SCHOOL OF CHEMICAL ENGINEERING (SCHEME)
Vellore Institute of Technology
Vellore 632014, Tamilnadu, INDIA

B.Tech Chemical Engineering (BCM)

Curriculum and Syllabus

[2021-2022 admitted students]

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

CONTENT

VISION AND MISSION STATEMENT
OF
VELLORE INSTITUTE OF TECHNOLOGY

VISION

- Transforming life through excellence in education and research

MISSION

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION AND MISSION STATEMENT
OF
SCHOOL OF CHEMICAL ENGINEERING

VISION

- To improve the quality of life through innovations in Chemical Engineering

MISSION

- To prepare the graduates for a rewarding career by providing quality education in Chemical Engineering in tune with evolving requirements of the society.
- To impart knowledge and develop technology through quality research in frontier areas of chemical and inter-disciplinary fields.
- To produce practicing engineers with professional ethics to cater the contemporary needs of the society and environment.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems in Chemical engineering and allied disciplines.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in the industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies leading to careers in engineering, management, teaching and research.

PROGRAMME OUTCOMES (POs)

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. The Engineer and Society : Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.

8. Ethics : Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team Work : Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning : Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAMME SPECIFIC OUTCOMES (PSOs)

1. Analyze and solve complex problems in process and allied Industries by applying core and multidisciplinary competencies.
2. Design and develop efficient chemical processes/products considering economic, safety and environmental aspects.
3. Implement the modern practices in industrial/research settings to serve as practicing engineers with professional ethics.

SCHOOL OF CHEMICAL ENGINEERING (SCHEME)

B. Tech Chemical Engineering

CREDIT STRUCTURE

Category-wise Credit distribution

S.NO	Category	Credits
1	Foundation Core	56
2	Foundation Core - Non Graded	2
3	Discipline-linked Engineering Sciences	11
4	Discipline Core	49
5	Discipline Elective	15
6	Projects and Internship	9
7	Open Elective	12
8	Non-graded Core Requirement	11
	Total Credits	152

LIST OF COURSES

Foundation Core									
Sl.No	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
1	BCHY101L	Engineering Chemistry	Theory Only	1.0	3	0	0	0	3.0
2	BCHY101P	Engineering Chemistry Lab	Lab Only	1.0	0	0	2	0	1.0
3	BCSE101E	Computer Programming: Python	Embedded Theory and Lab	1.0	1	0	4	0	3.0
4	BCSE103E	Computer Programming: Java	Embedded Theory and Lab	1.0	1	0	4	0	3.0
5	BECE101L	Basic Electronics	Theory Only	1.0	2	0	0	0	2.0
6	BECE101P	Basic Electronics Lab	Lab Only	1.0	0	0	2	0	1.0
7	BEEE101L	Basic Electrical Engineering	Theory Only	1.0	2	0	0	0	2.0
8	BEEE101P	Basic Electrical Engineering Lab	Lab Only	1.0	0	0	2	0	1.0
9	BENG101L	Technical English Communication	Theory Only	1.0	2	0	0	0	2.0
10	BENG101P	Technical English Communication Lab	Lab Only	1.0	0	0	2	0	1.0
11	BENG201P	Technical Report Writing	Lab Only	1.0	0	0	2	0	1.0
12	BFLE200L	Foreign Language	Theory Only	1.0	2	0	0	0	2.0
13	BHSM200L	HSM Elective	Theory Only	1.0	3	0	0	0	3.0
14	BMAT101L	Calculus	Theory Only	1.0	3	0	0	0	3.0
15	BMAT101P	Calculus Lab	Lab Only	1.0	0	0	2	0	1.0
16	BMAT102L	Differential Equations and Transforms	Theory Only	1.0	3	1	0	0	4.0
17	BMAT201L	Complex Variables and Linear Algebra	Theory Only	1.0	3	1	0	0	4.0
18	BMAT202L	Probability and Statistics	Theory Only	1.0	3	0	0	0	3.0
19	BMAT202P	Probability and Statistics Lab	Lab Only	1.0	0	0	2	0	1.0
20	BMEE102P	Engineering Design Visualisation Lab	Lab Only	1.0	0	0	4	0	2.0
21	BMEE201L	Engineering Mechanics	Theory Only	1.0	2	1	0	0	3.0
22	BPHY101L	Engineering Physics	Theory Only	1.0	3	0	0	0	3.0
23	BPHY101P	Engineering Physics Lab	Lab Only	1.0	0	0	2	0	1.0
24	BSTS101P	Quantitative Skills Practice I	Soft Skill	1.0	0	0	3	0	1.5
25	BSTS102P	Quantitative Skills Practice II	Soft Skill	1.0	0	0	3	0	1.5
26	BSTS201P	Qualitative Skills Practice I	Soft Skill	1.0	0	0	3	0	1.5
27	BSTS202P	Qualitative Skills Practice II	Soft Skill	1.0	0	0	3	0	1.5

Foundation Core - Non Graded									
Sl.No	**Course Code**	**Course Title**	**Course Type**	**Ver sion**	**L**	**T**	**P**	**J**	**Credits**
1	BENG101N	Effective English Communication	Lab Only	1.0	0	0	4	0	2.0

Discipline-linked Engineering Sciences									
Sl.No	**Course Code**	**Course Title**	**Course Type**	**Ver sion**	**L**	**T**	**P**	**J**	**Credits**
1	BCHE201L	Computational Methods in Chemical Engineering	Theory Only	1.0	3	0	0	0	3.0
2	BCHE201P	Computational Methods in Chemical Engineering Lab	Lab Only	1.0	0	0	2	0	1.0
3	BCHE204L	Transport Phenomena	Theory Only	1.0	3	1	0	0	4.0
4	BCHE206L	Materials Science and Engineering	Theory Only	1.0	3	0	0	0	3.0

