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

SEMESTER VI

CHEMICAL REACTION ENGINEERING-II (Common to CH & PC)					
Subject Code	:	15CH61	**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 understand and apply the principles of non-ideal flow in the design of reactor.
2. Be able to develop rate laws for heterogeneous reactions.

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**		
Basics of Non Ideal Flow: Importance & interpretation of RTD, C, E & F curves & Statistical interpretation. Dispersion model. Tanks in series model. Conversion in non- ideal flow reactors for simple systems.	10	L1,L2,L3
Module 2		
Introduction to Heterogeneous Systems: Rate equations, contacting patterns, fluid-particle non catalytic reactions, URC model, Spherical particles of unchanging size, shrinking spherical particles, determination of rate controlling steps. **Fluid-Fluid Non Catalytic Reactions:** Kinetic regimes for mass transfer and reaction; rate equations.	10	L2,L3,L4
Module 3		
Catalysis: Introduction to catalysis. Properties of catalysts. Estimation methods for catalytic properties. Promoters, inhibitors etc, Mechanism of catalysis. Rate equations for different rate controlling step. **Deactivation:** Deactivating catalyst. Mechanism, rate & performance equation.	10	L3,L4,L5
Module 4		
Solid Catalyzed Reactions: Heterogeneous reactions-Introduction, Kinetic regimes. Rate equation for surface kinetics. Pore diffusion resistance combined with surface kinetics. Thiele modulus and enhancement factor, Porous catalyst particles. Heat effects during reaction.	10	L4,L5
Module 5		

Solid Catalyzed Reactions (Contd.): Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates. Packed bed catalytic reactor & reactors with suspended solid catalyst. Fluidized reactors of various type. Gas-Liquid Reactors: Trickle bed, slurry reactors. Three phase fluidized bed.	10	L3,L4,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge to distinguish between various RTD curves and predict the conversion from a non-ideal reactor using tracer information.
2. Acquire practical knowledge about design of reactors for non-catalytic and catalytic reactions.
3. Know the use of reactors for gas–liquid operations with and without chemical reaction.

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,3Edition,JohnWiley&Sons, 2001.
2. **ChemicalEngineeringKinetics,**J.M.Smith,3rd Edition,McGrawHill.
3. **ElementsofChemicalReactionEngineering,**H.ScottFoggler,3rd Edition,PrenticeHall, 2001.

REFERENCE BOOKS:

1. **Chemical&CatalyticReactionEngineering,**JamesJ.Carberry,McGrawHill,1976

MASS TRANSFER OPERATIONS-II (Common to CH & PC)					
Subject Code	:	15CH62	**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 understand different separation techniques.
2. Be able to design distillation column, absorber and calculations involved in liquid liquid extraction.

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**		
Gas Liquid Contacting Systems: Types, construction and working of plate and packed columns, types and properties of industrial packing's, plate efficiencies, HETP and HTU concepts. **Absorption:** Absorption.Solventselectionforabsorption.Materialbalanceandconceptof drivingforceandminimumsolventrates. Multistageabsorptioncolumns.DesignofPlate columns.Absorptionanddesorptionfactors.	10	L1,L2,L3
Module 2 **Content**		
PackedTowerAbsorption:Liquidphaseholdupandpressuredropinabsorption towers. Designofpackedtowers(processdesign-heightanddiameter).Multi-componentabsorption. Absorptionwithchemical reaction. **Distillation:**Introduction.Vapourliquidequilibria(T-x,y,P-x,y.H-x,yandx-ydiagramsfor binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult'slaw.VLEformulti-component systems.Non-idealsystems.Azeotropes.Immiscible systems.Steamdistillation**,**Flashandsimpledistillation.	10	L2,L3,L4
Module 3 **Content**		
Distillation (Contd.):.Multi-stage rectification column. Design using McCabe Thiele and Lewis-Sorelmethodsforbinarymixtures. **Distillation(Contd.):**Ponchon-Savaritmethod.IntroductiontoMulticomponentdistillation, Vacuum,molecular,extractiveand azeotropicdistillations.	10	L3,L4,L5
Module 4 **Content**		
Liquid-LiquidExtraction:Ternaryequilibrium.Solventselection.Singlestage.Multi-stage cross-current,counter-currentextraction.Equipmentforliquid-liquidextraction.	10	L3,L4, L5
Module 5 **Content**		
LeachingOperation: Equipmentforleaching.Preparationofsolidsforleaching.Equilibrium diagrams.Calculationof singlestage andmulti-stageleachingoperation.	10	L2,L3,L4

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge for separation of components.
2. Acquire practical knowledge about design of mass transfer equipment.
3. Differentiate various separation techniques.

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. **MassTransferOperations-**RobertE Treybal,3rd Edition,McGrawHill,1981.
2. **UnitOperationsin 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,TMH6thReprint1998.
3. **Principlesof UnitOperation-**Foust*et.al*.,2nd Edition,JohnWiley,1994.
4. **TransportProcessesandUnitOperation-**GeankoplisCJ,PrenticeHall(I),2000.
5. **AppliedProcessDesignforChemicalandPetrochemicalPlant**Ludwig,2nd Edition,Gulf Publishing,2002.

