VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME & SYLLABUS OF TEACHING AND EXAMINATION
2015-2016
B.E PETROCHEM ENGINEERING SYLLABUS

SEMESTER-V

PROCESS INDUSTRY MANAGEMENT(Common to CH & PC)					
Subject Code	:	15CH51	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives: The students will be able to

1. Understand the roles of managers and historical evolution of various approaches to the study of management.
2. Demonstrate the process of planning which can be used as a tool for decision-making in organizations.
3. Create logical relationships between various organizational structures and designs.
4. Implement leadership practices towards the management and development of people within organizations.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Organization and Management: Forms of Business Organization, Basic concepts of management-classification, characteristics, objectives, Functions of management-planning, organizing, staffing, directing, Organization Structure-linear, functional, line and staff, staff and functional, Management by objectives, Management information system.	10	L1, L2
Module 2 **Content**		
Personnel (Human Resource) Management: Acquisition of manpower-functions and objectives of personnel management, manpower planning, Job analysis and evaluation, Induction, Orientation, Training and development, Maintenance of human resource. Industrial relations, Trade Unionism.	10	L1, L2
Module 3 **Content**		
Entrepreneurship and Project Management: Entrepreneurship-Types, Growth, functions, qualities, Project Planning-project implementation, monitoring and control, evaluation strategies, Gantt charts, Critical path method, Performance evaluation and review technique, application of network techniques.	10	L2, L3, L4
Module 4 **Content**		
Operation Research: Introduction, phases, scope, methodology, O R Models, techniques, applications of O R, Linear Programming, graphic method, simplex method, waiting line theory, game theory, Monte Carlo technique. Dynamic programming.	10	L2, L3.

Module 5	Content		
Materials Management: Purchasing, make or buy decision, stores management, inventory control, spare parts management, value engineering. **Marketing:** Marketing research, marketing management, consumer behavior and market promotion.		10	L1, L2

Course outcomes: Students after completion of course are expected to

1. Understand the principles of management theory & Recognize the characteristics of an organization.
2. Demonstrate the importance of key performance areas in strategic management & decision-making process.
3. Design appropriate organizational structures and possess an ability to conceive organizational dynamics.
4. Evaluate attitudes and personality traits for inter personal effectiveness and development within organizations. 5. Implement the right leadership practices in organizations that would enable systems orientation.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1. T R Banga S C Sharma Industrial Organization and Engineering Economics Khanna Publications 24th Edition ISBN No. 81-7409-078-9
2. Dr. Vilas Kulkarni &HardikBavishiEngineering Economics & Management:Vikas Publishing

REFERENCE BOOKS:

1. Stephen Robbins, Mary Coulter &Neharika Vohra, Management, Pearson Education Publications, 10th Edition, ISBN: 978-81-317-2720-1.
2. James Stoner, Edward Freeman & Daniel Gilbert Jr, Management, PHI, 6th Edition, ISBN: 81-203-0981-2.

MASS TRANSFER OPERATIONS-I (Common to CH & PC)					
Subject Code	:	15CH52	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:

The students will

1. Be able to formulate equations for estimation of diffusivities in fluids & solids using first principles of engineering sciences.
2. Be able to apply mass transfer fundamentals to calculate mass transfer rates and design the mass transfer equipment.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules		Teaching Hours	Blooms Taxonomy
Module 1	**Content**		
Typesof diffusionin fluids.Typesofdiffusionin solid.Measurementand calculationsofdiffusivities. Masstransfercoefficientsandtheircorrelations.TheoriesofmassTransfer. Interphasemasstransfer. M**a**terialbalanceforco-current,cross-currentandcounter-current operations.Conceptofstages,cascadesoperation,NTUandHTU concepts.		10	L1,L2, L3
Module 2	**Content**		
Humidification: General theory, Psychrometricchart. Concepts in humidification, dehumidification.Designofcoolingtowers.		10	L2,L3, L4
Module 3	**Content**		
Drying: Introduction,Equilibria,Dryingratecurves.Mechanismofdrying,typesofdryers. Designofbatch andcontinuousdryers.		10	L3,L4, L5
Module 4	**Content**		
Adsorption: Theoriesofadsorption.Isotherms,Industrialadsorbents.Equipment,Batch&continuousmultistageadsorption.		10	L4,L5, L6
Module 5	**Content**		
Crystallization: Factorsgoverningnucleationandcrystalgrowthrates.Controlledgrowthof crystals.Incorporationofprinciplesintodesignofequipment.Differenttypesofcrystallizer equipment. **IntroductiontoNovelSeparations:**Ionexchange**,**Membraneprocesses-ReverseOsmosis, Dialysis,UltraandMicro-filtrations,Super-criticalfluidextraction.(Workingprinciplesand operationsonly)		10	L2,L3, L4

