AY24-25 - SEMESTER-II - COURSE SYLLABUS

CHEMICAL ENGINEERING

E1-S2 (R22)					
S. No.	**Course Code**	**Course Name**	**Course Category**	**L-T-P**	**Credits**
1	MA1201	Differential Equations and Vector Calculus	BSC	3-0-1	4
2	PH1201	Engineering Physics	BSC	3-0-0	3
3	CY1202	Organic Chemistry	BSC	3-0-0	3
4	CH1201	Engineering Thermodynamics	ESC	3-0-0	3
5	HS1201	English	HSMC	2-0-0	2
6	BS1201	Environmental Science	MC	3-0-0	0
7	PH1801	Engineering Physics Lab	BSC	0-0-3	1.5
8	CE1801	Engineering Graphics	ESC	0-1-4	3
9	HS1801	English Lab	HSMC	0-0-2	1

MA1201 DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-1-0-4**

Learning Objectives:

- Methods of solving the differential equations of first and higher order.
- To study the methods of solving improper integrals and the concepts of multiple integrals
- The basic properties of vector valued functions and their applications to line, surface and volume integrals
- To study numerical methods to analyze an experimental data.

UNIT-I

Ordinary Differential Equations of first order: Exact first order differential equation, finding integrating factors, linear differential equations, Bernoulli's , Riccati , Clairaut's differential equations, finding orthogonal trajectory of family of curves, Newton's Law of Cooling, Law of Natural growth or decay.

UNIT-II

Ordinary Differential Equations of higher order:

Second order linear differential equations with constant coefficients: Non-Homogeneous terms of the type $e^{ax}, \sin(ax), \cos(ax)$, polynomials in $x, e^{ax}V(x), xV(x)$; method of variation of parameters; Equations reducible to linear ODE with constant coefficients: Legendre's equation, Cauchy-Euler equation.

UNIT-III

Integral Calculus:

Evaluation of the double integrals (Cartesian and Polar), change of order of integration (only Cartesian form), Evaluation of Triple integrals. Change of variables (Cartesian to polar) in case of double integrals (Cartesian to spherical and cylindrical) in case of Triple Integrals-Jacobians of transformations. Differentiation of integrals with variable limits - Leibnitz rule.

Applications: Finding Areas (using double integrals) and volumes (using double and Triple Integrals), Centre of mass, Centre of gravity for constant and variable densities by double and triple integrals (applications involving cubes, Sphere and rectangular parallelepiped)

UNIT-IV

Vector Differentiation: Vector point functions and scalar point functions. Gradient, Divergence and Curl. Directional derivatives, Tangent plane and normal line. Vector Identities. Scalar potential functions. Solenoidal and Irrotational vectors.

UNIT-V

Vector Integration: Line, Surface and Volume Integrals. Theorems of Green, Gauss and Stokes (without proofs) and their applications.

Numerical Methods: Introduction and motivation about numerical methods, True value, approximate value, error, error percentage, algebraic equations, transcendental equations, Newton-Raphson method, Bisection method.

Learning Outcomes:

At the end of the course student will be able to:

- Solve first order linear differential equations and special non linear first order equations like Bernouli , Riccati &Clairaut's equations
- Compute double integrals over rectangles and type I and II" regions in the plane
- Explain the concept of a vector field and make sketches of simple vector fields in the plane.
- Explain concept of a conservative vector field, state and apply theorems that give necessary and sufficient conditions for when a vector field is conservative, and describe applications to physics.
- Recognize the statements of Stokes' Theorem and the Divergence Theorem and understand how they are generalizations of the Fundamental Theorem of Calculus.
- Able to solve the problems in diverse fields in engineering science using numerical methods.

Text Books:

1. Advanced Engineering Mathematics (3rd Edition) by R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, New Delhi

References Books

1. Advanced Engineering Mathematics (8th Edition) by Erwin Kreyszig, Wiley-India.
2. Dr. M.D. Raisinghania,Ordinary andPartialdifferentialequations,S.CHAND,17thEdition2014.

PH1201 **ENGINEERING PHYSICS**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-3**

Course Objectives:
To learn about the basic concepts of optics and fibre optic applications, electricity and magnetism, magnetic materials and their applications, understanding the material at a microscopic level with applications of quantum physics

Unit I: Vectors and Mathematical Physics (6)

Gradient, Divergence, Curl and its applications, Line, surface and volume integrals, Stokes and Gauss theorem: Applications, Curvilinear Coordinates: Polar, Cylindrical and spherical co-ordinates, Problems.

Unit II: Electrodynamics (12)

Electrodynamics before Maxwell, Fixing of Ampere's Law, Maxwell Equations in Matter, Boundary Conditions, Continuity Equation, Poynting Theorem, Wave equation for E and B, Monochromatic Plane Waves, Energy and Momentum in EM Waves. Propagation in Linear Media, Reflection and Transmission at Normal Incidence. EM Waves in Conductors, Reflection at Conducting Surface.

Unit III: Quantum Mechanics (8)

Introduction to Quantum Mechanics, De-Broglie's waves and uncertainty principle, Wave Function and its Significance, Time dependant and time independent Schrodinger wave equations, Particle in a box - Problems.

Unit IV: Electron Structure of Solids (10)

Introduction to Crystallography, Bravais Lattices and crystal systems, Atomic Packing, Atomic Radii, Crystal Structures (SC, BCC and FCC), Miller Indices, Classical Free electron Theory, Kronig Penny model (E vs K), Band theory of solids.

Unit V: Semiconductor Physics (8)

Intrinsic and extrinsic semiconductors, Fermi level and carrier- concentration, Effect of temperature on Fermi level. Mobility of charge carriers and effect of temperature on mobility, Hall Effect, Energy band gap determination of semiconductors by four probe method, Direct and Indirect Band gap semiconductors.

Course outcomes:

- To apply the concepts of magnetic materials, Optics and quantum mechanics for a grass root level understanding of microscopic phenomenon and look at various applications.

Text Books:

1. Aruldhas. G, Engineering Physics, Prentice Hall India Publishers.

Reference Books:

1. Engineering Physics by H.K. Malik and Singh,
2. Electrodynamics by David.J.Griffiths
3. Quantum Mechanics by Aruldhas.
4. Solid State Physics by C. Kittel

CY1202 **ORGANIC CHEMISTRY**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-3**

Course Objectives:

- Students will be able to learn Reaction mechanisms, stereo chemistry, nitrogen compounds and hetero cyclic compounds.

Syllabus:

Unit 1: Reaction mechanisms

Introduction to reaction mechanism, Brief discussion on Free radicals, Electrophiles, Nucleophiles, Electron displacements in covalent bond- Inductive effect, Hyperconjugation, and mesomeric effect (resonance effect). Detailed discussion on types of reactions & mechanisms: Substitution reactions-(Free radical, Electrophilic (Benzene different substitutions reactions), Nucleophilic), Addition reactions-(Free radical, Electrophilic, Nucleophilic), Elimination reactions-(E1 & E2), Molecular rearrangement reactions-Pinacol-Pinacolone rearrangement, Fries rearrangement, Beckmann rearrangement, Hofmann rearrangement, Baeyer-Villiger rearrangement.

Unit 2: Stereochemistry

Introduction to Stereochemistry & Stereoisomerism, conformations of Ethane & Butane, Newman & Sawhorse projections, Cis & Trans isomerism (geometrical isomerism), E & Z configuration, sequence rules for E & Z, Optical isomerism, optical activity, (asymmetry-chirality) Enantiomers, Diastreomers, Recemic mixture, and meso compounds, Relative configurations (D & L, Absolute configuration (R & S), sequence rules for R & S, and examples of Glyceraldehyde, Alanine, Lactic acid and 2-Butanol.

Unit 3: Aldehydes, ketones & carboxylic acids

Introduction to Aldehydes, Ketones and Carboxylic Acids, Mechanism of Aldol condensation, Cannizzaro reaction, Benzoin condensation, Hell-Volhard-Zelinsky reaction.

Unit 4: Nitrogen compounds

Introduction to Amines, separation of amines by Hinsberg method, Brief discussion on Aryl diazonium salts & reactions of benzene diazonium chloride, Amino Acids-Classification, structure of Glycine, Alanine, Valine, Leucine, & Phenylalanine, preparations of Amino acids and synthesis of di & tri peptides.

Unit 5: Heterocyclic compounds

Introduction to heterocyclic compounds, methods of preparation & chemical reactions of Pyrrole, Furan, Thiophene & Pyridine.

Course Outcomes:

After studying these chapters, students

- Unit I: will learn different types of organic reactions, and their mechanism, which might be useful while working in the Industry.
- Unit II: will understand how the groups are arranged in the molecules and study the importance of stereochemistry.
- Unit III: can understand some reactions & mechanisms of aldehydes, ketones & carboxylic acids.
- Unit IV: able to define amines, Amino acids.& formation of peptide bond.
- Unit V: can understand the behavior of heterocyclic compounds.