RESERVOIR ENGINEERING [DC]			
Subject Code	**: 15PC63**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**: 04**	**Exam Marks**	**: 80**
Total No. of Lecture Hours	**: 50**	**Exam Hours**	**: 03**

CREDITS- 4

Course Objectives: To enable the students to

- Understand the rock and fluid properties of a hydrocarbon reservoir
- Describe the nature of the fluid flow and pressure distribution in a reservoir
- Understand the effects of production/ injection on recovery of reserves

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Introduction to Reservoir Engineering: Activities in reservoir engineering, The role of reservoir engineers, Technical responsibilities of reservoir engineers, The physical principles of reservoir engineering. **The Appraisal of Oil and Gas Fields:** Introduction, Pressure-volume-temperature fluid properties for oil, Calculation of the stock tank oil initially in place, Field unitization/equity determination, Calculation of gas initially in place, Pressure-depth plotting.	10	L1, L2
Module-2		
Reservoir Geology and Geophysics: Geological models, Hydrocarbon generation and migration, reservoirs, Traps, Seismic development survey, Example of reservoirs. **Fundamentals of reservoir fluid flow-** reservoir geometry, fluid flow equations, steady state and unsteady state flow, constant terminal pressure solution. Horizontal and vertical oil well and gas well performance.	10	L1, L2
Module-3		
Reservoir fluid behaviour and properties- classification of reservoir and reservoir fluids. Properties of natural gases. Direct calculation of compressibility factors. Methods of calculating viscosity of natural gases, properties of crude oil systems. Methods of calculating viscosity of the dead oil. Properties of reservoir water. **Analysis of reservoir fluid and rock properties-** composition of reservoir fluid, separation test, laboratory analysis of gas condensate system, porosity and capillary pressure. Rock compressibility, reservoir	10	L1, L2

heterogeneity. Dynamic pseudo-relative permeabilities, two phase and three phase relative permeability.		
Module-4		
Recovery mechanism and material balance- primary recovery mechanism, material balance equation, performance prediction methods and relating reservoir performance to time. Volumetric method and the material balance equations as a straight line in gas reservoir. **Oil well Testing:** Introduction, Essential observations in well testing, Well testing literature, The purpose of well testing, Basic. Radial flow equation, Constant terminal rate solution of the radial diffusivity equation, The transient constant terminal rate solution of the radial diffusivity equation, Pressure build-up testing, Miller, Dyes. Hutchinson (MDM) pressure build-up analysis, Pressure support during appraisal well testing.	10	L1, L2
Module-5		
Water flooding and vapour liquid phase equilibrium- factors to consider in water flooding, optimum time to water flooding, selection of flooding patterns, overall recovery efficiency, displacement efficiency, vertical sweep efficiency. Equilibrium ratio, flash calculations, equilibrium ratios for real solution. Application of the equilibrium ratio in reservoir engineering.	10	L1, L2

Course Outcomes:

Students will understand the location, formation, fluid content of a hydrocarbon reservoir; understand the definitions of reserves; be aware of the role of reservoir engineering in exploration and development

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. L.P.Dake L Elsevier, “Fundamentals of Reservoir Engineering”, Development in Petroleum Science. 1980
2. Craft B.C and Hawkins M.F. – Applied Petroleum Reservoir Engineering” 2nd Edition. Prentice Hall Englewood Cliffs, N.J., 1991

Reference Books:

1. Dake, L.P. Practice of Reservoir Engineering Elsevier 2001
2. William C.Lyons, Gary J.Plisga “Standard Hand Book of Petroleum & Natural Gas Engineering” Second Edition – (Elsevier), Gulf Publishing, Burlington U.S.A (2005).

PROCESS EQUIPMENT DESIGN AND DRAWING (Common to CH and PC)					
Subject Code	:	15CH64	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	04
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:

The students will

1. Be able to understand advances and types in the design of heat and mass transfer equipment and its accessories.
2. Be able to develop modifications based on design.

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

Detailedchemicalengineeringprocessdesignofthefollowing equipment should be studied.Standardcodebooksaretobeused.Thedetailedproportionate drawings shallincludesectional frontview,fulltop/sideviewdependingonequipmentandmajorcomponents. 1. **Classwork:** Students areto design the equipment. They shall also be trained to draw free hand proportionatesketches. 2.**FinalExamination:**Studentshavetoansweranyoneofthetwoquestions givenin theexamination.Aftercompletingthedesign,freehandproportionate sketchesaretobe drawnasrequired.	Teaching Hours	Blooms Taxonomy
Content		
1.DoublepipeHeatexchanger	07	L1,L2,L3, L4,L5,L6
2.ShellandTubeHeatexchanger	07	
3.Condensers–Horizontalandvertical	08	
4.Evaporator–Singleeffect	07	
5.Sieve TrayDistillationColumn	07	
6.Packed BedAbsorptionColumn	07	
7.RotaryDryer.	07	

Course outcomes:

After studying this course, students will be able to:

1. Design and modify process equipment relating to heat and mass transfer.
2. Will handle process parameters to alter and design process Equipment.

