M.TECH

CHEMICAL ENGINEERING

SYLLABUS

Submitted by

Department of Chemical Engineering,
MIT, Manipal.

M. TECH IN CHEMICAL ENGINEERING

FIRST SEMESTER							SECOND SEMESTER					
	Sub Code	Subject Name	L	T	P	C	Sub Code	Subject Name	L	T	P	C
FIRST YEAR	CHE 601	Mathematical and numerical techniques in Chemical Engineering	3	1	0	4	CHE 602	Advanced Reaction engineering	3	1	0	4
	CHE 603	Optimization of Chemical Processes	3	1	0	4	CHE 604	Advanced Process Dynamics and Control	3	1	0	4
	CHE 605	Advanced Thermodynamics	3	1	0	4	CHE 606	Process Modelling, Analysis and Simulation	3	1	0	4
	CHE607	Advanced Transport Phenomena	3	1	0	4	CHE 608	Advanced Separation Processes	3	1	0	4
	CHE 609	Elective I	3	0	0	3	CHE 610	Elective III	3	0	0	3
	CHE 611	Elective II	3	0	0	3	CHE 612	Elective IV	3	0	0	3
	CHE 613	Seminar-I	0	0	3	1	CHE 614	Process Simulation Lab	0	0	6	2
	Total		**18**	**4**	**3**	**23**	CHE 616	Seminar II	0	0	3	1
							Total		**18**	**4**	**9**	**25**
SECOND YEAR	CHE 618	Industrial Training report							0	0	0	2
	CHE 799	Project Work							0	0	0	40
	Total								**0**	**0**	**0**	**42**
								Total Credits				**90**

Elective I :
CHE 609.1 Bioprocess Engineering
CHE 609.2 Pollution Monitoring and Control
CHE 609.3 Interfacial Science and Engineering

Elective II
CHE 611.1 Bio Energy Engineering
CHE 611.2 Industrial Waste Water Engineering
CHE 611.3 Pinch Technology

Elective III
CHE 610.1 Metabolic Engineering
CHE 610.2 Solid Waste management
CHE 610.3 Membrane Science and Technology

Elective IV
CHE 612.1 Upstream and down stream bioprocessing
CHE 612.2 Environmental Management System
CHE 612.3 Nano Science and Technology

FIRST YEAR – FIRST SEMESTER

CHE 601 MATHEMATICAL AND NUMERICAL METHODS IN CHEMICAL ENGINEERING [3 1 0 4]

Introduction, linear algebraic equations Eigenvalues and Eigenvectors of Matrices, sparse Matrices – Tensors and their applications. Non linear algebraic equations function evaluation-least square curve fit-Newton inter-polation formula – orthogonal polynomials and functions-ordinary differential equations initial value problems and Boundary value problems – finite difference techniques. Orthogonal collocations on finite difference-Galerkin finite elements-shooting techniques partial differential equations-finite difference technique (Method of lines) orthogonal collocation on finite elements. The Galerkin finite Element technique variational forms of PDE's. Sturm-Louiville theory-separation of variables and Fourier Transforms-Green's function-uniqueness conditions for linear and Nonlinear systems, steady state characteristics of Nonlinear Dynamical systems-Linear stability and Limit cycles-secondary Bifurcations and chaos.

Text Books:

1. Mathematical Methods in Chemical Engineering S.Pushpavanam, PHI,1998.
2. Numerical methods for Engineer By Santhosh K.Gupta, Wiley Eastern Ltd, New Delhi.
3. Owen T.Hanna and Orville C.Sandall "Computations methods in Chemical Engineering" PHI, 1998.
4. Davis, H.T. and Thomson K., Linear Algebra and Linear operators in Engineering with applications of mathematica, Academic Press, 2000

CHE 603 OPTIMIZATION OF CHEMICAL PROCESSES [3 1 0 4]