Course outcomes:

After studying this course, students will be able to:

1. Estimate mass transfer co-efficients and provide valid conclusions on suitability of the operation.
2. Apply the analogies in transport processes for validating and reaching substantiated conclusions.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

4. Critical Thinking
5. Problem solving
6. Use of modern tools
7. Life - long Learning

TEXT BOOKS:

1. **MassTransferOperations-**RobertE Treybal,3rd Edition,McGrawHill,1981.
2. **UnitOperationsof ChemicalEngineering**-McCabe&Smith,6th Edition,McGrawHill, 2001.

REFERENCE BOOKS:

1. **Chemical Engineering VolI, II, IV and V -** Coulson and Richardson, 4th Edition, PergamonPress,1998.
2. **IntroductiontoChemicalEngineering-**Badger&Banchero,TMH6th Reprint1998.
3. **Principlesof UnitOperations-**Foust*et.al.*,2nd Edition,JohnWiley,1994.
4. **TransportProcessesandUnitOperations-**GeankoplisCJ,PrenticeHall(I),2000.
5. **AppliedProcessDesignforChemicalandPetrochemicalPlant**Ludwig,2nd Edition,Gulf Publishing,2002.

CHEMICAL REACTION ENGINEERING-I (Common to CH & PC)					
Subject Code	:	15CH53	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:

The students will

1. Be able to Analyze and interpret the data to determine rate equation and estimate the performance equation of ideal systems.
2. Be able to formulate and analyze the rate equations for various reactions using suitable mechanisms.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Introduction: ScopeofChemicalReactionEngineering.Classificationofreactions.Rate equationandrateofreaction.Factorsaffecting rateofreaction.Chemicalkineticsand ThermodynamicsEquilibrium.Temperaturedependency ofrateconstantfromArrhenius, CollisionandTransitionstatetheories.Molecularityandorderofreaction. **Non-ElementaryReactions:**Differencebetweenelementaryandnon-elementaryreactions. Kineticmodelsandmechanismsfornon-elementaryreactions.Typesofreactors.	10	L1,L2,L3
Module 2 **Content**		
HomogeneousReactions: Interpretationofbatchreactordata.Constant&VariableVolume batchreactor.Analysis:Differentialmethod,Integralmethod,half-lifemethod.Methodof excessandmethodofisolation(ForReversibleandIrreversible reactionsuptosecondorder). Autocatalyticreactions.	10	L2,L3,L4
Module 3 **Content**		
DesignOfIdealReactors: Conceptofideality.Developmentofdesignequationsforbatch, tubularandstirredtankreactorsforbothconstantandvariablevolumereactions.Evaluation of rateequationsfromdataobtainedinthesereactors. Numerical Problems.	10	L3,L4,L5
Module 4 **Content**		
ComparisonOfIdeal Reactors: Generalgraphicalcomparison. **MultipleReactorSystems:**Plugflowand/orMixedflowreactorsinSeries,parallelandseries parallel.Reactorsofdifferenttypesandsizesinseries. **DesignofReactorsforMultipleReactions:**DesignofBatchreactor,PlugandMixedflow reactorsforParallel,SeriesandSeries-Parallelreactions(Onlyirreversiblereactionsmustbe considered).	10	L4,L5,L6
Module 5 **Content**		
Non-IsothermalReactors: Introduction,effectoftemperatureonequilibrium constant andheat ofreaction,MaterialandEnergybalances,conversionsinadiabaticandnon-adiabaticreactors. **AnalysisofNonIsothermalReactor:**Designprocedure (Forsingle/simplereactionsonly). OptimumtemperatureProgression.	10	L3,L4,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge for interpretation of experimental data.
2. Acquire practical knowledge of reactors.
3. Know the use of reactors, problems associated and modifications.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1.**ChemicalReactionEngineering,**OctaveLevenspiel,3rdedition,JohnWiley&Sons,2001.
2. **ElementsofChemicalReactionEngineering,**H.ScottFogler,3rdedition,PrenticeHall 2001.

REFERENCE BOOKS:

1. **ChemicalEngineeringKinetics,**J.M.Smith,3rdEdition,McGrawHill,1984.