Question Paper Pattern:

This question paper will have two questions. Each full question consists of 80 marks. Each full question will have sub questions covering design of the equipment and proportionate drawing Top view, front view and side view of equipment. The students will have to answer any one full question.

Note: ChemicalEngineersHandbook,Perry&Green,McGrawHill,1997.
IS2825,IS4503,B.I.S.,NewDelhi,1969 are permitted for exam and internal.

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 DesignofEquipment – 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 - 15PC65X
PETROLEUM TRANSPORTATION ENGINEERING

Subject Code	**: 15PC651**	**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 get familiar with modes of transportation for oil and gas. To understand various transportation techniques, problems and remedial measures.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Modes of crude oil, product and gas transportation and pipeline transportation- tank-trucks and rail transportation, oceanic tanker transportation, inland water, coastal and oceanic, tanker size, power, cargo space, marine storage terminals, shore installation. Line specifications, plastic pipes.	8	L1, L2
Module-2		
Liquid transport & gas transportation- crude oil and product flow characteristics, transportation of cryogenic liquids, heat flux estimation, temp gradient in flowing fluid in exposed and buried pipeline, insulation types and thickness, rheology and non-newtonian behaviour, stress and pressure drop calculations. Flow equation, pressure drop calculations. Wey mouth and panhandle equation, design factors. Pressure drop in non-horizontal pipeline. Stress conditions in pipeline and analysis.	8	L1, L2
Module-3		
Branching and looping in pipelines and multiphase flow- equivalent diameter and length combined capacity. Steady state flow in pipes, flow networks. Flow pattern in gas- liquid flow, pressure drop estimation, design consideration. Pipe sizing, storage capacity, station spacing. Transportation problems and remedial measures, pressure surges, scaling, wax deposition, gas hydrate formation.	8	L1, L2

Module-4		
Pipeline practice and equipment and surface protection- route survey, transportation, trenching, stringing, bending, cleaning and coating, lowering And back filling, inspection, testing, internal cleaning, road, bridge and river crossing. Welding: techniques and equipment Internal and external corrosion & protection, cathode protection system.	8	L1, L2
Module-5		
Auxiliary equipment/ facilities and pumps & compressor Station- valves, regulators, types and operating features. Metering & storage: flow meter types, Calibration, proving, heating value. Storage of crude, product, natural gas and LNG. Layout, equipment, instrumentation, prime movers: two stroke vs four stroke. Naturally Design aspirated vs super charged engines, gas turbines, single vs multi shaft turbines, Emission control.	8	L1, L2
Course Outcomes: Students will have understanding on transportation techniques and the auxiliary equipments involved in the transportation process.		
Graduate Attributes • Critical Thinking • Problem solving • Use of modern tools • Life - long Learning • Collaborative and multidisciplinary work		
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. The Petroleum Shipping Industry: Operations and Practices, Penwell Books, 1996.		
Reference Books: 1. Introduction to the Oil Pipeline Industry (Oil Pipeline Transportation Practices), he University of Texas at Austin - Petroleum Extension Service; 3rd edition 1984.		

PROFESSIONAL ELECTIVE - 15PC65X MECHANICAL OPERATIONS			
Subject Code	**: 15PC652**	**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

- Study different properties of particulate solids, handling and mixing of solid particles.
- Study principles of commination and different types of equipment for size reduction like crushers, grinders etc.
- Understand mechanical separation aspect such as screening, filtration, sedimentation, transportation of solids etc.
- Understand energy requirements in solids handling, agitation and mixing, solid conveying and storage.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Particle technology: Particle shape, particle size, different ways of expression Of particle size, shape factor, sphericity, particle size Analysis, screens – ideal and actual screens, differential And cumulative size analysis, effectiveness of screen, Specific surface of a mixture of particles, number of Particles in a mixture, standard screens, industrial Screening equipment, motion of screen, grizzly, gyratory Screen, vibrating screen, trommels, sub sieve analysis - Air permeability.	8	L2, L3
Module-2		
Size reduction: Introduction – types of forces used for comminution, Criteria for communition, characteristics of comminuted Products, laws of size reduction, work index, energy Utilization, methods of operating crushers – free crushing, Choke feeding, open circuit grinding, closed circuit Grinding, wet and dry grinding, equipment for size Reduction – classification of size reduction equipment, Equipment – blake jaw crusher, gyratory crusher, smoothroll crusher, toothed roll crusher, impactor, attrition mill, Ball mill, critical speed of ball mill, ultra-fine grinders, Fluid energy mill, colloid mill, cutters – knife cutter.	8	L2, L3
Module-3		
Flow of fluid past immersed bodies:	8	L2, L3

