UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY:: CHENNAI 600 025

REGULATIONS - 2015

I TO IV SEMESTERS CURRICULUM AND SYLLABUS (FULL TIME)

M. TECH. PETROLEUM REFINING AND PETROCHEMICALS

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

1. To create mastery of the basic principles of engineering science that underlies modern chemical process principles used in petroleum industries.
2. To make employable process engineers in refinery fields and to work towards the development of sustainable technologies in petroleum and allied industries.
3. To function effectively in the complex modern work environment with the ability to assume professional leadership roles.
4. To exhibit professional, ethical codes of conduct, team work and continuous learning for catering the ever changing needs of the society.

PROGRAMME OUTCOMES (POs)

On successful completion of this programme, the students will have the

1. Ability to apply knowledge of mathematics, Science and Engineering.
2. Ability to design a system, component, or process to meet desired needs with realistic constraints such as economical, environmental, social, ethical, health, safety, manufacturability and sustainability
3. Ability to conduct experiments, analyze and interpret data.
4. Capacity to formulate and solve complex problems associated with refinery fields based on the realistic situation.
5. Ability to identify the impact of engineering solutions in a global, economic, and societal context.
6. Ability to communicate effectively by conveying technical material through both formal written medium and also through oral presentations.
7. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practices especially in petroleum and allied industries.
8. The competency in utilizing the available resources effectively and optimally.
9. Knowledge on the importance of professional and ethical responsibilities in an organization.
10. Inclination towards acquiring knowledge on the latest developments in the field of petroleum refining and petrochemicals.

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓	✓	✓	✓	✓	✓	✓			
II		✓	✓	✓		✓				✓
III		✓	✓	✓	✓	✓		✓		
IV		✓			✓	✓			✓	✓

Year	SEM	Subjects	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
Year 1	SEM 1	Advanced Numerical Methods	✓		✓							
		Environmental Health and Safety in Industries		✓			✓			✓		✓
		Petroleum Thermodynamics	✓	✓	✓	✓			✓			
		Petroleum Refinery Engineering	✓	✓	✓	✓			✓			
		Modeling of Transport Process	✓	✓	✓	✓			✓			
		Elective-I										
	SEM 2	Petrochemicals	✓	✓	✓	✓			✓	✓		
		Natural Gas Engineering	✓	✓	✓	✓			✓	✓		
		Process Dynamics And Control	✓	✓	✓	✓			✓			
		Multicomponent Distillation	✓	✓	✓	✓						
		Elective -II										
		Elective -III										
Year 2	SEM 3	Catalytic Reactor Design And Analysis	✓	✓	✓	✓			✓			
		Modeling and Simulation of Industrial Process	✓	✓	✓	✓			✓			
		Elective-IV										
		Project Work Phase I	✓	✓			✓	✓			✓	✓
	SEM 4	Project Work Phase II	✓	✓			✓	✓			✓	✓

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ANNA UNIVERSITY:: CHENNAI 600 025

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

I TO IV SEMESTERS CURRICULUM AND SYLLABUS (FULL TIME)

M. TECH. PETROLEUM REFINING AND PETROCHEMICALS

SEMESTER - I

S.N	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7155	Advanced Numerical Methods	FC	4	4	0	0	4
2.	PP7151	Environmental Health and Safety in Industries	FC	3	3	0	0	3
3.	PP7101	Modeling of Transport Process	PC	3	3	0	0	3
4.	PP7102	Petroleum Refinery Engineering	PC	3	3	0	0	3
5.	PP7103	Petroleum Thermodynamics	PC	3	3	0	0	3
6.		Elective -I	PE	3	3	0	0	3
Practicals								
7.	PP7111	Instrumental Method of Analysis Lab	PC	2	0	0	2	1
			TOTAL	**21**	**19**	**0**	**2**	**20**

SEMESTER - II

S.N	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PP7201	Natural Gas Engineering	PC	3	3	0	0	3
2.	PP7202	Petrochemicals	PC	3	3	0	0	
3.	PP7203	Process Dynamics and Control	PC	3	3	0	0	3
4.	PP7251	Multicomponent Distillation	PC	3	3	0	0	3
5.		Elective II	PE	3	3	0	0	3
6.		Elective III	PE	3	3	0	0	3
Practicals								
7.	PP7211	Petroleum Testing Lab	PC	2	0	0	2	1
			TOTAL	**20**	**18**	**0**	**2**	**19**

SEMESTER - III

S.N	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PP7301	Catalytic Reactor Design and Analysis	PC	3	3	0	0	3
2.	PP7302	Modeling and simulation of Industrial Process	PC	3	3	0	0	3
3.		Elective-IV	PE	3	3	0	0	3
Practicals								
4.	PP7311	Project Work - Phase-I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER – IV

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	PP7411	Project Work- Phase II	PC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS : 66

Foundation Courses (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Advanced Numerical Methods	FC	4	3	1	0	4
2.		Environmental Health and Safety in Industries	FC	3	3	0	0	3

Professional Core (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Petroleum Thermodynamics	PC	3	3	0	0	3
2.		Petroleum Refinery Engineering	PC	3	3	0	0	3
3.		Modeling of Transport Process	PC	3	3	0	0	3

4.		Petrochemicals	PC	3	3	0	0	3
5.		Natural Gas Engineering	PC	3	3	0	0	3
6.		Process Dynamics and Control	PC	3	3	0	0	3
7.		Multicomponent Distillation	PC	3	3	0	0	3
8.		Catalytic Reactor Design and Analysis	PC	3	3	0	0	3
9.		Modeling and simulation of Industrial Process	PC	3	3	0	0	3

Professional Electives (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CL7020	Corrosion Engineering	PE	3	3	0	0	3
2.	CL7075	Industrial Instrumentation	PE	3	3	0	0	3
3.	CL7081	Waste Management and Energy Recovery	PE	3	3	0	0	3
4.	CL7036	Separation Process Techniques	PE	3	3	0	0	3
5.	CL7079	Solvent Extraction	PE	3	3	0	0	3
6.	CL7076	Multiphase Flow	PE	3	3	0	0	3
7.	CL7071	Computational Fluid Dynamics	PE	3	3	0	0	3
8.	CL7024	Enhanced Oil Recovery	PE	3	3	0	0	3
9.	CL7031	Piping and Instrumentation	PE	3	3	0	0	3
10.	CL7030	Petroleum Economics	PE	3	3	0	0	3
11.	CL7077	Process Optimization	PE	3	3	0	0	3
12.	CL7027	Gas Transportation	PE	3	3	0	0	3
13.	CL7073	Fluidization Engineering	PE	3	3	0	0	3
14.	CL7078	Project Engineering of Process Plants	PE	3	3	0	0	3
15.	CL7035	Risk Analysis and Management	PE	3	3	0	0	3
16.	PP7001	Operation Research	PE	3	3	0	0	3
17.	CL7033	Reservoir Engineering	PE	3	3	0	0	3

Employability Enhancement Courses (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Project Work Phase-I	EEC	12	0	0	12	6
2.		Project Work Phase-II	EEC	24	0	0	24	12

MA7155 ADVANCED NUMERICAL METHODS L T P C
4 0 0 4

OBJECTIVE:

- The course objective is to impart knowledge on advanced numerical methods for solving differential equations in science and engineering.
- Analysis and application of advanced numerical methods for solving Partial Differential Equations (PDEs).

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations – Jacobi, Gauss Seidel, SOR methods, Thomas algorithm for tridiagonal systems; Systems of nonlinear equations - successive approximation method, methods for improved convergence, Newton Method and its variants, continuation methods for multiple solutions.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS – IVPs 12

Runge Kutta Methods, step size control and estimates of error, numerical stability, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations;

UNIT III ORDINARY DIFFERENTIAL EQUATIONS – BVPs 12

Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, shooting technique.

UNIT IV PARTIAL DIFFERENTIAL EQUATIONS – FINITE DIFFERENCE METHOD 12

Parabolic equations – Different explicit and implicit methods, alternating direction explicit and implicit methods; Elliptic equations – Point iterative methods, line iterative methods, ADI methods; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines.

UNIT V PARTIAL DIFFERENTIAL EQUATIONS – FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.Function approximation.

