Manipal University Jaipur
Department of Chemical Engineering

B.Tech. Revamped Curriculum
Programme Structure (Batch: 2015-2019 and onwards)

III Semester

	Teaching Scheme		L	T	P	C	Exam Duration (h)		Relative weightage %				
	Course Code	Course Title					Theory	Practical	CWS	PRS	MTE	ETE	PRE
III Semester	BB1101	Value, Ethics & Governance	2	0	0	2	2		--		--	--	
	MA1310	Engineering Mathematics III	3	0	0	3	3		30		40	30	
	CY1321	Organic Chemistry	3	1	0	4	3		30		40	30	
	CE1305	Chemical Process Calculations	3	0	0	3	3		30		40	30	
	CE1306	Momentum Transfer	3	0	0	3	3		30		40	30	
	CE1307	Process Synthesis	3	0	0	3	3		30		40	30	
	CE1304	Engineering Materials	3	0	0	3	3		30		40	30	
	CY1340	Organic Chemistry Lab	0	0	4	2		4	60				40
	Total		**20**	**1**	**4**	**23**							

IV Semester

	Course Code	Course Title	L	T	P	C	Exam Duration (h)		Relative weightage %				
							Theory	Practical	CWS	PRS	MTE	ETE	PRE
IV Semester	CE1405	Transport Phenomena	3	0	0	3	3		30		40	30	
	CE1406	Chemical Engineering Thermodynamics	3	0	0	3	3		30		40	30	
	CE1407	Heat Transfer Operations	3	0	0	3	3		30		40	30	
	CE1408	Numerical Methods in Chemical Engineering	3	0	2	4	3		30		40	30	
	CY1421	Physical and Analytical Chemistry	3	1	0	4	3		30		40	30	
		Open Elective I	3	0	0	3	3		--		--	--	
	CY1440	Physical and Analytical Chemistry Lab	0	0	4	2		4	60				40
	Total		**18**	**1**	**6**	**22**							

V Semester

V Semester	Teaching Scheme		L	T	P	C	Exam Duration (h)		Relative Weightage %				
	Course Code	**Course Title**					**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
	CE1505	Process Modeling and Simulation	3	0	0	3	3	-	30	-	40	30	-
	CE1506	Mass Transfer I	3	0	0	3	3	-	30	-	40	30	-
	CE1507	Chemical Reaction Engineering I	3	0	0	3	3	-	30	-	40	30	-
		Program Elective I	3	0	0	3	3	-	30	-	40	30	-
		Open Elective II	3	0	0	3	3						
	CE1531	Transport Phenomena Lab I	0	0	4	2	-	4	70	-	-	-	30
	CE1532	Process Modeling and Simulation Lab	0	0	4	2	-	4	70	-	-	-	30
	Total		**15**	**0**	**8**	**19**							

VI Semester

VI Semester	Teaching Scheme		L	T	P	C	Exam Duration (h)		Relative Weightage %				
	Course Code	**Course Title**					**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
	CE1604	Process Safety Analysis	3	0	0	3	3	-	30	-	40	30	-
	CE1605	Mass Transfer II	3	0	0	3	3	-	30	-	40	30	-
	CE1606	Chemical Reaction Engineering II	3	0	0	3	3	-	30	-	40	30	-
	PS1601	Industrial Psychology	3	0	0	3	3	-	30	-	40	30	-
		Program Elective II	3	0	0	3	3	-	30	-	40	30	-
		Open Elective III	3	0	0	3	3						
	CE1631	Transport Phenomena Lab II	0	0	4	2	-	4	70	-	-	-	30
	Total		**18**	**0**	**4**	**20**							

VII Semester

	Teaching Scheme		L	T	P	C	Exam Duration (h)		Relative Weightage %				
	Course Code	Course Title					Theory	Practical	CWS	PRS	MTE	ETE	PRE
VII Semester	CE1705	Process Plant Design	3	0	0	3	3	-	30	-	40	30	-
	CE1706	Chemical Process Industries	3	0	0	3	3	-	30	-	40	30	-
	CE1707	Process Dynamics and Control	3	0	2	4	3	-	30	-	40	30	-
	CE1708	Engineering Economics and Project Management	3	0	0	3	3	-	30	-	40	30	-
		Program Elective III	3	0	0	3	3	-	30	-	40	30	-
		Open Elective IV	3	0	0	3	3	-		-	-	-	-
	CE1731	Transport Phenomena Lab III	0	0	4	2	-	4		70	-	-	30
	CE1732	Chemical Reaction Engineering Lab	0	0	4	2	-	4		70	-	-	30
	CE1781	Industrial Training*	-	-	-	2	-	-	-	-	-	-	-
	Total		**18**	**0**	**10**	**25**							

***Industrial Training will be conducted in the summer after VI semester and evaluated in VII semester**

VIII Semester

	Teaching Scheme		L	T	P	C	Exam Duration (h)		Relative Weightage %				
	Course Code	Course Title					Theory	Practical	CWS	PRS	MTE	ETE	PRE
VIII Semester	CE1803	Process Intensification	3	0	0	3	3	-	30	-	40	30	-
	CE1804	Process Optimization	3	0	0	3	3	-	30	-	40	30	-
	CE1833	Process Control Lab	0	0	4	2	-	4		70	-	-	30
	CE1881	Design Project**	0	0	8	8	-	-	-	-	-	-	-
	Total		**6**	**0**	**12**	**16**							

****Evaluation will be based on Project Report Submission and Presentations**

Program Electives

Program Elective -I	
CE1553	Petroleum Production Technologies
CE1554	Conventional and Non-conventional Energy Resources
Program Elective -II	
CE1653	Petroleum Refinery Operations
CE1654	Environmental Systems Engineering
Program Elective -III	
CE1753	Petrochemical Production Technologies
CE1754	Energy and Process Integration

ABBREVIATIONS	
L	Lecture
T	Tutorial
P	Practical
C	Number of Credits
CWS	Class Work Sessional
MTE	Mid-Term Exam
PRE	End Term Practical Exam
PRS	Practical Sessional
ETE	End Term Exam

Detailed Syllabus for Revamped B. Tech. (Chemical Engineering) Curriculum (Batch: 2015-19)

III Semester

------ Value, Ethics & Governance [L T P C – 2 0 0 2]

Relevance of Value Education in day-to-day life, Mantra for success - Value, Moral and Ethics. Determinants of human nature (Three Gunas) and its impact on human life. Relevance of Personality, Attitude, Behaviour, Ego, Character, introspection, Motivation, Leadership and 4 Qs with relevant Case Studies*.

