynamic programming, Network analysis, Shortest path problems, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, network simplex, interior point methods, stochastic programming, Nonlinear goal programming applications, Geometric Programming.

Multi-objective Optimization Problems: Linear and non linear programming problems, Weighting and Epsilon method, P-norm methods, Gradient Projection Method, STEM method, Convex Optimization.

Text/Reference Books:

1. Rao, S. S., Engineering Optimization Theory and Practices, John Wiley and Sons, 2009
2. Ehrgott, M., Multi-criteria Optimization, Springer 2006
3. Miettien, K.M., Non-linear Multi-objective Optimization, Kluwers International Series, 2004
4. Deb, K., Multi-Objective Optimization using Evolutionary Algorithms, JohnWiley&Sons, 2001.

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Curriculum

List of Lateral Courses offered by School of Infrastructure for Other Schools

Subject Name	Code	L-T-P	Credit	Contact Hour	Syllabus Page No.
Lateral – I (Any one will be offered)					
Building materials and Construction	**CE2L011**	3-0-0	3	3	92
Infrastructure Planning and Management	**CE2L012**	3-0-0	3	3	92
Lateral – II/III (Any one will be offered)					
Traffic Engineering and Management	**CE3L021**	3-0-0	3	3	93
Construction Planning and Management	**CE3L022**	3-0-0	3	3	93
Environmental Pollution Management	**CE3L031**	3-0-0	3	3	94
Geo-environmental Management	**CE3L032**	3-0-0	3	3	94

Syllabus

Subject Code: CE2L011	Name: Building materials and Construction	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to Civil Engineering; Major Divisions; Civil Engineering Infrastructures; Ethics in Civil Engineering; Properties of construction material and their evaluation; test methods and specifications; Cement – chemical composition, properties such as setting, strength, fineness, hydration; Aggregates – sources, properties, chemical reactivity; Concrete - constituents, proportioning, properties in fresh and hardened state, characteristic strength, quality control, transportation and placing, testing, porosity; Admixtures – chemical, mineral; Steel – properties, types of steel, steel in civil engineering; Bricks – manufacture, properties and classification; masonry bonds; Wood - Structure, defects & preservation; Paints, New materials – Fibre reinforced plastics (FRPs), epoxy-coated bars, Geo-synthetics etc., Construction methodologies and equipment.

Books:

- Taylor, G.D., Materials of Construction, Prentice Hall
- Mehta P.K. and Montiero, P.M.J., Concrete – Material, Microstructure and Properties, Tata Mcgraw Hill
- Gambhir, M.L., Concrete Technology, Tata Mcgraw Hill
- Neville, A.M. and Brooks, J.J., Concrete Technology, ELBS/Longman
- Neville, A.M., Properties of Concrete, 4th Edition, ELBS/Longman
- Dayaratnam, P. Brick and Reinforced Brick Structures, Oxford and IBH
- Ghose, D.N., Construction Materials, Tata Mcgraw Hill
- Relevant IS codes for testing and specifications

Subject Code: CE2L012	Name: Infrastructure Planning and Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Basic concepts of infrastructure sectors in India (Power sector, Water Supply and Sanitation Sector, Road, Rail, Air, and Port Transportation Sectors, Telecommunications Sector, etc.); urban & rural infrastructure, infrastructure players; private involvement in infrastructure projects (Infrastructure Privatization, Types of PPPs, case studies); project assessment based on economic criteria- concept of NPV, EUAW, Benefit-Cost Ratio (BCR), IRR etc., multi-criteria analysis of infrastructure projects, ranking of influential parameters; network analysis, decision making processes- PERT and CPM analysis;

project monitoring, maintenance management, risks in infrastructure planning and implementation and its types (political risks, socio-environmental risks, cultural risks, legal or contractual issues), strategies for risk mitigation in infrastructure planning.