TOTAL : 60 PERIODS

OUTCOME:

- Be familiar with numerical solution of ODEs.
- Setup and solve partial differential equations numerically

REFERENCES

1. Gupta, S.K., Numerical Methods for Engineers, New Age Publishers, 2003
2. Jain, M. K., S. R. Iyengar, M. B. Kanchi, R. K. Jain, Computational Methods for Partial Differential Equations, New Age Publishers, 2007.

CL7151 ENVIRONMENTAL HEALTH AND SAFETY IN INDUSTRIES L T P C
3 0 0 3

OBJECTIVE

To illuminate the importance of environmental health and safety in industries besides the necessity for education and training at work place.

UNIT I INTRODUCTION 9

Need for developing Environment, Health and Safety systems in work places. Status and relationship of Acts, Regulations and Codes of Practice .Role of trade union safety representatives. International initiatives. Ergonomics and work place.

UNIT II OCCUPATIONAL HEALTH AND HYGIENE 9

Definition of the term occupational health and hygiene. Categories of health hazards. Exposure pathways and human responses to hazardous and toxic substances. Advantages and limitations of environmental monitoring and occupational exposure limits. Hierarchy of control measures for occupational health risks. Role of personal protective equipment and the selection criteria. Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress.

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS 9

Features of the satisfactory design of work premises HVAC, ventilation. Safe installation and use of electrical supplies. Fire safety and first aid provision. Significance of human factors in the establishment and effectiveness of safe systems. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising from the use of work equipment. Requirements for the safe use of display screen equipment. Procedures and precautionary measures necessary when handling hazardous substances. Contingency arrangements for events of serious and imminent danger.

UNIT IV TECHNIQUES OF ENVIRONMENTAL SAFETY 9

Elements of a health and safety policy and methods of its effective implementation and review. Functions and techniques of risk assessment, inspections and audits. Investigation of accidents- Principles of quality management systems in health and safety management. Relationship between quality manuals, safety policies and written risk assessments. Records and other documentation required by an organisation for health and safety. Industry specific EHS issues.

UNIT V EDUCATION AND TRAINING 9

Requirements for and benefits of the provision of information, instruction, training and supervision. Factors to be considered in the development of effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

TOTAL : 45 PERIODS

OUTCOME

To make students understand the importance of developing Environment, Health and Safety systems in work places.

REFERENCES

1. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
2. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.
3. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services 2005

PP7101 MODELING OF TRANSPORT PROCESS L T P C
3 0 0 3

OBJECTIVES

To give an overview of mass, momentum and energy transport, present the fundamental equations and illustrate how to use them to solve problems.

UNIT I INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS 6

Definition of Friction Factors, Friction Factors for Flow in Tubes, Pressure Drop Required for a Given Flow, Flow Rate for a Given Pressure Drop, Friction Factors for Flow around Spheres Determination of the Diameter of a Falling Sphere, Friction Factors for Packed Columns. Case studies

UNIT II MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS AND POLYMERIC LIQUIDS 12

The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance , Estimation of the Viscous Loss , Power Requirement for Pipeline Flow , Use of the Macroscopic Balances for Steady-State**,** Pressure Rise and Friction Loss in a Sudden Enlargement , Isothermal Flow of a Liquid through an Orifice. Examples of the Behavior of Polymeric Liquids, Rheometry and Material Functions, Non-Newtonian Viscosity and the Generalized Newtonian Models , Laminar Flow of an compressible Power-Law Fluid in a Circular Tube , Flow of a Power-Law Fluid in a Narrow Slit , Tangential Annular Flow of a Power- Law Fluid , Elasticity and the Linear Viscoelastic Models, Molecular Theories for Polymeric Liquids. Practical applications. Case studies

UNIT III INTERPHASE TRANSPORT IN NONISOTHERMAL SYSTEMS 9

Definitions of Heat Transfer Coefficients, Calculation of Heat Transfer Coefficients from Experimental Data **,** Analytical Calculations of Heat Transfer Coefficients for Forced Convection through Tubes and Slits **,** Heat Transfer Coefficients for Forced Convection in Tubes **,** Design of a Tubular Heater **,** Heat Transfer Coefficients for Forced Convection around Submerged Objects **,** Heat Transfer Coefficients for Forced Convection through Packed Beds **,** Heat Transfer Coefficients for Free and Mixed Convection, Heat Loss by Free Convection from a Horizontal Pipe , Heat Transfer Coefficients for Condensation of Pure Vapors on Solid Surfaces. Case studies

UNIT IV MACROSCOPIC BALANCES FOR NONISOTHERMAL SYSTEMS 9

The Macroscopic Energy Balance, The Macroscopic Mechanical Energy Balance, Use of the Macroscopic Balances to Solve Steady-State Problems with Flat Velocity Profiles, The Cooling of an Ideal Gas , Mixing of Two Ideal Gas Streams, Parallel- or Counter- Flow Heat Exchangers, Flow of Compressible Fluids through Head Meters. Case studies

UNIT V INTERPHASE TRANSPORT IN NONISOTHERMAL MIXTURES 9

Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Evaporation from a Freely Falling Drop, Mass Transfer in Creeping Flow through Packed Beds, Mass Transfer to Drops and Bubbles, Definition of Transfer Coefficients in Two Phases, Determination of the Controlling Resistance, Estimation of the Interfacial Area in a Packed Column, Estimation of Volumetric Mass Transfer Coefficients. Case studies

TOTAL : 45 PERIODS

OUTCOMES

To describe mass, momentum and energy transport at molecular, microscopic and macroscopic level, and to determine velocity, temperature and concentration profiles.

TEXT BOOK

1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., “Transport Phenomena”, Revised 2nd Edn., John Wiley and Sons, 2007.

REFERENCES

1. Welty, J.R., Wicks, C. E. and Wilson, R. E., “Fundamentals of Momentum, Heat Mass Transfer”, 5th Edn., John Wiley and Sons, 2010.
2. Brodkey, R. S. and Hershey, H. C., “Transport Phenomena – A Unified Approach”, Brodkey Publishing, 2004.

PP7102 PETROLEUM REFINERY ENGINEERING L T P C
3 0 0 3

OBJECTIVES

To impart detailed knowledge on petroleum refining operations, this course being the last part in a three parts series.

UNIT I **9**

Origin, Exploration and production of petroleum, Types of crudes, Composition, characteristics, products pattern and characteristics, indigenous and imported crudes, Availability Vs Demands, Future outlook.

UNIT II **9**

Engineering aspects of refining, Reaction stoichiometry; Chemical kinetics; Thermochemistry and chemical equilibrium; Mixing in flow systems; Reactor design. Crude heating, Primary distillation, principles, Separation of cuts, Gaps/ overlaps, Stripping, Desalting, heat balance in distillation, Energy input and recovery, Vacuum distillation, Types of trays, Draw offs, intermediate product quality control.

UNIT III **9**

Lube oil and wax processing, Solvent extraction, Dewaxing, Deciling, Deasphalting, Clay contacting, principles, technologies, operating parameters, Feed and product qualities and yields. Asphalt Manufacture, product qualities, Air blowing technology, Tankage operations, Storage and handling of crude products.

UNIT IV **9**

Fluid catalytic cracking, principles, recent developments, Feed stocks and product yields and qualities, Catalysts and operating parameters. Hydrocracking, principles, process requirements, product yields and qualities, Residcracking – implications and technology.

UNIT V **9**

Catalytic reforming and Isomerisation, Reforming, Principles, developments in technology, Catalyst types and their performance, Effects of operating parameters, Feed quality, Product improvement; Sulphur removal, Aromatics removal, Hydrofinishing, Catalyst regeneration, Catalytic dewaxing. Environmental aspects of refining.

TOTAL : 45 PERIODS

OUTCOMES

Students learn about the petroleum additives, support systems, safety measures, environmental, quality and economic aspects.

REFERENCES

1. Nelson, W.L "Petroleum Refinery Engineering" McGraw Hill Publishing Company Limited, 1985.
2. Hobson, G.D. – Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum U.K. 1973.
3. Smalheer, C.V and R.Kennedy Smith Lubricant Additives. The Lezius – Hill Company, Cleveland, Ohio. USA, 1987
4. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, Mc Graw – Hill Publishing Company, NY, 1990.
5. Watkins, R.N "Petroleum Refinery Distillation", 2nd Edition, Gulf Publishing Company, Texas, 1981.

