Master of Technology (Chemical Engineering)
Program: CE
Duration – 2 Years (Full time)

Paper Code: 14 for Dual Degree students
95 for student admitted from other institute

Program Scheme and Syllabus
(1st to 4th semester)

University School of Chemical Technology
GGS INDRAPRASTHA UNIVERSITY
SECTOR 16C, DWARKA, NEW DELHI-110078

Table of Contents

FIRST SEMESTER EXAMINATION

L	T	P	Credits
15	3	12	24

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14501	CT-501	Advanced Transport Phenomena	3	1	0	4
14503	CT-503	Advanced Separation Technology	3	1	0	4
14505	CT-505	Advanced System Engineering	3	1	0	4
Elective Course						
14511	CT-511	Design of Experiment and Analysis of Engineering Data	3	0	0	3
14513	CT-513	Environmental Engineering And Waste Management	3	0	0	3
14515	CT-515	Powder Processing &Technology	3	0	0	3
14517	CT-517	Chemical Process Quantitative Risk Analysis	3	0	0	3
Practical/Viva Voce						
14553	CT-553	Advance Control Lab	0	0	6	3
14555	CT-555	Advance Computational Lab	0	0	6	3
		Total	**15**	**3**	**12**	**24**

Note: Student can select **two electives** either offered by the department from the above list or from the list of intradepartmental electives.

Paper ID	Paper	L	T	P	Credit
14501	CT-501 Advanced Transport Phenomena	3	1	0	4

PHILOSOPHY AND FUNDAMENTALS OF THREE TRANSPORT PHENOMENA : Importance of transport phenomena; analogous nature of transfer process; basic concepts, conversation laws. Molecular transport of momentum, Heat and mass, laws of molecular transport, Newton's law of viscosity, Fourier law of heat conduction, and Fick's law of diffusion. Transport coefficients – viscosity, thermal conductivity and mass diffusivity. Estimation of transport coefficients and temperature / pressure dependence.

ONE DIMENSIONAL TRANSPORT IN LAMINAR FLOW (SHELL BALANCE) : Newtonian and non-Newtonian fluids, General method of shell balance approach to transfer problems; Choosing the shape of the shell; most common boundary conditions; momentum flux and velocity distribution for flow of Newtonian fluids in pipes, for flow of Newtonian fluids in planes, slits and annulus, heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous and chemical; forced and free convection; mass flux and concentration profile for diffusion in stagnant gas, systems involving reaction and forced convection.

EQUATIONS OF CHANGE AND THEIR APPLICATIONS : Conversation laws and equations of change; development of equations of continuity, motion and energy in single component systems in rectangular coordinates and the forms in curvilinear coordinates; simplified forms of equations for special cases, solutions of momentum, mass and heat transfer problems discussed under shell balance by applications of equation of change.

TRANSPORT IN TURBULENT AND BOUNDARY LAYER FLOW : Introduction to turbulent flows, comparisons of laminar and turbulent flows in simple systems such as circular tube, flat plate. Concept of Boundary Layer Flow.

Books & Reference :

1. R.B. Bird, W.E. Stewart and E.W. Lighfoot, Transport Phenomena, 2nd Edition. John Wiley, 2002
2. J.R. Wilty, R.W. Wilson, and C.W. Wicks, Fundamentals of Momentum Heat and Mass Transfer, 4th Edition, John Wiley, New York, 2001
3. Christie J. Geankopolis, Transport Processes and Separation Process Principles, 4th Edition. Printice-Hall, 2003
4. R.S. Brodkey, and H.C. Hershey, "Transport Phenomena – A Unified Approach", McGraw Hill, 1988

Paper ID	Paper	L	T	P	Credit
14503	CT-503 Advanced Separation Technology	3	1	0	4

Rate –Based Models for Separation: Rate models, transport-rate expression, estimation of transport co-efficient.

Membrane separation: Introduction and classification, transport model, membrane modules, module flow patterns, membrane selection procedure, membrane processes like. RO, NF, UF, Pervaporation, Electrodialysis, liquid membrane, design consideration, selective separation by combination/individual membrane process, industrial application and economic consideration.