Text books:

1. Organic chemistry, T.W Graham solomons, Craig B. Fryhle, 9th Ed., Wiley India Pvt Ltd, 2008.
2. Organic chemistry, K.S. Mukherjee, New age Publishers, 2007.

Reference Books:

1. The fundamental principles of organic chemistry by I.L.Finas, ELBS London.
2. Organic reaction mechanisms by V. K. Ahluwalia & R.K. Parashar, Narosha Publishers, 4th Ed., 2010.
3. Stereochemistry by P.S.Kalsi, New age International publishers, 2016.
4. Organic chemistry by L.G.Wade, Jr. Maya shaker singh, 4th Ed., Amazon,2011

CH1201 **ENGINEERING THERMODYNAMICS**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-3**

Course Objectives:

- To understand and apply the laws of thermodynamics
- To get familiar with various terminology of thermodynamics like system, properties, processes, reversibility, equilibrium, phases, components; the relationship between heat and work.
- To understand the various concepts on P-V-T behavior, Equations of state, thermodynamic diagrams and compressibility charts, entropy, irreversibility and problem solving skills.
- To understand various thermodynamic cycles.
- To learn about the various liquefaction and refrigeration processes and their working principle

Syllabus:

Unit-1

Scope and limitations of thermodynamics, definition and fundamental concepts, pressure, energy, work, heat. Equilibrium state. Zeroth law of thermodynamics. First law of Thermodynamics: General statement, thermodynamic state and state functions, Internal energy, Enthalpy.

The steady-state steady-flow process, Mass and energy balances, the reversible process, constant-V and constant- P processes, heat capacity, isobaric, isochoric, isothermal, adiabatic and polytrophic processes.

Unit-2

Volumetric properties of pure substances: The PVT behavior of pure substances, phase rule, virial equations, the ideal gas, the applications of the virial equations. Cubic equations of state, generalized correlations for gases, generalized correlations for liquids.

Unit-3

Heat effects: Sensible heat effects, Internal energy of ideal gases: Microscopic view, Latent heats of pure substances, heat effects of mixing processes. Standard heat of reaction, Standard heat of formation, Standard heat of combustion, temperature dependence of heat of reaction.

Unit-4

Second law of Thermodynamics-Statement, Heat engines, thermodynamic temperatures scales, thermodynamic temperature and the ideal gas scale. Entropy, Entropy changes of an ideal gas, mathematical statement of the second law, entropy from the microscopic view point, calculation of ideal work and lost work. Third law of Thermodynamics, Power Cycles-Carnot cycle, Rankine cycle.

Unit-5

Refrigeration and liquefaction: The Carnot refrigerator, the vapor compression cycle, the comparison of refrigeration cycles, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction processes.

Course Outcomes:

- A fundamental understanding of the first and second laws of thermodynamics and their application to a wide range of systems.
- Understanding of the first law of thermodynamics and various forms of work that can occur. An ability to analyze the work and heat interactions associated with a prescribed process path, and to perform a first law analysis of a flow system.
- An ability to evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations. Familiarity with calculations of the efficiencies of heat engines and other engineering devices.
- An understanding of the use of the Gibbs and Helmholtz free energies as equilibrium criteria, and the statement of the equilibrium condition for closed and open systems. An understanding of the interrelationship between thermodynamic functions and an ability to use such relationships to solve practical problems.
- Familiarity with the construction and principles governing the form of simple and complex one-component pressure-temperature diagrams and the use of volume-temperature and pressure-volume phase diagrams and the steam tables in the analysis of engineering devices and systems.
- Ability to determine the equilibrium states of a wide range of systems, ranging from mixtures of gases, mixtures of gases and pure condensed phases, and mixtures of gases, liquids, and solids that can each include multiple components.

Text Books:

1. Introduction to Chemical Engineering Thermodynamics, J M Smith, H C Van Ness and M Abbott, 6th Edition, TMH.

Reference Books:

1. A text book of Chemical Engineering Thermodynamics, K.V. Narayanan, PHI.
2. Engineering Thermodynamics, P.K Nag.
3. Chemical engineering thermodynamics, YVC Rao, Universities press, chemical engineering, 1997
4. 'Chemical and Process Thermodynamics, B.G Kyle, PHI Pvt. Ltd.

HS1201 **ENGLISH**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **2-0-0-2**

INTRODUCTION

In view of the growing importance of English as a tool for global communication and the consequent emphasis on training students to acquire language skills, the syllabus of English has been designed to develop linguistic, communicative and critical thinking competencies of Engineering students. In English classes, the focus should be on the skills development in the areas of vocabulary, grammar, reading and writing. For this, the teachers should use the prescribed text for detailed study. The students should be encouraged to read the texts leading to reading comprehension and different passages may be given for practice in the class. The time should be utilized for working out the exercises given after each excerpt, and also for supplementing the exercises with authentic materials of a similar kind, for example, newspaper articles, advertisements, promotional material etc. *The focus in this syllabus is on skill development, fostering ideas and practice of language skills in various contexts and cultures.*

Learning Objectives: The course will help to -

a. Improve the language proficiency of students in English with an emphasis on Vocabulary, Grammar, Reading and Writing skills.

b. Equip students to study academic subjects more effectively and critically using the theoretical and practical components of English syllabus.

c. Develop study skills and communication skills in formal and informal situations.

Course Outcomes: Students should be able to

1. Use English Language effectively in spoken and written forms.
2. Comprehend the given texts and respond appropriately.
3. Communicate confidently in various contexts and different cultures.
4. Acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

SYLLABUS

UNIT –I **(6 hours)**

'The Raman Effect' from the prescribed textbook 'English for Engineers' published by Cambridge University Press.

Vocabulary Building: The Concept of Word Formation --The Use of Prefixes and Suffixes.

Grammar: Identifying Common Errors in Writing with Reference to Articles and Prepositions.

Reading: Reading and Its Importance- Techniques for Effective Reading.

Basic Writing Skills: Sentence Structures -Use of Phrases and Clauses in Sentences Importance of Proper Punctuation- Techniques for writing precisely – **Paragraph writing** – Types, Structures and Features of a Paragraph - Creating Coherence-Organizing Principles of Paragraphs in Documents.

UNIT –II **(6 hours)**

'Ancient Architecture in India' from the prescribed textbook 'English for Engineers' published by Cambridge University Press.

Vocabulary: Synonyms and Antonyms.

Grammar: Identifying Common Errors in Writing with Reference to Noun-pronoun Agreement and Subject-verb Agreement.

Reading: Improving Comprehension Skills – Techniques for Good Comprehension

Writing: Format of a Formal Letter-**Writing Formal Letters** E.g.., Letter of Complaint, Letter of Requisition, Job Application with Resume.

UNIT –III **(6 hours)**

'Blue Jeans' from the prescribed textbook 'English for Engineers' published by Cambridge University Press.

Vocabulary: Acquaintance with Prefixes and Suffixes from Foreign Languages in English to form Derivatives-Words from Foreign Languages and their Use in English.

Grammar: Identifying Common Errors in Writing with Reference to Misplaced Modifiers and Tenses.

Reading: Sub-skills of Reading- Skimming and Scanning

Writing: Nature and Style of Sensible Writing- **Defining- Describing** Objects, Places and Events – **Classifying**- Providing Examples or Evidence

UNIT –IV **(6 hours)**

'What Should You Be Eating' from the prescribed textbook 'English for Engineers' published by Cambridge University Press.

Vocabulary: Standard Abbreviations in English
Grammar: Redundancies and Clichés in Oral and Written Communication.
Reading: Comprehension- Intensive Reading and Extensive Reading
Writing: Writing Practices--Writing Introduction and Conclusion - Essay Writing-Précis Writing.

UNIT –V **(6 hours)**

'How a Chinese Billionaire Built Her Fortune' from the prescribed textbook 'English for Engineers' published by Cambridge University Press.

Vocabulary: Technical Vocabulary and their usage
Grammar: Common Errors in English
Reading: Reading Comprehension-Exercises for Practice
Writing: Technical Reports- Introduction – Characteristics of a Report – Categories of Reports Formats- Structure of Reports (Manuscript Format) -Types of Reports - Writing a Report.
Prescribed Textbook:

1. Sudarshana, N.P. and Savitha, C. (2018). English for Engineers. Cambridge University
Press.

References:

1. Swan, M. (2016). Practical English Usage. Oxford University Press.
2. Kumar, S and Lata, P.(2018). Communication Skills. Oxford University Press.
3. Wood, F.T. (2007).Remedial English Grammar. Macmillan.
4. Zinsser, William. (2001). On Writing Well. Harper Resource Book.
5. Hamp-Lyons, L. (2006).Study Writing. Cambridge University Press.
6. Exercises in Spoken English. Parts I –III. CIEFL, Hyderabad. Oxford University Press.

