Common Curriculum for M. Tech. Program in Chemical Engineering
under
West Bengal University of Technology
(Paper codes Will be introduced latter)

First Semester:

Course Code	Course Name					Hrs / Week L	T	P	C
ChE01	Advanced Heat Transfer					3	1	0	4
ChE02	Advanced Process Control					3	1	0	4
ChE03	Advanced Fluid Mechanics					3	1	0	4
ChE04	Adv. Num. Methods in Chem. Engg	3	1			3	1	0	4
ChE05	Elective I					3	1	0	4
ChE06	Process Control Lab.					0	0	3	2
ChE07	Transf. Op/Petr. Eng./Polymer Lab	0				0	0	3	2
ChE08	Seminar					0	0	2	1
						15	**5**	**8**	**25**

ELECTIVES:
Elective I :
any one of the following

ChE05A	Process Modeling and Simulation					3	1	0	4
ChE05B	Bioprocess Engineering					3	1	0	4
ChE05C	Petroleum Ref. Engineering Engineering					3	1	0	4

Second Semester:

ChE09	Adv. Reactor Design & Analysis	3	1			3		1
ChE10	Advanced Mass Transfer					3		1
ChE11	Adv. Chemical Engg. Thermodynamics	3	1	0	Thermo	3		1
ChE12	Management Principles					3		1
ChE13	Elective II					3		1
ChE14	**Instrumental Methods of Analysis Lab**					0		0
ChE15	Env. Eng. & Pollution Con. Lab / Advanced Numerical Lab	0	0		Control. Lab.	0		0
						15		**5**

ELECTIVES:
Elective II:
any one of the following

ChE13A	Polymer & Engg Materials					3		1
ChE13B	Petrochemical Technology					3		1
ChE13C	Industrial Pollution Control					3		1
ChE13D	**Computer Aided Process Design**				**Design**	3		1

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Third Semester:

ChE17	Elective III	3	1	0	4
ChE18	Advanced Statistical Analysis	3	1	0	4
ChE19	Project/ Thesis	0	0	0	12
ChE20	Project Viva	0	0	0	3
		6	**2**		**23**

ELECTIVES:
Elective III
any one of the following

ChE17A	Adv. Transport Phenomena	3	1	0	4
ChE17B	Safety In Process Industry	3	1	0	4
ChE17C	Project Engineering	3	1	0	4

Fourth Semester:

ChE21	Project/ Thesis	, Report & Presentation			18
ChE22	Project Viva voce				7
ChE16	Comprehensive Viva Voce	0	0		**25**

	CREDIT
First Year First Semester	25
First Year Second Semester	27
Second Year Second Semester	23
Second Year Second Semester	25
Total Credit	**100**

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Syllabi for M. Tech Course in Chemical Engineering

Note: For Lab subjects Five Experiments are to be designed and performed in each course

ChE01: Advanced Heat Transfer

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Steady state conductive heat transfer with heat generation. Unsteady state heat transfer in different coordinates. Solution of unsteady state partial differential heat transfer equation using analytical and numerical methods.

Module II

Free convective heat transfer under different situations and application of dimensional analysis to estimate the convective heat transfer coefficients. Forced convective heat transfer in laminar-transition and turbulent zone. Heat transfer factor: Reynold's no. plot. Analogy equation for Heat Momentum transfer.

Module III

Convective heat transfer in molten method, Boiling heat transfer with particular reference to Nucleate and film boiling and estimation of boiling heat transfer coefficient. Heat transfer from condensing vapors. Nusselt equation for filmtype condensation of vapors over vertical surfaces and inclined tubes. Selection and design of condensers, single pass and multipass heat exchangers. Heat transfer in packed bed.

Module IV

Radiation heat transfer. Estimation of view factors and emissivity factors for different situation. Radiation shield and radiation error in pyrometry. Combined conduction, convection and radiation heat transfer. Convection and radiation furnaces – design considerations.

ChE02 : Advanced Process Control

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I
Review of dynamic process models - linear, and non-linear, lumped and distributed parameter systems. Control of linear systems - Laplace and Z transforms, review of single-loop feedback control systems.

Module II
Stability and controller tuning, Smith compensator for systems with large dead-time and inverse response, Multi-loop control-cascade, selective and split-range control, feed-forward control, Ratio control.

