FACULTY OF LIFE SCIENCES

SYLLABUS

FOR

M.Tech. (Environmental Science & Technology)

(Credit Based Evaluation & Grading System)

(Semester: I - II)

Examinations: 2019-20

GURU NANAK DEV UNIVERSITY AMRITSAR

M.Tech (Environmental Science & Technology) (Semester System)
(Credit Based Evaluation & Grading System)

Total No. of Seats: **20**

Admission Criteria:
Admission to M.Tech. programme will be open to the candidates who are GATE/NET (Environmental Sciences). The vacant seats, same will be filled on the basis of merit in the entrance test examination conducted by the university.

Semester-I

Course No.	Course Title	L	T	P	Credits
ETL-501	Chemistry for Environmental Engineering	3	1	0	4
ETL-502	Section Operations for Environment Engineering	3	1	0	4
ETL-503	Engineering Principles of Solid Waste Management	3	1	0	4
ETL-504	Fundamentals of Environmental Sampling	3	1	0	4
ETP-505	Industrial Tour/Field Visit/Case studies-1	0	0	2	2
ETP-506	Chemistry for Environmental Engineering Laboratory	0	0	2	2
	ID	4	0	0	4
					24

Semester-II

		L	T	P	Total credits
ETL-511	Instrumental Methods in Environmental Engineering	3	1	0	4
ETL-512	Applied Statistics and Design of Experiments	3	1	0	4
ETL-513	Biochemical Engineering Fundamentals	3	1	0	4
ETL-515	Enhanced Systems for Water Purifications, Wastewater Treatment	3	1	0	4
ETL-516	Optimization of Chemical Processes	3	1	0	4
ETP-517	Industrial Tour/Field Visit/Case studies-2	0	0	2	2
ETP-518	Instrumental Methods in Environmental Engineering Laboratory	0	0	2	2
	ID	4	0	0	4
					28

NOTE: PSL-053 ID Course Human Rights & Constitutional Duties (Compulsory Paper). Students can opt. this paper in any semester except the 1st Semester. This ID Paper is one of the total ID Papers of this course.

M.Tech (Environmental Science & Technology) (Semester-I)
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ETL-501 Chemistry for Environmental Engineering

Credits: 6

L	T	P
4	2	2

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Process chemistry: Chemical Equations: weigh relationships and conservation of mass and charge and thermodynamic equilibrium; Gas laws, Equilibrium and Le-Chatlier's principle, Variations of Equilibrium relationship and ways of shifting chemical Equilibrium, Acid-Base Equilibrium: Alkalinity and Acidity, Buffering in water system, Solubility Equilibrium, Water Stabilization, Corrosion, Langlier Saturation Index, Equilibria governing iron and manganese solubility; Oxidation Reduction Equilibria; Application of redox chemistry

Section-B

Fundamentals of Process Kinetics: Reaction rates and order, Reactor design, Fundamentals of surface and colloidal chemistry, Adsorption- physical adsorption , factors influencing adsorption, Adsorption isotherms, Design of adsorption column

Analytical Techniques: Methods employed in environmental chemical analysis, viz; Gravimetry, Titrimetry, Atomic absorption spectrophotometer, Gas Chromatography, High performance liquid chromatography, Mass spectrometry.

Section-C

Fundamentals for water chemistry: Water resources, structure and properties of water, Nutrient and biogeochemical cycles, Water acidity and carbon dioxide in water, alkalinity, BOD, COD, DO determinations, Physical and chemical quality of surface water, ground water and waste water, Aquatic biochemical processes

Atmospheric Chemistry: Chemical Composition and structure of atmosphere, Sources and classification of pollutants, Chemical and photochemical reactions, in atmosphere, Ozone chemistry- formation and depletion of ozone layer, oxides of nitrogen and sulphur, Photochemical smog, Greenhouse effect/ global warming, greenhouse gases and their effects.

Section-D

Soil Chemistry: Composition of soil, Chemical Weathering, Soil formation and soil classification, Soil clays, soil acidity, salinity, Acid Base and ion exchange reaction in soil, Humus-metal interaction, Nitrogen pathways and NPK in soil, Impact of industrial effluents and fertilizers on soil.