Governance: Understanding of Public and Private sector Governance systems; Courts & CAG. Public Sector Governance: Need, relevance, stakeholders. Private Sector Governance: Proprietary, Partnership, Company (Pvt Ltd & Ltd), Company' Act 2013, Board of Directors; its Roles and Responsivities. Regulatory bodies; its role in ethical governance. Projects on PPP mode-relevance & prospects. CSR: Relationship with Society, Philanthropy and Business strategy, CSR Policy, Triple Bottom Line

Reference Books:

1. Professional Module of ICSI.
2. Ghosh B.N., Business Ethics & Corporate Governance, McGraw Hill.
3. Mandal S.K., Ethics in Business & Corporate Governance, McGraw Hill .
4. Ray C.K., Corporate Governance, Value & Ethics, Vaya Education of India
5. Chatterjee Abha, Professional Ethics, Oxford Publications.

Suggestive Case Studies:

1. Uphar Theatre Tragedy- Engineering Ethics
2. Bhopal Gas Tragedy- Operational Engineering Ethics
3. Satyam Case- Financial Reporting Ethics
4. Enron Case- Business Ethics
5. Navin Modi Case- Financial Fraudulence

MA1310 Engineering Mathematics III [L T P C – 3 0 0 3]

Vector Calculus: Gradient, divergence and curl, vector integrals, related theorems, introduction of tensors, Laplace Transforms: Transforms of elementary functions, inverse transforms, convolution theorem .Application of Laplace in solutions of differential equations Fourier series, Fourier Transform: Fourier sine and cosine transforms, Fourier integrals, study of heat and wave equations, Z Transform, Bessel and Legendre differential equations, Rodrigues formula, orthogonal properties of Bessel and Legendre polynomials, Problems: Probability, regression, least square principle of curve fitting, distributions – binomial, poisson, normal.

Books:

1. Grewal, B. S., *Higher Engineering Mathematics*, Khanna Publishers, 2011.
2. Kreyszig, E., *Advanced Engineering Mathematics*, Wiley Eastern, 2012.

Reference Books:

1. Meyer, P. L., *Introduction to probability and statistical applications*, IBH 2010.
2. Sastry, S. S., *Introductory methods of Numerical analysis*, PHI 2012.
3. Hogg and Craig, *Introduction of Mathematical Statistics*, MacMillan, 2012.

CY1321 Organic Chemistry [L T P C – 3 1 0 4]

Organic Reaction Mechanism: Reaction intermediates, Inductive effect, Mesomeric effect, Electromeric effect, Hyperconjugation, Types of reactions with mechanism-addition, substitution and elimination, Aromatic and Heterocyclic compounds.

Stereochemistry: Constitutional isomerism, Geometric isomerism, Syn-anti, Optical isomerism, Configuration- *R,S* and *E,Z* Conformation.

Carbohydrates: Monosaccharaides, Disaccharides and Polysaccharides, Sources, Structure and Properties of Glucose, Fructose, Sucrose, Lactose, Starch and Cellulose.

Amino acids & Proteins: Amino acids, Peptides, Proteins, Nucleic acids, Enzymes

Organic Materials of industrial importance: Dyes-classification–modern theory of colour; Synthesis of methyl orange; Congo red, Malachite green, Indigo and Alizarin. Oils-Fats: Saponification value, Iodine and Acid value of oils, Solvent extraction of oils, Hydrogenation of oils, Soaps and Detergents, Petrochemicals.

Industrially Important Organic reactions: Beckmann Rearrangement, Perkin reaction, Hofmann rearrangement, Reamer-Tiemann reaction, Cannizzaro reaction, Skraup synthesis, Diels-Alder reaction, Aldol condensation etc.

Books:

1. Morrison, B.R. and Boyd, L.L., *Organic Chemistry* 6th ed., ELBS, New Delhi, 2008.
2. Sykes, P., *A Guidebook to Mechanism in Organic Chemistry*, Pearson Education, 6th ed., 1986.
3. Finar, *Organic Chemistry Vol. I & II*, Pearson Education, 6th ed., 2002.
4. Sharma, B.K., *Industrial Chemistry*, 16th ed., 2011.
5. Harvey, D., *Modern Analytical Chemistry*, Mc Graw-Hill, 1999.

CE1305 Chemical Process Calculations [L T P C – 3 0 0 3]

Guidelines for Problem Solving; Review of Basic concepts – Process variables & properties, Degree of Freedom, Steady State Material Balances – in non-reacting systems and reacting system, Recycle & purge, elemental vs. species balance, combustion of fossil fuels, Steady State Material balances in Multiphase systems, Steady State Energy Balances – in non-reacting & reacting systems, De-Coupled & coupled mass & energy balances, Calculations for network of units with recycle & bypass, Process Flow sheeting with sequential modular calculations, Unsteady State Balances.

Text Book:

1. Himmelblau, D. M. and Riggs, J. B., *Basic Principles and Calculations in Chemical Engineering*, 8th ed., Pearsons, TN, 2015.

CE1306 Momentum Transfer [L T P C – 3 0 0 3]

Review of Navier-Stokes' (NS) equations; non-dimensionalization of NS equations; introduction to turbulence; analogies; correlations for fluid flow Short introduction to non-Newtonian flows, Engineering Bernoulli Equation; f vs. NRe charts; K factors and equivalent lengths for various fittings; hydraulic diameter; Head vs. Q plots of centrifugal pumps; NPSH, cavitation and priming; pipeline system design including pseudo-steady state approximation; flow measurements; compressors and blowers. Compressible flows in conduits. Mixing and Agitation*:* Power consumption; mixing times; scale-up, Characterization of solids; fundamentals of two-phase flow; flow through packed beds and in fluidized beds (pressure drops, loading and flooding); pneumatic and hydraulic transportation. Filtration, Centrifuges and cyclones.

Books:

1. Wilkes, J. O., *Fluid Mechanics for Chemical Engineers with Microfluidics and CFD*, 2nd ed., Prentice Hall, 2006.
2. Foust, A. S., Wenzel, A. L., Clump, C. W., Maus, L., and Andersen, L. B., *Principles of Unit Operations*, 2nd ed., John Wiley, 2008.