Module III
Adaptive control, inferential control. Multivariable Control - controllability and observability, alternative control configuration, interaction and decoupling, control of complete plants. Digital control - sampling and reconstruction,

Module IV
Discrete-time response and stability, design of controllers, on-line process identification. Introduction to control of non-linear systems**.**

ChE03 : Advanced Fluid Mechanics

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two
Candidates are required to answer **five** questions taking at least one from each module.

Module I
Conservation Equations and analysis of finite control volumes, continuity equation – differential form and integral form, stream function, streamlines.

ModuleII
Rotational and irrotational flow, velocity potential. Momentum theorem : Euler's equation – control volume approach; Navier – stokes equation.

Module III
Creep flow and couette flow, Poiseulli flow. Boundary layer theory, momentum integral analysis, Karman – Pohlhausen method for momentum – integral equation.

Module IV
Turbulent flow : Prandtl's mixing length, universal velocity distribution law, turbulent flow in pipe. Flow of non-Newtonian fluids. Fluidization : principles, two phase theory. Elutriation. Fast fluidized bed: equation for pressure drop and voidage. Mixing and segregation.

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ChE04 : Advanced Numerical Methods in Chemical Engineering

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two
Candidates are required to answer **five** questions taking at least one from each module.

Module I
Matrices, Norms and inner products, Gram-Schmidt ortho normalization, Fredholm alternative, Rayleigh's quotient, Application in the solution of Chemical Engineering problems. Errors and error control; Interpolation and optimization;

Module II
Linear algebraic equations; Matrix inversion and matrix eigen values estimation
Step size selection and stability of Runge-Kutta and predictor corrector methods to solve IVP ordinary differential equations, stiff ODE's and Gear's method.

Module III
BVP - shooting methods for linear system, finite difference method, regular perturbation method. Method of weighted residuals and orthogonal collocation to solve first and higher order BVP in ODE's, application to Chemical Engineering Systems, concept of finite element, use of orthogonal collocation and Galerkin technique to solve BVP in ODEs.

Module IV
Review of finite difference techniques to solve Partial Differential Equations (PDE's). Similarity transformation, method of weighted residuals, orthogonal collocation, finite element methods to solve PDEs with application to Chemical Engineering Systems.

ChE09 : Advanced Reactor Design and Analysis

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I
RTD of non ideal reactors, interpretation of RTD data, flow models for non-ideal reactors – axial dispersion, N tanks in series, and multiparameter models, diagnosing the ills of reactors, influence of RTD and micromixing on conversion.

Module II
Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles, catalyst – measurement of surface area and pore size, effectiveness factor, selectivity, catalyst deactivation. Design of packed bed reactor, slurry reactor; trickle bed reactor and fluidized bed reactor.

Module III
Optimum operation policy of batch reactor, optimal temperature progression, analysis of multibed adiabatic reactors, autothermal operation, steady state multiplicity in CSTR. Stability and transient behavior of CSTR. Hot spot, runaway criteria.

Module IV
Non catalytic gas–solid reaction. Mass transfer with chemical reactions – principles and design. Modelling of multiphase reactors. Dynamic behavior of chemical reactors. Reactor Optimization and scale up.

ChE10 : Advanced Mass Transfer

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I
Multicomponent Distillation vapour-liquid equilibria, key components, Underwood's methods for minimum reflux, product distribution at total reflux. Theoretical Plate calculation by Lewis-Matheson, Thiele-Gieddes and Relaxation method. Multiple feeds and multiple product streams.

Module II
Multicomponent gas absorption : Edmister's method for plate calculation. Absorption with chemical reaction. Multicomponent liquid-liquid extraction. Extraction with chemical reaction.

Module III
Basic overview membrane separation processes, terminologies: MWCO, concentration polarization, rejection coefficient, backwash, Basic principles of membrane processes with modeling of equations: reverse osmosis, nano-filtration, ultra-filtration, micro-filtration, Osmotic controlled filtration, gel layer controlled filtration, dialysis. Detailed module design: dead end and cross flow mode, tubular, flat plate, spiral wound and hollow-fiber modules. Principle of membrane reactors with affinity binding.

Module IV
Electric field enhanced separation processes: zeta potential, electric double layer. Basic modeling of electric field enhanced filtration. Liquid membrane and its concept. Basic modeling of gas separation and pervaporation processes Industral application of membrane principles.