Books:

- Hudson, W. and Ralph, H., Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation and Renovation, Tata Mc Graw Hills.
- Garber, N.J. and Hoel, L.A., Principles of Traffic and Highway Engineering, Cengage Learning.
- Fricker, J.D., and Whitford, R.K., Fundamentals of Transportation Engineering: A Multimodal Systems Approach, Pearson Prentice Hall
- The India Infrastructure Report, Ministry of Finance, Govt of India.
- Jha, N.K., Construction Project Management, Pearson Education India
- Williams, T., Construction Management, Pearson Education India

Subject Code: CE3L021	Name: Traffic Engineering and Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction to traffic engineering; Fundamental parameters and relations of traffic flow; Traffic stream models; Traffic speed and volume measurement procedures: Capacity and Level of service LOS; Ramp metering; Principles of traffic control; Uncontrolled intersection; Channelization; Traffic rotary; Grade separated intersection; Basic principle and elements of Traffic signal design, Coordinated traffic signal;Specialised Traffic Studies: Parking Studies; Accident Studies; Fuel consumption and emission studies; Congestion studies; Toll operation: Pedestrian studies; Intelligent transportation system; Traffic Control, Traffic Management

Books:

- Mannering, F.L., Kilareski, W.P. and Washburn, S.S., Principles of Highway Engineering and Traffic Analysis, John Wiley & Sons.
- Drew, D.R., Traffic Flow Theory and Control, McGraw-Hill Book Company.
- May, A.D., Traffic Flow Fundamentals, Prentice Hall.
- Slinn, M., Guest, P. and Mathews, P., Traffic Engineering design, Elsevier.
- Roess, R.P., Prassas, E.S., McShane W.R., Traffic Engineering, Prentice Hall
- Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers.
- Pignatro, L.J., Traffic Engineering-Theory and Practice, Prentice-Hall
- Khanna, S. K. and Justo, C.E.G., Highway Material Testing, Nem Chand & Bros.
- Khisty, C.J. and Lal, B.K., Transportation Engg., Prentice Hall India.
- Papacostas C.S. and Prevedouros, P.D., Transportation Engineering & Planning, Prentice Hall

Subject Code: CE3L022	Name: Construction Planning and Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Construction and fabrication methods; Pre-fabrication techniques; choice of equipment safety features and Regulations; Agreements and Contracts; Use of IS codes and Building Laws; Value Analysis; Feasibility studies; Economics of project evaluation; Finance, material and man power development; Network analysis; Levelling of Resources; Site organisation; layout; work study; Decision making processes; CPM and L.P. Project monitoring; Maintenance management; Case studies.

Books:

- Jha, N.K., Construction Project Management, Pearson Education India
- Williams, T., Construction Management, Pearson Education India
- Chitkara, K., Construction Project Managemnet techniques and practice, Tata McGraw Hill
- Purifoy, Construction Planning, equipments and Methods, Tata McGraw Hill

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Subject Code: CE3L031	Name: Environmental Pollution Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Man and environment, Their inter relationships. Types of environmental pollutants, their sources and effects. Water Pollution and Control, Indoor pollution, Air pollution, sources, effects and controls technologies. Noise pollution and control, Industrial wastes and their treatment. Solid wastes, generation, collection, processing and disposal. Environmental impact assessment and auditing. Introduction to Environmental standards, laws and policies. Global issues on environment, Waste minimization, Building environment services.

Books:
- Kiely, G., Environmental Engineering, Tata McGraw Hill.
- Garg, S. K., Sewage Disposal and Air Pollution Engineering, Khanna Publication.
- Cunningham, W.P. and Cunningham, M.A. 2002, Principles of Environmental Science, Tata McGraw-Hill Publishing.
- Nathanson, J.A., (2002), Basic Environmental Technology, Prentice Hall of India, New Delhi.
- Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed.
- Masters, G.M., Ela, W.P., Introduction to Environmental Engineering and Science, Pearson Education.
- Asolekar, S. R. and Gopichandran, R. Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK).

Subject Code: CE3L032	Name: Geo-environmental Management	L-T-P: 3-0-0	Credit: 3

Prerequisite: None

Introduction, Perspectives, Forms of waste and their engineering properties; Geosysthetics and Applications; Waste disposal sites, Landfills; Ash ponds & dykes; Subsurface Contamination; Three "RS", Geotechnical Reuse of Waste materials; International Standards; Mechanics of erosion and erosion control; Landslides and their control.

Books:

- Sharma, H.D., and Reddy, K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc.
- Lakshmi N. Reddi, Hilary I. Inyang, Geoenvironmental Engineering: Principles and Applications, Marcel Dekker Inc, Publishers.
- Yong, R. N., Young, Raymond N., Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate, and Mitigation, Lewis Publication.