CHEMICAL EQUIPMENT DESIGN (Common to CH & PC)					
Subject Code	:	15CH54	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:
Students will

1. Understand advances and types in the design of Chemical equipment and its accessories.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules		Teaching Hours	Blooms Taxonomy
Module 1	**Content**		
Introduction: Basic considerations in design. General design procedure. Equipment classification. Variouscomponents ofprocess equipment.Designparameters.Pressure vessel codes. **DesignConsiderations**:Materialselection.Factorsaffectingdesign.Stressesduetostaticanddynamicloads(Internal&External).Temperatureeffects.Economicconsiderations. **DesignofPressureVessels:**Designparameters,conditions&stresses.Designofshell,andotherves selcomponents.Vesselatlow&highoperating temperatures.Designproblemsusing givenprocessparameters.		10	L1, L2, L3
Module 2	**Content**		
VesselComponentDesign: Designofsupportsforvessels-Bracket,Leg,Saddleand Skirtsupports. Designofflanges&nozzles,Classificationofflanges.Flangethickness calculation,Gasketselection,Boltselection,NozzleSelection. Design ofvesselclosures-Flatplates,Formedheads,Elliptical&Hemisphericalheads.		10	L2, L3, L5
Module 3	**Content**		
StorageVessels: Processconditionsanddesignparametersforstorageofvolatile,non-volatilefluids&gases.Designofcylindricaltankswithfixedroofs.Designofpartially filledspherical tanks.Designofcomponents, supports andselectionofvesselsaccessories&mountings. Numericalproblems.		10	L2, L3, L5
Module 4	**Content**		
ReactionVessels: Designof reactiontanks withagitationand jacket. Types of agitators,baffles. Powerrequirementcalculations.Designoftankdimensions andagitation systemcomponents. Drivecalculations&selectionofaccessories.Designofjackets.Support calculationsforthe system.Numericalproblems.		10	L1, L2, L3, L4
Module 5	**Content**		
Tall Vertical Vessels: Vessels subjected to various loads, Multi shell constructions. Determinationofshellthickness.Supportsforcolumns. **Pipe LineDesign:**Pipeline sizing,Condensateandsteam pipedesign,optimumsize of deliverylineinpumpingoperations.		10	L3, L4, L6

Course outcomes:
After studying this course, students will be able to:

1. Summarize on advances in process engineering design of many process equipment relating to heat and mass transfer.
2. Will handle process parameters toalter and design process Equipments.

Question Paper Pattern:
This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will

have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. **ProcessEquipmentDesign-**M.V.Joshi,3rd Edn.,Macmillan&Co. India,Delhi,1998.
2. **ProcessEquipmentDesign–VesselDesign,**Brownell&Young,JohnWilley,1959.
3. **Process Design of Equipment – Vol1,** S. D. Dawande, 3rd Edn, Central Techno Publications.2003.

REFERENCE BOOKS:

1. **ChemicalEngineersHandbook,**Perry&Green,7th Edn,McGrawHill,1997.
2. **PressureVesselCode–IS2825,**ISCode,B.I.S.,NewDelhi,1969.
3. **Flowof FluidsthroughValves,Fittings&Pipes**,CraneAmazon,2006.

PROFESSIONAL ELECTIVE- 15PC55X
POLYMER SCIENCE AND TECHNOLOGY
[As per Choice Based Credit System (CBCS) Scheme]
SEMESTER-V

Subject Code	**: 15PC551**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**

CREDITS- 03

Course Objectives: This course enables students to study the basic polymeric science about polymeric structure, chemical bonding and chemical reactions.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Introduction:types of polymers and polymerizations, nomenclature of polymers, linear, branched, and cross-linked polymers, molecular weight of polymers, physical state, applications of polymers. **Polymerization mechanisms:** chain reaction polymerization, ionic and coordination polymerization, step-growth polymerization, ring opening polymerization.	8	L1, L2
Module-2		
Chemical Bonding and Polymer Structure: Introduction, Chemical Bonding, Primary Structure, Secondary Structure, Tertiary Structure, Crystallinity and Polymer Properties. **Spectrometric Characterization of Polymers:** NMR, Infrared Spectroscopy, Raman Spectroscopy, X-Ray Spectroscopy and Electron Paramagnetic Resonance Spectroscopy	8	L1, L2
Module-3		
Polymer Reaction Engineering: Bulk, Solution, Suspension, Emulsion and Precipitation Polymerization. Viscoelastic Properties of polymers. Hooke's and Newton's equation. Maxwell, Voiget and Burger Model. Glass transition temperature, Heat distortion temperature. **Polymerization Reactors:** Batch, Tubular (Plug flow) and Continuous Stirred Tank Reactor.	8	L1, L2
Module-4		
Polymer technology: polymer processing—spinning and fiber production – melt spinning, dry spinning, wet spinning and other spinning. Non-spinning fiber production – natural fibers. Elastomers – elastomer processing. Film and sheets – calendering. Polymeric foams, reinforced plastics (composites) and laminates.	8	L1, L2