Discipline Core									
Sl.No	**Course Code**	**Course Title**	**Course Type**	**Ver sion**	**L**	**T**	**P**	**J**	**Credits**
1	BCHE202L	Chemical Engineering Thermodynamics	Theory Only	1.0	3	1	0	0	4.0
2	BCHE203L	Chemical Process Calculations	Theory Only	1.0	3	1	0	0	4.0
3	BCHE205L	Momentum Transfer	Theory Only	1.0	3	0	0	0	3.0
4	BCHE205P	Momentum Transfer Lab	Lab Only	1.0	0	0	2	0	1.0
5	BCHE207L	Mass Transfer I	Theory Only	1.0	2	1	0	0	3.0
6	BCHE208L	Heat Transfer	Theory Only	1.0	3	0	0	0	3.0
7	BCHE208P	Heat Transfer Lab	Lab Only	1.0	0	0	2	0	1.0
8	BCHE301L	Mechanical Operations	Theory Only	1.0	3	0	0	0	3.0
9	BCHE301P	Mechanical Operations Lab	Lab Only	1.0	0	0	2	0	1.0
10	BCHE302L	Mass Transfer II	Theory Only	1.0	3	0	0	0	3.0
11	BCHE302P	Mass Transfer Lab	Lab Only	1.0	0	0	2	0	1.0
12	BCHE303L	Chemical Reaction Engineering I	Theory Only	1.0	3	0	0	0	3.0
13	BCHE303P	Chemical Reaction Engineering Lab	Lab Only	1.0	0	0	2	0	1.0
14	BCHE304L	Chemical Process Technology and Economics	Theory Only	1.0	3	1	0	0	4.0
15	BCHE305L	Process Dynamics and Control	Theory Only	1.0	3	0	0	0	3.0
16	BCHE305P	Process Dynamics and Control Lab	Lab Only	1.0	0	0	2	0	1.0
17	BCHE306L	Chemical Reaction Engineering II	Theory Only	1.0	2	1	0	0	3.0

18	BCHE307L	Process Modelling and Simulation	Theory Only	1.0	2	0	0	0	2.0
19	BCHE307P	Process Modelling and Simulation Lab	Lab Only	1.0	0	0	2	0	1.0
20	BCHE308L	Chemical Process Equipment Design	Theory Only	1.0	3	0	0	0	3.0
21	BCHE308P	Chemical Process Equipment Design Lab	Lab Only	1.0	0	0	2	0	1.0

Discipline Elective									
Sl.No	**Course Code**	**Course Title**	**Course Type**	**Ver sion**	**L**	**T**	**P**	**J**	**Credits**
1	BCHE309L	Membrane Separation Processes	Theory Only	1.0	3	0	0	0	3.0
2	BCHE310L	Polymer Technology	Theory Only	1.0	3	0	0	0	3.0
3	BCHE311L	Process Utilities and Pipeline Design	Theory Only	1.0	3	0	0	0	3.0
4	BCHE312L	Chemical Process Optimization	Theory Only	1.0	3	0	0	0	3.0
5	BCHE313L	Environmental Pollution Control	Theory Only	1.0	3	0	0	0	3.0
6	BCHE314L	Fuels and Combustion	Theory Only	1.0	3	0	0	0	3.0
7	BCHE315L	Biochemical Engineering	Theory Only	1.0	3	0	0	0	3.0
8	BCHE316L	Pharmaceutical Technology	Theory Only	1.0	3	0	0	0	3.0
9	BCHE317L	Petroleum Refining Technology	Theory Only	1.0	3	0	0	0	3.0
10	BCHE318L	Safety and Hazard Analysis	Theory Only	1.0	3	0	0	0	3.0
11	BCHE319E	Process Plant Design and Simulation	Embedded Theory and Lab	1.0	2	0	2	0	3.0
12	BCHE320L	Chemical Product Design	Theory Only	1.0	3	0	0	0	3.0
13	BCHE321L	Natural Gas Engineering	Theory Only	1.0	3	0	0	0	3.0
14	BCHE322L	Nanoscience and Nanotechnology	Theory Only	1.0	3	0	0	0	3.0
15	BCHE323L	Fertilizer Technology	Theory Only	1.0	3	0	0	0	3.0
16	BCHE324L	Fermentation Technology	Theory Only	1.0	3	0	0	0	3.0
17	BCHE391J	Technical Answers to Real Problems Project	Project	1.0	0	0	0	0	3.0
18	BCHE392J	Design Project	Project	1.0	0	0	0	0	3.0
19	BCHE393J	Laboratory Project	Project	1.0	0	0	0	0	3.0
20	BCHE394J	Product Development Project	Project	1.0	0	0	0	0	3.0
21	BCHE395J	Computer Project	Project	1.0	0	0	0	0	3.0
22	BCHE396J	Reading Course	Project	1.0	0	0	0	0	3.0
23	BCHE397J	Special Project	Project	1.0	0	0	0	0	3.0
24	BCHE398J	Simulation Project	Project	1.0	0	0	0	0	3.0
25	BCHE401L	Petrochemical Technology	Theory Only	1.0	3	0	0	0	3.0

26	BCHE402L	Food Process Engineering	Theory Only	1.0	3	0	0	0	3.0
27	BCHE403L	Process Intensification	Theory Only	1.0	3	0	0	0	3.0
28	BCHE404L	Colloids and Interfacial Science	Theory Only	1.0	3	0	0	0	3.0
29	BCHE405L	Fluidization Engineering	Theory Only	1.0	3	0	0	0	3.0
30	BCHE406L	AI in Chemical Engineering	Theory Only	1.0	3	0	0	0	3.0

Projects and Internship

Sl.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	BCHE399J	Summer Industrial Internship	Project	1.0	0	0	0	0	1.0
2	BCHE497J	Project - I	Project	1.0	0	0	0	0	3.0
3	BCHE498J	Project - II / Internship	Project	1.0	0	0	0	0	5.0
4	BCHE499J	One Semester Internship	Project	1.0	0	0	0	0	14.0