Reference Books:

1. Bird, R. B., Stewart, W. E., and Lightfoot, E. N., *Transport Phenomena*, 2nd ed., John Wiley 2007**.**

CE1307 Process Synthesis [L T P C – 3 0 0 3]

Introduction to Process Systems Engineering; Strategy of Reaction Synthesis; Engineering Data on Reaction Paths; Screening of Reaction Paths; Reaction Paths with Recycle; Conservation of Mass; Material Balancing Pathways; Synthesis of Material Flow; Species Allocation; Introduction to Separation Technology; Solid-Solid separation methods; Liquid-Liquid separation techniques; Reduction of Separation Load; Selection of Separation Phenomena; Integration of Auxiliary Operations; Energy Balance; Sensible and Latent Heat; Heat of Chemical Reactions; Heat energy management and Heat-Exchanger Networks; Case studies from chemical and petroleum processing plants.

Books:

1. Rudd, D. F., Powers, G. J., and Siirola, J. J., *Process Synthesis*, Prentice-Hall international series in the physical and chemical engineering sciences, 1973.
2. Smith, R., *"Chemical Process: Design and Integration",* Wiley, ISBN: 978-0-471-48681-7, January 2005.
3. Seider, W. D., Seader, J. D., Lewin, D. R., Widagdo, S., *Product and Process Design Principles: Synthesis, Analysis and Design*, 3rd ed., Wiley, 2008.
4. Smith, R., *Chemical Process Design*, McGraw-Hill, New York, 1995.

CE1304 Engineering Materials [L T P C – 3 0 0 3]

Structure of materials-crystal structure, substructure, microstructure; Materials classifications – engineering standards, material selection (CES type packages); Material properties – mechanical,

electrical, physical, corrosion, etc. properties; Material treatment –Heat treatment, Various types of heat treatment such as Annealing, Normalizing, Quenching, Tempering (Austempering, Martempering), and various case hardening processes, surface treatment, etc.; Ferrous materials-Various types of carbon steels, alloy steels and cast irons, its properties and uses, effects of different alloying elements, super alloys; Non-Ferrous metals and alloys-Non-ferrous metals such as Cu, Al, Zn, Cr, Ni etc. and its applications, Various type of Brass and Bronze, bearing materials, its properties and uses. Aluminum alloys such as Duralumin; Ceramics – classification, characterization, properties; Plastics – Various types of polymers/plastics and its applications, Mechanical behaviour and processing of plastics, Future of plastics; Composite materials – structure, properties, classification, processing; other materials: Brief description of other material such as optical and thermal materials, Introduction to smart materials & nano-materials and their potential applications; Electric properties, Semiconductors and Super conductors- Energy band concept of conductor, insulator and semi-conductor. Intrinsic & extrinsic semi-conductors. Super conductivity and its applications; Magnetic properties-Concept of magnetism - Dia, para, ferro Hysteresis. Soft and hard magnetic materials; Surface engineering and applications – techniques, coatings, processing and heat treatment.

Books :

1. Raghvan, V., *Materials Science and Engineering*, 5th ed., PHI Learning, 2013.
2. Callister, W. D., *Fundamentals of Materials Science and Engineering*, Wiley, 2007.
3. Shackelford, F. J., *Introduction to Materials Science for Engineers*, 7th ed., Pearson Prentice Hall, 2009.
4. Kittle, C., *Introduction to Solid State Physics*, Wiley, 2007.
5. Cahn, R. W. and Haasen, P., *Physical Metallurgy*, North Holland, 1996.
6. Rohrer, G., *Structure and Bonding in Crystalline Materials*, Cambridge University Press, 2001.
7. Gerold, V., *Materials Science and Technology*, Vol. 1, VCH Publication, 1992.

CY1340 Organic Chemistry Lab [L T P C – 0 0 4 2]

Laboratory: Volumetric analysis, Chromatographic Separation, Complexometric titrations, Organic Synthesis, Oil analysis, Spectroscopic Interpretation.

IV Semester

CE1405 Transport Phenomena [L T P C – 3 0 0 3]
Pre-requisite: MA1310

Transport coefficients - viscosity, thermal conductivity and diffusivity. Dependence of transport coefficients on temperature, pressure and composition, Kinetic theory. Shell balance - momentum, energy and mass transfer - unidimensional velocity, temperature and concentration profiles, and flux at the surface - momentum, energy and mass. Introduction to general transport equations for momentum, energy and mass transfer in Cartesian cylindrical and spherical co-ordinates, solutions in one dimensional velocity, temperature, concentration distribution with more than one independent variable, velocity and temperature distribution in turbulent flow, concept of boundary layer of momentum transport and energy transport.

Text Book:

1. Bird, R. B., Stewart, W. E. and Lightfoot, E. N., *Transport Phenomena*, 2nd ed., John Wiley, Singapore, 2006.

Reference Books:

1. Thomson, W. J., *Introduction to Transport Phenomena*, Prentice Hall, 1999.
2. Brodkey, R. S. and Hershey, H. C., *Transport Phenomena: A Unified Approach*, Brodkey Publishing, 2003.

CE1406 Chemical Engineering Thermodynamics [L T P C – 3 0 0 3]
Pre-requisite: CE1305 and ES1103

Review of I and II Laws of Thermodynamics, P–V–T Relations of Pure Fluids - Graphical, Tabular and Mathematical representation; Generalized compressibility chart; Generalized EOS; Thermodynamic Potentials; Maxwell Relations, Thermodynamic Property Relations, Thermodynamic properties of real gases, Multicomponent mixtures, Properties of solutions, Phase Equilibrium (VLE, LLE, VLLE), Review of Thermochemistry; Chemical reaction equilibria.

Books:

1. Smith, J. M., Van Ness, H. C., and Abbott, M. M., *Introduction to Chemical Engineering Thermodynamics*, 6th ed., McGraw-Hill, 2001.
2. Rao, Y.V.C., *Chemical Engineering Thermodynamics*, University Press, 1997.
3. Kyle, B.G., *Chemical and Process Thermodynamics*, 3rd ed., PHI, New Delhi, 1999.

CE1407 Heat Transfer Operations [L T P C – 3 0 0 3]
Pre-requisite: CE1305 and ES1103

Heat conduction, Molecular diffusion, Convective heat transfer (laminar & turbulent), Heat exchanger design: Double-pipe / Shell-and-tube, compact exchangers. Boiling: pool and convective boiling, correlations, design of reboilers, Condensation: film-wise and drop-wise condensation, correlations, design of condensers. Radiation: thermal radiation, radiation properties, view factors, heat exchange between surfaces. Evaporators: type of equipment, single and multiple effect evaporators, Crystallization: phase equilibria, crystal growth, types of equipment, design. (Use of Aspen/MATLAB wherever possible)

Books:

1. Chapman, A. J., *Heat Transfer*, Maxwell Macmillan, 1984.
2. Kern, D. Q., *Process Heat Transfer*, Tata- McGraw Hill, 1950.
3. Holman, J. P., *Heat Transfer*, 10th ed., McGraw Hill, New York, 2002.