BS1201 **ENVIRONMENTAL SCIENCE**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-0**

Course Objectives:

- Stimulate interest in the environment and endeavors to generate awareness about environmental concerns among students.
- Develop an understanding of how natural resources and the environment affect quality of life and the quest for sustainable development.
- Develop knowledge and understanding of environmental issues and principle and apply their knowledge to mitigate the environmental problems.
- Understand and resolve some of today's most challenging scientific and policy issues including global climate change, pollution, biodiversity conservation, sustainability, environmental pollution and toxic waste disposal, disease control, disaster management, socio-environmental issues and balancing resource use and preservation.
- Design and evaluate strategies, technologies, and methods for sustainable management of environmental systems and for the remediation or restoration of degraded environments.
- Recognizes the global changes and responses for attaining a more sustainable environment.

Syllabus:

Unit-1

Multi disciplinary nature of environmental studies: Definition, scope and importance, need for public awareness

Unit -2

Natural resources: Renewable and non-renewable resources: Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
d) Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
e) Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources.
f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.

- Role of an individual in conservation of natural resources.
- Equitable use of resources for sustainable lifestyles.

Unit-3

Ecosystem and Biodiversity:

Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids.

Introduction, types, characteristic features, structure and function of the following ecosystems:-

a) i).Forest ecosystem ii).Grassland ecosystem iii).Desert ecosystem iv).Aquatic ecosystems (ponds, streams, lakes, rivers, oceans and estuaries).
b) Biodiversity- Definition: genetic, species and ecosystem diversity. Bio geographical classification of India Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values.
c) Biodiversity at global, National and local levels. India as a mega-diversity nation Hot-sports of biodiversity.
d) Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit-4

Environmental pollution: Definition, Cause, effects and control measures of :- Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards

a) Solid waste Management: Causes, effect s and control measures of urban and industrial wastes.
b) Role of an individual in prevention of pollution
c) Pollution case studies.
d) Disaster management: floods, earthquake, cyclone and landslides.
e) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies.
f) Environment Protection Act., Air (Prevention and Control of Pollution) Act. Water Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act.

Unit-5

Social issues and the environment: Human Rights, Value Education, HIV/AIDS. Women and Child Welfare. Role of Information Technology in Environment and human health.

Field work:

- Visit to a local area to document the environmental assets river/forest/grassland/hill/mountain.
- Visit to a local polluted site Urban/Rural/Industrial/Agricultural.
- Study of common plants, insects, birds. Study of simple ecosystems-pond, river, hill slopes etc.

Course Outcomes:

- Based on this course, the Engineering graduate will understand/evaluate/ develop technologies on the basis of ecological principles and environmental regulations which in turn help in sustainable development.

Text Books:

1. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad-380 013, India, Email:mapin@icenet.net

Reference Books:

1. Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner.
2. Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p
3. Clark R.S., Marine Pollution, Clanderson Press Oxford (TB).
4. Cunningham, W.P. Cooper, T.H. Gorhan i, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumabai, 116p.

PH1801 **ENGINEERING PHYSICS LAB**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **0-0-3-1.5**

Course objectives:

- To practice the study of dielectric properties, BH curve, PN Junction diode and solar cells.

List of Experiments:

1. Determination of Dielectric Constant and Phase transition temperature of PZT material.
2. To trace the BH-curve (Hysteresis) of Ferromagnetic specimen using CRO and Measurement of area of BH loop, evaluate energy loss in the specimen.
3. Determination of carrier concentration, mobility and Hall Coefficient of Ge crystal using Hall Effect experiment.
4. To draw the I-V characteristic of Solar cell and to calculate i) Fill factor , ii) Efficiency, iii) Series resistance of the solar cell.
5. To determine the lande g factor (spectroscopic splitting factor) using Electron Spin Resonance spectrometer for the DPPH sample.
6. To determine Plank's Constant and work function of photo metal.
7. To determine Temperature Characteristics of Thermistor and to find the constants.
8. Determination of the numerical aperture and acceptance angle of the given optical fiber optics.
9. Determination of wavelength of Laser source by using Diffraction grating.
10. To find the values of electrical conductivity and energy gap of Ge crystal by Four Probe method.

Course Outcomes:

- Students will be able to use the materials of dielectric, BH curve, PN Junction diode and solar cells.

CE1801 **ENGINEERING GRAPHICS**

Externals: 50 Marks **L-T-P-C**
Internals: 50 Marks **0-1-4-3**

Course Objectives:

- To introduce the students to the "Universal Language of Engineers" for effective communication through drawing.
- To understand the basic concepts of drawing through modern techniques.
- To impart knowledge about standard principles of projection of objects.
- To provide the visual aspects of Engineering drawing using AutoCAD.

Syllabus:

Unit-1

Introduction to Engineering Drawing: Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, types of lines and Dimensioning.

Over view of AutoCAD: Theory of CAD software (The Menu System, Tool Bars, Drawing area, Dialogue boxes, Shortcut Menu, the command lines, Select and erase objects, Introduction to layers etc.), Drawing simple figures- lines, planes, solids.

Unit-2

Geometrical constructions: Construction of regular polygons.

Conic sections: Construction of Ellipse, Parabola, Hyperbola (General method only), Cycloid, Epicycloid, Hypocycloid and Involutes.

Scales: Construction of Plain, Diagonal and Vernier scales.

Unit-3

Orthographic projections: Principles of Orthographic Projections

Projections of Points: Projections of Points placed in different quadrants

Projection of lines: lines parallel and inclined to both the planes (Determination of true lengths and true inclinations and traces)

Projection of planes: Planes inclined to both the reference planes

Unit-4

Projection of Solids: Projection of solids whose axis is parallel to one of the reference planes and inclined to the other plane, axis inclined to both the planes

Projection of sectioned solids: Sectioning of simple solids like prism, pyramid, cylinder and cone in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section.

UNIT-5

Development of surfaces: .Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone

Isometric Projections: Principles of Isometric projection – Isometric Scale, Isometric Views of planes and simple solids

Perspective projections: Basic concepts of perspective views.

Course Outcomes: At the end of the course, the student will be able to

- Use Engineering principles and techniques to understand and interpret engineering drawings.
- Understand the concepts of AutoCAD.
- Draw orthographic projections of lines, planes and solids using AutoCAD.
- Use the techniques, skills and modern engineering tools necessary for engineering practices.

Text Books:

1. Bhatt N.D., Panchal V.M. & Ingle P.R., Engineering Drawing, Charotar Publishing House,2014
2. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2007.

References:

3. Shah, M.B. &Rana B.C, Engineering Drawing and Computer Graphics, Pearson Education,2008
4. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age publications
5. Agrawal B. & Agrawal C. M., Engineering Graphics, TMH Publication 2012,
6. Narayana, K.L. & P Kannaiah, Text book on Engineering Drawing, Scitech Publishers, 2008
7. (Corresponding set of) CAD Software Theory and User Manuals

HS1801 **ENGLISH LAB**

Orals (Written): 50Marks **L-T-P-C**
Written (Externals): 50Marks **0-0-2-1**

Course Objectives:

- To facilitate computer-assisted multi-media instruction enabling individualized and independent language learning.
- To sensitize students to the nuances of English speech sounds, word accent, intonation and rhythm.
- To bring about a consistent accent and intelligibility in students' pronunciation of English by providing an opportunity for practice in speaking
- To improve the fluency of students in spoken English and neutralize their mother tongue influence
- To train students to use language appropriately for public speaking and interviews

Syllabus
Listening Skills:
Objectives:

- To enable students develop their listening skills so that they may appreciate its role in the LSRW skills approach to language and improve their pronunciation.
- To equip students with necessary training in listening so that they can comprehend the speech of people of different backgrounds and regions *Students should be given practice in listening to the sounds of the language, to be able to recognize them and find the distinction between different sounds, to be able to mark stress and recognize and use the right intonation in sentences.*
- Listening for general content
- Listening to fill up information
- Intensive listening for specific information

Speaking Skills:
Objectives:

- To involve students in speaking activities in various contexts
- To enable students express themselves fluently and appropriately in social and professional contexts
- Oral practice: Just A Minute (JAM) Sessions Describing objects/situations/people
- Role play – Individual/Group activities

Course Outcomes:
Students will be able to attain

- Better understanding of nuances of English language through audio- visual experience and group activities
- Neutralization of accent for intelligibility

Speaking skills with clarity and confidence which in turn enhances their employability skills.