The nature and organization of optimization – the essential features of optimization problems-Review of fitting models to data formulation of objective functions. Optimization theory and methods – Basic concepts of optimization-Convex and concave functions-optimization of un-constrained functions: one dimensional search, uni-dimensional and Multidimensional problems. Un-constrained Multivariable optimization. Simplex, conjugate search. Powells Method. Indirect and Secant Methods. Linear programming and applications – Non linear programming with constraints. Diagnosis of the failure of optimization codes to solve problems. Optimization of staged and Discrete processes Dynamic programming, integer and Mixed Integer programming-nonlinear. mixed integer programming algorithms. Application of optimization in Heat transfer and Energy conservation, separation processes, fluid flow systems chemical reactor Design and operation and optimization in large-scale plant Design and Operation.

Text Books:

1. "Optimization of chemical processes" T.F.Edgar, D.M.Himmelblau, L.S. Ladson, Mc Graw Hill international Editions, 2nd Ed., 2003
2. Engg. optimization-theory and applications, S.S. Rao, New Age Publishers, ND, 2000
3. Engineering optimizations, Theory and practice, M.C. Joshi and K.M. Moudagalya, Narosa Pub, New Delhi 2004.

CHE 605 ADVANCED THERMODYNAMICS [3 1 0 4]

Thermodynamic Analysis of Chemical engineering systems. Minimum energy requirements Estimation of properties in multicomponent multiphase systems. Analysis of high pressure and low temperature phase equilibria, intermolecular force, potential energy functions and virial coefficients and excess functions; Thermodynamic models and data reduction procedures for estimation of the interaction parameters; Theories of solutions; Phase instability and partially miscible systems; Estimation procedures for solubility of gases in pure and mixed solvents, computations methods for generation of Multicomponent phase equilibrium data for process design; Review of chemical equilibria in complex reacting systems and computational methods for optimum process conditions for maximum conversion, statistical thermodynamics. Schrodinger's equation, microcanonical and canonical ensembles, partition function, expressions for thermodynamic quantities, perfect gases. Analysis of problems in irreversible thermodynamics.

Text Books:

1. J.M.Prausnitz, Lichtenthalu R.M. and Edmundo G.De Azevedo, Molecular thermodynamics of fluid phase equilibria, 3rd Ed. 1998, PHI.
2. Tester J.W. and Modell, M. Thermodynamics and its applications 3rd Ed., PHI, 1997.
3. Bejan, A Advanced Thermodynamics, Wiley, 1988.

CHE 607 ADVANCED TRANSPORT PHENOMENA [3 1 0 4]

Advanced Transport Phenomena Analysis, Review of vectors and Tensor Review of similarities and difference between various transport phenomena and applications. Transport properties, shell balances; Navier Stokes equations. Unsteady and steady conduction, laminar, forced and natural convection phenomena, shell balances of mass species diffusion under various driving forces, diffusion with chemical reaction, convective diffusion in dilute solutions, integral balances in momentum, heat and Mass Transfer.

1. Bird,R.B., Stewart, W.E. and Lightfoot, E.W. Transport Phenomena Wiley 1994.
2. Robert S.Brodkey, Harry.C.Hershey. Transport Phenomena-A unified approach McGraw Hill Int.Ed.1988.
3. John C.Slattery, Advanced Transport Phenomena, Cambridge University Press -1999.

ELECTIVES:

CHE 609.1 BIOPROCESS ENGINEERING [3 0 0 3]

Review of fundamentals of microbiology and biochemistry. Bioprocess principles: Kinetics of biomass production. Substrate utilization and product formation. Batch and continuous cultures. Fed batch culture introduction. Fermentation processes. General requirements of fermentation processes. An overview of aerobic and anaerobic fermentation processes. Examples of simple and complex media. Design and usage of commercial media for industrial fermentation. Thermal death kinetics of microorganisms. Heat sterilizations of liquid media. Filter stabilizations of liquid media and air.