Drag, drag coefficient, pressure drop – kozeny-carmen Equation, blake-plummer, ergun equation, fluidization, Conditions for fluidization, minimum fluidization velocity, Types of fluidization, applications of fluidization, slurry Transport, pneumatic conveying. **Motion of particles through fluids:** Mechanics of particle motion, equation for one Dimensional motion of particles through a fluid in Gravitational and centrifugal field, terminal velocity, drag Coefficient, motion of spherical particles in stoke's region, Newton's region, and intermediate region, criterion for Settling regime, hindered settling, modification of Equation for hindered settling, centrifugal separators, Cyclones and hydro cyclones.		
Module-4		
Sedimentation: Batch settling test, application of batch settling test to Design of a continuous thickener, coe and clevenger Theory, kynch theory, thickener design, determination of Thickener area. **Filtration:** Introduction, classification of filtration, cake filtration, Clarification, batch and continuous filtration, pressure and Vacuum filtration, constant rate filtration and cake Filtration, characteristics of filter media, industrial filters, Sand filter, filter press, leaf filter, rotary drum filter, Horizontal belt filter, bag filter, centrifugal filtration – Suspended batch centrifuge, filter aids, application of Filter aids, principles of cake filtration, modification of Kozeny – carmen for filtration.	8	L2, L3
Module-5		
Agitation and mixing: Application of agitation, agitation equipment, types of Impellers – propellers, paddles and turbines, flow Patterns in agitated vessels, prevention of swirling, Standard turbine design, power correlation and power Calculation, mixing of solids, types of mixers – changecan mixers, muller mixers, mixing index, ribbon blender, Internal screw mixer, tumbling mixer. **Sampling, storage and conveying of Solids:** Sampling of solids, storage of solids, open and closed Storage, bulk and bin storage, conveyors – belt Conveyers, chain conveyor, apron conveyor, bucket Conveyor, screw conveyor.	8	L2, L3
Course Outcomes: • Classify and suggest different type of separation processes required for the feed material.		

- Suggest different types of size reduction methods such as crushing, grinding milling depending on the type and size of the material.
- Calculate the power requirements for different type of mechanical operations.
- Select different type of conveying methods.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. McCabe, W.L., et.al., "Unit Operations in Chemical Engineering", 5thedn., McGraw Hill International, Singapore, 2000
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", 3rd edn. Tata McGraw Hill International Edition, Singapore , 1999
3. Coulson J.H. and Richardson J.F., "Coulson and Richardson's Chemical Engineering", Vol-II Particle Technology and Separation Process, 6th edn., Asian Books (p) Ltd., New Delhi, 1998

Reference Books:

1. Brown G.G., et.al., "Unit Operations", I edn., CBS Publisher, New Delhi, 1995
2. Perry R.H. and Green W.D., "Perry's Chemical Engineers' Hand Book", VII edn., McGraw Hill International Edition, New York, 2000
3. Sarkar Samir, "Fuels and Combustion", II edn., Orient Longman, New Delhi, 1980
4. Foust A.S., et.al., "Principles of Unit Operations", III edn., John Wiley and Sons, New York, 1997

PROFESSIONAL ELECTIVE - 15PC65X CHEMICAL PLANT UTILITIES AND SAFETY			
Subject Code	**: 15PC653**	**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 role of utilities in process plant operations and criteria for selection and estimation of suitable utilities.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Introduction: Different utilities. Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities. **Water:** Water resources. Process water, Cooling water, drinking water and boiler feed water Quality Standards. Water treatment processes for drinking, process and boiler feed. Storage and handling of water. Types and selection of pumps, piping and accessories. Water pre treatment,	8	L1, L2
Module-2		
Air: Compressed air, blower air, fan air. Types of compressor and vacuum pumps and selection. Power requirements, performance and related calculations. Booster and receivers. Quality of compressed air for instruments and processes. Compressed air distribution system- piping and accessories. Air-water vapour system: humidification/ dehumidification and evaporative cooling-related calculations.	8	L1, L2
Module-3		
Steam And Power: Steam generation in chemical plants. Types of boilers and waste heat boilers. Fuels-types, emissions and global warming, green fuels. Calorific value. Proximate and ultimate analysis. HHV, LHV and related calculations. Cogeneration power plants. CHPs and Boiler performance. Related Calculations. Economy of steam generation with different fuels, related calculation. Steam storage and handling-piping and accessories.	8	L1, L2
Module-4		
Refrigeration: Different refrigeration systems and	8	L1, L2