SECOND YEAR (E2) – SEMESTER – II

E2-S2 (R22)					
S. No.	**Course Code**	**Course Title**	**Course Category**	**L-T-P**	**Credits**
1	CH2201	Process Heat Transfer	PCC	3-0-1	4
2	CH2202	Mechanical Unit Operations	PCC	3-0-0	3
3	CH2203	Mass Transfer Operations-I	PCC	3-0-1	4
4	EE2204	Basic Electrical& Electronics Engineering.	ESC	3-0-0	3
5	BM2202	Fundamentals of Management for Engineers	HSMC	3-0-0	3
6	CH2801	Process Heat Transfer Lab	PCC	0-0-3	1.5
7	CH2802	Mechanical Unit Operations Lab	PCC	0-0-3	1.5
8	EE2804	Basic Electrical and Electronics Engineering Lab	ESC	0-0-2	1
9	CH2000	Technical Seminar	ESC		0

CH2201 **PROCESS HEAT TRANSFER**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-1-0-4**

Course Objectives:

- Study various modes of Heat transfer and their fundamental relations.
- Study conduction heat transfer and develop mathematical relations for various solid geometries.
- Understand different types of heat transfer coefficients and their estimations in various types of flows in different geometries.
- Understand the working of Heat exchangers and to learn design of double pipe, shell and tube heat exchangers and design of evaporators and conduct experiments and to submit the report.
- Understand the phenomenon of radiation, radiation shields and estimation of emissivity.

Syllabus:

Unit-1

Introduction & Heat transfer by conduction: Nature of heat flow, Heat transfer by conduction in Solids Fourier's law, thermal conductivity, steady state conduction in plane wall & composite walls, compound resistances in series, Thermal Insulation.
Heat flow through a cylinder, conduction in spheres, thermal contact resistance, plane wall: variable conductivity. Unsteady state heat conduction Equation for one-dimensional conduction, Semi-infinite solid and finite solid.

Unit -2

Heat Transfer to Fluids without Phase change: Regimes of heat transfer in fluids, thermal boundary layer, heat transfer by forced convection in laminar flow, Heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy between transfer of momentum and heat.

Unit-3

Natural convection -Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer, free convection in enclosed spaces, mixed free & forced convection
Heat transfer to fluids with phase change -Heat transfer from condensing vapors, heat transfer to boiling liquids.

Unit-4

Heat exchange equipment: General design of heat exchange equipment, heat exchangers, condensers, Boilers and Calendrias, extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method).

Unit-5

Radiation -Properties and definitions, black body radiation, real surfaces and the gray body. Absorption of radiation by opaque solids, radiation between surfaces, radiation shielding, radiation to semi transparent materials.

Evaporators – Various types of Evaporators, performance of tubular evaporators, capacity and economy, single and multiple effect evaporators, vapor recompression.

Course Outcomes:

At the end of the course, the student will be able to

- Understand and solve conduction, convection and radiation problems.
- Design and analyze the performance of heat exchangers and evaporators.
- Design and analyze reactor heating and cooling systems.

Text Books:

1. Unit Operations of Chemical Engineering, W. L. McCabe, J. C. Smith & Peter Harriot, 6th Edition, McGraw-Hill.
2. Heat transfer: Principles and applications, Dutta Binay k, PHI learning pvt. Ltd, 2000.
3. Introduction to heat transfer, SK Som, PHI learning pvt. Ltd. 2008.

Reference Books:

1. Process heat transfer, D. Q. Kern, McGraw-Hill, New Delhi, 1997.
2. Heat Transfer, 9th ed., J.P. Holman, McGraw-Hill, New York., 2004.
3. Transport processes and Unit operations, Christie J. Geankoplis, PHI
4. Fundamentals of heat and mass transfer, Incropera, DeWitt, Bergman, Lavine, John Wiley and sons, 5th edition, 2006.

CH2202 **MECHANICAL UNIT OPERATIONS**

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-3**

Course Objectives:
This course deals with the different mechanical unit operations in chemical engineering. Specific attention is given on particle and separation techniques.

- Student will gain knowledge on various mechanical separation operations used in chemical industry.
- Classify and identify the storage, mixing and transportation equipment.
- Calculate the average size of solid particles of a given solid sample. Describe size reduction equipment and distinguish between different size reduction equipment.
- Choose the type of filtration process for a solid liquid separation.
- Explain the flow patterns in an agitator.

Syllabus:

Unit-1
Introduction to unit operations: Properties, handling and mixing of particulate solids: Characterization of solid particles(Micro, Macro and Nano), properties of particulate masses, storage and mixing of solids-Bulk storage, Bin storage & Silos, Transportation of solid particulate mass, belt, screw, apron conveyers, bucket elevators, pneumatic conveying.

Unit -2
Size reduction -Principles of comminution, size reduction equipment-Crushers (Jaw Crusher, Gyratory Crusher), Grinders (Ball mill, Tumbling mills), Ultra fine grinders (Fluid energy mills), Cutting machines, Equipment operation-Open circuit & closed circuit operation.
Laws of crushing: Kick's law, Bond's law, Rittinger's law.
Screening, differential & cumulative analysis, Industrial screening equipments-Stationary screens and grizzlies, Gyrating screens, Vibrating screens, comparison of ideal and actual screens, Material balances over screen, capacity and effectiveness of screens.

Unit-3
Filtration-Types of filters, cake filters, constant rate filtration, constant pressure filtration, centrifugal filters-Plate and Frame filter press, Chamber press, Rotary Drum filter, Vacuum Nutch filter, top suspended batch centrifuge, filter aids, Principles of cake filtration. Clarifying filters, liquid clarification, gas cleaning, Principles of clarification. Cross flow filtration, types of membranes, micro filtration.

Unit-4
Separations based on motion of particles through fluids, gravity settling processes-gravity classifiers, sorting classifiers- float and sink method, differential settling method, coagulation, flocculation and flocculating agents, Size Enlargement- Nucleation and growth of particles, centrifugal settling processes-cyclone separators & hydro cyclones. Centrifugal decanters-Tubular and Disk centrifuge.

Unit-5

Electro-static precipitators, Flotation-separation of ores, flotation agents, Magnetic separators-Ball Norton machine, magnetic pulley separator & magnetic drum separator.
Agitation and mixing of liquids: Agitation of liquids, Types of impellers-propellers, turbines, paddles. Flow patterns in agitated vessels, power consumption in agitated vessels

Course Outcomes:

At the end of the course, the student will be able to:

- Size piping networks, valves, pumps for flow systems.
- Understand flow past immersed objects especially in fixed and fluidized beds and derive the Ergun equation.
- Design a mixed tank, calculate its power requirements and scale-up the design.
- Understand and apply the basic methods of characterization of particles and bulk solids, e.g. average particle size, settling velocity.
- Describe the operation of filter processes and types of filters used to perform solid-liquid separations, and calculate their power requirements.

Text Books:

1. Unit Operations in Chemical Engineering, W.L. McCabe and J.C. Smith and Peter Harriott, McGraw Hill, 7^{th} ed. 2001.

Reference Books:

1. Chemical engineers hand book, J.H. Perry, 7th ed. McGraw Hill
2. Introduction to Chemical Engineering, J.T. Banchero & W.L. Badger, TMH, 1997.

CH2203 MASS TRANSFER OPERATIONS-I

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-1-0-4**

Course Objectives:

- To discuss the fundamental concepts of mass transfer principles and to apply those concepts to real engineering problems.
- To impart the basic concepts of molecular diffusion, mass transfer coefficients and analysis of different mass transfer processes
- Applies the concepts of diffusion mass transfer, mass transfer coefficients, convective mass transfer, inter-phase mass transfer, equipment for gas-liquid operations.

Syllabus:

Unit-1

Diffusion: Classification of the Mass-Transfer Operations, Molecular Diffusion in Fluids: Molecular diffusion, Fick's Law of Diffusion, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow. Gas-Phase Diffusion Coefficient: Use of Stefan Tube. Liquid-Phase Diffusion Coefficient estimation, Basics of Diffusion in Solids and Unsteady State Diffusion

Unit -2

Mass transfer coefficients: Mass Transfer Coefficients: F-type and k-type coefficients, Theories of Mass Transfer: Film theory, Penetration theory, surface renewal theory and Boundary layer theory. Wetted wall column, Mass, Heat and Momentum Transfer Analogies.

Unit-3

Inter-Phase Mass Transfer: Concept of Equilibrium, Diffusion between Phases, material Balances in Steady State Co-current and Countercurrent Processes, Stages, Kremser-Brown equations.

Gas-Liquid Operations: Tray Towers, Tray efficiency: Murphree tray efficiency. Packed Bed Towers: Types of Packing, Tray Towers versus Packed Towers.

Unit-4

Absorption and Stripping: Absorption equilibrium, Ideal and Non-Ideal Solutions: Raoult's law, Henry's law. Selection of a Solvent for Absorption, one component transferred: material balances, minimum liquid-gas ratio for absorbers. Countercurrent multistage operation: one component transferred, the Absorption factor, determination of number of stages. Continuous-contact equipment: HETP, HTU, NTU determination.

Unit-5

Humidification and Dehumidification: Humidification Principles, Absolute Humidity, Unsaturated vapor-gas mixtures, adiabatic saturation curves, wet bulb temperature, the Lewis relation, the Psychometric chart and its use. Description of cooling towers: construction and operation.