PP7103 PETROLEUM THERMODYNAMICS L T P C

3 0 0 3

OBJECTIVES

To present the application of thermodynamic principles in petroleum and allied processes from chemical engineering viewpoint.

UNIT I INTRODUCTION 9

Behaviour of Gases and Liquids – Gas laws, Density, Mole percent, Weight percent, Volume percent, Specific gravity, Heat, Work Closed and Open Systems, First and Second Laws of thermodynamics, specific heats, Compressibility factor, PVT relationships, Vapour pressure, Claussius – Clayperson equation, heat of vaporization.

UNIT II CHEMICAL THERMODYNAMICS OF PETROLEUM HYDROCARBONS 9

Free energy change, Heat of reaction, Entropy change, Heat capacity, Heat of formation, Fugacity, Pressure – Temperature diagram, Pressure – Volume diagram, Density – Temperature diagram for one and two component system. Pressure – Composition diagram, Temperature – Composition diagram, Temperature – Composition diagram, for multi component system Gibbs phase rule

UNIT III QUALITATIVE PHASE BEHAVIOUR OF HYDROCARBON SYSTEMS 9

Calculation of liquid and vapour composition of Bubble point and Dew point pressure for multi component system. Equilibrium constant

UNIT IV HYDROCARBON FLUID CHARACTERISTICS 9

Gas formation volume factor, Gas solubility, Oil formation volume factor, Viscosity

UNIT V PROPERTIES OF MIXTURES 9

Dalton Law Volumetric analysis of a gas mixture – apparent weight and gas constant – specific heats of a gas mixture – determination of calorific values of fuels – oil and fuel vapour mixtures – steam condenser.

TOTAL : 45 PERIODS

OUTCOME

The Students will be well versed with the behavior of fluids under PVT conditions and also apply them for practical purpose. The study further provides a comprehensive exposition to theory and application of solution thermodynamics.

TEXT BOOK

1. Smith J.M., H.C. Van Ness, M.M. Abbott .Introduction to Chemical Engineering Thermodynamics. VI Edition, Tata M.Graw-Hill publishing Company Limited, New Delhi

REFERENCES
1. Jean vidal, Thermodynamics Application in chemical Engineering and the petroleum industry, Institute Francais bu petrole publications,France 2003
2. Stanley.I.sandler,' Chemical and Engineering Thermodynamics' Wiley, 1988.
3. John J.McKetta Jr. ""Advances in Petroleum Chemistry and Refining"" – Volume 9 (Inter-science Publications), NY, 1983.
4. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad, 2005
5. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn.Prentice Hall, New Jersey, 1997.
6. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid-phase Equilibria, 3rd Edn, Prentice Hall Inc., New Jersey, 1999

PP7111 INSTRUMENTAL METHODS OF ANALYSIS LAB L T P C
0 0 2 1

OBJECTIVES
To impart practical knowledge on various instruments used in petroleum industries.

LIST OF EXPERIMENTS
1. UV-Visible spectrophotometer
2. Laser particle size diffraction analyzer
3. Gas chromatography
4. High performance liquid chromatography
5. Atomic absorption spectrophotometer.
6. Halogen moisture analyzer
7. Thermo gravimetric analyzer
8. Automated capillary microflow porometer
9. Electrochemical workstation

TOTAL : 30 PERIODS

OUTCOMES
Students learn the knowledge on working and usage of instruments like spectrophotometer, particle size analyzer, chromatography etc.,

PP7201 NATURAL GAS ENGINEERING L T P C
3 0 0 3

OBJECTIVES
To know the stages of production and processing of natural gas.

UNIT I INTRODUCTION 12
Availability of natural gas, Properties and composition, Exploration and control of gas, output, Estimation of availability quantity. Natural gas application in Chemical Process and transportation industry LNG technology, Natural gas storage and transport, Economics of natural gas utilization.

UNIT II GAS TREATMENT AND PROCESSING 12
General Hydrodynamic equations for flow of fluids through porous media, two dimensional flow problems and potential theory methods, gravity flow systems, systems of non uniform permeability, multiple well systems using computerized streamline tracking methods.

UNIT III MULTIPHASE SYSTEMS 11

Use of multiphase flow correlations to determine flow ratio and pressure traverse in flowing oil wells, gas condensate wells, gathering systems and pipe lines, application of correlations to the design of gas system

UNIT IV GAS TREATMENT 10

Reservoir fluid properties – PVT properties for oil gas systems, phase Behavior of complex hydrocarbon mixtures at high temperature and pressure – thermodynamic property evaluation, packages used in petroleum industry.

TOTAL : 45 PERIODS

OUTCOMES

To learn origin, properties, treatment, transportation, storage and liquefaction of natural gas.

REFERENCES

1. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, Mc Graw – Hill Publishing Company, NY, 1990.
2. Speight, J.G Fuel Science and Technology Handbook, Marcel Decker Inc. 2007.
3. Guide to Natural Gas Utilization Technologies, Fairmount Press Inc. 1987.
4. Lom. W.L and A.F. Williams, Substitute Natural Gas, Kalstod Willey, New York, 1976.
5. Dermott, M.C. Liquified Natural Gas Technology, Neysos Park Ridge, N.J. 1973.
6. M.J. Econonides A.Daniel “Petroleum Production Systems”, Prentice Hall Petroleum Engineering series 2012.
7. Michael J.Economides, A.Daniel Hill and Christine Ehlig – Economides, Petroleum Production Systems, PTR Prontice Hall, NJ, 2012.
8. Dring, M.M – The Natural Gas Industry – A review of World Resources and Industrial Applications, Butterworth, London, 1974.

PP7202 PETROCHEMICALS L T P C

3 0 0 3

OBJECTIVES

To impart knowledge on petrochemicals used in refinery industries.

UNIT I 5

Petrochemical industries and their feed stocks survey of petrochemical industry. Resources and generation of different feed stocks-their purification, separation of individual components by adsorption, low temperature fractionation and crystallization.

UNIT II 6

Production and utilization of synthesis gas: generation of synthesis gas by steam reforming of naptha and natural gas, fuel oil partial oxidation. chemicals from synthesis gas, methanol via synthesis gas route, formaldehyde from methanol, chloromethane by direct chlorination of methane, trichloroethylene, perchloroethylene by pyrolysis of carbon tetra chloride. Fischer-Tropsch process

UNIT III 10

Petrochemical based on methane, ethylene, acetylene, propylene and butane: acetylene and methanol from methane , VCM, VAM, ethylene oxide and ethylene glycol, ethanol amides from ethylene. VCM, VAM, acrylonitrile etc. from acetylene. Isopropanol, Propylene oxide, Glycerine, acrylonitrile, Acrylic acid, etc. From propylene. Production of butadiene by dehydrogenation of butane, nitrogen.

UNIT IV **12**

Separation and utilization of aromatics: catalytic reforming operation-seperation of BTX from Reformate .isolation of benzene, toluene, xylene. aromatics derived from thermal cracking of naptha, pyrolysis gasoline hydrogenation process. Alkylation of benzene. production of pthalic anhydride etc. synthetic detergents: classification of detergents production of KERYL Benzene Sulphonate etc., filter, binders, dyes, perfumes, etc. for detergents. Hard and soft detergents.

UNIT V **12**

Synthetic fibres, rubbers, plastics, resins: method, mechanism and types of polymerization , production of HDPE,LDPE, PP,PVC, polystyrene, poly butadiene, etc., manufacture of polyesters, nylons, acrylic fibres,etc. production of phenol formaldehyde resin, epoxy resin, production principle of ABS plastic, polycarbonates, etc.manufacturing techniques of butyl rubber, SBR, isoprene rubber, etc .

TOTAL : 45 PERIODS

OUTCOMES

To learn about resources,separation techniques in refining and concerned materials obtained from refining.