Reference Books:

1. Bird, RB, Stewart, WE, and Lightfoot EN, *Transport Phenomena* (Revised 2nd Edition), John Wiley, 2006.
2. Bergman, L., Theodore, Adrienne, S. Lavine, Incropera, Frank, P, DeWitt, David, P., *Introduction to Heat Transfer*, 6th ed., 2011.
3. Foust, A.S., Wenzel, L.A., Clump, C.W., Maus, L., and Andersen, L.B., *Principles of Unit Operations*, John Wiley 2008.

CE1408 Numerical Methods in Chemical Engineering [L-T-P-C: 3-0-2-4]

Finite Differences, Interpolation: Newton's, Stirling's interpolation formulae, Lagrange's Interpolation for unequal intervals. Numerical Integration: Simpson's and Trapezoidal Rule, Solution of Linear Algebraic Equations: Gauss's Elimination method, Gauss's Siedel Method, LU Decomposition Method, Eigen Values and Eigen Vectors: Introduction, Power method, Solutions of Non-Linear Equations, Regula Falsi Method, Newton-Raphson technique, Secant Method, Function Approximation: least square method of curve fitting, Numerical Solutions of Ordinary Differential Equations: Runga-Kutta Method, Pridictor-corrector Methods, Boundary value problems, Shooting Method, Finite difference Technique, Partial Differential Equations, Types of PDE, Finite difference technique(Method of lines), Numerical Solution of Heat, Wave and Laplace Equations.

Books:

1. Carnahan, B., Luther, H. A., and Wilkes, J.O., *Applied Numerical Methods*, John Wiley, New York, 1969.
2. Gupta, S. K., *Numerical Methods for Engineers*, New Age International Ltd., New Delhi, 1995.
3. Constantinides, A., and Mostoufi, N., *Numerical Methods for Chemical Engineers with MATLAB Applications*, Prentice Hall, 1999.

Reference Books:

1. Pal, S., *Numerical Methods*, Oxford University Press, 2012.
2. Guha, S., Srivastava, R., *Numerical Methods for Engineering and Science*, Oxford University Press, 2012.
3. Hanna, O.T. and Sandall, O.C., *Computational Methods in Chemical Engineering*, Prentice-Hall, 1995.
4. Davis, M.E., *Numerical Methods & Modeling for Chemical Engineers*, John Wiley, 1984.

5. Press, W. H., Teukolsky, S. A., Vellerling, W. T., Flannery, B. P., *Numerical Recipes in C*, 2nd ed., Cambridge University Press, New Delhi, 1992.

CY1421 Physical and Analytical Chemistry [L T P C – 3 1 0 4]

Surface Chemistry: Ideal and non- ideal solutions, Henry's & Raoult's law, Colligative properties, Colloids, Adsorption and catalysis.

Phase Diagram And Phase Transformations: Phase rule, Single component systems, Binary Phase Diagrams, Lever rule, Typical Phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron-carbon system.

Photochemistry: Jablonski diagram, Laws of photochemistry and quantum yield, Some examples of photochemical reactions, Applications of photochemistry.

Instrumental Analysis: Gas chromatography and High pressure liquid chromatography, Ion exchange separation, Electro analytical techniques, Spectral Techniques and Structural elucidation: UV- Vis, IR, NMR and Mass, Fuel analysis, Food analysis, Drug analysis.

Books:

1. Atkins, P., and de Paula, J., *Atkin's Physical Chemistry*, 9th ed., W. H. Freeman & Co., 2009
2. Puri, B.R., Sharma, L.R., and Pathania, M. S., *Principles of Physical Chemistry*, S.N. Chand and Co. Jalandhar, 31st ed., 1990.
3. Adamson, A.W., *Physical Chemistry of Surfaces*, Inter science Publishers Inc. New York 1997.
4. Harvey, D., *Modern Analytical Chemistry*, McGraw Hill, 2000.
5. Nelson, W.L., *Petroleum Refinery Engineering*, Mc Graw-Hill Book Company, 1969.
6. Speight, J. G., *Fuel Science &Technology Hand Book*, Marcel Dekker, New York 1990.

Open Elective I [L T P C – 3 0 0 3]

CY1440 Physical and Analytical Chemistry Lab [L T P C – 0 0 4 2]

- Characterization and analysis of crude oil and its products, Crude oil assay: inspection and comprehensive assay
- Electro analytical methods : pH meteric, Potentiometry- Conductometry analysis
- Instrumental analytical methods: Colorimetry, Adsorption- Photochemical reduction

V Semester

CE1505 Process Modeling and Simulation [3 0 0 3]
Pre-requisites: CE1307 and CE1408

Fundamentals and industrial applications of process modeling and simulation, Macroscopic mass, energy and momentum balances, integration of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models. Steady state lumped systems, modeling of chemical process equipment (reactors, distillation, absorption, extraction columns, evaporators, and heat exchangers). Modeling and simulation of complex industrial systems in petroleum, petrochemicals, polymer, basic chemical industries; Commercial steady state and dynamic simulators; Simulation of process flow sheets.

Use of Matlab and ASPEN for teaching purpose

Books:

1. Hangos, K., Cameron, I. T., *Process Modeling and Model Analysis*, Academic Press, 2001.
2. Ingham, J., Dunn, I. J., Heinzle, E., Prenosil, J.E., Snape, J.B., *Chemical Engineering Dynamics: An Introduction to Modelling and Computer Simulation*, 3rd ed., Wiley-VCH Verlag GmbH & Co. KGaA, 2007.
3. Babu, B. V., *Process Plant Simulation*, Oxford University Press, 2004.

Reference Books:

1. Luyben, W. L., *Process Modeling, Simulation and Control for Chemical Engineers*, McGraw Hill, 1989.
2. Holland, C. D., *Fundamentals and Modeling of Separation Processes*, Prentice Hall, 1975.
3. Ramirez, W.F., *Computational Methods for Process Simulation*, 2nd ed., Butterworth-Heinemann, 1997.
4. Himmelblau, D. M., & Bischoff, K. B., *Process analysis and simulation: Deterministic systems*, John Wiley, New York, 1968.