Enhanced and Hybrid Distillation: Salt distillation, Pressure swing-distillation, Heterogenous azeotropic distillation, reactive distillation-theory and design consideration, hybride separation process module and design consideration.

Supercritical fluid extraction: Theory, Process and Process Design; Molecular Sieve separation.

Books & Reference:

1. Seader J.D. and Henley J.E., Separation Process Principles, John Wiley & Sons1998
2. Taylor R and Krishna R., Multicomponent Mass Transfer, John Wiley & Sons, 1993
3. McHugh M. and Krukonis V., Supercritical Fluid Extraction-Principles and Practice, Butterworths-Heinman 1994.
4. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
5. Rautenbach, R. and Albrecht, R., Membrane Processes, John Wiley, 198
6. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elservier, 1995

Paper ID	Paper	L	T	P	Credit
14505	CT-505 Advanced System Engineering	3	1	0	4

Introduction to process engineering and optimization, Formulation of various process optimization problems and their classification, Basic concepts of optimization – convex and concave function, necessary and sufficient conditions for stationary points, optimization of one dimensional problems. **(05 Hrs)**

Unconstrained multi variable optimization – direct search methods, indirect first and second order methods; linear programming and its application: Simplex, Big M & Two Phase methods. **(8 Hrs)**

Constrained multi level optimization – necessary and sufficient for constrained optimum, quadratic programming (Wolfe's Method and Beale's Method), Generalized Reduced gradient method, optimization of stage and discrete processes, Dynamics Programming, Integer and Mixed Integer Programming (Gomory's algorithm and Branch & Bound technique) **(10 Hrs)**

Neural Network: Fundamentals of Neural Network, Back Propagation Network, Simulated annealing. Use of Neural networking in industries, Genetic Algorithm: Fundamentals of genetic algorithm, Genetic Modeling. **(07 Hrs)**

Course Objectives:

Introduction to various optimization techniques fo linear and non-linear problems to the students.

Use of various emerging tools e.g. Neural Network in optimizing the problems in process industries.

To make students capable for developing programs using MATLAB for optimization techniques.

Books & Reference :

1. T.F. Edgar and D.M. Himmelblan "Optimization of Chemical Proceses", McGraw Hill International editions.
2. Rao S S, "Engineering Optimization"
3. Sharma JK. "Operations Research", Macmillian.
4. Bart Kosko, "Neural Network and Fuzzy systems", Eastern Economy Edition
5. Rajasekaran R. and Vijaylakshmi GA, "Neural Networks, Fuzzy systems and Genetic algorithm", Eastern Economy Edition.
6. G.S. Beveridge and R.S. Schekhter "Optimization theory and practice, McGraw Hill New York.
7. G.V. Rekhlaitis, A. Ravindran and K.M. Ragidell "Engineering Optimization Methods applications, John Wiley, New York.
8. James A Anderson, "An Introduction to Neural Networks", Eastern Economy Edition.
9. George J Klier, "Fuzzy sets and Fuzzy Logic", Eastern Economy Edition.
10. James A Freeman and David m skapura, "Neural Network", Addison Wesley Longman inc.

Paper ID	Paper	L	T	P	Credit
14511	**CT-511 Design of Experiment and Analysis of Engineering Data**	**3**	**0**	**0**	**3**

Graphical methods of model selection from experimental data. Two variable empirical equations. Liner, logarithmic and semi logarithmic plots. Modified linear, logarithmic and semilogarithmic plots. Reciprocal plots. Equations for lumped data. Elongated "s" curves. Three variables empirical equations. Sterns methods. Multivariable empirical equations. Dimensionless numbers. Nomography: Introduction. Logarithmic charts. Equations of the form F1(x)+F2(y)=F3(z), F1(x)+F2(y)=F3(z), 1/ F1(x)+1/F2(y)=1/F3(z) and line coordinate charts. Statistical Analysis: Tests for Fluctuations in process variables. Test for deviation of the variables from standard conditions. Selection of theoretical model to fit the data. Design of experiments: Factorial design of experiments. Detection of significant variables in the absence of and in the presence experimental errors. 2k factorial design. Fractional factorial design. Box-Wilson method. Estimation of quantitative significance of the variables. Response surface analysis: Interpretation of results. Reduction of equations to canonic form. Steepest ascent along response surface.