REFERENCES

1. Brownstein A.M. Trends in Petrochemical Technology, Petroleum Publishing Company, 1976.
2. B.K.B.Rao, A Text on Petrochemicals, Khanna publishers.
3. I D Mall, Petrochemical process technology, Macmillan, 2006.
4. Robert Meyers, Handbook of Petrochemicals production Processes(McGraw Hill Handbooks), 2004

PP7203 PROCESS DYNAMICS AND CONTROL L T P C
3 0 0 3

OBJECTIVES

To familiarize the students with concepts of process dynamics and control leading to control system design.

UNIT I ADVANCED CONTROL STRATEGIES **9**

Feed forward, cascade, dead time compensation, split range, selective and override control; automatic tuning and gain scheduling

UNIT II INTERNAL MODEL CONTROL **9**

Model based control – IMC structure – development and design; IMC based PID control, MPC

UNIT III MULTIVARIABLE CONTROL **9**

Control loop interaction – general pairing problem, relative gain array and application, sensitivity. Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling

UNIT IV DISCRETE SYSTEMS **9**

Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability.

UNIT V DIGITAL FEEDBACK CONTROLLERS **9**

Design of digital feedback controllers, digital approximation of classical, effect of sampling, Case study of Industrial Instrumentation and Control system, DCS, PLC, shutdown system.

TOTAL : 45 PERIODS

OUTCOMES

To introduce dynamic response of open and closed loop systems, control loop components and stability of control systems along with instrumentation.

REFERENCES

1. Bequette, B. W., Process Control: Modeling, Design, and Simulation, Prentice Hall, 2003
2. Stephanopolous, G., "Chemical Process Control", Prentice Hall of India, New Delhi, 1985.
3. Kannan M. Moudgalya, Digital Process Control, John Wiley & Sons Ltd,2007.

PP7251 MULTI COMPONENT DISTILLATION L T P C
3 0 0 3

OBJECTIVES

To provide the knowledge on principles and operations on MCD.

UNIT I THERMODYNAMIC PRINCIPLE 9

Fundamental Thermodynamic principles involved in the calculation of vapor – liquid equilibria and enthalpies of multi component mixtures – Use of multiple equation of state for the calculation of K values – Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid – phase activity coefficients.

UNIT II THERMODYNAMIC PROPERTY EVALUATION 9

Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures – separation of multi component mixtures at total reflux.

UNIT III MINIMUM REFLUX RATIO FOR MCD SYSTE 9

General considerations in the design of columns – Column sequencing – Heuristics for column sequencing – Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rm for multi component distillation – Underwood method – Colburn method.

UNIT IV VARIOUS METHODS OF MCD COLUMN DESIGN 9

Theta method of convergence – Kb method and the constant composition method – Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Stage and reflux requirements – Short cut methods and Simplified graphical procedures.

UNIT V VARIOUS TYPES OF MCD COLUMNS 9

Design of sieve, bubble cap, valve trays and structured packing columns for multi component distillation – computation of plate efficiencies.

TOTAL : 45 PERIODS

OUTCOMES

Students will be able to develop a sound knowledge on application of thermodynamic principles in MCD, design of MCD columns and types of MCD columns.

TEXT BOOKS

1. Holland, C.D., "Fundamentals of Multi Component Distillation", McGraw Hill Book Company,1981
2. Van Winkle, "Distillation Operations", McGraw Hill Publications, 1987.

PP7211 PETROLEUM TESTING LAB L T P C
0 0 2 1

OBJECTIVES
To impart practical knowledge on different petroleum testing methods.

LIST OF EXPERIMENTS
1. Determination of flash point and fire point
2. Viscosity Determination
3. Aniline point determination
4. API gravity determination
5. Hydrogen sulphide content determination
6. Doctor's test
7. Determination of calorific value
8. Bitumen testing
9. Carbon residue determination (Conradson apparatus)
10. Cloud point and pour point estimation
11. Congealing point of wax
12. Foaming characteristics of lube oil
13. Smoke point estimation
14. Corrosion testing of petroleum oil
15. Distillation characteristics
16. Moisture content determination

Minimum of 10 experiments

TOTAL : 30 PERIODS

OUTCOMES
Students learn petroleum testing, determination of aniline point, softening point, carbon residue, foaming characteristics, sulphur content etc.

PP7301 CATALYTIC REACTOR DESIGN AND ANALYSIS L T P C
3 0 0 3

OBJECTIVES
To introduce the dynamics and design of heterogeneous reactors.

UNIT I INTRODUCTION 9
Design Principles, Continuous Reaction Model, Intrinsic and Global Rate Concepts

UNIT II CHEMICAL ENGINEERING KINETICS 9
Heterogeneous Catalysis, Chemical and Physical Characteristics of Solid Catalysts, Activity, Specific Activity, Selectivity. Kinetics of Heterogeneous Catalytic Reactions, Mechanisms and Kinetic Models, Experimental Reactors and Transport Criteria, Determination of Intrinsic Kinetics

UNIT III TRANSPORT PROCESSES IN SOLID-CATALYZED SYSTEMS 9
External Transport Processes, Internal Transport Processes, Fluidized-Bed Reactors

UNIT IV TWO-PHASE CATALYTIC REACTORS 9
Reactor Types, Fixed-Bed Gas-Solid Catalytic Reactors, Pseudo-homogeneous Fixed-Bed Models, One-Dimensional Heterogeneous Fixed-Bed Models, Design by Scale-Up, Fluidized-Bed Catalytic Reactors

UNIT V TWO-PHASE STRUCTURED REACTORS 9
Engineered Catalysts, Micro-structured Catalytic Reactors - Monolith Reactors, Microreactors

TOTAL : 45 PERIODS

OUTCOMES

Students will be able to study the behavior of catalytic heterogeneous reactors, gas-solid catalytic and non-catalytic reactors and gas-liquid reactors

TEXTBOOK

1. G.F. Froment, K.B, Bischoff, J. de Wilde, Chemical Reactor Analysis and Design, 3rd ed., Wiley & Sons, 2011.

REFERENCES

1. Carberry – J.J. Chemical and Catalytic, Reaction Engineering, McGraw – Hill Book Co., NY, 2001.
2. Muchlyonor I, Dobkina E.,.Deryozhkina V,.and Sorco V., Catalyst Technology – Catalyst Technology MIR Publication, Moscow, 1982.
3. Webterp K.R. Vanswaaij and Beenackers ACM, Chemical Reactor Design and Operations, Wiley, NY 1991.
4. Fogler S. Elements of Chemical Reaction Engineering, 4th edn, Prentice – Hall NJ, 2006.
5. L.K.Duraiswamy & R.A. Mashlekar, Chemical and Catalytic Reaction Engineering – Vol.1 & Vol.2 Wiley Eastern Limited, New Delhi, 1987.
6. Chen N.H. Process Reactor Design, Allyn & Bacon, Boston, 1983.
7. D. Shekawat, J.J. Spivey, D.A. Berry (Eds.), Z.İ. Önsan, A.K. Avci, Reactor Design for Fuel Processing", n "Fuel Cells: Technologies for Fuel Processing", pp. 451-516.

PP7302 MODELING AND SIMULATION OF INDUSTRIAL PROCESS L T P C
3 0 0 3

OBJECTIVES

To understand the principles and applications of modeling and simulation of industrial processes.

UNIT I INTRODUCTION 3

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II STEADY STATE LUMPED SYSTEMS 9

Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flowsheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.

UNIT III UNSTEADY STATE LUMPED SYSTEMS 9

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

UNIT IV STEADY STATE DISTRIBUTED SYSTEM 12

Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems. Empirical modeling, parameter estimation, population balance and stochastic modeling.

UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM 12

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations.

TOTAL : 45 PERIODS

OUTCOMES

To impart knowledge on modeling and simulation, classification of mathematical models,steady and unsteady state lumped and distributed systems and other modeling approaches

REFERENCES

1. Ramirez, W., "Computational Methods in Process Simulation", 2nd Edn., Butterworths, New York, 2000.
2. Luyben, W.L., "Process Modeling Simulation and Control", McGraw-Hill Book Co., 1990.
3. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", John Wiley, 2005.
3. Franks, R. G. E., "Mathematical Modeling in Chemical Engineering", John Wiley,1967.