Drying: Definitions, Drying operations: Batch drying, the rate of batch drying, the mechanism of batch drying, Continuous drying: Classification drying equipment: Conveyer dryer, rotary dryers.

Course Outcomes:

At the end of the course, student will be able to:

- Determine mass transfer rates using Fick's Law
- Estimate convective mass transfer rates and mass transfer coefficients using analogies
- Explain the concept of inter phase mass transfer
- Design absorber, striper and humidifier
- Estimate drying time
- Explain the working of batch and continuous drying equipment.

Text Books:

1. Mass Transfer Operations, 3rd ed., R. E. Treybal, McGraw-Hill, New York.
2. Principles of Mass Transfer and Separation processes, Binay K. Dutta PHI Learning Pvt. Ltd., New Delhi, 2012.

Reference Books:

1. Unit operations in chemical engineering, W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill, 7th ed. 2001.
2. Transport Processes and Unit Operations by Christie J. Geankoplis.
3. Separation Process Principles, J. D. Seader and E. J. Henley, John Wiley & Sons., Inc, New York.

EE2204 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-3**

Course Objectives:
This course introduces the concept of

- Electrical DC and AC circuits, basic law's of electricity and methods to solve the electrical networks
- Construction operational features of energy conversion devices i.e. transformers, DC motors and induction motors.
- Basics of electronics, semiconductor devices and their characteristics and operational features.

Syllabus:

Unit-1
DC CIRCUIT ANALYSIS:
Electrical circuit elements: R-L-C Parameters, V–I relationship for Passive elements, Diode, Voltage and Current Independent and Dependent Sources.
Circuit analysis: Kirchhoff's Laws, Network reduction techniques – series, parallel, series parallel, star–to-delta, delta-to-star transformation, Source Transformation, Mesh Analysis and Nodal Analysis.
Network Theorems - Thevenin's, Norton's, Maximum Power Transfer, and Superposition
Step response of RL, RC and RLC circuits.

Unit -2
AC CIRCUIT ANALYSIS:
Single Phase AC Circuits: R.M.S. and Average values, Form Factor, steady state analysis of series, Parallel and Series parallel Combinations of R, L and C with Sinusoidal excitation, concept of reactance, Impedance, Susceptance and Admittance – phase and phase difference, Concept of Power Factor, j-notation, complex and Polar forms of representation.
Resonance – Series resonance and Parallel resonance circuits.

Unit-3
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.

Unit-4
BASIC ELECTRONICS:
Introduction to electronics and electronic systems, Diode and Rectifier circuits (Half and Full wave), BJT, Transistor biasing. Small signal transistor amplifiers (CE), Operational amplifiers and their basic application, Introduction to digital circuits.

Unit-5

ELECTRICAL MACHINES:

Transformers : Construction, EMF equation, ratings, phasor diagram on no load and full load, equivalent circuit, regulation and efficiency calculations, open and short circuit test, applications.

DC machines: Construction, EMF and Torque equations, Characteristics of DC generators and motors, applications.

Induction motors: The revolving magnetic field, principle of orientation, ratings, equivalent circuit, Torque-speed characteristics and applications.

Course Outcomes:

At the end of the course, the student will be able to:

- Understand the basic concept of electrical circuits under DC and AC excitation and solve basic electrical circuit problems
- Understand basic concept and performance of transformers and motors used as various industrial drives

Text Books:

1. Electrical Technology- Hughes Prentice Hall, 7th edition
2. Problems In Electrical Engineering- S. Parker Smith, 9 edition
3. Electronic Devices and Circuits – R.L. Boylestad and Louis Nashelsky, PEI/PHI, 9th Ed, 2006.
4. Engineering circuit analysis- by William Hayt and Jack E. Kemmerly, Mc Graw Hill Company, 6th edition.
5. Electric Machines –by I.J.Nagrath & D.P.Kothari,Tata Mc Graw Hill, 7th Edition.2005

Reference Books:

1. Electronic Devices and Circuits - K. Lal Kishore, B.S. Publications, 2nd Edition, 2005.
2. Electronic Devices and Circuits – Anil K. Maini, Varsha Agarwal –Wiley India Pvt. Ltd. 1/e 2009.
3. Network Theory by N.C.Jagan & C.Lakshminarayana, B.S. Publications.
4. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007
5. Network Theory by Sudhakar, Shyam Mohan Palli, TMH.

CH2801 PROCESS HEAT TRANSFER LAB

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **0-0-3-1.5**

Course Objectives:

- This lab will provide practical knowledge on various heat transfer process and equipment like heat exchangers and evaporators.
- Learn basic Heat transfer principles.
- Impart the knowledge in heat transfer measurements and different heat transfer equipment.
- Learn how the convection takes place in natural and forced convection and gain knowledge of the heat transfer taking place in different heat exchangers.

List of Experiments:

1. Determination of total thermal resistance and thermal conductivity of composite wall.
   Major equipment - Composite wall Assembly.
2. Determination of thermal conductivity of a metal rod.
   Major equipment - Thermal Conductivity apparatus.
3. Determination of natural convective heat transfer coefficient for a vertical tube.
   Major equipment - Natural convection heat transfer apparatus.
4. Determination of critical heat flux point for pool boiling of water.
   Major equipment- Pool boiling apparatus.
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
   Major equipment – Forced convection heat transfer apparatus.
6. Determination of overall heat transfer coefficient in Shell and Tube heat exchanger.
   Major equipment – Shell and Tube heat exchanger apparatus.
7. Determination of thermal conductivity of a Liquid.
   Major equipment - Thermal Conductivity apparatus.
8. Determination of Stefan – Boltzmann constant.
   Major equipment - Stefan Boltzmann apparatus.
9. Determination of emissivity of a given plate at various temperatures.
   Major equipment - Emissivity determination apparatus.

Course Outcomes:

By the end of this course, the student should be able to:

- Understanding fundamentals of some major Heat transfer operation.
- Development of design processes
- Application of design principles for heat transfer devices.
- Learning operations of various heat transfer systems
- Building foundation for process intensification
- Motivation towards innovations for novel systems of heat transfer.

CH2802 MECHANICAL UNIT OPERATIONS LAB

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **0-0-3-1.5**

Course Objectives:

- To enable the students to develop a sound working knowledge on different types of crushing equipments and separation characteristics of different mechanical operation separators.

List of experiments:

1. To determine the time of grinding in a ball mill for producing a product with 80 % passing a given screen.
   Major equipment - Ball mill Apparatus, Sieve shaker, Different sizes of sieves, weighing balance.
2. To verify the laws of crushing using any size reduction equipment and to find out the working index of the material.
   Major equipment – Jaw Crusher, Sieve shaker, Different sizes of sieves, Weighing Balance, Energy meter.
3. To find the effectiveness of hand screening and vibrating screen of a given sample.
   Major equipment - Vibrating Sieve shaker, Different sizes of sieves, Weighing Balance.
4. To achieve beneficiation of a ore using froth flotation technique.
   Major equipment - Froth flotation cell
5. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions.
   Major equipment- Sedimentation apparatus
6. To determine the specific cake resistance and filter medium resistance of slurry in plate and frame filter press.
   Major equipment - Plate and frame filter press.
7. To determine reduction ratio of a given sample in a grinder.
   Major equipment - Grinder (Planetary ball mill)
8. To determine the viscosity of a liquid by using stokes law and by VISCOMETER Instrument
9. To calculate separation efficiency of particles in a mixture using cyclone separator.

Course Outcome:

By the end of this course, the student should be able to:

- Design a mixed tank, calculate its power requirements and scale-up the design.
- Understand and apply the basic methods of characterization of particles and bulk solids, e.g. Average particle size, settling velocity.
- Describe the operation of filter processes and types of filters used to perform solid-liquid separations, and calculate their power requirements.

EE2804 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **0-0- 2-1**

Course Objectives:

- To expose the students to the concepts of electrical and electronics circuits and their applications
- To expose the students to the operation of dc machines and transformer and give them experimental skills

List of Experiments:

List of Laboratory Experiments/Demonstrations (any eight of the following):

1. Introduction to Lab:
   (a) Basic safety precautions. Introduction and use of measuring instruments – voltmeter,
   ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
   (b) Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.

2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope).
   Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.

3. Transformers: Observation of the no-load current waveform on an oscilloscope (non sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.