Enzyme technology- Microbial metabolism enzymes classification and properties. Applied enzyme catalysis-kinetics of enzyme catalytic reaction. Metabolic pathways. Protein synthesis in cells. Bioreactor design and operations. Selection scale up operations of bioreactors. Mass transfer in heterogeneous biochemical reaction systems. Oxygen transfer rates and coefficients. Role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Recovery and purification of products. Introduction to instrumentation and process control in bioprocesses. Measurement of physical and chemical parameters in bioreactors. Monitoring and control of dissolved oxygen, pH, Impeller speed and temperature in a stirred fermenter.

Text books:

1. M. L. Shuler, F. Kargi. Bioprocess engineering. 2nd edition. PHI. New Delhi. 2002.
2. J. E. Bailey, D. F. Ollis. Biochemical engineering. 2nd edition. Mc Graw Hill Publication co. NY. 1985.
3. Pauline M. Doran, Bioprocess Engineering Principles, Academic Press, 2001

CHE 609.2 AIR POLLUTION MONITORING AND CONTROL [3 0 0 3]

Design of air monitoring survey networks criteria, models for monitoring site selection, principles and techniques for ambient and stack sampling, acquisition and analysis of monitored data, environmental indices Meterological monitoring and instrumentation, collection analysis and wind data, determination of atmospheric stability of wind roses and pollution roses principles methods Monitoring gaseous air pollutants like SO_2, H_2S, CO,CO_2 NOx, Hydrocarbons, collection and size analysis of particulates BS methods. Alternative routes of manufacturing and/or segruneing operation for pollution control and recovery of chemicals, Removal/recovery/destruction methods for Sox, NOx, Cl_2, F_2, Hg, H2S organic vapours and particulate matter through unit processes and unit operation like mass transfer, gas absorption, adsorption, filtration, membrane separation and chemical oxidation.

Text Books:

1. K.E Noll and T.L.Miller, Air Monitoring survey design, Ann Arber Science, 1977
2. S.M.Khopkar, Basic concepts of Analytical chemistry, Wiley Eastern, 1981.
3. A.C Perkin, Air Pollution, McGraw-Hill 1974.
4. I.Santis, F.De Allegrini Urban air pollution monitoring and control strategies (NATO ASI Series, Partne (Board Book).
5. S.M. Khopkar Environmental pollution Monitoring and control, New Age Int, ND – 2004.

CHE 609.3 INTERFACIAL SCIENCE & ENGINEERING [3 0 0 3]

General introduction of colloids, interfaces, surfactants, and micellization, Intermolecular forces, Van der Waals forces, Brownian motion and Brownian flocculation, Surface and interfacial tension and surface free energy, Surface tension for curved interfaces, Surface excess and Gibbs equation, Thermodynamics of interfaces, Thermodynamics of micelle formation, Electrical phenomena at interfaces (Electrokinetic phenomena, Electrical double layer), Colloidal systems and colloidal stability, Emulsion and micro-emulsion. Application: General applications, Enhanced petroleum recovery, Novel fabrication of nanostructured particles, Engineering surfaces and interfaces, Self-assembled & nanostructured biomimetic interfaces. Measurement techniques of surface tension, zetapotential, particle size.

Texts/References

1. Hiemenz, P. C. and Rajagopalan, R., Principles of Colloid and Surface Chemistry, 3rd Edition, MarcelDekker, N.Y.,1997.
2. M. J. Rosen, Surfactants and Interfacial Phenomena, Wiley-Interscience Publication, New York, 1978.
3. Adamson, A. W. Gast, A. P. Physical Chemistry of Surfaces, Wiley-Interscience, New York, 1997.

CHE 611.1 BIO ENERGY ENGINEERING [3 0 0 3]

Biomass sources and classification, Characteristics preparation, Chemical composition and properties of different biomass materials and bio-fuels. Sugarcane molasses and other sources for fermentation ethanol. Sources and processing of oils and fats for liquid fuels. Energy plantations. Briquette of loose biomass, drying storage and handling of biomass.