PP7311	PROJECT WORK PHASE I	L T P C 0 0 12 6

Students have to do a research-based project in the department or in an industry and should submit a report at the end of Phase I

PP7411	PROJECT WORK PHASE II	L T P C 0 0 24 12

Phase II of Project Work is a continuation of Phase I of Project. Students should submit a report at the end of Phase II.

CL7020	CORROSION ENGINEERING	L T P C 3 0 0 3

OBJECTIVES

To impart knowledge on corrosion in petroleum refining.

UNIT I TYPES OF CORROSION AND TESTING METHODS 9

Basic principles of corrosion and its control – Forms of corrosion, uniform, Galvanic, Crevis, pitting, selective leaching, erosion, stress-corrosion, cracking – Cavitation phenomena & their effects – Corrosion testing – Field testing – Electrochemical techniques for measurement of corrosion rates, corrosion detection and components examination – Accelerated salt-spray testing.

UNIT II CORROSION PROTECTION METHODS 9

Corrosion inhibitors, electroplated coatings, conversion coatings, anodizing, hot dipping, spray metal coatings, zinc coating by alloying, electrophoteric coatings and electro painting, powder coating, electrical methods of corrosion protection, composite materials in corrosion minimization – Cathodic and Anodic protections.

UNIT III CORROSION IN SPECIFIC ENVIRONMENTS 9

Corrosion damage to concrete in industrial and marine environments and its protection; biological corrosion, halogen corrosion of metals, environmental degradation of materials, corrosion and inspection managements in chemical processing and petrochemical industries.

UNIT IV CORROSION IN SPECIFIC CASES AND CONTROL 12

Corrosion in structure – corrosion of stainless steels – corrosion in power equipments, corrosion in electrical and electronic industry – corrosion and selection of materials of pulp and paper plants – corrosion aspects in nuclear power plants – corrosion of surgical implants and prosthetic devices.

UNIT V CORROSION AND COUNTRY'S ECONOMY 6

Corrosion protection management–process maintenance procedures under corrosion Environments

TOTAL : 45 PERIODS

OUTCOMES

Students learn about the types of corrosion, protection methods, corrosion in specific environments, corrosion in specific cases and control.

TEXT BOOK

1. Fontana, M.G., "Corrosion Engineering", Edn 3, McGraw Hill, 1989

REFERENCE

1. Roberge, P.R., Handbook of Corrosion Engineering, McGraw-Hill,2000

CL7075 INDUSTRIAL INSTRUMENTATION L T P C
3 0 0 3

OBJECTIVES

To introduce control equipments used to control the production process of a chemical factory and the mechanism of control through automation and computers.

UNIT I 5

Introduction – Variables, Units & standards of measurement, Measurement terms – characteristic. Data Analysis.

UNIT II 12

Process Variables Measurement–Temperature systems– Thermocouples, Thermo resistive system, Filled-system thermometers, Radiation thermometry, Location of temperature measuring devices in equipments, Pressure system – Mechanical pressure elements Pressure Transducers and Transmitters, Vacuum measurement, Resonant wire pressure Transducer, Flow system – Differential producers, Variable area flow meters, Velocity, vortex, mass, ultrasonic & other flow meters, positive displacement flow meters, Open – channel flow measurements, Force systems, Strain gauges Humidity Moisture system, Humidity Measurement, Moisture measurement system, Rheological system, Viscosity measurement, Radiation system, Nuclear radiation instrumentation.

UNIT III 12

Analytical instrumentation – Analysis instruments, Sample conditioning for process analyzers, X-ray Analytical methods, Quadrupole mass spectrometry, Ultra violet Absorption Analysis, Infra red process analyzers, Photometric reaction product analysers Oxygen analyzers, Oxidation – reduction potential measurements, pH measuring systems, Electrical conductivity and Resistivity measurements, Thermal conductivity, gas analysis, Combustible, Total hydro carbon, and CO analyzer, Chromatography.

UNIT IV **9**

Fundamentals of Automatic process control – Control algorithms-Automatic controllers – Electronic controllers -Electric controllers (Traditional) - Hydraulic controllers – Fluidics - Programmable controllers.

UNIT V **7**

Sensors, Transmitters and control valves - Pressure, Flow, Level, Temperature and Composition sensors, Transmitters, Pneumatic and electronic control valves, Types, Actuator, accessories, Instrumentation symbols and Labels.

TOTAL : 45 PERIODS

OUTCOMES

Students get the knowledge on how to measure process variables, analytical instrumentation, automatic process controls.

REFERENCES

1. Fribance, "Industrial Instrumentation Fundamentals" ,Mc Graw Hill Co. Inc. New Yor 1985
2. Eckman D.P. "Industrial Instrumentation", Wiley Eastern Ltd., 1989.
3. Considine D M and Considine G D "Process Instruments Controls" Handbook 3rd Edition, McGraw – Hill Book Co., NY, 1990.
4. Scborg D E,.Edgar T.F and Mellichamp D.A, "Process Dynamics and Control" John Wiley 1989.
5. Ernest Doebelin, Measurement systems, McGraw – Hill Book, Co., NY, 1975.
6. Astrom K.J., Bjon wittenmark, Computer controlled systems, Prentice- Hall of India, New Delhi 1994.
7. Cartis Johnson, Process Control Instrumentation Technology, Prentice-Hall of India, New Delhi 1993.

CL7081 WASTE MANAGEMENT AND ENERGY RECOVERY **L T P C**
3 0 0 3

OBJECTIVE

To focus on characteristics of various industrial wastes, management and energy recovery.

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES **6**

Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES **8**

Onsite handling, storage and processing – types of waste collection mechanisms - transfer Stations : types and location – manual component separation - volume reduction: mechanical, thermal – separation : mechanical, magnetic electro mechanical

UNIT III ENERGY GENERATION TECHNIQUES **16**

Basics, types, working and typical conversion efficiencies of composting – anaerobic digestion – RDF – combustion – incineration – gasification – pyrolysis

UNIT IV HAZARDOUS WASTE MANAGEMENT **8**

Hazardous waste – definition - potential sources - waste sources by industry – impacts – waste control methods – transportation regulations - risk assessment – remediation technologies – Private public paternership – Government initiatives.

UNIT V ULTIMATE DISPOSAL **7**

Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases.

TOTAL : 45 PERIODS

OUTCOMES

To make students understand about characteristics of various waste, their collection, transport and processing techniques,

TEXT BOOKS

1. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed. McGraw-Hill, New York, 1993.
2. Howard S. Peavyetal, Environmental Engineering, McGraw Hill International Edition, 1985

REFERENCES

1. LaGrega, M., et al., Hazardous Waste Management, McGraw-Hill, c. 1200 pp., 2nd ed., 2001.
2. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
3. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
4. ManojDatta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.

CL7036 SEPARATION PROCESS TECHNIQUES L T P C
3 0 0 3

OBJECTIVE

To present recent advances in separation techniques from a chemical engineering view point

UNIT I GENERAL 12

Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. process concept, theory and equipment used in cross flow filtration, cross flow electrofiltration, dual functional filter, surface based solid-liquid separations involving a second liquid, sirofloc filter.

UNIT II MEMBRANE SEPARATIONS 8

Types and choice of membranes, plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, commercial, pilot plant and laboratory membrane pemeators involving dialysis, reverse osmosis, nanofiltration, ultrafiltration, microfiltration and Donnan dialysis, economics of membrane operations, ceramic membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES 8

Mechanism, types and choice of adsorbents, normal adsorption techniques, affinity chromatography and immuno chromatography, types of equipment and commercial processes, recent advances and process economics

UNIT IV IONIC SEPARATIONS 8

Controlling factors, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes and applications

UNIT V OTHER SEPARATION TECHNIQUES 9

Separations involving lyophilization, pervaporation and permeation techniques for solids, liquids and gases, industrial viability and examples, zone melting, addiuctive crystallization, other separation processes, supercritical fluid extraction, oil spill management, industrial ffluent treatment by modern techniques.

TOTAL : 45 PERIODS

OUTCOMES
To learn Liquid-solid, Gas-Solid, Liquid-Gas separation process, membrane modules, separation techniques and membrane materials.