Module-5		
Unit Operations in Polymer Processing: Extrusion-Single Screw and Twin Screw Extruders. Injection molding and variations – The injection unit, Hot runners, Insert molding, Gas assisted injection molding, Sher controlled injection molding, Reaction injection molding, Compression molding, Transfer Molding. Blow molding – Extrusion blow molding, Injection Blow molding. Rotational molding, Thermoforming.	8	L1, L2
Course Outcomes: At the end of the course students are able to understand the basic polymeric science and technology and unit operations involved in polymer processing.		
Graduate Attributes • Critical Thinking • Problem solving • Use of modern tools • Research Skill • Life-long learning		
Question paper pattern: • The question paper will have Ten questions in total • Each full question consists of 16 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
Text Books: 1. Charles E. Carraher. "Polymer Chemistry" 7TH Edition, CRC Press 2008 2. V R Gowriker , N V Vishwanath and JayadevSreedhar "Polymer Science", New age International(P) Ltd 1986		
Reference Books: 1. George Odian "Principle of polymerization" John Wiley & Sons Inc. 2004		

PROFESSIONAL ELECTIVE- 15PC55X
PROBABILITY AND STATISTICS
[As per Choice Based Credit System (CBCS) Scheme]
SEMESTER-V

Subject Code	**: 15PC552**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**

CREDITS- 03

Course Objectives:
This course aims at providing the required skill to apply the statistical tools in engineering problems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
RANDOM VARIABLES: Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions.	8	L2, L3, L4
Module-2		
TWO - DIMENSIONAL RANDOM VARIABLES: Joint distributions – Marginal and conditional distributions – Covariance – Correlation and Linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).	8	L2, L3, L4
Module-3		
TESTING OF HYPOTHESIS: Sampling distributions - Estimation of parameters - Statistical hypothesis - Large sample test based on Normal distribution for single mean and difference of means - Tests based on t, Chisquare and F distributions for mean, variance and proportion - Contingency table (test for independent) - Goodness of fit.	8	L2, L3, L4
Module-4		
DESIGN OF EXPERIMENTS: One way and Two way classifications - Completely randomized design – Randomized block design – Latin square design - 2^2 factorial design.	8	L2, L3, L4
Module-5		
STATISTICAL QUALITY CONTROL: Control charts for measurements (X and R charts) – Control charts for attributes (p, c and np charts) – Tolerance limits - Acceptance sampling.	8	L2, L3, L4

Course Outcomes: The students will have a fundamental knowledge of the concepts of probability. Have knowledge of standard distributions which can describe real life phenomenon. Have the notion of sampling distributions and statistical techniques used in engineering and management problems.		
Graduate Attributes • Critical Thinking • Problem solving • Use of modern tools • Research Skill • Life-long learning		
Question paper pattern: • The question paper will have Ten questions in total • Each full question consists of 16 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
Text Books: 1. J. S. Milton and J.C. Arnold, " Introduction to Probability and Statistics", Tata McGraw Hill, 4th edition, 2007. (For units 1 and 2) 2. R.A. Johnson and C.B. Gupta, "Miller and Freund‟s Probability and Statistics for Engineers", Pearson Education, Asia, 7th edition, (2007)		
Reference Books: 1. Walpole, R. E., Myers, R. H. Myers R. S. L. and Ye. K, "Probability and Statistics for Engineers and Scientists", Seventh Edition, Pearsons Education, Delhi, 2002. 2. Navidi, W, "Statistics for Engineers and Scientists", Special Indian Edition, Tata McGraw-Hill Publishing Company Ltd, New Delhi,2008. 3. Spiegel, M.R, Schiller, J and AluSrinivasan, R, "Schaum‟s Outlines Probability and Statistics", Tata McGraw-Hill Publishing Company Ltd. New Delhi ,2007.		