their characteristics. Air-conditioning systems. Coefficient of performance. Power requirements and refrigeration effect- related calculations for each type of refrigeration system. Refrigerant properties and selection. Some commonly used refrigerants and secondary refrigerants. **Insulation:** Insulation Materials & Selection- Economics of insulation. Insulating factors. Properties & Classification. Cold insulation and cryogenic insulation.		
Module-5		
Introduction To Process Safety: Intrinsic & Extrinsic Safety. The Hazards- Toxicity, Flammability, Fire, Explosions. Sources of ignition, Pressure. Hazard and risk assessment methods. MSDS. **Safety Devices:** Pressure relief valves. Ruptures discs. Blow down systems. Flare systems. Flame arrestors. Deflagration arrestors and explosion suppression. Personal safety devices.	8	L1, L2
Course Outcomes: At the end of the course students are able understand the role of utilities in process plant operations and criteria for selection and estimation of suitable utilities and the safety things required.		
Graduate Attributes • Critical Thinking • Problem solving • Use of modern tools • Life - long Learning • Collaborative and multidisciplinary work		
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. **Thermal Engineering,** B.K. Sarkar, Tata McGraw Hill, 8th Reprint, 1998. 2. **Heat Engines,** K.P. Roy, Media Promoters and Publishers, 1995. 3. **Power Plant Engineering,** P.K. Nag, 2nd Edition ,TataMcGraw Hill, 1998. 4. **Water and Waste water engineering- Vol 2,** Gordon M Fair, John C. Geyer and Daniel A Okun, Jhon Hutey,1996.		

5. **Water and waste water Technology,** Mark J. Hammer Jr.,4thEdition, Prentice Hall, 1997.
6. **Chemical Engineers Handbook,** Perry, 8th Edition, 2007.
7. **Chemical Engineering- Vol 6,** R.K. Sinnot, Coulson and Richardson's, 3rd Edition, BH, Reprint, 2000.

Reference Books:

1. **Loss prevention in chemical process industries, Vol. 1,2,3,** Frank P Lees, Butterworth-Heiremann,1980.

PROFESSIONAL ELECTIVE - 15PC65X WELL DRILLING EQUIPMENTS AND OPERATION			
Subject Code	**: 15PC654**	**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 learn about the Drilling Process and Drilling Equipments**.**

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
DRILLING MUDS AND COMPLETION SYSTEMS - Functions of Drilling Muds, Classifications, Testing of Drilling Systems, Completion and Workover Fluids, Safety Aspects of Handling Brines, Preventing Contamination. **DRILL STRING: COMPOSITION AND DESIGN -** Drill Collar, Drill Pipe, Drill String Inspection Procedure	8	L1, L2
Module-2		
AIR AND GAS DRILLING - Bottomhole Pressure, Minimum Volumetric Flow Rate, Drill Bit Orifices or Nozzles, Injection Pressure, Water Injection, Saturation of Gas, Eliminate Stickiness, Suppression of Hydrocarbon Combustion, Aerated Drilling (Gasified Fluid Drilling), Stable Foam Drilling, Completions Operations, Compressor and Inert Air Generator Units, Highly DeviatedWell Drilling and Completions, Down hole Motors. **DIRECTIONAL DRILLING -** Glossary of Terms used in Directional Drilling, Dogleg Severity (Hole Curvature) Calculations - Tangential Method, Radius of Curvature Method, Deflection Tool Orientation, Vectorial Method of D. Ragland, Three-Dimensional Deflecting Model.	8	L1, L2
Module-3		
SELECTION OF DRILLING PRACTICES - Health, Safety and Environment, Production Capacity, Well Planning and Implementation, Drilling Implementation, Post-Run Evaluation. **WELL PRESSURE CONTROL –** Introduction, Surface Equipment, When and How to Close the Well, Gas-Cut Mud, The Closed Well, Kick Control Procedures, Maximum Casing Pressure, Maximum	8	L1, L2

Borehole Pressure.		
Module-4		
FISHING OPERATIONS AND EQUIPMENT - Causes and Prevention, Pipe Recovery and Free Point, Parting the Pipe, Jars, Bumper Subs and Intensifiers, Attachment Devices, Fishing for Junk, Abandonment, Wirelines, Electrical Conductors, Simple ArmoredWirelines, ArmoredWirelines with Electrical Conductors, Wireline Operating and Breaking Strengths, Wireline Stretching. **CASING AND CASING STRING DESIGN -** Types of Casing, Casing Data, Combination Casing Strings, Running and Pulling Casing.	8	L1, L2
Module-5		
TUBING AND TUBING STRING DESIGN - API Physical Property Specifications, Running and Pulling Tubing, Preparation and Inspection before Running, Packers, Protecting the Casing. **ENVIRONMENTAL CONSIDERATIONS FOR DRILLING OPERATIONS –** Introduction, Well Site, Environmental Regulations, Site Assessment and Construction, Environmental Concerns While in Operation.	8	L1, L2
Course Outcomes: At the end of the course: Students will understand the concepts and techniques used in well drilling. They will learn the design requirements of well planning and construction. Students would be able to optimize the design of a drilling program		
Graduate Attributes • Critical Thinking • Problem solving • Use of modern tools • Life - long Learning • Collaborative and multidisciplinary work		
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. Rabia.H. 'Oil Well Drilling Engineering, Principles And Practices' Graham And Trotman Ltd. 1985. 2. D.P Helander 'Fundamentals Of Formation Evaluation'.		
Reference Books: 1. Standard Handbook of Petroluem and Natural Gas Engineering, 2nd Edition, William C		

Lyons, Gary C Pilisga, Gulf Professional Publishing
2. Working guide to Drilling equipment and Operations, William c. Lyons, first edition 2010 Published by Elsevier.