ChE11 : Advanced Chem. Eng. Thermodynamics

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Introduction to Statistical of thermodynamics. Interpretation of laws of thermodynamics in classical form. Fugacity and Activity coefficient for multicomponent systems.

Module II

Chemical equilibrium of multicomponent system. Effects of temperature on equilibrium constants, free energy and enthalpy. Equation of state – compressibility factor

Module III

Solution thermodynamics, partial molar properties, VLE, Gibb's Duhem equation, Lewis Randall equation, Concept of S.F. and its applications.

Module IV

Refrigeration and Liquefaction. Application of thermodynamics in cryogenics.

ChE12 : Management Principles

Number of Questions to be set:

Broad Questions:	Module I	: Two
	Module II	: Two
	Module III	: Two
	Module IV	: Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Major schools of management theory: classical school, behavioural school, quantitative school, contingency school. Organizational structure: Behavoiur formalization, centralization and decentralization, departmentalization, span management, organizational effectiveness, organizational life cycle criteria.

Module II

Principles of production: Production planning and control, different mathematical methods and case studies, Resource management: Human resource management, HR planning process, different facets of HRM. Training and development: Introduction, steps in training, training methods, training evaluation, job evaluation and incentives. Conflict management: Conflict, managing conflict, negotiation process, creative conflict management.

Module III

Tool and techniques for quality management, Total quality management, quality gurus, Kaizen, Zembas and other parameters; Quality circles, Type A and Type B techniques, SWOT analysis, brain storming, check sheet, stratification and pareto

analysis; Stress management: understanding stress, human stress response, stress diary, stress management. Technology management: components of technology, technology acquisition, transfer and protection

Module IV

Statistical quality control: process capability, tolerance limit and SQC limit, Shewart's control chart : X bar – R chart, p- chart and C- chart.
Acceptance sampling: basic concept, application of probability in acceptance sampling, single sampling and double sampling plan, Chain sampling plan, Dodge-Romig and Mil-std. plan

Che18 : Advanced Statistical Analysis

Number of Questions to be set:

Broad Questions:	Module I	: Two
	Module II	: Two
	Module III	: Two
	Module IV	: Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Probability Distributions and its applications in Chemical Engineering: Bionomial, Poisson, Normal. Basic approach towards central limit theorem

Module II

Tests of Hypothesis: Type I and type II error, Z, t, F and Chi-square distributions Contingency test and goodness of fit

Module III

Factorial Design of Experiments and Analysis of Variance: one way and two way classification models, factorial design for fixed effect, random effects and nested type models: applications in Chemical Engineering

Module IV

Partial, multiple correlation and regression; applications in Chemical Engineering
Non parametric methods, nonlinear least square technique – parametric sensitivity - applications in Chemical Engineering

ChE05A : Process Modeling and Simulation

Number of Questions to be set:

Broad Questions:	Module I	: Two
	Module II	: Two
	Module III	: Two
	Module IV	: Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Introduction and fundamentals of process modeling and simulation; industrial usage of process modeling and simulation; Macroscopic mass, energy and momentum balances; incorporation of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models.

Module II

Simulation of steady state lumped systems including simultaneous solution, modular solution, nested inside-out algorithms, partitioning and tearing with reference to chemical process equipments like reactors; distillation, absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.

Module III

Unsteady state lumped systems and dynamic simulation; Commercial steady state and dynamic simulators; Computer algorithms for numerical solution of steady state and unsteady state models; Microscopic balances for steady state and dynamic simulation; process modeling with dispersion; axial mixing; micro-mixing; diffusion etc. Computer algorithms for microscopic models; Simulation of process flowsheets and Boolean digraph algorithms.

Module IV

Modeling and simulation of complex industrial systems in petroleum, petrochemicals, polymer, basic chemical industries. Introduction to application of advanced Artificial intelligence based modeling methods using Artificial Neural Networks, Wavelets and induced learning algorithms.

ChE05B : Bioprocess Engineering

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Revision of fundamental principles of Bioprocess Engineering.Cellular growth, From Genotype to Phenotype, Transport process (free diffusion, facilitated transport, active transport), Catabolism, Glycolysis, anabolism, secondary metabolism, biotech processes – an overview.