Books & Reference:

1. Mokhtar S. Bazara & C.M.Shetty; Non linear Programming, Theory & Algorithums; John Wiley & Sons.
2. Stephan G.N., Ariela Sofer; Linear & nonlinear programming, McGraw Hill.
3. T.F. Edgar and D.M.Himmelblan " Optimization of Chemical Processes", McGraw Hill International editions.
4. G.S.Beveridge and R.S.Schekhter " Optimization theory and practice, McGraw Hill, New York.
5. G.V. Rekhlaitis, A.Ravindran and K.M. Ragidell "Engineering Optimization Methods & applications, John Wiley, New York.

Paper ID	Paper	L	T	P	Credit
14513	**CT-513 Environmental Engineering and Waste Management**	**3**	**0**	**0**	**3**

Ecology and Environment: Source of air, water and solid wastes.
Air pollution: Micrometeorology and dispersion of pollutants in environment. Fate of pollutants.
Air pollution control technologies: Centrifugal collectors, electrostatics precipitator, bag filter and wet scrubbers. Design and efficiencies. Combustion generated pollution, vehicle emission control. Case studies.
Water pollution: Water quality modeling for streams. Characterisation of effluents, effluent standards.
Treatment methods: Primary methods; setting, pH control, chemical treatment.
Secondary methods; Biological treatment, Tertiary treatments; like ozonization, disinfection, etc.
Solid waste collection, treatment and disposal. Waste recovery system.

Books & Reference:

1. L.Canter " Environment Impact Assessment", McGraw Hill..
2. E.P.Odum " Fundamentals of Ecology " V.B.Saunders and Co. 1974.
3. W.J.Weber " Physics-Chemical Process for water quality control, Wiley-international ed.
4. L.L.Gaccio water and water population Handbook Marcel Dekkar, New York

Paper ID	Paper	L	T	P	Credit
14515	CT-515 Powder Processing and Technology	3	0	0	3

Powder sampling: importance of sampling, sampling techniques for static powders and flowing powders. Sampling errors. Properties of powder: size and size distribution. Number, area and volume distributions and their significance. Interconversion of distributions. Size analysis in subsieve size range. Impaction, centrifugation, light scattering and light diffraction techniques. Shape characterization, shape factor, Heywood numbers and their significance. Fractal and Fourier techniques. Shape distribution by sieve cascadograph. Production of powder: review of classical laws of grinding. Definition, terms and concepts, analogy of reaction kinetics to mill grinding. The first order grinding hypothesis.

Experimental estimation of selection function (specific rate of breakage) and breakage distribution functions. The size mass balance equations. Analysis of batch grinding equation. Solution of equation for batch grinding circuits. Storage of solids: flow properties, segregation. Funnel and bulk flow of solids, arch formation. Stresses in bulk solids. Design of silo for reliable flow of the solids. Flow improving techniques. Dust explosion: condition for dust explosion for stored and flowing solids. Methods of measurement of dust explosion.

Book & Reference:

1. A.S.Foust et.al.; " Principles of Unit Operations"Woley, New York.
2. Geankoplis " Transport Processes and Unit Operations, Prantice Hall, India.
3. W.L.McCabe, J.Smith and P.Harriot " Unit Operations of Chemical Engineering.