References:

1. Chemistry for Environmental Engineering and Science, C.N. Sawyer, P.L. McCarty and G.F. Parkin.
2. Chemistry for Water Treatment, S.D. Faust and O.M. Aly
3. Environmental Engineering, H.S. Peavy and D.R. Rowe

M.Tech (Environmental Science & Technology) (Semester-I)
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ETL-502 Section Operations for Environment Engineering

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Role of Chemical Section operations in processing water and wastewater, chemical coagulation, types of charged particles in wastewater, particle-particle interactions, particle destabilization, Clarifiers and Thickeners, flocculation, principles of sedimentation, cyclones, decanters, principle of filtration, equipments for filtration, filter aids, continuous and batch filtration, centrifugal filtration

Section-B

Membrane separation processes: Porous membranes, polymer membranes flow pattern in membrane separations, applications, dialysis, reverse osmosis, screening, classification of screens, screening characteristics, grinders, design considerations, grit removal, types of grit chambers, aerated grit chambers, grit separation and washing, disposal of grit, floatation, design of dissolved air floatation system

Section-C

Reactors for wastewater treatment, modeling ideal flow in plug flow and complete mix reactors, factors responsible for non ideal flow in reactors, types of tracers, tracer tests, modeling non ideal reactors, types of reactions, reaction rate and order for environmental modeling, modeling treatment processes, complete mix and plug flow reactors with reaction, basic principles of mass transfer, gas-liquid and liquid-solid mass transfer

Section-D

Theory of mixing, mixers for rapid mixing, continuous and batch mixing, energy dissipation in mixing, Principle of adsorption, basic equations for adsorption, equipments, activated carbon adsorption kinetics, activated carbon treatment, design of granular and powdered activated carbon contractor, chemistry of ion exchange, ion exchange materials, ion exchange reactor design, capacity of ion exchange resins, applications

References:

1. Section Operations in Environmental Engineering, R. Elangovan, New Age International (P) Limited, New Jersey, 2001.
2. Section Operations in Environment & Process Engineering, T. D. Reynolds, P. A. Richards, PWS Publishing Company, New York, 1996.
3. Section Operations & Processes in Environment Engineering, R. Reynolds, Cengage Learning, New York, 2009.
4. Encyclopedia of Section Operations & Processes in Environment Engineering, M. F. Rebelo, N. Aarts, N. B. Raut, Auris Reference, UK, 2016.
5. Section Operations in Environment Engineering, R. Noyes, Noyes Publications, New Jersey, 1994.

M.Tech (Environmental Science & Technology) (Semester-I)
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ETL-503 Engineering Principles of Solid Waste Management

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Solid waste importance, Design and assessment of solid waste management facilities. Material mass balance: preparation, analysis and application. Factors affect generation rate, Public attitude and legislation, Geographic and physical factors. Waste characterization and diversion: handling and separation of solid waste. Storage and processing of solid waste at source, at residential dwellings, commercial and industrial facilities. Solid waste collection systems, equipment and personal requirements and collection routes.

Section-B

Solid waste materials: separation, reuse and recycle, drop-off and bye back centres, Unit operations for processing, handling, moving and storing. Materials recovery facilities (MRFs): development and implementation. Planning and design process for MRFs. Waste transportation through combustion and aerobic composting. Transportation of solid waste: transport method, type of transfer station and their design. Disposal of Solid waste and residual method: landfill method and landfill classification. Composition, characteristics, and control of landfill gases. Surface water management, Environmental quality monitoring at landfill. Closure of Landfill.

Section-C

Materials Separation and processing Technologies: Section operation, size reduction & size separation, Density Separation, Magnetic and Electric field separation and Densification. Thermal Conversion Technologies: Fundamental of Thermal Processing, Combustion system, Pyrolysis system, Gasification System, Environmental Control and Energy Recovery Systems. Biological and Chemical Conversion Technologies: Biological Principles, Aerobic Composting, Low- Solids and High Solids Anaerobic Digestion, development and technologies for treatment of organic fraction of Municipal Solid Waste (MSW). Chemical Transformation Processes.

Section-D

Recycling of Material found in MSW: Aluminium Cans, Plastics, Glass, Paper and cardboard, Ferrous and non-ferrous metal, wood, waste oil, used tire, Lead acid batteries, Household batteries. Implementation of Solid Waste Management options. Planning sitting and permitting of waste management facilities: Developing a facility plan and securing a site and obtaining permit.

M.Tech (Environmental Science & Technology) (Semester-I)
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References:

1. Bomberger, D. C., R. Lewis, and Valdes: Waste Characterization Study: Assessment of Recyclable and Hazardous Components, report prepared for California Waste Management Board, SRI International, Menlo Park, CA, 1988.
2. Tchobanglous, G., Theisen, H. and Vigil, A. S.: Integrated Solid Waste Management Engineering Principles and Management Issues, McGraw-Hill International Edition, 1993.