Biogas technology, Feedstock for biogas production, Aqueous waste containing biodegradable organic matter, animal residues, microbial and biochemical aspects, operating parameters for biogas production, kinetics and mechanism, dry and wet fermentation. Digesters for natural applications, High rate digesters for industrial waste water treatment. Bio-ethanol and bio-diesel technology, Production of fuel ethanol by fermentation of sugars, gasohol as a substitute for petro, Trans-etherification of oils to produce bio-fuels, Pyrolysis and gasification of biomass, Thermo chemical conversion lignocelluloses biomass, Biomass processing for liquid fuel production, Pyrolysis of biomass. Pyrolysis regime, effect of particle size, temperature and products obtained, Thermo-chemical gasification principles, Effect of pressure temperature and introduction of steam and oxygen, Design and operation of fixed and fluidized bed gasifiers.

Combustion of biomass and co-generation systems, Combustion of woody biomasss. Theory, calculation and design of equipments. Co-generation in biomass processing industries, Case studies, Combustion of rice husk, use of bagasse for cogeneration.

Text Book

1. A. Chakraverthy, Biotechnology and alternative technologies for utilization of biomass or agricultural wastes. Oxford & IBA pub. Co. New Delhi. 1989.
2. K. M. Mittal. Biogas systems: Principles and applications. New Age International Publishers (P) Ltd. 1996.

3. P. Venkata Ramana, S. N. Srinivas. Biomass energy systems. Tata energy Research Institute. New Delhi. 1996.

CHE 611.2 INDUSTRIAL WASTE WATER ENGINEERING [3 0 0 3]

Waste treatment water quality criteria and effluent standards Examination of waste water characteristics, significance and interpretation of results. Physical unit operations, screens, grit chamber, flow equalization, Primary sedimentation tank. Biological unit processes. Bacterial growth and biological oxidation, kinetics of biological growth Design of aerobic suspended and attached growth treatment process Anaewbic suspended and attached growth treatment processes, Low cost waste treatment systems-stabilization ponds, aerated lagoons, oxidation ditch and carrousel system. Treatment and disposal, waste water disposal in receiving bodies of water on land. Recent development in membrane. Bio Reactors (MBR) in waste water treatment.

1. Joseph D.Edwards Industrial Waste Water Treatment A Guide Book – CRC Press, Inc - 1995.
2. Driscoll, Terence P.Barber, John B.Chandran Kartik."Industrial Waste water Management, Treatment and Disposal" McGraw Hill, Prof.Publishign 3rd Ed.-2008.
3. A.D.Patwardhan "Industries Waste Water Treatment PHI – 2008.
4. Metcaff and Eddy, Ind. Waste Water Engg., Treatment, Disposal, Reuse, 5th Ed. TMH Publishing Co.Ltd, 2007.

CHE 611.3 PINCH TECHNOLOGY [3 0 0 3]

Process Integration and its Building Blocks: Definition of Process Integration (PI), School of thoughts, Areas of application and Techniques available for PI, Onion diagram. Pinch Technology - An Overview: Introduction, Basic concept, How it is different from energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology. Key Steps of Pinch Technology: Data extraction, Targeting, Designing, Optimization- Supertargteing. Basic Elements of Pinch Technology: Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.

Targeting of Heat Exchanger Network (HEN): Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting.

Designing of HEN: Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.

Heat Integration of Equipments: Heat engine, Heat pump, Distillation column, Reactor, Evaporator, Drier, Refrigeration systems.
Heat and Power Integration: Co-generation, Steam turbine, Gas turbine.

Texts/References

1. V. Uday Shenoy, Heat Exchanger network synthesis, Gulf Publishing Co, USA, 1995
2. James M. Douglas Conceptual Design of Chemical Processes, McGraw Hill, New York, 1988.