Module I

Enzyme Kinetics: Concepts of Michelis Menten equations and Briggs Haldane equation in terms of mathematical interpretation. Integral and differential methods for finding the intrinsic kinetic parameters. Two substrate reaction, Ping –

pong mechanism, Allosteric enzyme, The Adair and Hill equation, MCW model, KNF model, Immobilized enzymes, effect of external and internal mass transfer resistances on the global rate.

Module III

Inhibition studies: Inhibition by foreign substances, substrates (self inhibition) and products. Derivation of kinetic inhibition constants using steady state assumptions.

Module IV

Kinetic cell growth, structured and unstructured, segregated and un-segregated models. Substrate and product inhibition kinetics. Optimum operation of chemostat. Scale up of bioreactor, Basic requirements and reactor type, Physical processes of importance for scale up.

ChE05C : Petroleum Refinery Engineering

Number of Questions to be set:

Broad Questions:	Module I	: Two
	Module II	: Two
	Module III	: Two
	Module IV	: Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Origin of petroleum crude oil. Evaluation of crude oil, evaluation and characterization of crude oil : TBP and other distillation tests. Petroleum products, their properties, specification and testing. different properties like flash point, fire point, smoke point, aniline point. carbon residue, kinematic viscosity, pour point, freezing point etc.

Module II

Use of crude book data. Petroleum refinery distillation, pre-fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Stabilization of naphtha. Vacuum distillation of RCO. Reforming of naphtha.

Module III

Other secondary processes like Vis-breaking, Furfural/Phenol/NMP extraction, Solvent dewaxing, propane deasphalting. Delayed coking process. FCC unit. Hydrotreatment processes in refining: hydro-desulfurisation, hydrofinishing, Hydrocracking.

Module IV

Production of lube oil base stock. Refinery equipment: furnaces, distillation columns, reactors, pumps, compressors and piping. Environmental impact of refineries.

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ChE13A : Polymer and Engineering Materials

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Polymerization Processes, Polymerization Catalysts, Polymerization Reactors, Polymer Reaction Engineering

Module II

Polymer Rheology : Visco-elastic non-Newtonian flow phenomena and material functions, Power law, relaxation & hysteresis, Deformation and fracture behaviour of polymers, Polymer Morphology.

Module III

Mixing : Characterization of mixed state, Dispersive and distributive mixing, Importance of processing, Extruders, Extrusion Dies, Film blowing, Multilayer Extrusion, Fibre spinning, Moulding and forming : Injection and Jet moulding, Thermoforming

Module IV

Composite Materials : Plastic Composites, Metal-matrix Composites, Ceramic-matrix Composites, Nano-composites; Engineering polymers, Polymer blends, Engineering Ceramics, Engineering alloys; Service Performance : Corrosion and Fatigue

Suggested Books

1. Fundamentals of Polymer Science and Engineering : Anil Kumar and S.K.Gupta
2. Polymer Processing : B.R.Gupta
3. Rheology of Polymers : B.R.Gupta
4. Principles of Material Science and Engineering : William F. Smith
5. Elements of Material Science and Engineering : Lawrence H.Van Black
6. Material Science and Metallurgy : S.V.Kodgiri and V.D.Kodgiri
7. Properties and Applications of Engineering Materials : NIIT Publication

ChE13B : Petrochemical Technology

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Petrochemical feedstock; Process of naphtha cracking, Production of olefins, Separation of aromatics, uses of synthesis gas.

Module II

Manufacture of acetic anhydride, adipic acid, aniline., ethyl acetate, maleic anhydride.

Manufacture of benzoic acid, Pure tere-pthalic acid, phthalic anhydride, butyl acetate,

Module III

Manufacture of Urea-formaldehyde resin, ABS plastic, Acrylic fiber, Carbon fiber, Styrene-Butadiene Rubber, chloroprene.

Module IV

Process intensification & Emerging technologies in petrochemical industry.

Transportation of hazardous materials; Health and safety in petrochemical industries.

ChE13C : Industrial Pollution Control

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Air pollution : Revision of basic concepts regarding sources and effects of different air pollutants,; Sampling and analysis of air pollutants, Air pollution control methods and equipment, Cyclone Separator, Baghouse, ESP, Venturi Scrubber with emphasis on design aspects

Module II

Water pollution: Revision of basic concepts regarding sources sampling and classification of water pollutants, determination of basic parameters and computations associated with: BOD, COD, TS, TDS, SS;

Industrial Wastewater treatment: primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA; non conventional: WSP, Root zone, anaerobic treatment with special reference to AFFR, UASB

Module III

Pollution control in selected process industries – fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Tanning industries, Sugar industries, Dairy, Alcohol industries, Electroplating and metal finishing industries, Radioactive wastes, ranking of wastewater treatment alternatives.