Open Elective: 12 Credits

Non-graded Core Requirement

Sl.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	BCHE101N	Introduction to Engineering	Project	1.0	0	0	0	0	1.0
2	BCHY102N	Environmental Sciences	Project	1.0	0	0	0	0	2.0
3	BEXC100N	Extracurricular Activities	Project	1.0	0	0	0	0	2.0
4	BHUM101N	Ethics and Values	Online Course	1.0	0	0	0	0	2.0
5	BSSC101N	Essence of Traditional Knowledge	Project	1.0	0	0	0	0	2.0
6	BSSC102N	Indian Constitution	Project	1.0	0	0	0	0	2.0

DISCIPLINE LINKED ENGINEERING SCIENCE COURSES – 4 (11 CREDITS)

Course code	Course Title	L	T	P	C
BCHE201L	**Computational Methods in Chemical Engineering**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To formulate problems for roots of a function, solution of simultaneous equations, optimized value of a given function, numerical integration and differentiation, ODE and PDE.
2. To compute the roots of a function, solution of simultaneous equations, optimized value of a given function, numerical integration and differentiation, ODE and PDE.
3. To develop MATLAB algorithm for roots of a function, solution of simultaneous equations, optimized value of a given function, numerical integration and differentiation, ODE and PDE.

Course Outcomes:

1. Formulate mathematical model for solving engineering problems using computational methods.
2. Solve roots of a single and simultaneous equation using computational methods.
3. Select suitable numerical regression and interpolation techniques for data analysis.
4. Compute numerical integration and optimization.
5. Determine the numerical solution for ordinary and partial differential equations.

Module:1	Single Algebraic and Transcendental Equations	6 hours

Computers and its components, approximation, and concept of error and error analysis, Mathematical models for solving engineering problems. Finding roots of a single equation- Direct methods (bisection, Regula falsi) and Indirect methods (Newton-Raphson, Secant method). Case study using MATLAB / MS Excel.

Module:2	Linear and Nonlinear System of Equations	6 hours

Types of matrices and matrix operation rules, Solution for linear system of simultaneous equations – Direct methods (Gauss Elimination, Gauss Jordan), Iterative methods (Gauss-Jacobi and Gauss-Seidel). Overview of non-linear system of equations. Case study using MATLAB / MS Excel / Aspen Plus.

Module:3	Interpolation and Regression Analysis	6 hours

Newton’s divided-difference interpolating polynomial – Linear, polynomial and quadratic rules, Lagrange interpolating polynomial, Linear and polynomial Regression. Case study using MATLAB / MS Excel.

Module:4	Optimization	7 hours

One-Dimensional Unconstrained Optimization – Golden section search and Newton’s Method, Overview on multidimensional unconstrained optimization – gradient and non-gradient methods, Constrained optimization – Simplex method. Case study using MATLAB / MS Excel. Overview of optimization techniques in Aspen Plus – Design Spec and sensitivity analysis.

Module:5	**Integration and Differentiation**	**5 hours**
Newton Cotes Integration- Trapezoid method, Simpson's 1/3rd and Simpson's 3/8th rule, Forward, Backward and Central Difference methods, Richardson Extrapolation. Case study using MATLAB.		
Module:6	**Ordinary Differential Equations**	**6 hours**
Initial Value Problems – Euler, Predictor-corrector and Runge-Kutta methods, Boundary Value Problems – Shooting method and Central difference method. Case study using MATLAB.		
Module:7	**Partial Differential Equations**	**7 hours**
Finite difference solutions of elliptic equations – Liebmann's method, finite difference solutions of parabolic equations – Crank-Nicolson and implicit methods, Overview of hyperbolic equations. Case study using MATLAB / MS Excel.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organisations		
	Total Lecture hours:	**45 hours**

Text Book:	
1.	Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, 2016, 7th ed., McGraw Hill Publications, USA.
Reference Books:	
1.	Gupta, S. K., "Numerical Methods for Engineers, 2012, 3rd ed., New Academic Science, UK.
2.	Kamal I.M. Al-Malah, Aspen Plus: Chemical Engineering Applications, 2016, John Wiley & Sons Inc., USA.

Mode of Evaluation: Assignment, Continuous Assessment Test (CAT), Quiz, Final Assessment Test (FAT).

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE201P	**Computational Methods in Chemical Engineering Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To formulate, solve and analyses complex chemical engineering problems.
2. To apply numerical methods for their research to solve complex problems.
3. To establish the limitations, advantages, and disadvantages of numerical methods.

Course Outcomes:

1. Develop efficient MATLAB code with different programming construct
2. Construct effective reports of the engineering solutions
3. Use modern tools from commercial/open source software (example: MATLAB, MS Excel, ASPEN Plus) to solve Chemical Engineering problems

Indicative Experiments:

1.	Develop MATLAB code for bisection / Regula falsi method.
2.	Develop MATLAB code for Newton Raphson / Secant method.
3.	Develop MATLAB code for Gauss Elimination / Gauss Jordan method.
4.	Develop MATLAB code for Gauss Jacobi / Gauss Seidel method.
5.	Develop Aspen Plus simulation for solving simultaneous equations in distillation column.
6.	Develop MATLAB code for Numerical Integration
7.	Develop MATLAB code for ODE: Euler / Modified Euler method.
8.	Develop MATLAB code for ODE: Runge-Kutta method.
9.	Develop MATLAB code for PDE:Liebmann's method.
10.	Develop Aspen Plus simulation/ MS Excel package to optimize a chemical process involving PDE.
Total Laboratory Hours	**30 hours**

Mode of assessment: Assignment, Final Assessment Test (FAT)

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE204L	Transport Phenomena	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To emphasis the basic concepts of transport phenomena, the similarities of the governing relations of momentum, heat, and mass transfer
2. To illustrate the common mathematical structure of transport problems
3. To formulate appropriate differential equations to obtain velocity, temperature and concentration profiles of transport processes

Course Outcomes:

1. Understand transport properties of molecular transfer of momentum, energy, and mass transport.
2. Relate simultaneous heat, mass, and momentum transfer analysis.
3. Interpret one-dimensional steady state momentum, heat and mass transfer problems.
4. Apply Navier-Stokes equation to examine the problems related to fluid, heat, and mass transfer.
5. Develop industrial transport problems along with appropriate approximations and boundary conditions

Module:1	Introduction	7 hours

Concepts in Chemical Engineering - momentum transport, mass transport, and energy transport - level of analysis - molecular transport properties of gases and liquids - effect of pressure and temperature.