3. Linnhoff, B. TownseQd D.W., Boland D., Hewitt G.F., Thomas, B.E.A., Guy, A.R. and Marsland, R.H., "A User's guide on process integration for the efficient use of energy", Inst. Of Chemical Engineers, London (1982).
4. Smith, R., "Chemical Process Design", McGraw Hill (1995).

CHE 613 Seminar-I **[0 0 3 1]**

This course is designed for the students to develop skills in searching technical literature, analyzing and evaluating it to compare the various approaches and prepare a written report and also presenting it orally. The students will choose appropriate topic specifically related to Chemical engineering.

FIRST YEAR – SECOND SEMESTER

CHE 602 ADVANCED REACTION ENGINEERING [3 1 0 4]

Homogeneous Reactor design and Analysis for ideal reactors. Review of isothermal design for batch, semi batch and flow reactors, multiple reactions and reaction networks, yield selectivity concepts. Analysis for first order networks, reaction networks of general order. Reactor energy balance and its applications to reactor design and analysis. Homogeneous reactor design and analysis for non ideal reactors. Review of basic concepts of residence time distributions (RTD). Single and Multiparameter models for real reactor behavior, macro mixing and micro mixing, segregated flow model and Zweitering's Analysis of maximum mixedness, IEM and other models for micro mixing.

Heterogeneous reactors-gas-solid systems-Reviews of kinetics of gas-solid catalytic reactions with and without diffusion limitations. Reactor design for fixed and fluidized bed reactors, selected case studies. Non catalysis gas solid reactions review of kinetics reactor design case studies. Gas-liquid systems-Basic theories of mass transfer with chemical reaction model systems and model reactors. Reactor design for mechanically agitated and bubble column reactors selected case studies.

1. Rawlings J.B. and Ekerd, J.G., Chemical Reactor Analysis and Design Fundamentals Nole. Hill 2002.
2. Scot Foggler, H, Elements of Chemical Reaction Engg – PHI- 4th Edition- 2005.
3. Carberry, J.J. Chemical and Catalytic reaction engineering, Doven Publishers, 2001
4. Froment G.F. and Bischoff, K.B. Chemical Reactor Design and Analysis, 2nd Ed., John Wiley and Sons NY, 1997.

CHE 604 ADVANCED PROCESS DYNAMICS AND CONTROL [3 1 0 4]

A brief review of preliminary concepts of process control, Modeling few complicated systems. Degree of freedom analysis, Control degree of freedom, Understanding first and second order systems and PID controllers, State space and transfer function matrix models, Development of empirical models from process data. Identifying discrete time models from experimental data, Design of feed forward and ratio controls, Study of cascade control system. Digital sampling, filtering and control, sampling period, Analog and digital filters, Z-transform, use of Simulink, design of digital controllers, Multiloop control, Calculation of extent of interaction and pairing of controllers and manipulated variables, Implementation of real time optimization in computer control, Study of model predictive control (MPC). Concepts of statistical process control. Plant wide Controllability and resiliency assessment and design

Text books

1. D.E. Seborg, T.F. Edgar, Mellichamp, Process dynamics and control. John Wiley & sons, 2nd ed. 2004
2. W. Harmon Ray, Babatunde Ogunnaike. Process dynamics, modeling and control. Oxford University press. 1994
3. B. Wayne Bequette. Process control, Modelling, analysis and simulation. Prentice Hall Int. Series. 2nd ed. 2003.

CHE 606 PROCESS MODELING, ANALYSIS AND SIMULATION [3 1 0 4]

Fundamental principles and process model development. Systematic approach to model building, Conservation principles, Constitutive relations, Dynamic models- Lumped parameters and distributed parameter systems and their solution strategies. Process model hierarchies, Basic tools for process model analysis, data acquisition and analysis, statistical model calibration and validation, Analysis of dynamic process models, Process modeling for control and diagnostic purposes, Modeling discrete event systems, Modeling hybrid systems, Modeling applications in process systems, Computer aided process modeling, Empirical model building. Basic mathematical tools, Introduction to population balance modeling.