Paper ID	Paper	L	T	P	Credit
14517	CT-517 Chemical Process Quantitative Risk Analysis	3	0	0	3

1. **Introduction to CPQRA (Chemical Process Quantitative Risk Analysis): -**
   Techniques of CPQRA
   Scope of CPQRA Studies
   Management of incident lists
   Application of CPQRA
   Limitations of CPQRA

2. **Consequence Analysis: -**
   Source Models
   Explosion & Fires
   Effect Models

3. **Event Probability and Failure Frequency Analysis: -**
   Incident Frequencies from Historical Record
   Frequency Modeling Techniques

4. **Measurement, Calculation & Presentation of Risk Estimates: -**
   Risk Measures
   Risk Presentation
   Risk Calculations
   Risk Uncertainty, Sensitivity & Importance

5. **Creation of CPQRA Data Base: -**
   Historical Incident Data
   Process & Plant Data
   Chemical Data
   Environmental Data
   Equipment Reliability Data

6. **Case Studies: -**
   Chlorine Rail Tank Car Loading Facility
   Distillation Column

Books & References

1. Guidelines for Chemical Process Quantitative Risk Analysis, CCPS of AIChE
2. Risk Analysis for Process Plant, Pipelines & Transport; J.R. Taylor

SECOND SEMESTER EXAMINATION

L	T	P	Credits
14	2	16	24

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14502	CT-502	Computer Aided Process Design	3	1	0	4
14504	CT-504	Advanced Chemical Engineering Thermodynamics	2	1	0	3
Elective Course						
14512	CT-512	Alternative Energy Sources	3	0	0	3
14514	CT-514	Process plant Utilities	3	0	0	3
14516	CT-516	Catalysis and Reactor Design	3	0	0	3
14518	CT-518	Membrane Science &Technology	3	0	0	3
14520	CT-520	Design & Analysis of Biological Reactors	3	0	0	3
Practical/Viva Voce						
14554	CT-554	Minor Project	0	0	16	8
		Total	**14**	**2**	**16**	**24**

Note: Student can select three electives either offered by the department from the above list or from the list of intradepartmental electives.

Paper ID	Paper	L	T	P	Credit
14502	CT-502 Computer Aided Process Design	3	1	0	4

Process and cost models, Role & application of mathematical models in process design and optimization, Process synthesis, modelling and development. **(8 Hrs)**

Process flow sheeting. Dynamic modelling and simulation of chemical process with / without recycle structure. Use of generic software for steady unsteady state material, momentum & energy balance flow sheet simulation, software development for design of process equipment & flowsheet. **(8 Hrs)**

Introduction to design of Separation network, Reactor-Separator network, Flow sheet optimisation. **(8 Hrs)**

Process design under uncertainty: Accommodating to future developments; Anticipating the future, Accommodating to linear demand forecast, Non zero initial demand, sizing new chemical plants in a dynamic, economy, Accounting for uncertainty in Data; engineering on safe side, The propagation of uncertainty through designs, Failure tolerance; introduction, Catastrophic results from minor events, preliminary flow, sheet review, theory of reliability & its application, Engineering around variation; variability, effects of storage on pulsed supply, analysis of queing theory, intersystem variation, economically optimal utilization, adapting to a variable power supply. **(8 Hrs)**

Course Objectives :

- Train students for various process design problems in industries using computer tools available like ASPENTECH.
- To make students capable for development of the software in process designing.

Books & Reference:

1. Alexander C. Dimian, Integrated Design and Simulation of Chemical Processes, Elsevier,
2. Seider W.D. and Seader J.D., Process Design Principles, John wiley & sons, inc.
3. Rudd and Watson; strategy of process engineering, John wiley & sons, inc. Babu
4. B.V. Babu, Process Plant Simulation, Oxford Luyben, W.L. Process MOdeling, Simulation and Control, McGraw Hill Book Co., 1990.
5. Hussain Asgher, Chemical Process Simulation, wiley eastern Ltd., New Delhi, 1986.