Module:2	Momentum Transport	7 hours

Basics of momentum transport - Phenomenological laws; Newtonian and non-Newtonian fluids; Rheological models, Transport Coefficient, Dimensional analysis.

Module:3	Vector and Tensor analysis	6 hours

Basic concepts - Vector and Tensor Analysis –Coordinate system - tutorials

Module:4	1D Viscous Flow: Shell Balance	10 hours

Shell momentum balance, boundary conditions - rectilinear flow - curvilinear flow - momentum flux and velocity distribution, flow through pipes

Module:5	Equations of Change	10 hours

Eulerian and Lagrangian viewpoint, laminar and turbulent flows, Equation of Motion and Continuity - Integral Conservation Equations - Navier-Stokes - Applications to isothermal flow of Newtonian and non-Newtonian fluids

Module:6	Steady state Heat Transfer – Shell Balance	10 hours

Basics of energy transport, conductive, convective, and viscous dissipation energy fluxes - Steady state heat temperature distribution.

Module:7	Mass Transfer- Shell Balance	8 hours

Basics of mass transport, mechanisms, mass and molar fluxes - Derivation of equation of continuity for a binary mixture and its application to convection diffusion problems.

Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**60 hours**

Text Book:	
1.	Bird R. B., Stewart W. E., Lightfoot E. N., Transport Phenomena, 2012 2nd ed., John Wiley & Sons Inc., Wiley Student Edition, India.
Reference Books:	
1.	Geankoplis C.J., Transport Processes and Separation Process Principles, 2018, 5th ed., Pearson Education India.
2.	William M. Dean, Analysis of Transport Phenomena, 2013, 2nd ed., Oxford University Press, India.
3.	Plawsky Joel L, Transport Phenomena fundamentals, 2020, 4th ed., CRC Press, USA.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE206L	Materials Science and Engineering	3	0	0	3
Pre-requisite	BCHE201L, BCHE201P	Syllabus version			
		1.0			

Course Objectives:

1. To outline the structure, properties, and applications of engineering materials
2. To recall the structure of solids and the various crystal imperfections
3. To understand the fundamental principles behind the material characterization methods

Course Outcomes:

1. Assess the fundamentals of materials and atomic interactions
2. Assess the crystal imperfections
3. Interpret the phase diagrams of the alloys, polymers, and ceramic materials
4. Analyse materials characterization techniques
5. Design the material manufacturing process and material property charts

Module:1	Basics of Materials and Structure	7 hours

Classification of materials: metals, alloys, ceramics, polymers and composites, atomic structure, crystal systems, Chemical Bonds, Intermolecular forces, forces of interaction – van der Waals and electrostatic interactions, aggregation, structures of metals, ceramics, polymers, and amorphous materials.

Module:2	Crystal Systems	7 hours

Basics of crystal systems- space lattice- miller indices of atomic planes and directions, Bravais lattices, unit cells, primitive cells, crystallographic planes, and directions, crystal defects, 0-D, 1-D and 2-D defects; vacancies, interstitials, solid solutions in metals and ceramics, Frenkel and Schottky defects; dislocations; grain boundaries, twins, stacking faults, surfaces, and interfaces, and problems in crystallography.

Module:3	Phase Diagrams of the engineering materials	7 hours

Chemical alloying, steps in polymerization, phase rules for metals, ceramics, polymers - equilibrium diagrams, solid solution, cooling curves of metals, alloys, polymers, non-equilibrium cooling, isomorphous- eutectic- peritectic and eutectoid reactions with examples

Module:4	Evaluation of engineering materials	8 hours

Stress-strain response, corrosion, degradation of materials, methods of measuring piezo- and ferroelectric behaviour of metals and alloys, properties of materials, refractive index, electromagnetic materials

Module:5	Characterization of materials	5 hours

Basics of the Microstructure, Fundamentals of the microscope, Bragg's law, X-ray diffraction-Metallography, preparation of the specimen, microstructure examination and application, spectroscopic techniques such as UV-Vis, IR, Fluorescence and Raman; optical microscopy, electron microscopy, composition analysis in electron microscopes.

Module:6	Electrochemical Characterization of the materials	5 hours

Cyclic voltammetry, Linear sweep voltammetry, polarization curves, Tafel slope, Evans's diagram, Impedance spectroscopy, Problems in building polarization curve, Evaluation of electrochemical properties of the battery, fuel cells, electrolyzer, and capacitor materials		
Module:7	**Nano materials**	**4 hours**
Preparation of nano-materials, Heat treatment, sintering; thin film deposition: evaporation and sputtering techniques, and chemical vapour deposition, and thin-film growth phenomena.		
Module 8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**45 hours**

Text Books:

1.	W. D. Callister, Jr., "Materials Science and Engineering", 2003, 6th ed., Wiley India, India.
2.	W. F. Smith, J. Hashemi, and R. Prakash, "Materials Science and Engineering", 2008, 4th ed., Tata Mc Graw Hill, India.

Reference Book:

1.	David Michael Rowe, "Thermoelectric Handbook: Macro to Nano", 2006, CRC Press, USA.

Mode of Evaluation: Continuous Assessment Test, written assignment, Quiz, Final Assessment Test.