PROFESSIONAL ELECTIVE- 15PC55X GREEN CHEMISTRY SEMESTER-V			
Subject Code	**: 15PC553**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**
CREDITS- 03			

Course Objectives: This course enables students:

- To get acquainted with the development of latest technologies and methodologies for environmentally benign processes currently practiced in various industrial sectors with an emphasis on the design, manufacture, and use of chemicals and processes that have little or no pollution potential or environmental risk and are both economically and technologically feasible.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Introduction: Why green chemistry? Toxicity of chemicals. Accidents with chemicals. Waste and its minimisation. Sustainability (including social, political & economic factors).The green political movement. The roles and responsibilities of chemists and chemical engineers. Definition and overview of the twelve principles of green chemistry.	8	L1, L2
Module-2		
Green Synthesis: Establishing a full mass balance. Waste treatment/recycle. Synthetic Efficiency. Green Chemistry Metrics. Individual Reactions Analysis. Atom Economy, E-factor, & Reaction Mass Efficiency (RME).Synthesis Plans Analysis: Synthesis Tree Algorithms for Linear and Convergent Plans Raw Material Cost Estimate Material Efficiency & Synthetic Elegance Ranking. Trade off with economics. Less Hazardous Materials in Synthesis. Designing Safer Products. Renewable feedstocks.	8	L1, L2
Module-3		
Green Solvents: Safer Solvents and Auxiliaries. Critical review of organic solvents typically used in chemical processes. Critical review of: ionic liquids, supercritical CO2, water, fluorous phase chemistry, solvent-free / solid phase chemistry. Examples of green reagents.	8	L1, L2

Module-4		
Energy Efficiency: Energy Efficiency. Quantifying and minimising the use of utilities and other inputs. Overview of emerging frontiers in energy efficient synthesis such as Photochemistry, Microwave Chemistry, Sono-chemistry, Electro-synthesis.	8	L1, L2
Module-5		
Catalysis: Role of Catalysis. Heterogeneous Catalysis. Solid acids. Templated silica. Polymer-supported reagents. Homogeneous catalysis. Phase transfer catalysis. Biocatalysis. Photocatalysis. **Hazard Minimization:** Design for Degradation. Rules for degradation. Process safety and thermal hazards. Process control using real-time analysis. Process intensification.	8	L1, L2

Course Outcomes: At the end of the course students are able to acquire a fundamental understanding of basic chemistry/technology principles within the framework of Green Chemistry.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Question paper pattern:

- The question paper will have Ten questions in total
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Anastas, P.; Warner, J. Green Chemistry: Theory and Practice; Oxford University Press: London, 1998.
2. Lancaster, M.; Green Chemistry an Introductory Text, Royal Society of Chemistry, Cambridge, UK 2002.

Reference Books:

1. Albert S. Matlack; “Introduction to Green Chemistry” Marcel Dekker, Inc., New York, 2001.
2. Zimmerman, J.B.; Anastas, P.T. “The 12 Principles of Green Engineering as a Foundation
for Sustainability” in Sustainability Science and Engineering: Principles. Ed. Martin Abraham, Elsevier Science, 2005.
3. Anastas, P.; Zimmerman, J. “Design through the Twelve Principles of Green Engineering,”

Environmental Science and Technology, 37, 94A – 101A, 2003

PROFESSIONAL ELECTIVE- 15PC55X
PROFESSIONAL ETHICS IN ENGINEERING
SEMESTER-V

Subject Code	**: 15PC554**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**

CREDITS- 03

Course Objectives:
To enable the students to create an awareness on Engineering Ethics and Human Values, to Instil Moral and Social Values and Loyalty and to appreciate the rights of others.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
HUMAN VALUES: Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.	8	L1, L2
Module-2		
ENGINEERING ETHICS: Senses of 'Engineering Ethics' – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles - Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.	8	L1, L2
Module-3		
ENGINEERING AS SOCIAL EXPERIMENTATION: Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law.	8	L1, L2
Module-4		
SAFETY, RESPONSIBILITIES AND RIGHTS: Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk - Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.	8	L1, L2

Module-5		
GLOBAL ISSUES: Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership –Code of Conduct – Corporate Social Responsibility.	8	L1, L2

Course Outcomes:

Upon completion of the course, the student should be able to apply ethics in society, discuss the ethical issues related to engineering and realize the responsibilities and rights in the society.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Question paper pattern:

- The question paper will have Ten questions in total
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Mike W. Martin and Roland Schinzinger, “Ethics in Engineering”, Tata McGraw Hill, New Delhi, 2003.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, “Engineering Ethics”, Prentice Hall of
India, New Delhi, 2004.