M.Tech (Environmental Science & Technology) (Semester-I)
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ETL-504 Fundamentals of Environmental Sampling

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Nature of Analytical Chemistry, General Guidelines of Chemical Analysis, Laboratory Hazards including Chemical and Fire Hazards, Safe Handling of Compressed Gases, Stockroom safety rules, Safety rules for laboratory, Quality Assurance, Control and Assessment, Sampling , Sampling Custody, Sample preparation for Analysis, Analytical methodology, Statistics in Chemical Analysis, Quality Control Charts

Section-B

Labware Materials: Soft laboratory Glassware vs. Heat- Resistant Glassware, Plastic, Porcelain, Platinum and Nickel Crucible, Volumetric Glassware, The Analytical Balance, Desiccators, Grades and Purity of chemicals, Storage and standards of Chemicals, Methods of preparation of pure water, Expressing concentration of solutions, Handling Reagents and solutions, Stock standards solutions and their standardization, preparation and standardization of common standard solutions.

Section-C

Common Laboratory Techniques including Filtration, Gravity Filtration versus Vacuum Filtration, Centrifugation, Centrifuge Safety rules, Distillation, Simple Distillation, Fractional Distillation, Vacuum Distillation, Refluxing, Ion-Exchange, Drying and Ashing Samples, Sohxlet Extraction, Gravimetric Methods of Analysis, Introduction to Titrimetric Analysis, Calculating the result of Titration, Back Titration

Section-D

Arrhenius theory of acids and bases, Bronsted-Lowry Concepts of acids and bases, Acid-Base Equilibrium, pH Calculations, Buffers, Acid-base Titrations- their curves and indicators, Complexometric Titration, Oxidation-Reduction Titration, Precipitation Formation Titration, Mohr method for halides, Volhard Method, The use of Adsorption Indicators: The Fajans Method, Laboratory First Aid, Log-Book Forms and useful tables applicable in analytical work, Documentation Forms For Quality Control Data

M.Tech (Environmental Science & Technology) (Semester-I)
(Credit Based Evaluation & Grading System)

References:

1. Environmental Sampling and Analysis, M. Csuros, Lewis Publishers, New York
2. Analytical Chemistry for Technicians, John Kenkel, Lewis Publishers, 1990.
3. APHA-AWWA-WPCF, Standard Methods for the Examination of Water and Wastewater, 17edition, 1989and 18th ed., 1994.
4. Quality Assurance in Chemical Measurements, John Keenam Taylor, Lewis Publishers, 1998.
5. Methods of Chemical Analysis of Water and Wastes, EPA-600/4-79-020,Rev. March, 1983.

M.Tech (Environmental Science & Technology) (Semester-II)
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ETL-511 Instrumental Methods in Environmental Engineering

Credits: 6

L	T	P
4	2	2

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Ultraviolet and Visible spectrometry and absorption methods: Fundamental laws of photometry, Radiation sources and wavelength selections, Cells, sampling device and detectors, Accuracy and precision , Differential or expanded-scale spectroscopy, Difference and derivative spectroscopy, Correlation of electronic absorption spectra with Molecular structure.

Section-B

Fluorescence and Phosphorescence spectrophotometry: Structural factors, Photoluminescence power as related to concentration, Instrumentation Fluorescence lifetime measurements, Room temperature phosphorescence, Comparison of luminescence and ultraviolet-visible absorption methods. Flame emission and atomic absorption spectroscopy: Introduction and instrumentation, Atomic fluorescence spectrometry, Comparison of FES and AAS.

Section-C

Atomic emission spectroscopy with plasma and electrical discharge sources: Introduction, Instrumentation, Applications, ICP atomic fluorescence spectroscopy, Comparison of methods: ICP versus AAS. Infrared Spectrometry: Correlation of Infrared spectra with molecular structures, Instrumentation, Sample handling, Quantitative analysis.

Section-D

General principles of chromatography, classification of chromatography methods, Behaviour of solutes, Column efficiency and resolution, Time of analysis and resolution, Quantitative determination and retention data for sample characterization, Gas chromatography, High performance liquid chromatography. Process instruments and automated analysis: Introduction, Industrial process analyzer, oxygen analyzer, Process gas chromatography, Automatic chemical and elemental analyzers.