Text Books:

1. K. M. Hangos, I. T. Cameron. Process modeling and analysis. Academic press. 2007
2. Ramirez, W, Computational methods in process simulation 2nd ed, butterworths, NY 2000
3. D. Ramakrishna, Population balances: theory and applications to particulate systems in engineering, academic press, 2000.
4. J. Ingham, I.J. Dunn, E. Heinzle, J.E. Peensoil, Chemical Engineering Dynamics, Modelling and Computer Simulation, 3rd Ed., Wiley VCH, Verlog, GMbH & LOKGaA-2007

CHE 608 ADVANCED SEPARATION PROCESSES [3 1 0 4]

Thermodynamics of separation operations-Energy entropy and availability balances-Review of ideal gas and ideal solution Models-Non ideal thermodynamic property Models, P-v-t – equations of state Models Activity coefficients-Margules-Van Laar. Wilson-NRTL UNI QUAC and UNI FAC Models Liquid-liquid equilibra, Review of equilibrium based methods for binary systems. Equilibrium based methods for Multi component Absorption stripping Distillation and Extraction. Equation tearing procedures-Simultaneous correction procedures Inside out methods, Enhanced Distillation and super critical Extraction – Residue curve Maps-Heterogeneous Azeotropic Distillation, Reactive Distillation – usage of software Super critical fluid extraction – Rate Based Models for Distillation – Thermodynamic properties and transport rate expressions – Methods of calculation – Multi component batch distillation Rapid Solution Methods – Membrane separations Dialysis and Electrodialysis. Adsorption, ion exchange and chromatography.

Text Books:

1. J.D.Seader and Ernest J.Henley “Separation process principles” John Wiley & Sons, Inc – 2006.
2. Wanket P.C., Separation Process Engg., 2nd Ed. PHC, NJ 2007.
3. C. Judson King, Separation Processes, TMH, New Delhi 1974

ELECTIVES:

CHE 610.1 METABOLIC ENGINEERING [3 0 0 3]

The essence of metabolic engineering, Review of cellular metabolism, Transport processes-passive transport, facilitated diffusion, Active transport fuelling reactions. Biosynthesis reactions, Polymerizations, Comprehensive models for cellular reactions, Material balances and data consistency, Regulation of metabolic pathways, Examples of pathway manipulations, Metabolic engineering practice, enhancement of product yield and productivity improvement of cellular properties, Metabolic pathway synthesis. Metabolic flux analysis, Methods for experimental and determination of metabolic fluxes by isotope labeling, Application of metabolic flux analysis, Metabolic control analysis, Analysis of structure of metabolic networks, Flux analysis of metabolic networks, Extension and control analysis, Intermetabolic reaction groups, Consistency tests and experimental validation, Thermodynamics of cellular processes, Determination of ΔG^o by group contribution, Non-equilibrium thermodynamics, Applications of thermo kinetics to MCA.

Text Books:

1. Gregory N. Stephanopoulos, Aristose A. Aristidose, Jens Nielsen. Metabolic engineering principles and Methodologies. Academic press.
2. Sang You Lee, Eleftherios Terry, Terry Papoutsakis, Metabolic Engg., 2nd ed., CRC Press, 1999
3. B.N. Khdoderko, Thomas and H.V. Westerhoft B., Metabolic engg in Post Genomic Era, Horizon Bio Science, Amsterdam, The Netherlands, 2004

CHE 610.2 SOLID WASTE MANAGEMENT [3 0 0 3]

Solid Waste – A consequence of life, evolution of solid waste management, engineering principles, generation of solid waste, onsite handling, storage and processing, collection of solid waste, transfer and transport, processing techniques and equipment, recovery of resources, conversion products and energy, disposal of solid waste including sanitary land fill, composting, in cineration and pyroslysis, hazarders waste, management issues, planning, choices in onsite handling storage and processing, collection alternatives, transfer and transport options, dispersal options, planning, development, selection and implementation, Land fill design exercises.