REFERENCES

1. King, C. J., "Separation Processes", Tata McGraw Hill Co., Ltd., 1982.
2. Nakagawal, O. V., "Membrane Science and Technology", Marcel Dekker, 1992.
3. Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 2009.
4. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
5. Phillip C. Wankat , Separation Process Engineering (2nd Edition),Printice Hall,2007

CL7079 SOLVENT EXTRACTION L T P C
3 0 0 3

OBJECTIVES
To impart knowledge on principles of solvent extraction and the design of extractors.

UNIT I EQUILIBRIUM IN LIQUID-LIQUID SYSTEM 12
Binary and ternary liquid equilibria, Tie-lines, Critical solution temperature, Tie line correlations ,Contour/prism diagrams, Binary / Ternary prediction methods of activity coefficient, Theory and Prediction of diffusivity in liquids, Theory of inter phase mass transport, Estimation and prediction of mass transport coefficients.

UNIT II DIFFERENTIAL / STAGE-WISE EQUILIBRIUM CONTACT OPERATIONS 9
Equilibrium stage-wise contact, Single and multiple contacts with co-current and counter current flow of phases for immiscible and partially miscible solvent phases , Calculation methods, Fractional extraction with reflux of raffinate and extract. Differential contact, HETS, NETS, HTU, NTU concepts and Estimation of these parameters, Mass transfer efficiency, Axial mixing and Residence time distribution in extractors and their estimation.

UNIT III DISPERSION AND COALESCENCE IN EXTRACTORS 12
Characteristics of dispersion involving single and multiple nozzle distributors, Drop size and formation and coalescence, Mean drop size at dispersion and their settling velocities/relative characteristics velocities. Effect of drop oscillation ,wobbling and Internal circulation, Effect of surface active agents, Prediction of drop size and characteristics velocity in spray , packed and mechanically agitated contactors as in RDC, pulsed columns, solute transfer effects on drop dynamics.

UNIT IV DESIGN OF LIQUID EXTRACTION COLUMNS 12
Design of extractor height and diameter, Prediction of flow capacities in terms of flooding rates, Regime of operating envelops, Hydrodynamic design variables such as hold up, characteristic velocities, pressure drop, Effect of direction of solute transfer on these variables and their prediction methods, Correction of mass transfer data, Axial mixing correction for column height, Interfacial area estimations, using slow, fast and instantaneous reactions and their application with models for mass transfer coefficients.

TOTAL : 45 PERIODS

OUTCOMES
Student will be able to develop a sound knowledge on equilibrium in liquid-liquid system, HETS, NETS, HTU, NTU, dispersion and coalescence in extractors and design of extraction column.

REFERENCES

1. Laddha, G. S. and Degaleesan, T. E., "Transport Phenomena in Liquid Extraction", Tata McGraw Hill, New Delhi, 1976.

2. Hanson, C., Baird, M. H. I. and Lo, T. C., “Hand Book of Solvent Extraction”, Wiley International, New York, 1983.
3. Hanson, C., “Recent Advances in Liquid Extraction”, Pergamon Press, London, 1972.
4. Treybal, R. E., “Liquid Extraction”, McGraw Hill, New York, 1963.

CL7076 MULTIPHASE FLOW L T P C
3 0 0 3

OBJECTIVE

To analyze, characterize the multiphase systems and appreciate the role of structure in multiphase flows. To understand the limitations of modeling in multiphase flows and to comprehend engineering problems involving multiphase flows

UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS 9

Significance of multiphase flows, important non-dimensional numbers, parameters of characterization, particle size measurement, size distribution and moments, size distribution models

UNIT II PARTICLE FLUID INTERACTION 9

Equation of motion for a single particle, calculation of drag, motion of a particle in two dimensions, effects of unsteady and non-uniform flow fields, effect of acceleration, effect of coupling; Interaction between particles, mechanism of interaction, interparticle forces, hard sphere model, soft sphere model, discrete element modeling, semi-empirical methods, kinetic theory, force chains.

UNIT III MODELING OF MULTIPHASE FLOWS 9

Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

UNIT IV CONSERVATION EQUATIONS 9

Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling.

UNIT V MULTIPHASE SYSTEMS 9

Flow regime and hydrodynamic characteristics of packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds; Conventional and novel measurement techniques for multiphase systems including CARPT, Laser Doppler anemometry, Particle Image Velocimetry.

TOTAL : 45 PERIODS

OUTCOMES

Students develop a sound knowledge on underlying concepts of multiphase flows and different approaches to model such flows under different conditions.

REFERENCES

1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 2005.
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 2011
3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press,2005
4. Govier, G. W. and Aziz. K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold, New York, 1972.
5. Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003
6. Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York.2008.
7. Wallis, G.B., “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969.

CL7071 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

OBJECTIVE

To educate engineering graduates in the principles of computational fluid dynamics modeling and in interpretation of fluid dynamics principles.

UNIT I CONSERVATION LAWS AND TURBULENCE MODELS 9

Governing equations of fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Characteristics of turbulent flows, time averaged Navier Strokes equations, turbulence models-one and two equation, Reynolds stress, LES and DNS

UNIT II FINITE DIFFERNCE APPROXIMATION 9

Mathematical behaviour of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods, error and stability analysis

UNIT III FINITE VOLUME METHOD 15

Diffusion problems – explicit and implicit time integration; Convection-diffusion problems – properties of discretisation schemes, central, upwind, hybrid, QUICK schemes; Solution of discretised equations.

UNIT IV FLOW FIELD COMPUTATION 6

Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

UNIT V GRID GENERATION 6

Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

TOTAL : 45 PERIODS

OUTCOMES

Students will be able to demonstrate competence in setting up computational fluid dynamics models for some industrially important applications. This technical competence in building and conducting CFD simulations is a skill which enhances employability.

REFERENCES

1. Anderson, J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw-Hill, 1995.
2. Fletcher, C. A. J., “Computational Techniques for Fluid Dynamics”, Springer Verlag, 1997.
3. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education Ltd., 2007.
4. Chung T.J Computational Fluid Dynamics Cambridge University Press 2003.
5. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, NarosaPublishing House, New Delhi, 2001.
6. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw – Hill Publishing Company Ltd. 1998.
7. Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
8. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stock Equation”, Pineridge Press Limited, U.K., 1981.

CL7024 ENHANCED OIL RECOVERY L T P C
3 0 0 3

OBJECTIVES
To impart knowledge on how residual oil is recovered and the problems associated with Enhanced Oil Recovery.

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY 9
Pore Geometry, Microscopic aspects of displacement. Residual oil magnitude and mobilization. Buoyancy forces and prevention of trapping, Wettability, Residual oil and Oil recovery. Macroscopic aspect of displacement.

UNIT II WATER FLOODING 9
Properties, sampling and analysis of oil field water; Injection waters; Water flooding - Sweep efficiency, Predictive techniques, Improved water flood processes, Performance of some important water floods.

UNIT III ENHANCED OIL RECOVERY OPERATIONS-1 10
Flooding – miscible, CO2, polymer, alkaline, surfactants, steam;

UNIT IV ENHANCED OIL RECOVERY OPERATIONS-2 10
Gas injection, in-situ combustion technology, microbial method.

UNIT V PROBLEMS IN ENHANCED OIL RECOVERY 7
Precipitation and deposition of Asphaltenes and Paraffins, Scaling problems, Formation of damage due to migration of fines, Environmental factors.

TOTAL : 45 PERIODS

OUTCOMES
Students would gain knowledge on residual oil recovery, operations and problems of Enhanced Oil Recovery.

REFERENCES

1. Donaldson, E.C. and G. V. Chilingarian, T. F. Yen, “Enhanced oil Recovery – I & II”, Fundamentals and Analysis, Elsevier Science Publishers, New York, 1985.
2. Lake, L.W., “Enhanced oil recovery”, Prentice Hall, 1989.
3. Schumacher, M.M., “Enhanced oil recovery: Secondary and tertiary methods”, Noyes Data Corp., 1978.
4. Van Poollen, H.K. “Fundamentals of enhanced oil recovery”, PennWell Books, 1980.

CL7031 PIPING AND INSTRUMENTATION L T P C
3 0 0 3

OBJECTIVES
To impart knowledge on piping technology and instrumentation on pipelines.