4. Torque Speed Characteristic of separately excited dc motor.

5. Torque-Slip Characteristic of an induction motor.

6. Characteristic of the lamps (Tungsten, Fluorescent and Compact Fluorescent Lamps).

7. Verification of Network Theorems.

8. V-I characteristics of Diodes and BJT.

9. Half-wave and full-wave rectifiers, rectification with capacitive filters, zener diode

10. Studies on logic gates

11. Small signal transistor amplifiers (CE)

Course Outcomes:

- Get an exposure to basic electrical laws.
- Understand the response of different types of electrical circuits to different excitations.
- Understand the measurement, calculation and relation between the basic electrical parameters
- Understand the basic characteristics of transformers and electrical machines

THIRD YEAR (E3) – SEMESTER – II

E3-S2 (R22)					
S. No.	**Course Code**	**Course Title**	**Course Category**	**L-T-P**	**Credits**
1	CH3201	Chemical Reaction Engineering-II	PCC	3-0-0	3
2	CH3202	Instrumentation& Process Control	PCC	3-0-1	4
3	CH3203	Process Equipment Design	PCC	3-0-0	3
4		Professional Elective Course-III	PEC	3-0-0	3
	CH3232	**Renewable Energy Sources**			
5	**CH3241**	Professional Elective Course-IV(Petroleum Engineering)	PEC	3-0-0	3
6		Open Elective Course –I	OEC	3-0-0	3
	BS3402	**Biopharmaceutical Techology**			
7	HS3203	Soft Skills	HSMC	0-0-2	1
8	CH3801	Chemical Reaction Engineering Laboratory	PCC	0-0-3	1.5
9	CH3802	Instrumentation& Process Control Laboratory	PCC	0-0-3	1.5
10	CH3901	Theme Based Project	SIP	0	1

CH3201 CHEMICAL REACTION ENGINEERING-II

Externals: 60 Marks **L-T-P-C**
Internals: 40 Marks **3-0-0-3**

Course Objectives:

- Learn to characterize and diagnose the non-ideal reactors. Learn the modeling of Non-ideal flow reacting vessels.
- Calculate the conversions in non-ideal reactor using various flow models.
- Understand the concepts in heterogeneous reaction systems. Determine the rate controlling step in catalytic reactions. Understand the internal and external diffusion effects.
- Learn the factors influencing catalyst decay, the role of pore diffusion on catalyst
- Learn the kinetics and reactor design of various heterogeneous reaction systems

Syllabus:

Unit-1

Non-Ideal Flow: Basics of Non-Ideal Flow; E, the age distribution of fluid, the RTD, Pulse Response Experiments, Conversion in Non-Ideal flow reactors, Compartment Models.

Unit-2

The Dispersion Model-Axial Dispersion, Correlations for Axial Dispersion, Chemical Reaction and Dispersion.

The Tanks-in-series Model- RTD, Chemical Conversion.

Unit-3

The Convection Model for Laminar Flow: The Pure Convection Model and its RTD, Chemical Conversion in Laminar Flow reactors.

Earliness of Mixing, Late mixing, Segregation and RTD, Self Mixing of a single fluid, Mixing of two miscible fluids.

Unit-4

Reactions Catalyzed by solids: Heterogeneous Reactions-Introduction, Solid Catalyzed Reactions, The Rate Equation For surface Kinetics, Pore diffusion resistance combined with surface kinetics, porous catalyst particles, Heat effects during reaction, Performance equations for reactors containing porous catalyst particles, Experimental methods for finding rates. Rate-Controlling Step.

Various types of fixed bed reactors and fluidized bed reactors. Design aspects
Deactivating Catalysts-Mechanisms of Catalyst deactivation, rate and performance equation.

Unit-5

Non-Catalytic Systems, Fluid-Fluid Reaction Kinetics, Fluid-Fluid reactor design aspects, Fluid-Particle Reaction Kinetics-Selection of a model, Shrinking Core Model for spherical particles of unchanging size, Rate of reaction for shrinking spherical particles and Rate-Controlling Step.

Course Outcomes:

- Ability to distinguish between various RTD curves and predict the conversion from a non-ideal reactor using tracer information.
- Develop rate laws for heterogeneous reactions
- Design of reactors for non-catalytic and catalytic reactions.
- Design of towers for gas–liquid operations with and without chemical reaction.

Text Books:

1. Chemical Reaction Engineering, Octave Levenspiel, 3rd Edition, John Wiley & Sons India Edition.
2. Reaction Engineering principles, Himadari roy ghatak, CRC press.
3. Chemical reactor analysis and design fundamentals, James B. Rawlings, John G.E Kerdt, Nob Hill Publications.

References:

1. Elements of Chemical Reaction Engineering, Scott Fogler. H, 4th Edition. PHI
2. The Engineering of Chemical Reactions, 2nd ed., L.D. Schmidt, Oxford University Press, New Delhi, 2010
3. Chemical and catalytic reaction engineering by James J Carberry

CH3202 INSTRUMENTATION AND PROCESS CONTROL

Externals: 60 Marks **L-T-P-C**

Internals: 40 Marks **3-1-0-4**

Course Objectives:

- Develop mathematical and transfer function models for dynamic processes.
- Analyze and characterize different process.
- Analyze process stability and dynamic responses.
- Empirically determine process dynamics for step response data.
- Development of block diagrams, reading block diagrams, process and instrumentation diagrams.
- Familiarity with different types of feedback controllers.
- Develop different advanced control strategies.
- Knowledge of real time applications of process control implementation.
- Knowledge and working principles of different instruments used in Industry.

Syllabus:

Unit-1

Characteristics of Measurement System, Pressure Measurement, Temperature Measurement, Flow Measurement, Measurement-Instruments For Analysis. Introduction to Digital control.

Unit- 2

Mathematical Modeling, Development of mathematical models, modeling considerations for control purposes. Dynamic Behavior of Chemical Processes, Brief of Laplace transforms.

Unit- 3

Transfer functions and the input-output models, Dynamics and analysis of first, second and higher order systems- Multiple capacitance systems, Dead time, Inverse Response.

Unit-4

Feedback Control Schemes, Concept of feedback control, Dynamics and analysis of feedback-controlled processes, Stability analysis- Routh Hurwitz criterion, Root Locus analysis, Controller design- control valve characteristics.

Unit-5

Frequency response analysis-Bode plots, polar plots Bode stability criterion, controller tuning. Advanced Schemes- Dead time compensator, Inverse response compensator, Cascade controller, Split range controller, Over-ride controller and Feed forward controller.

Course Outcomes:

- Knowledge of field instrumentations.
- Dynamic modeling and system behavior study.
- Design of controllers.

- Application of control systems in processes and Knowledge of field instrumentations.

Text Books:

1. Principles of Industrial Instrumentation, Patranabis D- 2nd Edition - Tata McGraw Hill Publishing Company, New Delhi (1999)
2. Chemical process control by G. Stephanopolous, PHI,1998

References Books

1. Industrial instrumentation by Donald P. Eckman, Wiley eastern.
2. Process systems analysis and control by D.R. Coughanowr, 2nd ed. Mc Graw Hill
3. Process Control by Wayne Bequette, PHI.

CH3203 **PROCESS EQUIPMENT DESIGN**

Externals: 60 Marks **L-T-P-C**

Internals: 40 Marks **3-0-0-**3

Course Objectives:

- Study design safe process and design appropriate equipment like reactors, mass transfer heat transfer equipment, pipelines storage tanks etc.
- Study relevant codes for design of chemical plant equipment as per the standard procedures specified by design code books.
- Learn the fabrication techniques and testing methods.
- Learn design and engineering skills directly applied in design, installation and commissioning of equipments.

Syllabus:

Unit-1

Introduction to plant design. Process design development: Design project procedure, design information from the literature, flow diagrams, preliminary design, comparison of different processes, equipment design, scale-up in design, safety factors, specifications.

Unit-2

General design considerations: Health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, thermal pollution control, noise pollution and control, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling.

Materials and fabrication selection: Materials of construction, selection of materials, fabrication of equipment.

Unit-3

Mechanical design of process equipment: Pressure vessels – calculation of thickness of cylindrical and spherical shells subjected to internal pressure, heads or covers. Storage vessels – storage of nonvolatile liquids, storage of volatile liquids, storage of gases. Supports for vessels – bracket or lug supports, leg supports, skirt supports, saddle supports.

Unit-4

Material transfer, handling and treatment equipment: Process specifications of Pumps and compressors, piping design.

Heat transfer equipment design: Shell and tube Heat Exchanger, condenser, single effect evaporator.

Unit-5

Mass transfer equipment design: Finite-stage contactors- bubble cap tray, sieve tray and valve tray units, maximum allowable vapor velocities, plate and column efficiency, other

design factors. Continuous contactors – types of packing, liquid distribution, pressure drop, packing efficiencies. Relative merits of plate and packed towers.

Reactors: Batch reactors, tubular plug flow reactors, back mix reactors, mechanical features of jacketed reactors.

Course Outcomes:

- Knowledge of basics of process equipment design and important parameters of equipment design
- Ability to design special vessels (e.g. tall vessels) and various parts of vessels (e.g. heads)
- Ability to design internal pressure vessels and external pressure vessels
- Knowledge of equipment fabrication and testing methods
- Able to process design of shell & tube heat exchanger.
- Able to process design of plate heat exchanger.
- Able to process design of sieve tray distillation column.
- Able to process design of packed bed distillation column.