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

DISCIPLINE CORE COURSES – 21 (49 CREDITS)

Course Code	Course Title	L	T	P	C
BCHE202L	**Chemical Engineering Thermodynamics**	**3**	**1**	**0**	**4**
Pre-requisite	**Nil**	**Syllabus Version**			
		1.0			

Course Objectives:

1. Enhance the basic knowledge and intuitive understanding of the thermodynamics of physical and chemical systems.
2. Introduce the concepts of partial molar properties, fugacity, activity, and vapour-liquid equilibrium for ideal and real substances existing in more than one phase under equilibrium.
3. Generalize design thinking skills on property estimation relevant to chemical industries.

Course Outcomes:

1. Define and illustrate thermodynamic equilibrium state and equations of state.
2. Relate properties such as change in enthalpy, entropy, free energy, heat and work requirements for batch and flow processes occurring in chemical industries.
3. Construct and analyze phase equilibrium data, P-x-y, T-x-y diagrams for ideal, binary, miscible vapour-liquid systems.
4. Device methodologies for qualitative and quantitative analysis of VLE data for non-ideal, binary, miscible systems using van Laar, Margules, and property estimation models.
5. Estimate the feasibility of a chemical reaction and determine the equilibrium rate constant for chemical reactions.

Module:1	Fundamental Concepts and Definitions	6 hours

Introduction - definitions and basic concepts - classical and statistical thermodynamics - concept of continuum - thermodynamic steady state - equilibrium state process - Volumetric properties of pure fluids - P-V-T relationships - ideal gas - real gas - law of corresponding states.

Module:2	Laws of Thermodynamics	5 hours

First law – closed non-flow system – steady-state flow systems and their analysis - Second law - change in internal energy - enthalpy - entropy calculations - phase change - Heat effects - standard heat of reaction.

Module: 3	Thermodynamic Properties of Pure Fluids	7 hours

Gibbs free energy - Helmholtz free energy - exact differential equation - thermodynamic property relations – Maxwell’s relations and applications - fugacity - activity of pure substances - determination of fugacity of pure gases, solids, and liquid-fugacity coefficient-activity coefficient.

Module: 4	Thermodynamic Properties of Solutions	7 hours

Mixtures of pure fluids - partial molar properties - chemical potential - fugacity in solution - Ideal solutions - Raoult's law - Henry's law - Lewis Randall rule - Gibbs - Duhem equation - Residual properties - property changes of mixing for ideal and non-ideal solutions - excess property relations - Gibbs free energy calculations.		
Module:5	**Phase Equilibria**	**6 hours**
Phase rule - criteria of phase equilibrium - single component - multiple components - Vapour-Liquid Equilibria for ideal solutions - phase diagram for binary systems using Aspen Plus - constant temperature equilibria - constant pressure equilibria - phase equilibrium curves.		
Module:6	**Vapour-Liquid Equilibria – Non-ideal Solutions**	**7 hours**
Non-ideal solutions – azeotropic systems - minimum boiling – maximum boiling – VLE – P-x-y diagram and T-x-y diagram using Aspen Plus; Bubble point – dew point calculation methods – van Laar equation - Margules equation - Wilson equation - Multicomponent systems – flash vaporization - Consistency test for VLE data.		
Module:7	**Chemical Reaction Equilibria**	**5 hours**
Chemical reaction equilibria - reaction coordinates - criteria for chemical equilibrium - equilibrium constant - Gibbs free energy of a reaction - effect of temperature on equilibrium constant - equilibrium constant of homogeneous gas and liquid phase reactions.		
Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organisations		
	Total Lecture Hours:	**45 hours**

Textbook:

1.	Narayanan K.V., A Textbook of Chemical Engineering Thermodynamics, 2013, 2nd ed., Prentice Hall India Learning Private Limited, India.

Reference Books:

1.	Smith J.M., Van Ness H.C., Abbott, M.M., Swihart M.T., Bhatt, B.I., Introduction to Chemical Engineering Thermodynamics, 2019, 8th ed., McGraw Hill India, India.
2.	Matsoukas T., Fundamentals of Chemical Engineering Thermodynamics, 2012, 1st ed., Pearson Prentice Hall, USA.
3.	Dahm K.D., Visco D.P., Fundamentals of Chemical Engineering Thermodynamics, 2012, 1st ed., Cengage Learning India Private Limited, India.

Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignments, and Final Assessment Test.

Recommended by Board of Studies:	11-02-2022		
Approved by Academic Council:	No.65	Date:	17-03-2022

Course code	Course title	L	T	P	C
BCHE203L	**Chemical Process Calculations**	**3**	**1**	**0**	**4**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To formulate material balances for compositions and flow rates of process streams
2. To solve single and multiple reactions involved in chemical processes
3. To perform material and energy balance calculations for various unit operations

Course Outcomes:

1. Apply mole concept and ideal gas equation to express the composition of mixtures
2. Understand the method of solving steady state material balances without chemical reactions
3. Estimate the extent of reaction in material balances for systems involving chemical reactions
4. Analyze the recycle and bypass processes involving chemical reactions
5. Apply simultaneous material and energy balance to industrial processes.

Module:1	Introduction to Basic Concepts	7 hours

Units and dimensions – conversion factors – mole concept –normality, molarity, and molality – density and specific gravity – methods of expressing composition of mixtures and solutions – weight fraction – mole fraction –volumetric composition – Ideal gas law – Dalton’s law – Amagat’s law

Module:2	Vapor pressure and Humidity calculations	8 hours

Vapor pressure of liquids – Clausius-Clapeyron equation - Antoine equation - vapor pressure of immiscible liquids and ideal solutions – Raoult’s law – Henry’s law - humidity and saturation – wet bulb and dry bulb temperature - relative and percentage saturation

Module:3	Material Balance without Chemical Reaction	9 hours

General material balance equation for steady and unsteady state - typical steady state material balances in distillation – absorption – extraction – crystallization – agitated batch crystallization – vacuum crystallizer – Drying: tray dryer – drum dryer – spray dryer – vacuum dryer

Module:4	Material balance with Chemical Reaction	9 hours

Stoichiometric equation – stoichiometric ratio – limiting reactant – excess reactant – percentage excess reactants – conversion – yield – selectivity – material balance with single and multiple chemical reactions.