Text Books:

1. Tchobanoglous, Getal, Integrated Solid Waste Management, 2nd Ed. McGraw Hill New York – 2001.
2. LaGrega, Mi, Bucking ham P., and Evans, J., Hazardous Waste Management, 2nd Ed., McGraw Hill, 2001
3. McBean E., Rovers F. and Farquhar G., Solid Waste landfill Engineering and Design PHI, New York, 1995.

CHE 610.3 MEMBRANE SCIENCE & TECHNOLOGY [3 0 0 3]

Membrane preparation and structure, membrane permeability, flow pattern and classification: micro filtration, ultra filtration, nano filtration, reverse osmosis, electrodyalysis, dialysis, membrane modules and plant configuration, liquid separation: pervaporation, vacuum membrane distillation, transport through membrane, solution diffusion model and Donnan equilibrium, Kimura-Sourirajan model, Spiegler and Kedem model, Extended Nernst-Planck model.

Gas separation: complete mixing model (binary and multi component) for gas separation, cross flow model, counter current flow model, single stage membrane separation, multistage membrane separation and analogy with multi component distillation, differential permeation with point permeate withdrawal, bubble point type curve, dew point type curve.

Membrane reactor: perovskite type, bio catalytic membrane reactor, application of membrane in separation of optical isomers of valued bioactive materials. Transport through bio membrane like kidney.

Texts/References

1. E. J. Hoffman, "Membrane separations Technology: single-stage, Multistage, and Differential Permeation"
2. M.A.V. Mulder, Membrane Separation, Springer Publ. -2007.
3. K.S. Scott, Robert Hughes (Editors), Industrial Membrane Separation Technology, Blackie Academic & Professional Chapmann & Hall, Glasgaw, 1996

CHE 612.1 UPSTREAM AND DOWN STREAM BIOPROCESSING [3 0 0 3]

Substrate processing (milling, grinding and extraction etc), Sterilization of air and medium in batch and continuous mode, the development of inocula for industrial fermentation, the development of inocula for yeast, bacterial and mycelia processes, the aseptic inoculation of plant fermenters.

An overview of bioseparations, Characteristics of bioseparators, Removal of insolubles. Filtration and micro filtration, Equipments for conventional filtration. General theory-continuous equipments, Laboratory tests, Centrifugtion scale-up of centrifugation, Cell disruption chemical methods, Mechanical methods, Isolation, extraction, Batch, staged operation, Differential extractions and fractional extractions with a stationary phase. Fractional extractions with two mixing phases, Adsorption-Batch and continuous operation, Product purification- Elution, chromatography-yield and purity-scaling-up chromatography, precipitation, ultrafiltration and electrophoresis, Polishing crystallization, batch crystallization, Drying-basic concepts-ancillary operations, water quality, solvent recovery, waste disposal. Biosafety.

Text Books:

1. Paul A. Belter, E. L. Cussler, Wei-Shan Hu. Bioseparations, Downstream processing for biotechnology. John Wiley and Sons. 1988
2. Pauline M. Doran. Bioprocess engineering principles. Academic press. 1995
3. H.J. Rehm, G. Reed, G. Stephanopoulos (ED), Biotechnology 2nd ed, Bio Processing, Vol. 3, John Wiley, 1993.
4. Stanbury P.F., A.Whitakar, S.J. Hall, Principles of Fermentation Technology, Elsevier Publishers, 2nd edn, 2005.

CHE 612.2 ENVIRONMENT MANAGEMENT SYSTEM [3 0 0 3]

Introduction to air, water and air pollutants and solid wastes, Sampling and analysis techniques. Introduction and need for Impact assessment National and International regulation-legislation and pollution control acts and notifications, ISO series. Application of Impact assessment in specific developmental projects-Impact assessment report, Concepts for development projects-Ranking Impacts-concept and content of environmental management plan-Environmental audits, Life cycle analysis, sustainable development-parameters, Case studies Industrial symbiosis-clean technology options.