Text Books:

1. Chemical Engineering Vol. VI (An introduction to Chemical Engineering Design), Coulson J.M. and Richardson J.F Pergamon Press, 1993.
2. Process Equipment Design, M. V. Joshi, 3rd Edition, Macmillan India Limited 2003.

References:

1. Process Plant Design, Backhurst, J.R And Harker, J. H, Heieman Educational Books, London (1973).

CH3241 PETROLEUM ENGINEERING
(Professional Core Elective-III)
Externals: 60Marks **L-T-P-C**
Internals: 40Marks **3-0-0-3**

Course Objectives:

- Learn the formation, refining of crude oil and products of refinery.
- Understand the means of processing data including thermal properties, important products characteristics.
- Develop skills in drawing neat flow diagrams of different petroleum refining processes
- (cracking/reforming/alkylation/isomerization/hydrocracking etc.,) that are aimed at producing high value/demand products.
- Identify important testing methods for important petroleum products.

Syllabus:

Unit-1

Origin of prtoleum crude oil: thernal properties of petroleum fractions, petroleum evaluation, charecterization of crude oil: TBP and other distillation tests. Petroleum products, their properties, specification and testing , different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc.

Unit-2

Fractions of petroleum: dehydration and desalting of crudes, heating of crude-pipe still heaters, distillation of petroleum, blending of gasoline

Treatment techniques: fractions – impurities, gasoline treatment, kerosene treatment, treatment of lubes, wax and purification.

Unit-3

Thermal and catalytic cracking process: Cracking, theory of thermal cracking reactions, properties of cracked materials, depth of cracking and soaking factor, rate of reaction, heat of decomposition, visbreaking.

Unit-4

Thermal and catalytic cracking process: Cracking for the production of gasoline, catalytic cracking, commercial cracking catalysts, catalytic cracking process, fixed bed crackers, moving bed crackers, houdri flow process, flexi cracking.

Unit-5

Hydrotreatment process in refining: hydro-desulfurization, hydrofinishing, production of lube oil base stock

Course Outcomes:

- Understanding the role of petroleum as energy source amidst world energy scenario
- Learning design and operation of petro refineries and petrochemical complexes
- Learning safe practices in operations of refineries and petrochemical complexes
- Identifying challenges, energy security issues and environmental issues
- Techno-economic analysis & trouble shooting
- Building foundation for process intensification
- Motivation towards innovations

Text Books:

1. Modern Petroleum Refining Processes, B.K.Bhaskara Rao, Oxford & IBH Publishing, 2002, 4th ed:
2. Petroleum refining Engineering, WL Nelson Mc Graw Hill company, 4th addition:

References:

1. Shreve's Chemical Process Industries edited by Austin, Mc-Graw Hill, 5th Edition, 1985.
2. Dryden's outlines of Chemical Technology edited by M. Gopal Rao and M. Sitting, 2nd Edition, 1973.

BS3402 TECHNOLOGY OF PHARMACEUTICALS AND FINE CHEMICALS
(Open Elective-I)

Externals: 60 Marks	**L-T-P-C**
Internals: 40 Marks	**3-0-0-3**

Course Objectives:

- To understand the grades of chemicals and impurities in chemicals.
- Outlines of Preparation, properties, uses and testing of the following Pharmaceuticals like sulfacetamide, paracetamol, riboflavin, nicotinamide
- To study the properties and preparation methods pharmaceuticals like aspirin, penicillin and calcium gluconate.
- To study the manufacturing process and analyzing process flow sheets.
- To know the tablet making and coating, preparation of capsules.

Syllabus:

Unit-1

A brief outline of grades of chemicals, sources of impurities in chemicals, principles (without going into details of individual chemicals) of limit test for arsenic, lead, iron, chloride and sulfate in Pharmaceuticals.

Unit-2

Outlines of Preparation, properties, uses and testing of the following Pharmaceuticals - sulfacetamide, paracetamol, riboflavin, nicotinamide,

Outlines of Preparation, properties, uses and testing of the following fine chemicals - Methyl orange, fluorescence, procaine hydrochloride, paramino salicylic acid, isonicatinic acid hydrazide.

Unit-3

Manufacture with flowsheets, properties uses and testing of the following Pharmaceuticals – aspirin, penicillin, calcium gluconate.

Unit-4

Manufacture with flowsheets, properties uses and testing of the following ferric ammonium citrate, pthallic anhydride and phenol flourobenzene process and benzene sulfate process, other processes in outline only.

Unit-5

Tablet making and coating, granulation equipments. Preparation of capsules, extraction of crude drugs.

Sterilization: introduction, risk factor, methods of sterilization, heat (dry and moist), heating with bactericide, filtration, gaseous sterilization and radiation sterilization, suitable example to be discussed.

Course outcomes:

At the end of the course, the students will be able to:

- Learn the principles of limit test for pharmaceuticals and sources of impurities in chemicals.
- Preparation outlines for the manufacture of pharmaceuticals and fine chemicals.
- Design various unit operations pertinent to fine chemicals and pharmaceuticals sectors
- Investigate environmental impacts in the field of pharmaceuticals and fine chemicals

Text Books:

1. Remington's Pharmaceutical Science,16th ed, Mac publishing company, 1980.
2. Industrial Chemicals, 3rd ed., Faith, Kayes and Clark, John Wiley & Sons,. 1965.

References:

- Blently's Text Book of Pharmaceutical Chemistry, 8th ed, H A Rawlins, B Tindell and Box,. Oxford University Press, London, 1977.

CH3801 CHEMICAL REACTION ENGINEERING LAB

Externals: 60Marks **L-T-P-C**

Internals: 40Marks **0-0-3-1.5**

Course Objectives:

- Operate lab equipments like CSTR, Batch, PFR reactors.
- Analyze the concentration versus time data and determine the specific rate constant and the order of the reaction.
- Compare theoretical and experimental conversions in a CSTR and PFR.
- Estimate RTD and model parameters in a CSTR, PFR, packed bed and CSTRin-series.

List of equipments:

1. To determine the specific reaction rate constant of a reaction of a known order using a batch reactor
2. To determine the specific reaction rate constant of a reaction of a known order using a CSTR.
3. Determination of the activation energy of a reaction using a Batch reactor, CSTR
4. To determine the order of the reaction and the rate constant using a tubular reactor.
5. CSTRs in series- comparison of experimental and theoretical values for space times and volumes of reactors.
6. Mass transfer with chemical reaction (solid-liquid system)(Benzoic acid and aqueous NaOH)
7. RTD in tubular reactor
8. RTD in Mixed flow reactor.
9. Study catalytic reaction

Course Outcomes:

- Design the experiments to acquire the kinetic and RTD data.
- Analyze the experimental data to obtain the reaction rate expression (reaction order and specific reaction rate constant).
- Attain competency in running the bench scale and pilot scale reactors.

CH3802 INSTRUMENTATION AND PROCESS CONTROL LAB

Externals: 60Marks **L-T-P-C**

Internals: 40Marks **0-0-3-1.5**

Course Objectives:

- To evaluate response of fist and higher order characteristics.
- Study the installed characteristics of the valve.
- Study if there is a hysteresis in the control valve and sensor.
- Evaluate the tuning of a PID control via manual and automatic tuning.
- Evaluate the effect controller on the control system

Course Outcomes:

- To measure the steady state response and dynamic response of a process system
- To compare the responses with those obtained from the mathematical model
- To validate the methods for closed-loop stability analysis in context to a practical controller
- To validate the controller tuning methods in context to a practical controller.

List of Experiments (List of Equipments (15) and operate 10)

1. Study of Flow control trainer
2. Study of Level control trainer
3. Study of Pressure control trainer
4. Study of Temperature control trainer
5. Control valve characterization
6. Characterization of thermocouples
7. Study of Flapper nozzle
8. Differential pressure transmitter
9. Study of I/P and P/I Converter
10. Interacting and Non interacting system

E4-S2 (R19)					
S. No.	**Course Code**	**Course Title**	**Course Category**	**L-T-P**	**Credits**
1	CH4251	Professional Core Elective -V	PCE	3-0-0	3
	CH4251	**Process Optimization**			
	CH4253	**Advance Separation Process**			
2		Open Elective- III	OCE	3-0-0	3
	BM4416	**Entrepreneurship and New Ventures (ENV-5)**			
	BM4414	**Intellectual Property Rights (IPR-3 and IPR-6)**			
	BS4401	**Sustainable Technology (ST-5)**			
3	CH4902	Major Project	SIP	0	8

Code: BM4414

INTELLECTUAL PROPERTY RIGHTS (IPR)

(Open Elective)

Externals:60 Marks **L-T-P-C**

Internals: 40 Marks **3-0-0-3**

Course Objectives: At the end of the course the student will be able to

 To introduce fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries.

 To disseminate knowledge on patents, patent regime in India and abroad and registration aspects

 To disseminate knowledge on copyrights and its related rights and registration aspects

 To disseminate knowledge on trademarks and registration aspects.