Module:5	Recycle and Bypass Operation	7 hours

Recycle, purge and bypass calculations in unit operations: single and multiple effect evaporators - distillation - drying.

Module:6	Combustion calculations	9 hours

Calorific value of fuels, flue gas analysis, Orsat analysis, air/ fuel ratio calculations - theoretical and excess air requirement for solid, liquid and gaseous fuels.

Module:7	Energy balance	9 hours
General steady state energy balance equation, heat capacity, enthalpy, heat of formation, heat of reaction, heat of combustion and Calorific values. Heat of solution, heat of mixing, heat of crystallization, determination of ΔH_R at standard and elevated temperatures. Calculations using Excel tool.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organisations		
	Total Lecture hours:	**60 hours**

Text Book:			
1.	Himmelbalu DM Riggs JB "Basic Principles and Calculations in Chemical Engineering" 2015, 8th ed., Pearson India Educational Services, India.		
Reference Books:			
1.	O.A.Hougen, K.M.Watson, R.A.Ragatz, "Chemical Process Principles Part-I: Material and Energy Balances", 2004, 2nd ed., CBS Publishers, New Delhi, India.		
2.	Bhatt B.I., Thakore S. B., Stoichiometry, 2011, 5th ed., Tata McGraw – Hill Book Company, New Delhi, India.		
Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE205L	**Momentum Transfer**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To inculcate the fundamental laws governing the fluid flow.
2. To understand the importance and application of fluid mechanics.
3. To apply the physical and mathematical models to analyse the fluid flow phenomena in Engineering applications.

Course Outcomes:

1. Evaluate the fluid properties and hydrostatic pressure
2. Analyze fluid flow dynamics using governing equations
3. Measure the flow parameters and energy losses across pipe flow, packed and fluidized bed
4. Perform dimensional analysis
5. Explain the characteristics and problems related to pump

Module:1	Basic Concept of Momentum Transfer	7 hours

Introduction and Significance of Momentum Transfer in Chemical Engineering. Definition of fluid- Classification of fluids – Newtonian and Non-newtonian Fluids – Characteristic properties of fluids – Fluid statics: Pascal's law and Hydrostatic law of equilibrium; Pressure and its measurement – Manometers

Module:2	Fluid Flow Phenomena	7 hours

Kinematics of fluid flow, Dynamics of fluid flow – Basic equations governing fluid flow – types of fluid flow. Equation of Continuity and its application, Equation of motion – Derivation of Navier Stokes and Euler's equation, Bernoulli's equation and its application in fluid flow

Module:3	Flow Measuring Devices	4 hours

Importance of metering – Classification flow measuring devices, Principle and working of Orifice meter, Venturi meter, Pitot tube, Variable area meters : Rotameter, Elbow meter

Module:4	Flow through Pipes	6 hours

Flow of fluids in pipes –Velocity Profile, Shear Stress Distribution – Hagen - Poiseuille equation - Concept of average velocity –Turbulent flow- Kinetic energy correction factor - Fluid friction – Friction factor – Application of Moody's diagram - Minor losses and major losses

Module:5	Dimensional and Model Analysis	5 hours

Dimensional homogeneity– Raleigh and Buckingham π theorems– Non-dimensional numbers - Model laws – model types - Similitude

Module:6	Flow through Packed and Fluidized Bed	7 hours

Flow past immersed bodies - Concept of Drag, Drag Coefficients and Particle Reynolds number – Flow of fluids through packed beds – Packing and types of packing- Pressure drop across packed beds –Kozeny Carman equation – Ergun's equation- Loading and Flooding Packed Beds - Fluidization –Types of fluidization minimum fluidization velocity

Module:7	**Transportation of Fluids**	**7 hours**
Pipes - Fittings and Valves – Fluid Moving Machinery: Pumps – Classification : Reciprocating and Centrifugal pump – Pump Characteristics – Priming and Cavitation - Net Positive Suction Head - Stuffing Boxes, Mechanical Seals -– Factors Influencing selection of pump.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**45 hours**

Text Books:

1.	Cengel Y.A., Cimbala J.M., Fluid Mechanics (SIE): Fundamentals and Applications, 2019, 4th ed., McGraw Hill, New York.
2	McCabe W.L., Smith J.C., Harriott P., Unit Operations of Chemical Engineering, 2017, 7th ed., McGraw Hill, New York.

Reference Books:

1.	Fox R.W., McDonald A.T., Pirtchard P.J., Mitchell J. W., Introduction to Fluid Mechanics, 2015, 9th ed., Wiley Publications, Delhi.
2.	Munson, B. R., Young, D.F., Okiishi, T.H., Fundamentals of Fluid Mechanics, 2015, 8th ed., Wiley Publications, Delhi.
3.	R.K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines, 2015, 8th ed., Laxmi Publications, New Delhi.

Mode of Evaluation: Continuous Assessment Test, written assignment, Quiz, Final Assessment Test.