References

1. Instrumental Methods of analysis, Willard, H.H., Merrit, L.L., Dean, J.A., Settle, F.A., CBS Publication, New Delhi.
2. A Manual of Fluorometric and Spectrophotometric Experiments, Gillespie, A.M., JR., Gordon and Breach Science and Publishers, New York , 1985.
3. Experiments in Morden Analytical Chemistry, Kealey, D., Chapman and Hall, New York, 1986.

M.Tech (Environmental Science & Technology) (Semester-II)
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ETL-512 Applied Statistics and Design of Experiments

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Empirical Models, Simple Linear Regression, Properties of the least squares estimators, Hypothesis tests in simple linear regression, Use of t-tests, Analysis of Variance approach to test significance of Regression, Confidence Intervals, Adequacy of the regression model, Residual Analysis, Coefficient of Determination, Lack-Of-Fit Test, Transformations to a straight line, Correlation, Multiple Linear Regression model, Hypothesis Tests in multiple Linear Regression, Confidence intervals in multiple linear regression, Model Adequacy Checking, Aspects of Multiple Regression Modeling.

Section-B

Design and analysis of Single-Factor Experiments: The Analysis of Variance, Designing Engineering Experiments, Completely Randomized Single-Factor Experiment, Random Effects Model, Randomized Complete Block Design with Random Factors, Application of Designed Experiments, Factorial Experiments, Two Factor Factorial experiments, Factorial Experiments with Random Factors, 2K Factorial Designs, Fractional replication of the 2k design, Response Surface Methods and other approaches to Process optimization.

Section-C

Nonparametric Statistics, Sign Test, Sign Test for Paired Samples, Type-II Error for the Sign Test, Comparison of sign test to t-test, Wilcoxon Signed-Rank Test, Comparison of Wilcoxon Signed-Rank Test to t-test, Wilcoxon Rank-Sum Test, Nonparametric Methods in the analysis of variance, Kruskal-Wallis Test, Rank Transformation.

Section-D

Use of software in Design of Experiments (DOE): Design Expert, SPSS, Statistica etc.

References:

1. Applied Statistics and Probability for Engineers, D.C. Montgomery, G.C. Runger, Wiley-India, 2008.
2. Design and Analysis of Experiments, D.C. Montgomery, Wiley-India, 2007

M.Tech (Environmental Science & Technology) (Semester-II)
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ETL-513 Biochemical Engineering Fundamentals

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Enzyme kinetics with one or two substrates, Michaelis-Menten kinetics, Determination of Elementary-Step Rate Constants, Effects of pH and temperature on enzyme kinetics, Enzyme reactions in heterogeneous systems, Applications of enzymes, Immobilized enzyme technology, Thermodynamics principles, Biosynthesis, Metabolic organization and regulation, End product of metabolism, Stoichiometry of cell growth and product formation.

Section-B

Ideal reactors for kinetics measurements, Kinetics of balanced growth, Overall kinetics and thermal death kinetics of cells and spores, Transport phenomena in bioprocess systems: gas liquid mass transfer in cells, Determination of oxygen transfer rates and $K_{La,}$ Heat transfer correlations and sterilization of gases and liquids by filtration.

Section-C

Ideal bioreactors and dynamic models, Reactors with non-ideal mixing, Fermentation technology, Multiphase bioreactors, Anaerobic digestion process, Aerobic digestion, Activated sludge process and nitrification, Anaerobic denitrification process, UASB, Animal and plant cell reactor technology.

Section-D

Instrumentation and control: Sensors of the physical environment, Gas analysis, Data smoothening and interpolation, Programmed batch bioreactions, Design and operating strategies for batch plans

References:

1. Biochemical Engineering Fundamentals. Bailey, J.E. and Ollis. D.F., McGraw Hill.
2. Biochemical Engineering , Aiba, S., Humphrey, A.E. and Millis, N. F., Academic Press.
3. Topics in Enzyme and Fermentation Biotechnology, Wiseman, A. (editor), Ellis Horwood Limited, Chichester.
4. Mathematical models in Biological Waste water Treatment, Jorgenson, S.W. and Gromlec, M.J.,
5. Microbiological Methods for Environmental Bio-technology, Grainer, J.M. and Lynch, J.M., Academic Press.