CE1506 Mass Transfer I [3 0 0 3]
Pre-requisites: CE 1406

Introduction to mass transfer operations. Theory of interphase mass transfer, estimation of mass transfer coefficient, individual and overall mass transfer coefficients for gas-liquid and liquid-liquid operations. Gas Absorption, graphical calculation of number of theoretical stages for absorption and stripping column. Adsorption, adsorption isotherm, batch and continuous stage adsorption, design of adsorption column, and adsorption equipment. Vapor gas mixtures, terminology, Psychometric chart, Water cooling operations, Gas-Liquid contact operations, adiabatic operations, Types of equipment, Design calculations, Cooling towers, design of cooling towers, Recirculating Liquid-gas humidification cooling.

Books:

1. Seader, J. D. and Henley, E. J., *Separation Process Principles*, 2nd ed., Wiley, 2010.
2. Treybal, R. E., *Mass Transfer Operations*, 3rd ed., McGraw Hill, 2012.

Reference Books:

1. Geankoplis, C. J., *Transport Processes and Unit Operations*, 3rd ed., PHI, New Delhi, 2000.
2. Foust, A.S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., *Principles of Unit operations*, 2nd ed., John Wiley and Sons, 1980.
3. McCabe and Smith, *Unit Operations in Chemical Engineering*, 5th ed., McGraw-Hill, NY, 1993
4. Hill, G. B., *Cooling towers principles and practice*, BH, London, 1990.
5. Sinnott, R. K., *Coulson & Richardson's Chemical Engineering Design: Chemical Engineering Design: Vol. 6*, 2006.

CE1507 Chemical Reaction Engineering I [3 0 0 3]

Pre-requisites: CE1406

Kinetics of homogeneous chemical reactions, Rate expressions, Temperature dependence of rate Differential, integral, half-life and total pressure method theories, Elementary and Non elementary reaction kinetics - Pseudo, steady state hypothesis mechanism. Isothermal reactor design. Design of batch, semi-batch, CSTR's and PFR's. Multiple reactor systems, Reactors in series or/and parallel, CSTRs series Performance analysis, Batch, Semi-Batch, Continuous and Recycle reactors. Multiple reaction systems, Series and parallel reactions in flow reactors, Product distribution, Yield and selectivity. Maximizing the desired product in parallel reactions, Different reactors and schemes for minimizing the unwanted product, maximizing the desired product in series reactions. Non isothermal homogeneous reactions, Temperature effects, Principles of stability, Design procedures for adiabatic and non-isothermal conditions for batch semi-batch and flow reactors, Optimum temperature progression, multiple reactions and effect of temperature on product distribution.

Text Book:

1. Levenspiel, O., *Chemical Reaction Engineering*, 3rd ed., Wiley India Pvt Ltd., 2010.

Reference Books:

1. Fogler, H. S., *Elements of Chemical Reaction Engineering*, 4th ed., Prentice-Hall of India, Delhi, 2003.
2. Smith, J. M., *Chemical Engineering Kinetics*, 3rd ed., McGraw-Hill, 1981.
3. Levenspiel, O., *The Chemical Reactor Omnibook*, OSU Bookstores, Corvallis Oregon, 1993.
4. Froment, G. F., and Bischoff, K. B., *Chemical Reactor Analysis and Design*, 3rd ed., John Wiley and Sons, 2010.
5. Richardson, J.F., and Peacock D.G., *Coulson and Richardson's Chemical Engineering,* vol. 3, 3rd ed., Asian Books Pvt. Ltd., New Delhi, 1998.

	Program Elective I	**[3 0 0 3]**
	Open Elective II	**[3 0 0 3]**
CE1531	**Transport Phenomena Lab I**	**[0 0 4 2]**
CE1532	**Process Modeling and Simulation Lab**	**[0 0 4 2]**

VI Semester

CE1604 Process Safety Analysis [3 0 0 3]
Pre-requisites: CE1305

Concept and definitions, safety culture, storage of dangerous materials, plant and plant layout, safety systems, selection of technology and process, scale of disaster. Vapor cloud, explosion, and control of toxic chemicals, run away reactions, fire and explosion, high pressure relief system, hazardous properties of chemicals. Risk and hazard management, safety vs production, risk assessment and analysis, hazard models and risk data, identification, minimization and analysis of hazard. Tackling disaster, plan of emergency, risk management routines, emergency shutdown systems, Role of computer in safety, prevention of hazard, human element, technology and process selection, design of safety audit system and disaster management.

Text Book:

1. Crowl, D. A., and Louver, J.F., *Chemical Process Safety: Fundamentals and Applications*, 3rd ed., Pearson India, 2014.

Reference Books:

1. Wells, G.L., *Safety in Chemical Process Industries*, Mc Graw Hill.
2. Cameron, I., and Raman, R., *Process Systems Risk Management*, Elsevier Science, 2005.

CE1605 Mass Transfer II [3 0 0 3]
Pre-requisites: CE1506

Distillation, concept of vapor liquid equilibrium, Raoult's law, deviations from ideal law, azeotropic distillation and steam distillation. Enthalpy concentration diagrams, binary and multi component systems, dew and bubble point calculations, flash vaporization, simple distillation, binary component distillation, Ponchan Savarit method: minimum reflux ratio, optimum reflux ratio- total reflux ratio, partial condenser, total condenser, McCabe Thiele method: concept of q line, optimum reflux ratio- total reflux ratio, partial condenser, total condenser. Multi component distillation: azeotropic, extractive, molecular distillation. Liquid-Liquid Extraction: liquid-liquid-equilibria, ternary systems triangular and rectangular coordinates-choice of solvent-single stage and multi stage cross current, equipment's such as mixer settler, packed and tray towers. Leaching, Drying and design criteria, Design of rotary dryers.

Text Book:

1. Seader, J. D. and Henley, E. J., *Separation Process Principles*, 2nd ed., Wiley, 2010.
2. Treybal, R. E., *Mass Transfer Operations,* 3rd ed., McGraw Hill, 2012.

Reference Books:

1. Geankoplis, C. J., *Transport Processes and Unit Operations,* 3rd ed., PHI, New Delhi, 2000.
2. King, C. J., *Separation Processes,* 2nd ed.., Tata McGraw Hill, New Delhi, 1982.
3. Skelland, A. H. P. *Diffusional Mass Transfer*, John Wiley, NY.

CE1606 Chemical Reaction Engineering II [3 0 0 3]

Pre-requisites: CE1507

Isothermal non-ideal flow reactors, RTD in chemical reactors, distribution functions. Conversion in non-ideal flow reactors, Single and multi-parameter models for non-ideal flow, Concepts of mixing, Micro and macro mixing. Heterogeneous reactions, Rate equation for heterogeneous systems, Contacting patterns for two phase systems, Fluid particle non-catalytic reactions, Different models, Derivation of rate equations, Application to design Fluid-fluid non- catalytic reactions. Introduction to Slurry, Trickle bed reactors, and Fluidized bed reactors.