OPEN ELECTIVE - 15PC66X
MODERN SEPARATION TECHNIQUES

Subject Code	**: 15PC661**	**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 understand the role of separation techniques in process plant operations and criteria for selection and estimation of suitable techniques.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Adsorptive Separations: Review of fundamentals. Mathematical modeling of column factors. Pressure swing & thermal swing adsorption. Counter current separations. **Membrane Technology:** Overview of membrane science and technology, Membrane transport theory, Membranes and Modules, Reverse osmosis, Ultrafiltration.	8	L1, L2
Module-2		
External Field Induced Separations: Magnetic field separations. Centrifugal separations. Separation by thermal diffusion. **Mechanical–Physical Separation Process:** Introduction, Classification, Filtration in solid liquid separation. Settling & sedimentation in particle fluid separation.	8	L1, L2
Module-3		
Surfactant Based Separations: Fundamentals. Surfactants at inter phases and in bulk. Liquid membrane permeation. Foam separations. Micellar separations.	8	L1, L2
Module-4		
Super Critical Fluid Extraction: Principle, Supercritical fluid solvents and their properties, Phase diagram, Extraction process unit, Advantages, Applications – Extraction of bitter flavour from hopes, Decaffeination of coffee, Rose process for separating residuum.	8	L1, L2

Module-5		
Other Techniques: Separations involving Lyophilization, Pervaporation and permeation techniques for solids, liquids and gases. Zone melting, Adductive crystallization. Heavy media separation.	8	L1, L2

Course Outcomes: At the end of the course students are able understand the role of separation techniques in process plant operations and criteria for selection and estimation of suitable techniques and the safety things required.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. **Encyclopedia of Chemical Technology,** Kirk-Othmer, John Wiley & Sons,2001.
2. **Rate Controlled Separations,** Phillip C Wankat, Kluwer Academic Pub, 1990.
3. **Transportation and Separation Process,** Gaenkopolis, Printice Hall, 2003.
4. **Surfactant Based Separation,** T.O. Hatton, Vol 23.
5. **Supercritical Fluid Extraction**, M A McHugh & V. J. Krukonis, Butterworth, 1987.

Reference Books:

1. **Handbook of Separation Process Technology,** R.W.Rousseu, John Wiley & Sons,1987.

OPEN ELECTIVE - 15PC66X PROCESS MODELING AND SIMULATION			
Subject Code	**: 15PC662**	**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

- To take an overview of mathematical models of Chemical Engineering systems
- To understand the various simulation examples
- To get acquainted with the advanced control systems

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Introduction-Role of Process Dynamicsand Control, Laws and Languages of Process Control. **Mathematical Models of Chemical Engineering Systems-** Uses of Mathematical Models, Scope of Coverage, Principles of Formulation, Fundamental Laws.	08	L1, L2, L3
Module-2		
Computer Simulation- Computer Programming, Iterative Convergence Methods, Numerical Integration of Ordinary Differential Equations. **Simulation Examples-** Gravity-Flow Tank, Three CSTRs in Series, Nonisothermal CSTR, Binary Distillation Column, Multicomponent Distillation Column.	08	L1, L2, L3
Module-3		
Time-Domain Dynamics and Control- Classification, Linearization and Perturbation Variables, Responses of Simple Linear Systems, Steadystate Techniques. **Conventional Control Systems and Hardware-** Control Instrumentation, Performance of Feedback Controllers, Controller Tuning.	08	L1, L2, L3
Module-4		
Advanced Control Systems- Ratio Control, Cascade Control, Computed Variable Control, Override Control, Nonlinear and **Adaptive Control Valve** -Position Control.	08	L1, L2, L3

Frequency-Domain Analysis of Closed loop Systems- Nyquist Stability Criterion, Closedloop Specifications in the Frequency Domain, Frequency Response of Feedback Controllers.		
Module-5		
Process Identification- Direct Methods, Pulse Testing, Step Testing, Least-Squares Method, State Estimators, Relationships Among Time, Laplace, and Frequency Domains. **Multivariable Processes -** Matrix Mathematics, Matrix Properties, Representation of Multivariable Processes, Openloop and Closedloop Systems, Computer Programs For Matrix Calculations Problems	08	L1, L2, L3

Course Outcomes:

After studying this course, students will be able to: learnt the basic concepts ofSimulation and mathematical models applicable in Chemical Engineering.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. Luyben W. L. “Process Modeling, Simulation and Control for Chemical Engineering” McGRAW Hill Publishing Company.