Reference Books:

1. Charles B. Fleddermann, “Engineering Ethics”, Pearson Prentice Hall, New Jersey, 2004.
2. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, “Engineering Ethics – Concepts and Cases”, Cengage Learning, 2009
3. John R Boatright, “Ethics and the Conduct of Business”, Pearson Education, New Delhi, 2003
4. Edmund G Seebauer and Robert L Barry, “Fundametals of Ethics for Scientists and Engineers”, Oxford University Press, Oxford, 2001
5. Laura P. Hartman and Joe Desjardins, “Business Ethics: Decision Making for Personal Integrity and Social Responsibility” McGraw Hill education, India Pvt.Ltd.,New Delhi 2013

OPEN ELECTIVE - 15PC56X COMPOSITE MATERIALS SEMESTER-V			
Subject Code	**: 15PC561**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**
CREDITS- 03			

Course Objectives: This course will enable students to

- Understand concepts on properties and selection of metals, ceramics and polymers for design and manufacturing.
- Study detailed information on processing techniques based on reaction techniques.
- Learn information on Characteristics & applications in marine, aerospace.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Synthesis and Fabrication: of advanced and future materials with emphasis on ceramic, Semiconducting and Super-conducting materials with superior structural, optical and electrical properties. **Preparation Techniques:** Techniques for preparation of ultra-pure, ultra-fine powders: of oxides, nitrides, carbides etc., with very well defined characteristics and superior properties.	08	L1, L2
Module-2		
Processing Techniques: Techniques such as sintering, hot pressing, hot isostatic pressing, tape casting, sol-gel processing for the formation of monolithic ceramics. Composites (ceramic, ceramic metal, as well as metal matrix). SiO_2. Glasses from above powders**.** Reinforcement, additives, fillers for polymer composite, master batch& compounding.	08	L1, L2
Module-3		
Processing Techniques Based on Reaction Methods: such as Chemical vapour deposition (CVD), vapour phase epitaxial, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI). Self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibres and semi	08	L1, L2

conducting materials such as Si and Gallium Arsenide.		
Module-4		
Synthesis and processing of mixed ceramic oxides with high temperature super conducting properties. Reinforcement, additives, fillers for polymer composite, master batch& compounding	08	L1, L2
Module-5		
Polymer composite. Fibre reinforced composites. Stress – Strain modulus relationship Nano composites. Characteristics & applications in marine, aerospace. Manufacturing methods, hand layouts.	08	L1, L2

Course Outcomes: At the end of the course students are able understand the useful of ceramic materials, Polymeric composite used in industries for the production of products and also study the characterization of the materials.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Question paper pattern:

- The question paper will have Ten questions in total
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Introduction to Ceramics**,W.D. Kingrey, 2nd Edn., John Wiley, 1976.
2. **Advanced Composites,** Chawla, Kluner, Academic Publisher, 2003.

Reference Books:

1. **Introduction to Material Science for Engg.,** James T. Schockel Ford, 2nd Edition, McMillan Publications.
2. **Elements of Material Science and Engineering,** L.H. Van Vlack, 4th Edition, 1980.
3. **Fibre Reinforced Plastic Deskbook,** Nicholas P, Paul N, Chermisinoff, Ann Arbor science publishing Inc, 1978

OPEN ELECTIVE - 15PC56X ORGANIC CHEMISTRY SEMESTER-V			
Subject Code	**: 15PC562**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**
CREDITS- 03			

Course Objectives: This course to enable the students to learn the type of components in which organic reactions take place and also to know the preparation of the essential organic compounds.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Unit process - Definitions – reagents-mechanism – catalyst – illustrations of the following unit process– nitration – halogenation – oxidation & reduction – esterification.	08	L1, L2
Module-2		
Organic reactions mechanism and estimation- Electrophilic reaction - Friedel craft reaction, RiemerTimenn Reaction; Nucleophilic reactions - Aldol condensation, Benzion condensation; Free radical reaction - Halogenation of Alkane, Addition HBR on Alkene in presence of peroxide.	08	L1, L2
Module-3		
Stereochemistry- Elements of symmetry, stereochemistry of compounds containing one and two carbon atoms. Racemates and their resolution, conformation of cyclic and acyclic systems, E and Z isomers of olefins, Idea of asymmetric synthesis.	08	L1, L2
Module-4		
Synthetic chemistry- Synthesis of different types of compounds like alcohol, aldehyde, acid, amine and synthesis of dicarboylicacids	08	L1, L2, L3

and unsaturated acids. Synthesis of azodyes – methyl orange and congo dye. Synthesis of triphenyl methane dyes – alizarin-melachite green.		
Module-5		
Amino acids and proteins- Amino acids and proteins- classification - synthesis of amino acids - reactions of carboxyl group and amino group - peptide linkage - end group analysis - colour reaction of proteins- denaturation.	08	L1, L2

Course Outcomes: At the end of the course students will be in a position to have knowledge on various reaction mechanism, preparation of organic compounds and their properties.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Question paper pattern:

- The question paper will have Ten questions in total
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Tiwari K.S. Vishnoi N.K. and Marhotra S.N., A text book of Organic Chemistry, II Edition ,Vikas Publishing House Pvt.Ltd., (1998), New Delhi.