Paper ID	Paper	L	T	P	Credit
14504	CT-504 Advanced Chemical Engineering Thermodynamics	2	1	0	3

Fundamentals of Statistical Thermodynamics: Quantum energy levels and degeneracy, Boltzmann statistics, Maxwell statistics and thermodynamics properties, Thermodynamics equilibrium of process, Molecular theory of ideal gases, Dense gases and liquids, Phase transitions and phase equilibrium. **(14 Hrs)**

Irreversible Thermodynamics: Definition, Entropy production and flow, Thermodynamics forces, Onsager's reciprocal relation and application to chemical processes. **(6 Hrs)**

Molecular Simulation: Thermodynamics modeling and molecular simulation of equilibrium separation processes. **(8 Hrs)**

Course Objectives:

- To introduce the fundamentals of statistical thermodynamics and to give students a foundation for molecular simulation of chemical engineering processes.
- To train students to apply this fundamental body of knowledge in thermodynamics to the solution of practical problems.
- To understand the fundamentals concepts of chemical engineering thermodynamics and to explain these concepts to other chemical engineers. We will re-drive the essential conclusions of statistical thermodynamics so that students will comprehend the breadth as well as the limitations of thermodynamics.

Books & Reference :

1. J M Prausnitz, R N Lichtenthaler, E G de Azevedo, Molecular Thermodynamics of Fluid Phase Equilibrium, 3rd Edition., Prentice-Hall, 1999.
2. V P Carey, Statistical Thermodynamics and Microscale Thermophysics, Cambridge University Press, 1999.
3. T L Hill, An Introduction to Statistical Thermodynamics, Dover Publications, New York.
4. J M Haile, Molecular Dynamics Simulations-Elementary Methods, J Wiley & Sons.
5. Introduction to Chemical Engineering Thermodynamics, Smith J.M, Van Ness H.C., Abbott M.M. The McGraw Hill Companies, Inc., USA, 5th Edition, 1996.
6. Chemical and Engineering Thermodynamics, Sandler S.I. John Wiley and Sons, Inc., New York, 3rd Edition, 1999.
7. Introductory Chemical Engineering Thermodynamics, Elliot J.R and Lira C.T., Prentice Hall, 1999.

Paper ID	Paper	L	T	P	Credit
14512	CT-512 Alternative Energy Sources	3	0	0	3

Energy Scenario : Indian and global energy crisis, Classification of various energy sources, renewable and non renewable energy sources, remedial measures to energy crisis.

Energy Conservation: Laws of energy efficiencies, Ways of conserving energy in chemical and allied industries, viz, better house keeping, scope of improvements in design of equipments, waste heat recovery, concept of multiple effect and recycling etc. Energy audit.

Bioenergy, bio-gas plants and their operation, biomass and its conversion routes to gaseous and liquidfuels, its potential and generation by wind mills

Nuclear energy: status, nuclear raw materials , nuclear reactors and their classification, generation of nuclear power, nuclear installation in India and their capacity generation, limitation of nuclear energy, reprocessing of spent nuclear fuel.

Cogeneration of fuel and power, Energy from tidal and ocean thermal sources..

Books & Reference :

1. Brame J. S. S. and King J. G. Edward Arnold, " Fuel solid liquid and gases"
2. Sukhatme S.P., "Solar Energy"

Paper ID	Paper	L	T	P	Credit
14514	CT-514 Process Plant Utilities	3	0	0	3

Various process utilities, their role and importance in chemical plants.

Water sources: sources of water, their characteristics, storage and distribution of water, water for boiler use, cooling purposes, drinking and process water treatment reuse and conservation of water, water resources management.

Steam : Steam generation and its application in chemical process plants, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps, their characteristics, selection and application, waste heat utilization.

Compressors and Vacuum Pumps : Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum development and their limitations, materials handling under vacuum, piping systems, lubrication and oil removal in compressors in pumps.

Refrigeration Systems: Refrigeration system and their characteristics, load calculation and load calculation and humidification and de humidification equipments, drying and cooling tower, air blending, exhaust, ventilation, cryogenics, their characteristics and production of liquid N_2 and O_2

Insulation: Importance of insulation for meeting for the process equipment, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and sub zero temperatures including cryogenic insulation, determination of optimum insulation thickness.

INERT GASES: Introduction**,** properties of inert gases & their use, sources and methods of generation, comparison of nitro generation routes, general arrangement for inerting system, operational, maintenance and safety aspects.