M.Tech (Environmental Science & Technology) (Semester-II)
(Credit Based Evaluation & Grading System)

ETL-515 Enhanced Systems for Water Purifications, Wastewater Treatment

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Historical overview of Water Treatment, Different types of Water Treatment Processes, Aeration, Liquid-Gas Contact Systems, Solids Separation: Type-1 Settling, Type-2 Settling, Design Consideration for Settling operations, Coagulation, Colloidal Stability, Softening, Design Criteria for Softening, Single-Stage Softening, Two-Stage Softening, Ion-Exchange Softening, Filtration, Filter Hydraulics, Design and Operation of Sand filters, Pressure filters, Modified methods of filtration, Dissolved Solids Removal.

Section-B

Wastewater Characteristics, Important Wastewater Contaminants, Effluent standards, Terminology in wastewater treatment, Types of Wastewater Treatment Processes: Primary Treatment, Screening and Grit Removal, Design Parameter for aerated grit chambers, Flow Measurement, Primary Sedimentation, Secondary Treatment, Growth and Food Utilization, Disinfection of Effluents , Chlorination Practices and its design and operation.

Section-C

Suspended-Culture Systems, Activated Sludge, Design and Operational Parameters for activated-sludge Treatment Processes, Ponds and Lagoons, Attached Culture Systems, Trickling Filters, Rotating Biological Contractors and its design considerations, Secondary Clarification, Sludge Characteristics, Typical Solids content of Sludge, Sludge Digestion, Typical Design Parameters of Digestion, Sludge Treatment and Disposal.

Section-D

Advanced Wastewater Treatment Processes, Nutrient Removal, Nitrogen and Phosphorus Removal, Miscellaneous methods, Absorption, Adsorption, Reverse Osmosis, Electro dialysis and Ion Exchange, Wastewater Disposal and Reuse, Hydraulic Analysis of Water and Wastewater Treatment, Treatment Plant Design and Operations.

References

1. Environmental Engineering, H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Mc-Graw Hill, New York, 1985.
2. Wastewater Engineering: Treatment Disposal and Reuse, Metcalf & Eddy, Mc-Graw Hill, New York, 2003.
3. Water and Waste Water Engineering, Fair, G.M. Geyer, J.C. and Okun, Vol.2, John Wiley.
4. Physico-chemical Processes for Water Quality Control, Weber, W.J., Wiley Interscience, New York, 1972.

M.Tech (Environmental Science & Technology) (Semester-II)
(Credit Based Evaluation & Grading System)

ETL-516 Optimization of Chemical Processes

Credits: 4

L	T	P
3	2	0

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Section-A

Introduction to Optimization, Need, Scope and Applications of Optimization, Developing Models for Optimization along with their classification, Economic Objective Functions, Measures of Profitability. Basics of Optimization, Continuity of Functions, Interpretation of Objective function in terms of Quadratic Approximation, One-Dimensional Search,

Section-B

Numerical methods for Optimizing a function of one variable, Scanning and Bracketing Procedures, Newton Quasi-Newton Methods, Polynomial Methods of One-dimensional search, Unconstrained Multivariable optimization using methods including function values only, using First Derivatives, Newton and Quasi-Newton Method, Geometry of Linear Programs, Simplex Algorithm, Barrior methods, Sensitivity Analysis, LP Software, Non-Linear programming (NLP) with constraints, Advantages and disadvantages of NLP, available NLP software

Section-C

Mixed-Integer Programming, Branch-and- Bound Methods using LP relaxations, Solving MINLP Problems using Branch-and Bound Methods, Outer Approximation, Methods of global optimization; Branch and Bound Methods, Multistart Methods and Heuristic Search Methods, Other Software for global optimization

Section-D

Optimizing Recovery of Waste Heat, Optimal Shell and Tube Heat Exchange Design, Boiler/ Turbo-Generator system optimization, Optimal Design and operation of a conventional staged- distillation column Fitting vapour-liquid Equilibrium data via nonlinear regression, Optimization of thermal cracker via linear programming, optimal design of an Ammonia Reactor, Optimization of Low-Pressure Chemical Vapor Deposition reactor for the deposition of thin films, Reactor synthesis Via MINLP, Optimization in large-scale plant design using Equation based process simulators and Modulator –Based Simulators

References

1. Optimization of chemical processes, McGraw-Hill International Edition, Thomas F. Edgar David M. Himmelblau, 2001.
2. Engineering Optimization methods and applications, Wiley-India Edition, A. Ravindran, K.M. Ragsdell, G.V. Reklaitis, 2006.