UNIT I FUNDAMENTALS OF PIPING ENGINEERING 9
Definitions, Piping Components their introduction, applications. Piping MOC, Budget Codes and Standards, Fabrication and Installations of piping.

UNIT II PIPE HYDRAULICS AND SIZING 9
Pipe sizing based on velocity and pressure drop consideration cost, least annual cost approach, pipe drawing basics, development of piping general arrangement drawing, dimensions and drawing of piping.

UNIT III PLOT PLAN **9**

Development of plot plan for different types of fluid storage, equipment layout, process piping layout, utility piping layout. Stress analysis -Different types of stresses and its impact on piping, methods of calculation, dynamic analysis, flexibility analysis.

UNIT IV PIPING SUPPORT **9**

Different types of support based on requirement and its calculation.

UNIT V INSTRUMENTATION **9**

Final Control Elements; measuring devices, instrumentation symbols introduction to process flow diagram (PFD) and piping & instrumentation diagram (P&ID)

TOTAL : 45 PERIODS

OUTCOMES

Students gain knowledge on fundamentals of piping engineering, pipe hydraulics, piping supports and instrumentation.

TEXT BOOKS

1. Piping Handbook, 6 th edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook edited by Johan J McKetta, CRC Press, 1992.
3. Luyben, W. L.," Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.

CL7030 PETROLEUM ECONOMICS **L T P C**
3 0 0 3

OBJECTIVES

To introduce process economics and industrial management principles.

UNIT I **9**

Introduction to upstream economics analysis, energy overview of India – Time value of money, cash flow analysis, capital budgeting techniques, general probability, elements of oil and gas project cash flows.

UNIT II **9**

Reserves classification methods, quantification, assessment of geoscience and reservoir engineering uncertainties – Assessment of reserves, production and demand in international market.

UNIT III **9**

Inflation and cost escalation, oil market and OPEC, share of non OPEC countries in oil production – International oil and gas pricing mechanism – Geopolitics.

UNIT IV **9**

Petroleum Fiscal system, classification and analysis – Reserves Auditing – Accounting systems for oil and gas.

UNIT V **9**

Project Economic Evaluation and petroleum economic models – Decision analysis – Valuation of petroleum properties.

TOTAL : 45 PERIODS

OUTCOMES

Students will be able to make cost estimation, feasibility analysis,management, organization and quality control that will enable the students to perform as efficient managers.

REFERENCES

1. Abdel-Aal, H. K. Bakr, A. B. Al-Sahlawi. A : Petroleum Economics and Engineering, Dekrer Publication, 1992
2. Cronquist, C., Estimation and classification of Reserves of Crude oil, Natural Gas, and Condensate, SPE (2001)
3. Johnston, D, "International Exploration Economics, Risk, and Contract Analysis", Pennwell Books, 2003.
4. Seba R. D., "Economics of Worldwide Petroleum Production", OGCL Publications, USA, 1998.
5. Thompson R. S. and Wright J. D., "Oil Property Evaluation", 2nd Edition, Thompson Wright Associates, 1985.

CL7077 PROCESS OPTIMIZATION L T P C
3 0 0 3

OBJECTIVE

To impart basic knowledge in process optimization.

UNIT I INTRODUCTION 5

Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, Types of optimization problem.

UNIT II LINEAR PROGRAMMING 10

Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III NONLINEAR UNCONSTRAINED OPTIMIZATION 10

Convex and concave functions unconstrained NLP, Newton's method Quasi-Newton's method, Examples.

UNIT IV CONSTRAINED OPTIMIZATION 10

Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT V MULTI OBJECTIVE OPTIMIZATION 10

Weighted Sum of Squares method, Epsilon constrain method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

TOTAL : 45 PERIODS

OUTCOMES

Students would be able to optimize the process for a given chemical industry at the end of the course.

REFERENCES

1. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
2. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer, 2003.
3. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
4. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 2000

CL7027 GAS TRANSPORTATION L T P C
3 0 0 3

OBJECTIVES
To present various gas transportation methodologies.

UNIT I 9
Introduction, widespread use, the various types, the advantages and the special features of pipelines.

UNIT II 9
The fluid mechanics of various types of pipe flow including incompressible and compressible flows of Newtonian fluids, non-Newtonian fluids, flow of solid/liquid mixture (slurry), flow of solid/air mixture (pneumatic transport), and flow of capsules (capsule pipelines).

UNIT III 9
Various types of pipes (steel, concrete, PE, PVC, etc.), valves (gate, globe, ball, butterfly, etc.) and pressure regulators in pipelines. Blowers and compressors (for gases). Various kinds of flowmeters, sensors, pigs (scrapers) and automatic control systems used in pipelines.

UNIT IV 9
Various means to protect pipelines against freezing, abrasion and corrosion, such as cathodic protection, Planning, construction and operation of pipelines, including modern use of advanced technologies such as global positioning systems (GPS), directional drillings, automatic control using computers, and pipeline integrity monitoring such as leak detection.

UNIT V 9
Structural design of pipelines —load considerations and pipe deformation and failure. Economics of pipelines including life-cycle, Cost analysis and comparison of the cost ffectiveness of pipelines with alternative modes of transport such as truck or railroad. Legal, safety and environmental issues about pipelines.

TOTAL : 45 PERIODS

OUTCOMES
Students would gain knowledge on selection of right type of transport and various types of pipes, pipeline protection techniques and design of pipeline.

REFERENCES

1. Liu, H., R. L. Gandhi, M. R. Carstens and G. Klinzing, "Freight pipelines: current status and anticipated use,"(Report of American Society of Civil Engineers (ASCE) Task Committee on freight Pipelines), ASCE J. of Transportation Engr., vol. 124, no.4, pp.300-310, Jul/Aug 1998.
2. Liu, H and T. Marrero, "Pipeline engineering research and education at universities in the United States," C.D. Proc. of Intl. Conf. on Engr. Education (ICEE-98), Rio de Janeiro Brazil, 15 pages, August 17-20, 1998.

CL7073 FLUIDIZATION ENGINEERING L T P C
3 0 0 3

OBJECTIVE
To encompass the new areas and introduce reactor models specifically for these contacting regimes.

UNIT I INTRODUCTION 5
The Fluidized state, Nature of hydrodynamic suspension, particle forces, species of Fluidization, Regimization of the fluidized state, operating models for fluidization systems, Applications of fluidization systems.

UNIT II HYDRODYNAMICS OF FLUIDIZATION SYSTEMS 12

General bed behaviour, pressure drop, Flow regimes, Incipient Fluidization, Pressure fluctuations, Phase Holdups, Measurements Techniques, Empirical Correlations for Solids holdup, liquid holdup and gas holdup. Flow models – generalized wake model, structural wake model and other important models.

UNIT III SOLID MIXING AND SEGREGATION 8

Phase juxtapositions operation shifts, Reversal points, Degree of segregation, Mixing Segregation equilibrium, Generalised fluidization of poly disperse systems, liquid phase Mixing and gas phase mixing.

UNIT IV HEAT AND MASS TRANSFER IN FLUIDIZATION SYSTEMS 12

Mass transfer – Gas Liquid mass transfer, Liquid Solid mass transfer and wall to bed mass transfer, Heat transfer – column wall – to – bed heat transfer, Immersed vertical cylinder to bed heat transfer, Immersed horizontal cylinder to bed heat transfer.

UNIT V MISCELLANEOUS SYSTEMS 8

Conical Fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and Three phase inverse fluidized bed, Draft tube systems, Semifluidized bed systems, Annular systems, Typical applications, Geldart's classification for power assessment, Powder characterization and modeling by bed collapsing.

TOTAL : 45 PERIODS

OUTCOMES

Students would be able to determine the minimum fluidization velocity for the given bed of particles. To find the bed expansion with increasing gas velocity. To qualitatively observe the behaviour of a gas fluidized bed with increasing gas velocity.

REFERENCES

1. Fan, L. S., "Gas- liquid Solid Fluidization Engineering", Butterworths, 1989,
2. Kwauk, M., "Fluidization - Idealized and Bubbleless, with applications", Science Press, 2009.
3. Kunii, D. and Levenspiel, O., "Fluidization Engineering", 2nd Edn., Butterworth Heinemann, London, 1991.