Books & Reference:

1. Jack Broughton; Process utility systems; Institution of Chem. Engineers U.K.
2. Reid, Prausnitz poling; The properties of gases & liquids, IV ed. McGraw Hill international ed.
3. S.C.Arora & S.Domkumdwar; A course in refrigeration and air conditioning; Dhanpat Rai & Co.(P) ltd.

Paper ID	Paper	L	T	P	Credit
14516	CT-516 Catalysis and Reactor Design	3	0	0	3

Catalysis and catalytic process , catalyst formation, adsorption on solid surfaces, physical - chemical adsorption model, multiplayer adsorption theory; catalytic reaction kinetic model, real and ideal surface models; various models for data analysis, adsorption enhancement, multi step rate control, significances of dual rate – determining step and non equilibrium kinetic model, catalyst deactivation, catalyst classification.

Fixed bed catalytic reactor; reactor and reaction parameter, chemical and physical dimensionless parameters, radial peclet, aspect and biot numbers, velocity variance, adiabatic and non adiabatic fixed bed reactor, design and modeling of fixed bed reactors

Fluidized bed catalytic reactor; character and quality of fluidization, fluid bed reactor modeling; Davidson Harrison model, Kunii - Levenspiel model, anatomy of overall rate coefficient, Olsons's fluid bed reactor analysis. Introduction and performance of catalytic gaze reactor, trickle bed reactor, catalyst deactivation in fixed bed, batch fluid bed, moving bed and continuous fluid bed reactors, comparison of fixed moving and fluid beds; reactor poisoning in terms of spm, thermal waves in fixed bed regeneration, optimization of regeneration cycles.

Books & References:

1. James J. Carberry: Chemical and catalytic reaction engineering McGraw Hill.
2. J.M.Smith, " Chemical Engineering Kinetics", McHill.
3. O.Levenspiel, "Chemical Reaction Engineering", Wiley Eastern, 2nd ed, 1972
4. Froment G.F., Bischoff K.B.; Chemical Reactor Analyser and design, John Wiley & Sons.
5. R.E.Hayes; Introduction to Chemical Reactor Analysis", Gordan and Breach science publishers.

Paper ID	Paper	L	T	P	Credit
14518	CT-518 Membrane Science & Technology	3	0	0	3

Membrane development, preparation and characterization for RO, UF, NF and micro filtration, design of membrane support structure, membrane modules for industrial applications.

Membrane polymer/preparation : polymer selection, phase inversion membranes, thermodynamics; interfacial polymerization and membrane morphology

Catalytic membranes; non porous and porous inorganic membranes, design and use of membrane reactors for industrial applications.

Bio functional membranes: immobilized enzymes , covalent attachment methods, affinity chromatography, transport models, functionalized membranes, membrane based sensors.

Books & Reference:

1. Ho and Sirkar, Membrane Handbook, Chapman Hall, 1992
2. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
3. Sourirajan, S. and Matsuura, T., Reverse Osmosis/Ultrafiltration Principle, National Research Council of Canada, Ottawa, Canada, 1985
4. Rauenbach, R. and Albrecht, R., Membrane Processes, John Wiley, 1989
5. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elservier, 1995
6. Howell, J.A., Sanchez, V., and Field, R.W. (EDITORS), Membranes in Bioprocessing, Chapman Hall, 1993
7. Kesting, R.E.Synthetic Polymeric Membranes: A Structural Perspective, John Wiley, 1985
8. Biofunctional Membrane (ed. By D.A.Butterfield), Plenum Press, 1996

Paper ID	Paper	L	T	P	Credit
14520	CT-520 Design & Analysis of Biological Reactors	3	0	0	3

Ideal Bioreactors: Fed-Batch Reactor, Enzyme-catalysed reactions in CSTRs, CSTR reactors with recycle and wall growth, The ideal plug-flow tubular reactor.

Reactor Dynamics: Dynamics model, Stability

Reactors with non-ideal mixing: Mixing time in agitated tanks, Resident time distributions, Models for no-ideal reactors, Mixing-Bio reaction interactions.