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE205P	**Momentum Transfer Laboratory**	**0**	**0**	**2**	**1**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To expose the student to various flow measuring devices
2. To impart knowledge about friction factor for fluid flow in pipe and packed bed
3. To understand the performance characteristics of centrifugal pump

Course Outcomes:

1. Evaluate the velocity in the pipe line using different flow measuring devices
2. Determine the energy losses and pressure drop in pipes
3. Estimate the minimum fluidization velocity

Indicative Experiments

1.	Flow through Venturi meter
2.	Flow through Orifice meter
3.	Flow through circular pipe
4.	Flow through non circular pipe
5.	Determination of Minor losses
6.	Reynolds Experiment
7.	Verification of Bernoulli's theorem
8.	Characteristics of Centrifugal pump
9.	Flow through Packed bed
10.	Flow through Fluidized bed
Total Laboratory Hours	**30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course Code	Course Title	L	T	P	C
BCHE207L	**Mass Transfer I**	**2**	**1**	**0**	**3**
Pre-requisite	BCHE202L	**Syllabus version**			
		1.0			

Course Objectives:

1. To understand the fundamentals of diffusion and the theories of mass transfer
2. To impart the knowledge of humidification, drying and crystallization
3. To solve application oriented problems using separation techniques

Course Outcomes:

1. Derive molecular diffusion in gases, liquids and solids
2. Compute the molecular diffusion in gases, liquids and solids
3. Compute mass transfer coefficient and flux for various mass transfer operations
4. Solve humidification/dehumidification by considering the aspects of design
5. Select suitable equipments used for mass transfer operations (humidification/dehumidification, Drier and crystallizers)

Module:1	**Diffusion**	**6 hours**

Introduction to Mass transfer operation, Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion coefficient measurement and prediction

Module:2	**Molecular diffusion in fluids**	**6 hours**

Molecular diffusion in gas and Liquids, Multicomponent diffusion, Diffusion through variable cross-sectional area, Diffusivity in solids and its applications

Module:3	**Mass transfer coefficients**	**6 hours**

Introduction to mass transfer coefficient, Correlation for convective mass transfer coefficient, Correlation of mass transfer coefficients for single cylinder, Packed column, flow over a flat plate

Module:4	**Theories of Mass Transfer**	**6 hours**

Penetration theory, Surface Renewal Theory, Interphase mass transfer, two film theory, Overall mass transfer coefficients

Module:5	**Humidification**	**7 hours**

Basic concepts, Principles of Humidification –Definitions Wet Bulb Temperature &Adiabatic Saturation Temperatures –Air/Water System psychrometric and Psychrometric Charts – Utilisation of Psychrometric Charts – Dehumidification – Cooling Towers –Mechanical Draft Towers: forced draft towers and induced draft towers, Design calculations of cooling tower.

Module:6	**Drying**	**7 hours**

Principles of Drying – Definitions of moisture and other terms on Drying –Classification of Drying operations - Rate of Drying – Constant and Falling Rate Drying – Moisture movement in solids - Through Circulation Drying - Rate of drying for Continuous Direct heat Driers. Types of Dryers used in practice and their operation – Batch and Continuous Dryers

Module:7	**Crystallization**	**5 hours**

Crystal Geometry - Invariant Crystals - Principles of Crystallization- Super saturation Nucleation - Crystal growth -Material & Energy Balance applied to Crystallizers – Types of Crystallizers

used in practice		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	45 hours

Text Books:	
1.	B.K. Dutta, Principles of Mass transfer and Separation Processes, 2010, 1st ed., PHI, India.
2.	R.E. Treybal, Mass-Transfer Operations, 2017, 3rd ed., McGraw-Hill Inc., USA.
Reference Books:	
1.	E.L.Cussler, Diffusion: Mass Transfer in Fluid Systems, 2017, 3rd ed., Cambridge University Press, United Kingdom.
2.	Christie J, Geankoplis, Transport processes and Unit Operations, 2003, 4th ed., Prentice Hall India Pvt. Ltd., India.
3.	N.Anantharaman, K.M.Meera Sheriffa Begum, Mass transfer-Theory and practice, 2011, Prentice-Hall of India, New Delhi, India.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE208L	Heat Transfer	3	0	0	3
Pre-requisite	BMAT102L	Syllabus version			
		1.0			

Course Objectives:

1. Explain the fundamental principles of heat transfer and various modes of heat transfer
2. Solve heat transfer problems using the principles of heat transfer in different modes
3. Design and estimate heat loads for heat transfer equipment such as heat exchangers and evaporators

Course Outcomes:

1. Identify Classify the different modes of heat transfer with their significance for stady and unsteady state processes
2. Model and solve steady/unsteady state heat transfer problems
3. Compute the convective heat transfer parameters n fluids involving phase and no phase changes
4. Estimate radiative mode heat transfer with and without radiation shields through shape factor concept
5. Explain the performance of various types of heat exchangers and evaporators/condensers

Module:1	Conduction	6 hours

Basic concepts – Conduction – Fourier’s Law of Heat conduction – Concept of Thermal Conductivity – Generalized conduction equation in cartesian, cylindrical and spherical systems; Steady State Conduction – Heat transfer composite systems – Critical thickness of insulation – Conduction with heat Generation.

Module:2	Extended Surfaces and Unsteady state conduction	5 hours

Extended surfaces – types and applications of fins – Fin efficiency and effectiveness – Fin performance - Unsteady state heat conduction – Lumped parameter system – Conduction through semi-infinite solids

Module:3	Convection (without phase change)	7 hours

Fundamentals of Convection – Thermal boundary layer & Convective heat transfer coefficients – Convection correlations through Dimensional analysis; Laminar flow over a flat plate – Turbulent flow over a flat plate – Flow over cylinders – Internal flow through pipes – annular spaces – Natural convection in vertical - inclined and horizontal surfaces.