Reference Books:

1. Smith C. L., Pike R. L. and Murill P. W. “ Formulation and Optimization of Mathematical Models”. International Text, Pennsylvania 1970

2. Roger G. E. “ Modelling and Simulation in Chemical Engineering” Wiley Inter Science, New Jersey 2006

OPEN ELECTIVE - 15PC66X
MATERIALS SCIENCEFOR PETROCHEMICAL ENGINEERING

Subject Code	**: 15PC663**	**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 variety of engineering applications through knowledge of atomic structure, electronic structure, chemical bonding, crystal structure, x-rays and x-ray diffraction, defect structure.
- Study Microstructure and structure-property relationships, Phase diagrams, heat treatment of steels.
- Study detailed information on types of corrosion and its prevention.
- Learn information on selection of materials for design and manufacturing

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
INTRODUCTION: Introduction to material science, Classification of engineering materials, Level of structure, Structure property relationships in materials. **CRYSTAL GEOMETRY AND STRUCTURE DETERMINATION:** Geometry of crystals – the Bravais lattices, Crystal directions and planes – the miller indices, Structure determination – X – Ray diffraction – Bragg law, The powder method. **ATOMIC STRUCTURE, CHEMICAL BONDING AND STRUCTURE OF SOLIDS:** Structure of atom, Periodic table, Ionization potential, Electron affinity and Electro-negativity, Primary and secondary bonds, variation of bonding character and properties, Covalent solids, Metals and alloys, Ionic solids, structure of silica and silicates, Polymers.	8	L1, L2, L3
Module-2		
CRYSTAL IMPERFECTIONS:	8	L1, L2, L3

Point Imperfections, Line imperfections – edge and screw dislocations, the Burgers vector, line energy of dislocations, Surface imperfections. **PHASE DIAGRAM AND PHASE TRANSFORMETIONS:** Phase rule, Single component systems, Binary phase diagrams, Lever rule, Typical phase diagrams for Magnesia-Alumina, Copper – Zinc, iron – carbon systems, Nucleation and growth, Solidification, Allotropic transformation, Cooling curve for pure iron, Iron – Carbon equilibrium diagram, Isothermal transformations (TTT curves).		
Module-3		
DEFORMATION OF MATERIALS AND FRACTURE: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture. **HEAT TREATMENT**: Annealing, normalizing, Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Carburising, Cyaniding, Nitriding, Flame hardening.	8	L1, L2, L3
Module-4		
CORROSION AND ITS PREVENTION: Direct corrosion, Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factors influencing corrosion rate, Control and prevention of corrosion modification of corrosive environment, Inhibitors, Cathodic protection, Protective coatings.	8	L1, L2, L3
Module-5		
TYPICAL ENGINEERING MATERIALS: Ferrous metals, Non ferrous metals and alloys – Aluminum and its alloys, Copper and its alloys, Lead and its alloys, Tin, Zinc and its alloys, Alloys for high temperature service, Ceramic materials – Structure of ceramics, Polymorphism, Mechanical, electrical and thermal properties of ceramic phases, Refractories, Glasses, abrasives, Organic materials – Mechanism of polymerization, Additives to polymers, Plastics, fibres and elastomers, Organic protective coatings.	8	L1, L2, L3
Course Outcomes: After studying this course, students will be able to: • Classify different types of engineering materials depending on structure property, crystal geometry and X-Ray diffraction. • Explain atomic structures, types of bonding and crystal imperfections. • Draw phase diagrams of different metals, TTT curves and explain deformation of materials. • Suggest different type of heat treatment techniques depending on the type of the		

material and they can analyze different types of corrosions and suggest preventive methods.
- Select materials depending on type of application.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. Raghavan V., "Materials Science and Engineering – A First Course", 3rdedn., Prentice Hall of India Pvt. Ltd., New Delhi, 1996
2. Hajra Choudhury S.K., "Materials Science and Processes", Indian book distributing Co., 1982

Reference Books:

1. Van Vlack H.L., "Elements of Material Science", 2ndedn., Addison – Wesly Publishing Company, New York, 1964.

OPEN ELECTIVE - 15PC66X CATALYSIS SCIENCE AND TECHNOLOGY			
Subject Code	**: 15PC664**	**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 understand the concepts of functionality of catalyst and kinetics of catalytic processes.
- To develop idea of important properties of industrial catalysts, methods of manufacturing catalyst and its characterization.
- To get acquainted with industrial catalytic reactors, their design and operations.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module-1		
Catalytic Reaction Pathways- Heterogeneous Catalysis, Selectivity, activity, functionality, active site, Turnover number, Inhibitor, Reaction Pathways, Adsorption, Adsorption Isotherm, Important Characteristics of Industrial Catalysts. Homogeneous catalysis.	08	L1, L2, L3
Module-2		
Kinetics of Catalytic Reaction- Rate and Kinetics Models of Catalytic Reactions: Langmuir-Hinshelwood Model, Rideal Model, Identifying limiting step of reaction, Poisoning and Deactivation of Catalysts, Regenerability of Spent Catalyst.	08	L1, L2, L3
Module-3		
Manufacture of Catalysts and their Characterization- Catalyst preparation and manufacturing: Precipitation Method, Impregnation, Special preparative Methods, Catalyst Supports, Promoters, Catalyst Characterization, Surface area, Pore Volume, Pore size Distribution, Mechanical Properties.	08	L1, L2, L3
Module-4		
Different Type of Catalysts- Supported Metal Catalysts: Metal activity, Metal	08	L1, L2, L3