Sterilization Reactors: Batch Sterilization, Continuous Sterilization

Immobilized Bio Catalysits: Formulation and characterization of immobilized cell bio catalysts, Application of immobilized cell bio catalysts

Multiphase Bio reactors: Conversion of heterogeneous substrates, Packed bed reactors, Bubble column Bio-reactors, Fluidised bed Bio-reactors, Trickle bed reactors

Fermentation Technology: Medium formulation, Design and operation of a typical aseptic, alrobic fermentation process, Alternate bio reactor configuration.

Animal & Plant Cell Reactor Technology: Environmental requirements for animal cell cultivation, Reactor for large-scale production using animal cells, Plant cell cultivation.

Books & References:

1. Biochemical Engineering Fundamentals by James E.Bailey & David F.Ollis, Publishers: McGrew-Hill.
2. Bioprocess Engineering by Shuler & Kargi, Prentice Hall
3. Encyclopedia of Chemical Engineering by Kirk & Othmer.

Paper ID	Paper	L	T	P	Credit
14554	CT-554 Minor Project	0	0	16	8

The student should select an existing experimental rig from U.G. Labs. Analyze the existing experiment being performed. Suggest modification for better performance. If required, update the existing manual. Suggest new experiment that may be carried out an existing or modified set up or entirely new set up.

THIRD SEMESTER EXAMINATION

L	T	P	Credits
6	0	36	24

Elective Course						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14611	CT-611	Advanced Petroleum Refining	3	0	0	3
14613	CT-613	Industrial Pollution Engineering	3	0	0	3
14615	CT-615	Introduction to Nanotechnology	3	0	0	3
Practical/Viva Voce						
14651	CT-651	Major Project Part-I	0	0	30	15
14653	CT-653	Project Seminar*	0	0	6	3
		Total	**6**	**0**	**36**	**24**

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Note: Student can select two electives either offered by the department from the above list or from the list of intradepartmental electives.

Paper ID	Paper	L	T	P	Credit
14611	CT-611 Advanced Petroleum Refining	3	0	0	3

Composition and properties of crude oil. Distillation methods: Atmospheric distillation, Vacuum distillation. Thermal cracking processes: Burton cracking processes, Visbreaking and different type of coking.

Catalytic Conversion Processes: Fluid Bed and Orthoflow Catalytic Cracking, Catalytic Hydrocracking: Two stage and H-oil hydrocracker, Different type of catalysts used.

Reforming-type of catalysts, hydrotreating processes, hydrodesulphurization, Alkylation, Polymerization and isomerization

Supporting processes: solvent Extraction processes for deasphalting of Gasoline, Kerosene and Diesel oil. Wax separation and preparation as a finished product.

Course Objectives:

- A brief knowledge about chemical composition, characterization and evaluation of Crude Oil.
- To introduce the various processes of refinery and get familiarized with various type of refining processes to obtain finished petroleum products.

Books & References:

1. Petroleum Refining Technology and Economics, J.H. Gary, G.E. Handiwerk, Marcl and Dekker Inc., New York.
2. The chemistry and Technology of Petroleum, J.G. Speight, Marcel Dekker, 1991
3. Modern Petroleum Refining Processes, B.K. Bhaskar Rao Oxford and IBM Pub. Co. Pvt Ltd, New Delhi, 1990.

Paper ID	Paper	L	T	P	Credit
14613	CT-613 Industrial Pollution Engineering	3	0	0	3

General : Different water quality requirements of various industries for different pressure boiler feed waters, cooling water and process water. Waste generation and characterization from different industries like paper and pulp, breweries and distilleries, tanneries, textile, dairy, fertilizer, sugar mill, steel, oil refinery, petrochemical and pharmaceutical industries.