 To disseminate knowledge on Design, Geographical Indication (GI) ,Plant Variety and Layout Design Protection and their registration aspects.

 To aware about current trends in IPR and Govt. steps in fostering IPR.

Course Outcomes:

 Upon completion of this course the students shall get adequate knowledge on patent and copyright for their innovative research works.

 During their career, the knowledge gained through this course shall provide useful insights on the novelty of their idea from a state-of-the-art patent search. This provides a further way for developing their idea or innovations.

 This course shall pave the way for the students to catch up Intellectual Property (IP) as a career option.

Unit-1:

Introduction to IPR: Definition of Intellectual Property, Meaning of Intellectual Property, Evolution of IPR, Kinds of Intellectual Property Rights - Patents, Trademarks, Copy Rights, Industrial Design, Trade Secrets, Geographical Indications, Agencies responsible for Intellectual Property Rights- USPTO, INTA, WIPO, TRIPS, International Conventions-Patent treaty, Madrid15 Protocol, Berne Convention.

UNIT-II:

Patent Rights: Introduction, Definition of Patent, Importance of Patents, Types of Patents, Patentable Inventions, Non- Patentable Inventions, Persons entitled to apply for Patent, Who can apply for a Patent, Expiry of a Patent, Rights of patentee, Registration of patent.

Unit-III:

Industrial designs: Definitions of Designs, Essentials of a Design, Who can file for Design Registration, Term of Design, Registration of Designs, Cancellation of a Registered designs, Restoration of a lapsed design.

Unit-IV:

Trademarks: Introduction to Trademark, Meaning of Trademark, Types of Trademark, Features of Trademarks, Functions of Trademarks, Objectives of Trademarks, What to avoid when selecting a Trademark, Trademark Registration procedure, Infringement of Trademarks, Passing off.

Unit-V:

Copy Right: Introduction, Subject matter of Copy Right, Objectives of Copy Rights, Rights of a copyright holder, Works covered under Copy Right, Works not covered under Copy Right, Duration of Copy Right, and Registration of Copy Right.

Case studies are discussed wherever applicable.

Text Books:

2. Cornish.W.R, “Intellectual Property Patents”, CopyRight and Trademarks and Allied rights,

Sweet & Maxwell 1993.

3. P.Narayanan: Intellectual Property Law, Eastern Law House, 2ndedition 1997.

4. Roy Chowdhary, S.K. & Other: Law of Trademark, Copyrights, Patents and Designs, Kamal Law House, 1999.

5. Dr.G.B.Reddy, Intellectual Property Rights and theLaw5thEd.2005GogiaLawAgency.

6. B.L.Wadhera: Intellectual Property Law, UniversalPublishers,2nd Ed.2000.

ENTREPRENEURSHIP AND NEW VENTURES

Course code: BM4416

Externals: 60Marks **L-T-P-C***

Internals: 40Marks **3-0-0-3**

Course Objective:.

- The course objective is to teach effective entrepreneurial and general management practice from the perspective of the founder and stakeholders.
- To apply the entrepreneurial perspective in order to approach business problems from a value creation framework.

LEARNING OUTCOMES :

1. Students will be able to understand the principles of Entrepreneurship management and growth through strategic plans, consulting projects and /or implementing their own businesses.

2. The Learner will understand the role of small scale industries and the institutional support provided by various organizations for business. Students will be able to identify the principles of preparing start-up business plan emphasizing financing, marketing and organizing.

3. After learning this, the students will be able to know the role of entrepreneurs in the development of a country and the needed capabilities of an Entrepreneur and develop the skill in Work analysis and material management that could help in efficient management of an enterprise and identify the models used in planning for new venture growth and internationalization.

4. Students will be able to identify and or apply the principles of viability of new business proposals and opportunities within existing businesses and understand the organizational challenges in launching & growing a new venture and how to plan & manage for growth and expansion.

Course Contents:

1. **Introduction to Entrepreneurship:** Learning objectives, Entrepreneurship in Indian Scenario and Future prospects, Emerging economies, Entrepreneurial traits, motivation and leadership (7Modules)

2. **Entrepreneurial Process:** Opportunity Identification, Idea Generation and Evaluation. (6 Modules)

3. **Business Model:** Business Plan, Business Models (Creating a business model with technology differentiators) (5 Modules)

4. **Financing Venture**: Funding, Valuation of a new company, Marketing, Company Growth, Acquisitions and Exit Strategies. (6 Modules)

5. **Building the Team and IPR:** Launching and managing venture, Human resource aspects. Intellectual Property and Corporate Law. (12 Modules)

Suggested Reference Books:

1. Kuratko & Hodgetts, *Entrepreneurship-Theory, Process Practice*, Thompson South Western Publication, (2008).

2. Holt, *Entrepreneurship – New Venture Creation*, PHI Publication, (1992).

3. Kawasaki, *The Art of the Start*, Portfolio Publication, (2004).

4. Lusk & Harrison, *The Mouse Driver Chronicles: The True-Life Adventures of Two First Time Entrepreneurs*, Perseus Books Group, (2002).

5. Dorf & Byers, *Technology Ventures: From Idea to Enterprise*, McGraw Hill Publication, (2010).

6. Kaplan, Startup: *A Silicon Valley Adventure*, Penguin Books, (2001).

SUSTAINABLE TECHNOLOGIES

Course code: BS4401

Externals: 60 Marks

L-T-P-C

Internals: 40 Marks **3-0-0-3**

Learning objectives: To give an overview of existing technologies and their associated problems. The main objective of the course is to stress on the need of innovation in development

of sustainable technologies.

Learning outcome: This paper sets out to discuss the commonalities that can be found for sustainable development. The commonalities include systemic or holistic thinking, the integration of different perspectives, skills such as critical thinking, diverse attitudes and values.

Student will get the knowledge to resolve the environmental problems of the planet, work towards community-oriented problems with coherent and inferential problem solving skills.

UNIT 1: DRAW BACKS OF CURRENT TECHNOLOGIES

Environmental degradation, financial constraints, social issues with automation in technology, extinction of fossil fuels, risks involved in operations. Global environmental issues- Resource

degradation, Climate change (Carbon credits and carbon trading, carbon foot print), Global warming, Ozone layer depletion, Regional and Local Environmental Issues.

UNIT 2: ENVIRONMENT REMEDIATION

Environment Impact Assessment (EIA) - Procedures of EIA in India, Physical and Chemical technologies for reclamation, Need for ecosystem restoration, Bioremediation.

Alternative Hirarchy Process (AHP), Selection of best technology using AHP, Alternative resources and technologies, resource recovery from waste, energy recovery from waste, Sustainable Development vs Environmental Engineering - Energy Issues.

UNIT 3: SUSTAINABLE TECHNOLOGIES

Sustainability - Introduction, Need and concept of sustainability; People, planet and profit; Social, environmental and economic sustainability concepts. Sustainable development, Nexus between Technology and Sustainable development, Challenges for Sustainable Development.

Multilateral environmental agreements and Protocols - Clean Development Mechanism (CDM),

Green technologies.

UNIT 4: BIOMIMICRY

Defining biomimicry, why biomimicry matters? Biomimicry examples - Bioplastics,

biomaterials, bioluminescence for LED's, neural networks, swarm intelligence, aerodynamics for

automobile engineering, DNA computing.

UNIT 5: BIOLOGICAL RESOURCES FOR SUSTAINABILITY

Organic Farming for sustainable agriculture, Microbial leaching of low grade mineral ores,

Bioelectricity (Microbial fuel cells), Biomagnetism (for therapy), Biofuels (for energy),

Microbial engineering for cleaning environmental pollution, biosynthesis of industrial products.

Reference:

1. *Perspectives on Sustainable Technology- M. Rafiqul Islam*

2. Sustainable Energy Consumption and Society- David L. Goldblatt

3. Sustainable development (energy, engineering and technologies, manufacturing and environment) - Chaouki Ghenai

4. Sustainability and Environmental Impact of Renewable Energy Sources - R. E. Hester, R. M. Harrison

5. Sustainable Natural Resources Management - Prof. Abiud Kaswamila.

6. Sustainable Communities Design Handbook - Woodrow W. Clark

7. Handbook of Bioplastics and Biocomposites Engineering Applications - Srikanth Pilla

8. Modeling & Imaging of Bioelectrical Activity: Principles and Applications (Bioelectric Engineering) - Bin He

9. Handbook of Swarm Intelligence: Concepts, Principles and Applications – YuhuiShi, Meng Hiot Lim, Bijaya ketan Panigrahi.

10. DNA Computing and Molecular Programming - DNA 16 – Yasubumi sakkibara, yongli Mi

11. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.

12. Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning .

13. Environment Impact Assessment Guidelines, Notification of Government of India, 2006

14. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998 .

15. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System

16. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.

17. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).

18. Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication.

19. Biomimicry: Innovation Inspired by Nature by Janine Benyus