Books:

1. Fogler, H. S., *Elements of Chemical Reaction Engineering*, 4th ed., Prentice-Hall of India, Delhi, 2003.
2. Levenspiel, O., *Chemical Reaction Engineering*, 3rd ed., Wiley India Pvt Ltd., 2010.
3. Smith, J. M., *Chemical Engineering Kinetics*, 3rd ed., McGraw-Hill, 1981.

Reference Books:

1. Carberry, J. J., *Catalytic Reaction Engineering*, McGraw-Hill, 1976.
2. Levenspiel, O., *The Chemical Reactor Omnibook*, OSU Bookstores, Corvallis Oregon, 1993.
3. Froment, G. F., and Bischoff, K. B., *Chemical Reactor Analysis and Design*, 3rd ed., John Wiley and Sons, 2010.

PS1601 Industrial Psychology [3 0 0 3]

Introduction to Industrial & Organizational Psychology: Nature, scope and methods of study; Challenges for I/O psychology, problems for I/O psychologists. Employee Selection and recruitment: Principles and techniques. Training & development: Principles and techniques. Job Performance Evaluation & Appraisal: Meaning and nature, techniques. Motivation and Work: Theories of motivation, job satisfaction, job involvement. Work stress & management: Nature and meaning, sources, individual differences, consequences of job stress; Stress management techniques.

Books:

1. Schultz, S.E. and Schultz, D.P., *Psychology and Work Today: An introduction to Industrial and Organizational Psychology*, 8th ed., Pearson Education, 2009.
2. Landy, F.J. and Conte, J.M., *Work in the 21st Century: An Introduction to Industrial and Organizational Psychology*, 2nd ed., Wiley India Private Limited, 2009.

Reference Books:

1. Blum, M. L. and Naylor, J.C., *Industrial Psychology: Its Theoretical and Social Foundations*, CBS Publishers, 2004.
2. Riggio, R.E., *Introduction to Industrial and Organizational Psychology*, 6th ed., Pearson, 2012.
3. Zedeck, S., *APA Handbook of Industrial and Organizational Psychology-Volumes: I, II and III*, American Psychological Association, New York, 2011.

	Program Elective II	**[3 0 0 3]**
	Open Elective III	**[3 0 0 3]**
CE1631	**Transport Phenomena Lab II**	**[0 0 4 2]**

VII Semester

CE1705 Process Plant Design [3 0 0 3]

Prerequisites: CE1306, CE1407 and CE1605

Process Design and Development: The hierarchy of chemical process design, General design considerations, nature of process synthesis and analysis. Development of a conceptual design and determining the best flow sheet: input information and batch versus continuous, Input/output structure of the flow sheet; Recycle structure of flow sheet; Separation system; Heat Exchanger Networks. Plant Design: Process design development and general design considerations. Process Economics: Economic feasibility of project using order-of-magnitude cost estimates, plant and equipment cost estimation, product cost estimation.

Use of Matlab and ASPEN for teaching purpose.

Books:

1. Douglas, J. M., *Conceptual Design of Chemical Processes*, McGraw-Hill, 1988.
2. Peters, M. S., Timmerhaus, K. D., and West, R, E., *Plant Design and Economics for Chemical Engineers*, 5th ed., McGraw-Hill, 2003.
3. Seider, W.D., Seader, J.D., and Lewin, D.L., *Product and Process Design Principles: Synthesis, Analysis, and Evaluation*, 3rd ed., John-Wiley and Sons, 2008.
4. Turton, R., Bailie, R. C., Whiting, W. B., Shaeiwitz, J. A. and Bhattacharyya, D., *Analysis, Synthesis and Design of Chemical Processes*, 4th edition, Prentice Hall India Learning Private Limited, 2015.

Reference Books:

1. Biegler, L., Grossmann, I. E. and Westerberg, A. W., *Systematic Methods of Chemical Engineering and Process Design*, Prentice Hall, 1997.
2. Towler G., and Sinnot R., *Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design*, 1st ed., CBSPD, 2009
3. Rudd, D. F., and Watson, C.C., *Strategy of Process Engineering*, 1st ed., John Wiley and Sons, Inc., New York, 1968.
4. Westerberg, A.W., Hutchison, H. P., Motard, R. L., and Winter, P., *Process Flowsheeting*, Cambridge University Press, 2011.

CE1706 Chemical Process Industries [3 0 0 3]

Overview of typical chemical processes, unit operations and unit processes, Indian chemical process industries, inorganic chemical industry, study aspects of chemical process industries- raw materials, process, chemical reactions, process and block flow diagram, major engineering issues and uses of industries for Water conditioning and treatment, Common salt (NaCl) manufacture, Coal gasification, Manufacture of ammonia, urea, nitric acid and ammonium nitrate.

Books:

1. Austin, G. T., *Shreve's Chemical Process Industries*, 5th ed., Mc Graw-Hill international edition, 2012.
2. Rao, M. G., and Sittig, M., *Dryden's Outlines of Chemical Technology*, 3rd ed., East-West Press Ltd, 2010.

Reference Books

1. Groggins, P. H., *Unit processes in organic synthesis*, 5th ed., Mcgraw-Hill, 2004.

CE1707 Process Dynamics and Control [3 0 2 4]
Pre-requisites: CE 1505

Introduction to process control, Laplace transforms. Linear Open-Loop Systems, First-Order Systems: Transfer function, transient response (step response, impulse response, and sinusoidal response), and response of first-order systems in series: non-interacting systems and interacting systems. Second-Order Systems: Transfer function, step response, impulse response, sinusoidal response, transportation lag. Linear Closed-Loop Systems. Control system: Components of a control system, block diagram, negative feedback and positive feedback, servo problem and regulator problem. Controller and final control element: Mechanism of control valve and controller, transfer functions (P, PI, PD, PID), Example of a chemical-reactor control system.

Books:

1. Coughanowr, D. R., *Process Systems Analysis and Control*, 3rd ed., McGraw Hill, 2008.
2. Seborg, D. E., Mellichamp, D. A. and Edgar, T. F., *Process Dynamics and Control*, 3rd edition, John Wiley & Sons, 2010.