dispersion, Alloy catalysts, Sintering, Mobility, Redispersion, Carbon formation and Poisoning Acid Catalysts: Source of acidity, Determination of acid strength, correlations between acidity and catalytic activity, mechanism of catalytic cracking, Acid-Base catalysts Zelolites: Pore structure, Synthesis, Diffusion, Shape selective catalysis, Activity, Catalytic Cracking with zeolites.		
Module-5		
Industrial Applications in Petrochemical Industry- Manufacture of phthalic anhydride: Reactor configuration, hot spot formation, Ethylene to ethylene oxide, Steam reforming: Catalysts, Reforming process, Fischer-Tropsch synthesis: Mechanism, Catalysts, Process, Water gas shift reaction: High temperature shift catalyst, Low temperature shift catalyst, Methanol synthesis: High temperature process, Low temperature process, Kinetics, Ammonia synthesis: Reactor configuration.	08	L1, L2, L3
Course Outcomes: At the end of the course students are able understand the useful of catalysts used in industries for the production of products and also study the characterization of the catalyst activity.		
Graduate Attributes • Critical Thinking • Problem solving • Use of modern tools • Life - long Learning • Collaborative and multidisciplinary work		
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. Satterfield C. N., "Heterogeneous Catalysis in Industrial Practice", Second Edition, McGraw Hill, 1993.		
Reference Books: 1. Smith J. M., "Chemical Engineering Kinetics", Third Edition, McGraw Hill, 1984. 2. Froment G. F. and Bischoff, K. B. "Chemical Reactor Analysis and Design", John Wiley & Sons, 1995.		

CHEMICAL REACTION ENGINEERING LABORATORY			
Laboratory Code	**: 15PCL67**	**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 reactors.

Laboratory Experiments: **Minimum of 10 experiments are to be conducted**	**Revised Bloom's Taxonomy (RBT) Level**
1. Isothermal Batch Reactor – Integral Analysis	
2. Isothermal Batch Reactor – Differential Analysis	
3. Adiabatic Batch Reactor	
4. Packed Bed Reactor	
5. Effect Of Temperature On Rate Of Reaction	
6. Kinetic Studies In Mixed Flow Reactor	
7. RTD Studies In Mixed Flow Reactor	
8. Plug Flow Reactor	
9. Semi Batch Reactor	
10. Batch Reactive Distillation	
11. Gas-Liquid Reaction	
12. Catalytic Reaction	
13. Photochemical Reaction	
14. CSTR in Series	

Course Outcomes:
To impart knowledge on reaction engineering by practice.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. **Chemical Reaction Engineering,** Octave Levenspiel, 3rd Edition, John Wiley & Sons, 2001.
2. **Chemical Engineering Kinetics,** J.M. Smith, 3rd Edition, McGraw Hill.
3. **Elements of Chemical Reaction Engineering,** H. Scott Foggler, 3rd Edition, Prentice Hall, 2001.

PETROLEUM PRODUCT ANALYSIS LABORATORY			
Laboratory Code	**: 15PCL68**	**IA Marks**	**: 20**
No. of Lecture Hours/Week	**(1I + 2L)**	**Exam Marks**	**: 80**
		Exam Hours	**: 03**
CREDITS- 02			

Course Objectives:
To impart practical knowledge on different petroleum testing methods

Laboratory Experiments: **Minimum of 10 experiments are to be conducted**	**Revised Bloom's Taxonomy (RBT) Level**
1. Estimation of ASTM Distillation	
2. Estimation of TDP Distillation	
3. Estimation of Red Vapour Pressure	
4. Determination of Calorific Value of the fuel	
5. Determination of Copper strip corrosion	
6. Determination of Moisture Content	
7. Determination of Sulphur Content	
8. Determination of Demulsibility number	
9. Analysis of fertilizer	
10. Determination of Aromatic Content Determination	
11. Determination of foaming Characteristics	
12. Determination of Aniline Point	
13. Analysis of coal- Moisture Volatile matter & Ash content	
14. Acid – Base Titration	

Course Outcomes:
Students would be able to understand basic principles involved in testing of Petroleum products by different techniques.

Graduate Attributes

- Critical Thinking
- Problem solving
- Use of modern tools
- Life - long Learning
- Collaborative and multidisciplinary work

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. **Modern Petroleum Refining Processes,** Bhaskara Rao, 3rd Edition, Oxford & IBH Publication, Reprint, 1999.