Reference Books:

1. P. H. Groggins Unit processes in organic synthesis. (Third Edition). McGraw-Hill, New York, 1947.

OPEN ELECTIVE - 15PC56X RESERVOIR ROCKS AND FLUID PROPERTIES SEMESTER-V			
Subject Code	**: 15PC563**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**
CREDITS- 03			

Course Objectives: This course enables students to

- Petroleum reservoir system and fluid properties
- Basic principles and operations in upstream petroleum industry

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
The earth, crust, plate tectonics and geologic times. Sedimentary geology, Basins and Margins. Origin, accumulation and migration of petroleum. Properties of subsurface fluids. Petroleum Chemistry.	08	L1, L2
Module-2		
Porosity and Permeability relationship – Porosity. Permeability. Porosity – Permeability relationship. Electrical properties of rocks. Measurement of formation resistivity. Correlation of FR with porosity, permeability and water saturation. FR of Shaley Reservoir rocks. Formation evaluation.	08	L1, L2
Module-3		
Capillary Pressure and Well ability – Fluid Saturation and Capacity pressure. Determination of capillary pressure. Pore size distribution. Wettability. Evaluation of wettability and its effect on oil recovery. Alteration of wettability. Effect of wettability on electrical properties of rocks.	08	L1, L2

Module-4		
Linear flow of incompressible fluids. Darcy's Law. Linear flow of gas. Darcy's and Poiseuille's laws. Various flow systems. Multiple permeability rocks.	08	L1, L2
Module-5		
Reservoir fluid properties – Phase behaviour of hydrocarbon system. Fluid rock interactions. Reservoir fluid characteristics. PVT analysis. Flash liberation and differential liberation study.	08	L1, L2

Course Outcomes: At the end of the course students are able to learn the use of Darcy's Law to calculate permeability of single phase; definition of interfacial tension; use of capillary pressure to determine saturation changes in reservoir; definition of effective and relative permeability; use of drainage/imbibition curves to characterize reservoir relative permeability.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Question paper pattern:

- The question paper will have Ten questions in total
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Craft, B.C. and Hawkins M.F. "Applied Petroleum Reservoir Engineering" second edition, Prentice-Hall (1991)

2. DjebbarTiab : "Theory and pratice of measuring Reservoir rock and fluid Transport properties

Reference Books:

1. Amyx, J.W., Bass D.M. & Whiting., R.L., "Petroleum Reservoir Engineering" McGraw Hill 1998

OPEN ELECTIVE - 15PC56X NATURAL GAS PROCESSING SEMESTER-V			
Subject Code	**: 15PC564**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 03**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 40**	**Exam Hours**	**: 03**
CREDITS- 03			

Course Objectives:
Enable the students to learn the basic concept and applications of Natural Gas processing

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Natural gas technology: Branches of petroleum Industry. Sources of Information for natural gas engineering and its applications. Geology and earth sciences: Earth sciences-Historical geology, Sedimentation process, Petroleum reservoirs, Origin of petroleum. Earth temperatures & pressure, Earth temperatures, Earth pressure. Natural gas, LP gas, Condensate,Crude oil.	08	L1, L2
Module-2		
Phase behaviour fundamentals: Qualitative hydrocarbon phase behavior-phase rule, pressure-temperature diagram for single component and multicomponent systems, vapor-liquid equilibrium. Equations of state- real and ideal gases, the compressibility factor approach, van der wals equation, Redlich-Kwong equation, Peng Robinson equation. Viscosity of gases, specific heat for hydrocarbon gases.	08	L1, L2
Module-3		
Gas Compression: Types of compressors-Reciprocating Positive displacement and rotary positive displacement compressors and centrifugal compressors; Sliding-vane compressors, two impeller straight lobe compressors, liquid piston compressors, centrifugal compressors, axial flow	08	L1, L2