Text Books:

1. Peter Wathern, "Envormenta Impact assessment-Theory and practice Unnin Hyman Ltd, 1988.
2. Environmental Health and Safety Auditing Hand Book, McGraw Hill NewYork, 1994.
3. Noel Denevers "Air pollution control Engineering" McGraw hill 1999.
4. Tapas K.Das "Toward Zero discharge Innovative Methodology and Techniques for process Pollution" Wiley-VCH-2005.

CHE 612.3 NANO SCIENCE & TECHNOLOGY [3 0 0 3]

Broad introduction to nanotechnology, a rapidly evolving field of increasing relevance to engineering. What makes the nanoscale so different from the other lengthscales by considering the underpinning science (i.e. nanoscience) and some key examples of nanotechnology. Main engineering activities of design, manufacture and testing in a nanotechnology context.

Physical Chemistry of Nanomaterials. Methods of synthesis of nanometerials fabrication-"Top-down" vs. "bottom-up" approaches. Equipment and processes needed to fabricate nanodevices and structures. Self-assembly of nano particles and nano structural molecular materials, nanoscale molecular self assembly and self organization of surfactant solutions, Polymers, biological system and liquid crystals.

Focus on different nanomaterials: Carbon nanotubes, Inorganic nanowires-, Organic molecules for electronics, Biological and bio-inspired materials, Metallic nanomaterials, Different shape nanomaterials. Characterization of nano particles by Atomic Force Microscopy, Scanning Tunneling Microscopy, Transmission Electron Microscopy, Scanning Electron Microscopy. Focus on emerging applications.

Texts/References

1. "Nano science and technology: novel structures and phenomena", Tang, Zikang and Sheng, Ping, Taylor and Francis, 2003
2. "Nano-Engineering in Science and Technology: An Introduction to the World of Nano design", Michael Rieth, World Scientific, 2003
3. R. Kelsall, I. Hamley and M. Geoghegan (Eds.), "Nanoscale Science and Technology", Wiley, 2005.
4. M. Di Ventra, S. Evoy and J. R. Heflin, Jr. (Eds.), Introduction to Nanoscale Science and Technology, Springer, 2004.
5. C. P. Poole, Jr., F. J. Owens, Introduction to Nanotechnology, Wiley, 2003.
6. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford, 2001.

CHE 614 Process Simulation Lab [0 0 6 2]

Introduction to simulation software packages, Aspen Plus, Fluent CFD, FEM Lab etc. Data reconciliation techniques. Dynamic simulation practice sessions with software for steady state and dynamic simulation of chemical process plants.

CHE 616 Seminar-II [0 0 3 1]

This course is designed for the students to develop skills in searching technical literature, analyzing and evaluating it to compare the various approaches and prepare a written report and also presenting it orally. The students may choose appropriate topic specifically related to their specialization or research project they propose to carry out in the second year.

SECOND YEAR – THIRD AND FOURTH SEMESTERS

CHE 618 Industrial Training report [0 0 0 2]

Industrial training spanning a period of not less than four weeks can be undertaken at the end of second semester in any industry or research laboratory. The report must be submitted for the examination and evaluation at the end of IV semester.

CHE 799 Project Work [0 0 0 40]

The M.Tech project is aimed at training the students to analyse independently any problems posed to them. The project may be theoretical, experimental or a combination. In few cases the project may also involve sophisticated design work. The project report is expected to show the clarity of thought and expression, critical appreciation of existing literature and analytical, experimental skills. This can be carried out either in the institute or at any other industry/research laboratory in India or Abroad under the supervision of guide(s). The project should be completed and submitted for evaluation at the end of the year.