Treatment methods for water and waste: Volume reduction, strength reduction, Neutralization, equalization and precipitation: Basic Processes of Treatment: Pretreatment - Primary Treatment - Sedimentation - Flotation - Secondary Treatment - Design of Conventional biological treatment - Activated Sludge -Trickling Filters - Sludge digestion - Disposal of treated effluent and sludge. Tertiary Treatment systems- Removal of Dissolved Solids, Nitrogen, Phosphorous

Air pollutants – generation, characterization - stack height - dispersal mechanisms. Control methods, particulate emission control methods such as gravitational settling chambers, cyclone separators, fabric filters, electrostatic precipitators, wet scrubbers, control of gaseous emissions by adsorption on solids, and by absorption in liquids, combustion.

Generation and treatment of sludge and solid wastes - identification of hazardous wastes - disposal methods.

Waste minimization and Life Cycle Analysis of a pollutant.

Books & References:

1. Waste Water Treatment , M.N.Rao and A.K. Dutta, 1987, Oxford & IBH Pub.Co.
2. Environmental Pollution Control, C.S.Rao, 1993, Wiley Eastern Ltd.
3. Industrial wastes their disposal and treatment W. Rudolfs 1997.
4. Industrial environment, assessment and strategies S.K. Agarwal 1996.
5. Hazardous waste management, Charles A. Wertz. 2nd edition.
6. Integrated solid waste management Goerge Tchobanoglous, Hilary Theisen & Samuel A. Vigil.
7. Hazardous waste management Micheal La. Grege, Philip Buckingham, Jeffery Evans

Paper ID	Paper	L	T	P	Credit
14615	CT-615 Introduction to Nanotechnology	3	0	0	3

Introduction to Nanotechnology – Histroy of nano-revolution, nano scale materials and their applications, Carbon nano tubes, organic and inorganic nano structures. Future of the nanotechnology.

Materials used in Nanotechnology – An overview of the physical (mechanical, electrical) and chemical properties of different classes of solid materials such as metals, semiconductors, insulators and polymers. Examples of size effects of properties observed in thin films, colloids and nanocrystals.

Conventional Fabrication Techniques – Topdown and bottom up process, techniques used in conventional microfabrication including thin film deposition (e.g. CVD, PVD(, lithography, chemical etching and electrodeposition.

Analytical Techniques – Analytical techniques such as Electron Microscopy, Electron and X-ray Diffraction, Ellipsometry, Photoelectron, Optical and Ion spectroscopy and Probe Microscopy.

Applications – Examples of applications in Micro and Nano technology including, Micro fluidics, Micro Electron Mechanical Systems (MEMS) membrane technology, and catyalyst and coatings

Books & Reference :

1. M. Wilson, K. K. G. Smith, M. Simmons and B, Raguse; Nanotechnology, Chapman & Hall/CRC press 2002
2. M. Meyyappan; Carbon Nanotubes, Science and application; CRC Press, 2005
3. Alexei Nabok; Organic and Inorganic Nanostructures; Publisher Artech House, London, 2005
4. H. Watarai, N. Teramae and T Sawada; Interfacial Nanochemistry; Kluwer Academic/Plenum press, 2005

Paper ID	Paper	L	T	P	Credit
14651	CT-651 Major Project Part-I	0	0	30	15

The student should select any one of the topics offered from the department or select one on his own duly approved from the department. As part of the project work, candidate should give oral presentation of the work atleast one in a semester **(CT - 651).** The candidate is required to submit the detailed synopsis of the work that he would complete in the part-II **(CT - 652)** along with the report of the work already completed.

Paper ID	Paper	L	T	P	Credit
14653	CT-653 Project Seminar	0	0	6	3

FOURTH SEMESTER EXAMINATION

L	T	P	Credits
0	0	36	18

Practical/Viva Voce						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14652	CT-652	Major Project Part-II	0	0	30	15
14654	CT-654	Project Seminar*	0	0	6	3
		Total	**0**	**0**	**36**	**18**

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Paper ID	Paper	L	T	P	Credit
14652	CT-652 Major Project Part-II	0	0	30	15

Students has to continue the work of CT-651, Major Project Part-I, and complete the work and submit the thesis for evaluation after giving Project Seminar (CT - 654).

Paper ID	Paper	L	T	P	Credit
14654	CT-652 Project Seminar	0	0	6	3