Module IV

Environmental legislations for industries: methodology of consent to establish and operate. Basic acts applicable for Indian industries: water act. 1974 and its revision, Air Act 1981and its revision, solid waste and biomedical waste handling rules, efflument and discharge standards for selected chemical industries. Structure of Green Bench and appellate authority.
Basic aspects of EIA, environment audit and ISO 14000

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ChE13D : Computer Aided Process Design

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two
Candidates are required to answer **five** questions taking at least one from each module.

Module I

Computer graphics hardware: Interactive input-output devices, output primitives and their attributes, line drawing and ellipse generating algorithm, interactive picture construction techniques, 2D geometric transformation.

Module II

3D display methods and object representation, 3D geometric and modeling transformation, wire frame, surface and solid modeling, open and closed loop mechanism.

Module III

Formulation and classification of optimization problems, simplex method of linear programming, one dimensional minimization based on elimination and interpolation, unconstrained optimization, constrained optimization.

Module IV

Geometric, dynamic, integer and quadratic programming, computer aided optimum design of machine elements.

ChE17A : Advanced Transport Phenomena

Number of Questions to be set:
Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Molecular transport and general property balance, steady transport in one direction involving input-output with no generation, constant area transport, variable area transport, heat and mass transport with generation at steady state.

Module II

Integral methods of analysis: Integral mass balance, integral balance of individual species, integral momentum balance, mechanical energy equation and the engineering Bernoulli equation.

Module III

Transport past immersed bodies: laminar boundary layer, heat and mass transfer during boundary layer flow past flat plates, flow over cylinders and spheres, gas-solid and liquid-solid fluidization.

Module IV

Unsteady state transport: heat transfer equations mass transfer equations, error function, heat transfer with negligible internal resistance, Fourier series solution, Laplac transform solution, numerical solutions.

ChE17B : Safety in Process Engineering

Number of Questions to be set:

Broad Questions:	Module I	: Two
	Module II	: Two
	Module III	: Two
	Module IV	: Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I

Engineering aspects of industrial safety, scientific principles of industrial safety in relation to economic and operational aspects, safety regulations, hazards due to fire , explosions, and toxic chemicals, fire triangle, runaway reactions.

Module II

Industrial plant layout, ventilation and lighting, electric system fire prevention, tools for hazards identification HAZOP, fault tree, event tree.

Module III

Dow fire and explosion index, Mond index, risk analysis methodology, risk concept and measurement, risk acceptance criteria, quantitative risk analysis

Module IV

Engineering control of chemical plant hazards, intensification and attenuation of hazardous materials, fire prevention, personnel protection devices, safety systems and disaster management.

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ChE17C : Project Engineering

Number of Questions to be set:

Broad Questions: Module I : Two
Module II : Two
Module III : Two
Module IV : Two

Candidates are required to answer **five** questions taking at least one from each module.

Module I
Basis of chemical plant design: Steps in process development, feasibility survey, pilot and semi commercial plant design, scale up and scale down techniques, plant location and plant lay out, plant utilities, environment and safety clearances. plant utilities.

Module II:
Depreciation: Revision of methodology of calculating depreciation, MACRS
Costing and project evaluation: different methods of cost estimation for plants, present worth, cash flow and discounted cash flow and rate of return, pay-back period, perpetuity and capitalized costs, sensitivity analysis, alternative investments and replacements.

Financial analysis: risk and return, liabilities, importance of ratio analysis, liquidity ratio, defensive interval ratio, capital structure ratio, debt equity ratio, activity ratio, Du-Pont chart.

Module III:
Optimum Design and Design strategy: Basic principle of Optimum Design, general procedure for determining optimum conditions, Breakeven analysis, Optimum production rate in plant, determination of optimum economic pipe diameter and optimum flow rate in condenser, optimum design in separation columns.

Module IV:
Bar chart, Gantt chart, Milestone Chart, Concepts of Network Analysis: PERT, CPM, Numbering a network, Statistical distribution associated with PERT network, Earliest Expected time and Latest allowable occurrence time calculation, Slack, determination of critical path, concepts of Float.

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