Reference Books:

1. Stephanopoulos, G., *Chemical Process Control*, PHI, New Delhi, 2008.
2. Riggs, J. B., and Karim, M.N., *Chemical and Bio-Process Control*, 3rd edition, Ferret Publication, 2007.
3. Luyben, W. L., *Process Modeling, Simulation and Control for Chemical Engineers*, 2nd ed., McGraw Hill, 1990.

CE1708 Engineering Economics and Project Management [3 0 0 3]
Cash Flow Concepts, Present Future and Annual Values, Net Present Value, Present value Ratio, Rate of Return, Breakeven, Depreciation and taxes, Project Definition, Project network, scheduling resource and cost, Managing project risk, Project progress, Performance measurement, and evaluation.

Books:

1. Peters, M. S., Timmerhaus, K. D. and West, R. E., *Plant Design and Economics for Chemical Engineers*, 5th ed., McGraw-Hill Education, 2003.
2. Stermole, F.J. and Stermole, J. M. *Economic Evaluation and Investment Decision Methods*, 14th ed., Investment Evaluations Corp, 2014.
3. Taha, H. A., Natarajan, A. M., Tamilarasi, A., and Balasubramanie, P., *Operations Research: An Introduction*, 9th ed., Prentice Hall, 2010.

Reference Books:

1. Koontz, D., *Essentials of management*, 5th ed., Mc graw Hill, New York, 1989
2. Drucker, P., *The practice of management*, Harper Business, 2006.
3. Thuesen G. J., and Thuesen, H. G., *Engineering economy*, 5th ed., Prentice Hall of India, New Delhi, 1981.

4. de Garmo, L. P., and Sullivan, W. G., *Engineering Economy*, 10th ed., Prentice Hall College, 1996.
5. Riggs, J. L., Bedworth, D. D., and Randhawa, S. U., *Engineering Economics*, Tata Mc Graw-Hill publishing company, New Delhi.
6. Pannerselvum, R., *Engineering Economics*, PHI Learning Pvt Ltd., 2001.

	Program Elective III	**[3 0 0 3]**
	Open Elective IV	**[3 0 0 3]**
CE1731	**Transport Phenomena Lab III**	**[0 0 4 2]**
CE1732	**Chemical Reaction Engineering Lab**	**[0 0 4 2]**
CE1781	**Industrial Training***	**[- - - 2]**

VIII Semester

CE1803 Process Intensification [3 0 0 3]

Pre-requisites: CE 1705

Introduction to Process Intensification; Sustainability related issues in process industry; definitions of process intensification; fundamental principles and approaches of PI; Design of a sustainable and inherent safer processing plants; PI case study; Mechanisms involved in PI: Intensified heat transfer, intensified mass transfer, electrically enhanced processes, micro fluidics; Compact and micro heat exchangers; Reactors: Reactor engineering theory, spinning disc reactors, oscillatory baffled reactors, micro reactors, reactive separations, membrane reactors, supercritical operations, Field enhanced reactors, Rotating fluidized beds. Intensification and separation processes: Distillation (reactive, extractive), centrifuges, membranes, drying, precipitation and crystallization; Intensified mixers.

Books:

1. Stankiewicz, A., and Moulijn, J. A., *Re-Engineering the Chemical Processing Plant: Process Intensification*, 1st ed., CRC Press, 2003.
2. Reay, D., Ramshaw, C., and Harvey, A., *Process Intensification – Engineering for efficiency, sustainability and flexibility*, Butterworth Heinemann, 2013.

CE1804 Process Optimization [3 0 0 3]

Pre-requisites: CE1408 and CE1505

Formulation of the objective function. Unconstrained single variable optimization: Newton, Quasi-Newton methods, polynomial approximation methods. Unconstrained multivariable optimization: Direct search method, conjugate search method, steepest descent method, conjugate gradient method, Newton's method. Linear Programming: Formulation of LP problem, graphical solution of LP problem, simplex method, duality in Linear Programming, two-phase method. Nonlinear programming with constraints: Necessary and sufficiency conditions for a local extremum, Quadratic programming, successive quadratic programming, Generalized reduced gradient (GRG) method. Use of MS-Excel and MATLAB for solving optimization problems. Introduction to global optimization techniques. Applications of optimization in Chemical Engineering.

Text Book:

1. Edgar, T.F., Himmelblau, D. M., Ladson, L. S., *Optimization of Chemical Process*, 2nd ed., McGraw-Hill, 2001.

Reference Books

1. Rao, S. S., *Optimization Techniques*, Wiley Eastern, New Delhi, 1985.
2. Godfrey, C.O. and Babu, B.V., *New Optimization Techniques in Engineering*, Springer-Verlag, Germany, 2004.
3. Beveridge, G. S. and Schechter, R. S., *Optimization Theory and Practice*, McGraw- Hill, New York, 1975.
4. Reklaitis, G.V., Ravindran, A. and Ragsdell, K. M., *Engineering Optimization-Methods and Applications*, Wiley India Pvt Ltd., 2006.

CE1833	**Process Control Lab**	**[0 0 4 2]**
CE1881	**Design Project**	**[0 0 8 8]**

Syllabus of Program Electives

Program Elective I

CE1553 Petroleum Production Technologies [3 0 0 3]

Pre-requisites: None

Introduction to exploration and onshore/offshore production facilities and processes, Oil, natural gas and produced water properties for designing and analyzing oil and gas production systems. Performance of oil and gas wells such as reservoir deliverability, wellbore performance, choke performance, well deliverability. Production enhancement- Matrix acidizing, Hydraulic Fracturing Equipment design- Well tubing, separation systems, transportation systems.

Books:

1. Guo, B., Lyons, W. C., and Ghalambor, A., *Petroleum Production Engineering, A Computer Assisted Approach*, Gulf Professional Publishing, 2011.
2. Economides, M.J., Hill, A. D., Ehlig-Economides, C., and Zhu, D., *Petroleum Production Systems*, 2nd ed., Prentice Hall, 2012.
3. Lyons, W., Working Guide to *Petroleum and Natural Gas Production Engineering*, Gulf Professional Publishing, 2010.
4. Abdel, H. K., Aggour, M. and Fahim, M. A., Petroleum and Gas Field Processing, Marcel Dekker, 2003.