CL7078 PROJECT ENGINEERING OF PROCESS PLANTS L T P C
3 0 0 3

OBJECTIVE

To understand the basic criteria to formulate a project with engineering concepts.

UNIT I 9

Project definition, Project Profile and standards, Feed back information (MIS), Evaluation and Modification, Selection, Criteria.

UNIT II 9

Planning the process, Strategic and Managerial Planning, Organising the process planning, cost and costing, Cost Control systems, Economic Balancing, Network Planning, Methods (PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Cost – Benefit Ratio Analysis, Project Budgeting, Capital Requirements, capital Market, Cash Flow Analysis, Break even strategies.

UNIT III **9**

Plant Engineering Management, Objectives, Programme, Control, Plant Location and Site Selection, Layout diagrams, Selection and procurement of equipment and machineries, Installation, Recommission, Commissioning and performance appraisal, Strategies choice and Influence, Product planning and development, Provision and maintenance of service facilities.

UNIT IV **9**

Process safety, Materials safety and Handling regulations, Safety in equipment and machinery operations, Design considerations of safety organization and control, Pollution, Pollution control and Abatement, Industrial Safety Standard Analysis.

UNIT V **9**

Government regulations on procurement of raw materials and its allocation. Export – Import regulations, Pricing policy, Industrial licensing procedure, Excise and other commercial taxes, Policies on depreciation and corporate tax, Labour laws, Social welfare legal measurements, Factory act, Regulations of Pollution Control Board.

TOTAL : 45 PERIODS

OUTCOMES

Students would be able to design a project at the end of the course by themselves.

REFERENCES

1. Cheremisinoff, N. P., Practical Guide to Industrial Safety: Methods for Process Safety Professionals, CRC Press, 2001
2. Couper, J. R., Process Engineering Economics, CRC Press, 2003.
3. Perry, J. H. “Chemical Engineer’s Hand Book”, 8th Ed., McGraw Hill, New York, 2007.
4. Peters, M. S., Timmerhaus, C. D. and West, R. E., “Plant Design and Economics for Chemical Engineers”, 5th Edn., McGraw Hill, 2003.
5. Silla, H., Chemical Process Engineering: Design and Economics, CRC Press, 2003
6. Vinoski, W., Plant Management Handbook, Pearson Education, Limited, 1998
7. Watermeyer, P., Handbook for Process Plant Project Engineers, John Wiley and Sons, 2002**.**

CL7035 **RISK ANALYSIS AND MANAGEMENT** **L T P C**
3 0 0 3

OBJECTIVE

To know about various risks in the process industries.

UNIT I **9**

General: Risk types, Completion, Permitting, Resource, Operating, Environmental, Manageable, Insurable, Risk Causes, Risk Analysis types and causes.

UNIT II **9**

Techniques: General, Risk adjusted discounted rate method, Certainty Equivalent Coefficient method, Quantitative Sensitivity analysis, Probability distribution, Coefficient of variation method, Simulation method, Crude Procedures, Payback period, Expected monetary value method, Refined procedures, Shackle approach, Hiller’s model, Hertz model, Goal programming.

UNIT III **9**

Risk Management: Emergency relief Systems, Diers program, Bench scale experiments, Design of emergency relief systems, Internal emergency planning, Risk management plan, mandatory technology option analysis, Risk management alternatives, risk management

tools, risk management plans, Risk index method, Dowfire and explosion method, Mond index Method.

UNIT IV **9**

Risk Assurance and Assessment: Property Insurance, Transport insurance, Liability insurance, Pecunious insurance, Risk Assessment, Scope Canvey study, Rijimond pilot study, Low Probability high consequence events. Fault tree analysis, Event tree analysis, Zero Infinity dilemma.

UNIT V **9**

Risk Analysis in Chemical Industries: Handling and storage of Chemicals, Process plants, Personnel protection equipments. Environmental risk analysis, International environmental management system, Corporate management system, Environmental risk assessment, Total quality management, Paradigms and its convergence.

TOTAL : 45 PERIODS

OUTCOMES

To analyze, reduce and minimize the risks identified through risk analysis.

REFERENCES

1. Srivastav, S., "Industrial Maintenance Management", Sultan Chand & Co., 1998.
2. Rao, P. C. K., "Project Management and Control", Sultan Chand & Co., Ltd., 1996
3. Sincero, A. P. and Sincero, G. A., "Environmental Engineering – A Design Approach", Prentice Hall of India, 1996.
4. Pandya, C. G., "Risks in Chemical Units", Oxford and IBH Publishers, 1992.
5. Fawcett, H. H., "Safety and Accident Prevention in Chemical Operations by John Wiley & Sons, 1982.
6. Kind, R. W., "Industrial Hazard and Safety Handbook" Butterworth, 1982.
7. Steiner, H. M., "Engineering Economic Principles", McGraw Hill Book Co., New York, 1996.

PP7001 **OPERATION RESEARCH** **L T P C**
3 0 0 3

OBJECTIVE

To provide a general idea of how to approach engineering problems using scientific approach.

UNIT I MATHEMATICAL PROGRAMMING **12**

Introduction, Linear Programming, Solution by simplex method, Duality, Sensitivity analysis, Dual simplex method, Integer Programming, Branch and bound method, Geometric programming and its application.

UNIT II DYNAMIC PROGRAMMING **10**

Elements of DP models, Bellman's optimality criteria, Recursion formula, Solution of multistage decision problem by DP method. Application is Heat Exchange Extraction systems.

UNIT III PERT, CPM and GERT **9**

Network representation of projects, Critical path calculation, construction of the time chart and resource leveling, Probability and cost consideration in project scheduling, Project control. Graphical Evaluation and Review Techniques.

UNIT IV ELEMENTS OF QUEUING THEORY **7**

Basic elements of the Queuing model, M/M/1 and M/M/C Queues.

UNIT V ELEMENTS OF RELIABILITY THEORY 7

General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.

TOTAL : 45 PERIODS

OUTCOMES

To learn various methods of solving engineering problems using mathematical tools.

REFERENCES

1. Carter, M. W. and Price, C. C., Operations Research: A Practical Introduction Contributor, CRC Press, 2001.
2. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
3. Hillier, F. S., and Lieberman, G. J., Introduction to Operations Research, McGraw- Hill, 2005
4. Taha, H. A., "Operations Research, An introduction", 6th Ed., Prentice Hall of India, New Delhi, 2006.

CL7033 RESERVOIR ENGINEERING L T P C

3 0 0 3

OBJECTIVES

To provide a general idea about Reservoir Drive Mechanisms and also to understand the effects of production/ injection on recovery of reserves.

UNIT I 12

Fluid Flow Through Porous Media. Single Phase and Multiphase Flow Equations, Linear and Radial flow in Reservoir: Derivation of Diffusivity Equation, PVT Analysis for Oil: Hydrocarbon Phase Behavior, Determination of the PVT Parameters.

UNIT II 12

Gas Reservoir Engineering, Condensate Reservoirs, Reserve estimation Methods: Volumetric and Material Balance Equation. Reservoir Simulation.

UNIT III 12

Reservoir Drive Mechanisms, Natural Water Influx Reservoir, Pressure Maintenance water Flooding Performance Calculations for Stratified Reservoirs.

UNIT IV 9

Productivity Index, IPR. Water and Gas Coning, Decline Curve Analysis

TOTAL : 45 PERIODS

OUTCOMES

To enable the student to interpret cross plots, flow through porous media, PVT analysis for oil, simulation and gas condensate reservoirs.

REFERENCES

1. Petroleum Reservoir Engineering Physical Properties James W. Amyx, Daniel M. Bass and Robert L. Whiting
2. Oil Reservoir Engineering S.J. Pirson
3. Applied Petroleum Reservoir Engineering B.C Craft, M. Hawkins, and Ronald E. Terry.
4. Integrated Petroleum Reservoir Management: A. satter, G. Thakur.
5. Gas Reservoir Engineering: John W. Lee and R.A. Wattenbarger.
6. Towler, B. Fundamental Principles of Reservoir Engineering
7. Dake, L.P; Fundamentals of reservoir Engineering