compressors. Compressible flow fundamentals, Compressible Flow in Pipes,Fundamental equations of flow: continuity, momentum, energy equations.		
Module-4		
Gas Liquid separation: Separation equipment, types of separators, separation principles- centrifuge separators, gravity settling, impingment. Factors affecting separation, gas cleaning, gas hydrates-hydrate phase behaviour, hydrate formation, prevention. Gas dehydration: Adsorption dehydration, types of adsorbents.	08	L1, L2
Module-5		
Gas desulfurisation : Meaning of sour gas and sweet gas, reasons for removal of H_2S Gas flow measurement: Attributes of flow devices, methods of measurement-different types of flowmeter, The orifice metering systems. Factors affecting orifice meter accuracy, common measurement problems encountered in gas metering.	08	L1, L2
Course Outcomes: Students will be able to understand the Natural gas processing, Gas Compression, Gas Gathering and Transport Installation, Operation and trouble shooting of natural gas pipelines.		
Graduate Attributes Critical Thinking Problem solving Use of modern tools Research Skill Life-long learning		
Question paper pattern: • The question paper will have Ten questions in total • Each full question consists of 16 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
Text Books: 1. Katz D.L.et al., Natural Gas Engineering (Production & storage), McGraw-Hill, Singapore.		
Reference Books: 1. Standard Handbook of Petroleum and Natural Gas Engineering. 2nd Edition. William C Lyons, Gary C Plisga. Gulf Professional Publishing.		

MASS TRANSFER LABORATORY SEMESTER-V			
Laboratory Code	**: 15PCL57**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**01 Hr. Tutorial(Instructions) + 02 hours Laboratory**	**Exam Marks**	**: 80**
		Exam Hours	**: 03**
CREDITS- 02			

Course Objectives:
Students develop a sound working knowledge on different types of mass transfer equipments.

Laboratory Experiments: **Minimum of 10 experiments are to be conducted**	**Revised Bloom's Taxonomy (RBT) Level**
1. Surface Evaporation	
2. Determination of Diffusion Coefficient	
3. Simple Distillation	
4. Solid – liquid leaching	
5. Adsorption studies	
6. Tray dryer	
7. Steam distillation	
8. Extraction of oil from pyrolysis method	
9. Liquid - liquid extraction	
10. Vacuum Dryer	
11. Ternary System	
12. Solid dissolution	

Course Outcomes:
To impart knowledge on mass transfer by practice on equipments.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Conduct of Practical Examination:

- Minimum of 10 experiments are to be conducted andall 10experiments are to be included for practical examination.
- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and 15% Marks allotted to the procedurepart to be made zero.

Reference Books:
1. Robert E Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. McCabe & Smith "Unit Operations in Chemical Engineering", 6th Edition, McGraw Hill, 2001.

NUMERICAL METHODS AND COMPUTER APPLICATION IN CHEMICAL

ENGINEERING LABORATORY SEMESTER-V			
Laboratory Code	**: 15PCL58**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**01 Hr. Tutorial(Instructions) + 02 hours Laboratory**	**Exam Marks**	**: 80**
		Exam Hours	**: 03**
CREDITS- 02			
Course Objectives: This course enables students to implement numerical techniques for chemical engineering applications.			
Laboratory Experiments: **Minimum of 6 experiments from Part Aand 4 experiments from Part B are to be conducted**			**Revised Bloom's Taxonomy (RBT) Level**
Part - A			
1. Non-linear algebraic equation- Newton Raphson (Specific volume of binary mixture)			
2. Ordinary Differential Equation- R-K Method ($dCa/dt=kCa^2$)			
3. Numerical Integration- Simpson's 1/3 Rule (Batch Reactor to find time)			
4. Curve Fitting-Least Square (Nrevs f)			
5. Calculation of Bubble Point and Dew Point for Ideal multi-component system			
6. Flash Vaporisation for multi-component system			
7. Design of Adiabatic Batch Reactor			
8. Adiabatic Flame Temperature			
9. Double pipe heat exchanger (Area, Length and Pressure drop)			
10. Distillation Column (Bubble cap)			
11. Pressure Pipe in a Drop			
12. Distillation Column (Plates)			
Part - B			
Process simulation study involving mixing, reactor, distillation, heat exchanger for any of the following:			
13. Propylene - Propane Splitter			
14. Reboiled Stripper from Seader and Henley			
15. Extractive Distillation			
16. Binary Distillation in a Double Feed Column			
17. Distillation of Ethanol Water mixture			

18. Homogeneous Azeotropic Distillation	
19. Absorber	
20. Reboiled Absorber	

Course Outcomes: At the end of the course students are able to apply numerical techniques to analyse and solve chemical engineering problems using computer programmes.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Research Skill
- Life-long learning

Conduct of Practical Examination:

- Minimum of 10 experiments are to be conducted andall 10experiments are to be included for practical examination.
- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and 15% Marks allotted to the procedurepart to be made zero.

Reference Books:

1. PradeepAhuja “Introduction to Numerical Methods in Chemical Engineering”, PHI Learning PVT. Ltd. New Delhi.