CE1554 Conventional and Non-Conventional Energy Resources [3 0 0 3]

Pre-requisites: None

Introduction of coal, natural gas and oil as sources of energy. Introduction to world energy scenario. Application of coal in industries. *In situ* Coal Gasification. Oil and Gas from condensate and oilfields. Scope of Oil and Natural gas industry. Concepts of thermodynamics and system energy in Natural Gas Engineering. Physical properties of natural gas and the associated hydrocarbon liquids. Reservoir aspects of natural gas and oil. Conversion of coal and gas to liquid. Renewable energy resources, Radiation, Solar Geometry, radiation models; Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures, introduction to thermal systems (flat plate collector), Biomass, Biomass resources, wood composition, biogas, biodiesel, ethanol; Wind, types of wind machines, Hydro resources, types of hydro turbine, small hydro systems; Other systems, Geothermal, wave energy, ocean energy.

Books:

1. Probstein, R. F., Hicks, R. E., *Synthetic Fuels*, Dover Publications, 2013.
2. Hall, D.D., Grover, R.P., *Biomass Regenerable Energy*, John Wiley, 1987.
3. Twidell, T., Weir,T., *Renewable Energy Resources*, E & F N Spon Ltd, 1986.
4. Duffie, J. A., and Beckman, W. A., *Solar Engineering of Thermal Processes*, 4th ed., John Wiley, 2013.

Program Elective II

CE1653 Petroleum Refinery Operations [3 0 0 3]

Pre-requisites: None

Petroleum resources, petroleum industry in India. Composition and classification of petroleum crude, ASTM, TBP and FEV distillation. Properties and specifications of petroleum products – LPG, Gasoline, naphtha, kerosene, diesel oil, lubricating oil, wax etc. Design and operation of topping and vacuum distillation units. Tube still furnaces. Solvent extraction processes for lubricating oil base stocks and for aromatics from naphtha and kerosene, solvent dewaxing. Thermal and catalytic cracking, vis-breaking and coking processes, reforming, hydro processing, alkylation, polymerization and isomerization. Safety and pollution considerations in refineries.

Text Book:

1. Gary, J. H. and Handwrek, G. E., *Petroleum Refining, Technology and Economics*, 5th ed., CRC Press, 2007.

Reference Books

1. Nelson, W. L., *Petroleum Refinery Engineering*, 4th ed., McGraw Hill, 1987.
2. Rao, B.K.B., *Modern Petroleum Refining Processes*, Oxford, IBH, 2008
3. Watkins, R.N. *Petroleum Refinery Distillation*, 2nd ed., Gulf Publishing, Houston, TX, 1979.
4. Kobe, K. A. and McKetta, J. J., *Advances in Petroleum Chemistry and Refining*, Wiley Interscience.

CE1654 Environmental Systems Engineering [3 0 0 3]

Pre-requisite: None

Characterization of Industrial wastewater, primary, secondary and tertiary treatment, segregation, screening, equalization, coagulation, flocculation, precipitation, flotation, sedimentation, aerobic treatment, anaerobic treatment, absorption, ion exchange, membrane filtration, electro dialysis, sludge dewatering and disposal methods. Sources and classification of air pollutants, nature and characteristics of gaseous and particulate pollutants, pollutants from automobiles. Air pollution meteorology, plume and its behavior and atmospheric dispersion, control of particulate emissions by gravity settling chamber, cyclones, wet scrubbers, bag filters and electrostatic precipitators. Control of gaseous emissions by absorption, adsorption, chemical transformation and combustion. Hazardous and non-hazardous waste, methods of treatment and disposal, land filling, leachate treatment and incineration of solid wastes.

Books:

1. Metcalf & Eddy, Inc., *Wastewater Engineering: Treatment and Reuse*, 4th ed., Tata McGraw Hill, New Delhi, 2002.
2. Peavy, H. S., Rowe, D. R., Tchobanoglous, G., *Environmental Engineering*, McGraw Hill, 2013.
3. De Nevers, N., *Air Pollution Control Engineering*, 2nd ed., Mc-Graw-Hill, 2000.
4. Eckenfelder, W. W., *Water quality engineering and practicing engineers*, Rarebooksclub.com, 2012.
5. Perkins, H. C., *Air Pollution*, Mc-Graw Hill, 1974.

6. Rich, L. G., *Environmental Systems Engineering*, Mc-Graw Hill, 1973.
7. Bhatia, S.C., *Environmental Pollution and Control in Chemical Process Industries*, Khanna Publishers, Delhi, 2001.
8. Mahajan, S. P., *Pollution Control in Process Industries*, Tata McGraw-Hill, New Delhi, 1998.

Program Elective III

CE1753 Petrochemical Production Technology [3 0 0 3]

Pre-requisites: None

Survey of petrochemical industry; Availability of feed stocks; Production, purification and separation of feed stocks; Methane and synthesis gas derivatives, Ethylene and Ethylene derivatives, Propylene and propylene derivatives, Chemicals from C_2, C_3, C_4 and higher carbon compounds, Oxo reactions, etc. Production of chemicals from acetylene; Catalytic reforming of naphtha and isolation of aromatics; Chemicals from aromatics and BTX derivatives; Polymers, elastomers, polyurethanes, Synthetic fibers, detergents, rubbers and plastics; Petroleum coke.

Books:

1. Rao, B.K.B., *A Text on Petrochemicals*, 2nd ed., Khanna publishers, 1996.
2. Mall, I. D., *Petrochemical process technology*, Mac Millan India Ltd, 1997.
3. Mathar, S., Hatch, L. F., *Chemistry of petrochemical processes*, 2nd ed., 2001.

CE1754 Energy and Process Integration [3 0 0 3]

Pre-requisites: None

Introduction – Energy Targeting and the Pinch Principle, Problem Table, Cascade Diagram, Composite / Grand Composite Curves, Pinch Point, Utility Pinch; Maximum Energy Recovery Network – Pinch Design Method, Grid\Diagram, Stream Splitting / Matching; Evolution / Evaluation of Networks – Euler's Principle, Identification and Breaking of Loops Using Paths; Capital Cost targeting, Continuous Targeting – Area / Cost Targeting, Vertical Heat Transfer, Threshold Problem, Super targeting; Distillation Column Targeting Principles, Grand Column Composite Curves, Column Composite Curves, Evaluation of Energy Saving Options; Introduction to Heat and Power Systems.

Text Book:

1. Shenoy, U.V., *Heat exchanger network synthesis: Process optimization by energy and resource analysis*, Gulf publishing, 1995.

Reference Books:

1. Klemes, J. J., Varbanov, P. S., Alwi S. R. W. W., and Manan, Z. A., *Process Integration and Intensification: Saving Energy, Water and Resources*, De Gruyter, 2014.
2. Kemp, I. C., *Pinch analysis and process integration: A user guide on process integration for the efficient use of energy*, Butterworth Heinemann, 2006.