Module:4	Convection (with phase change)	6 hours

Condensation and Boiling – Drop wise and Film wise condensation – Film condensation on a vertical plate; Boiling – Nucleate boiling and film boiling correlations – Critical flux

Module:5	Radiation	6 hours

Radiation heat transfer – Thermal radiation – Laws of radiation – Blackbody concepts – Emissive power – Radiation shape factor – Gray bodies – Radiation shields

Module:6	Heat Exchangers	7 hours

Heat exchangers – Types and practical application –Concept of LMTD & Overall heat transfer coefficient; Effectiveness – NTU method for heat exchanger design - Fouling factor and estimation of Overall heat transfer coefficient - Special type of heat exchangers		
Module:7	**Evaporators**	**6 hours**
Introduction – Types of Evaporators – Capacity – Steam economy – Boiling point elevation (Duhring rule); Material and energy balance of single effect evaporator - multiple effect evaporators - Design of single and multiple effect evaporators		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**45 hours**

Text Book:	
1.	Ghajar A.J., Cengel Y.A., Heat and Mass Transfer: A Practical Approach, 2015, 5th ed., McGraw-Hill, USA.
Reference Books:	
1.	Frank Kreith, Raj M Manglik, Principles of Heat Transfer, 2016, 8th ed., Cengage Learning, USA.
2.	Donald Q. Kern, Process Heat Transfer, 2017, 2nd edition, McGraw Hill Education, USA.
3.	B.K. Dutta, Heat Transfer Principles and Applications,2000, 1st ed., PHI, India.

Mode of Evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE208P	**Heat Transfer Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BMAT102L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To expose the students to various modes of heat transfer (Conduction, Convection and Radiation) and their application in process industries
2. To troubleshoot various heat transfer equipment by analysis the design parameters
3. To introduce advanced computer tools and software in designing heat exchange equipment

Course Outcomes:

1. Model and solve steady/unsteady state heat transfer problems
2. Analyze the heat transfer phenomena in fluids involving phase and no phase changes
3. Examine the radiative heat transfer with and without radiation shields

Indicative Experiments:

1.	Measurement of thermal conductivity of metal rod and liquids
2.	Analysis of Transient Heat Conduction
3.	Analysis of Fin efficiency & effectiveness
4.	Performance of Natural Convection heat transfer
5.	Performance of Forced Convection heat transfer
6.	Emissivity measurement
7.	Performance of Double Pipe Heat Exchanger
8.	Performance of Plate type Heat Exchanger
9.	Performance of shell and tube Heat Exchanger
10.	Analysis of Heat Exchanger using Aspen Plus – EDR and PROSIM software
	Total Laboratory Hours **30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE301L	Mechanical Operations	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To impart knowledge about size analysis, size reduction and solid handling adopted in process Industries
2. To understand mechanical separation aspects such as filtration, sedimentation, flotation
3. To choose the right separation technology for easy separation of chemical components

Course Outcomes:

1. Describe properties of particulate solids
2. Classify size reduction methods based on characteristics of the feed material
3. Understand the mechanical separation aspect of screening
4. Identify the suitable separation technique based on particle dynamics.
5. Explain the process of agitation, mixing and solids conveying.

Module:1	Properties and Storage of Solids	7 hours

Particle shape and size, Mixed particle sizes, Average particle sizes. Solids in bulk – the angle of repose, angle of internal friction. Storage and transportation of bulk solids - Problems associated with the flow of bulk solids - Transportation equipment – Belt conveyors, Screw conveyors, Pipe conveyors, Apron conveyors, Flight conveyors, Bucket elevators.

Module:2	Size reduction of Solids	6 hours

Principles of Comminution – Energy and Power Requirements in Comminution, Crushing Efficiency, Mechanical Efficiency. Laws of Crushing, Size Reduction Equipment – Crushers – Grinders – Cutting Machines. Open and Closed Circuit Operation, Feed Control, Mill Discharge, Energy Consumption, Removal of Heat.

Module:3	Size separation of solids	6 hours

Screening, Screen analysis, Screen efficiency and capacity, Screening Equipment – Grizzlies - Trommels, Vibrating screen, Gyratory screen, Banana screen.

Module:4	Separation of solids based on specific properties	6 hours

Gravity settling chamber, Wet scrubber, Elutriator, Electrostatic separation, Cyclone separation, Magnetic separation, Froth flotation, Jigging.

Module:5	Settling and Sedimentation	5 hours

Particle dynamics – terminal settling velocity, free and hindered settling - Gravity sedimentation – Design of Equipment: Thickeners, Clarifiers, Centrifugal sedimentation.

Module:6	Filtration	7 hours

Principles of Cake Filtration- Constant Pressure Filtration - Constant Rate Filtration - Compressible and Incompressible Filter Cakes - Specific Cake Resistance - Filter Medium Resistance - Continuous Filtration - Principles of Centrifugal Filtration - Washing of Filter Cake - Filtration Equipment – Plate and frame filter Press - Leaf Filter- Rotary drum filter - Filter Media - Filter Aids.

Module:7	Agitation and Mixing	6 hours

Agitation and Mixing of Liquids – Principles of Agitation – Agitation Equipment –Impellers –

Flow Pattern in Agitated Vessel - Power Consumption in Agitated vessel. Calculation of power consumption - Mixing equipment for liquids and suspensions - Mixing of solids - Measurement of the extent of mixing – Mixing index - the rate of mixing - Mixing equipment for solids.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**45 hours**

Text Books:	
1.	McCabe W., Smith J., Harriott P., Unit Operations of Chemical Engineering, 2017, 7th ed., McGraw Hill Education, New York.
2.	Anup K. Swain, G.K. Roy, Hemlata Patra, Mechanical Operations, 2017, 1st ed., McGraw Hill Education Pvt Ltd, New Delhi, India.
Reference Books:	
1.	C.M. Narayanan, B.C Bhattacharya, Mechanical Operations For Chemical Engineers, 2010, 3rd edition, Khanna Publishers, New Delhi, India.
2.	Christie J Geankoplis, Transport processes and Unit Operations, 2003, 4th ed. Prentice Hall India Pvt. Ltd, India.
3.	Coulson and Richardson’s, Chemical Engineering, Vol.2A: particulate systems and particle technology, 2019, 6th ed., Butterworth Heinemann, USA.

Mode of Evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE301P	**Mechanical Operations Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To develop an understanding of size analysis and size reduction
2. To impart knowledge about solid-liquid, and gas-solid mechanical separation
3. To understand the importance of agitation in process industry

Course Outcomes:

1. Determine particle size distribution of a given sample
2. Estimate the energy requirement for size reduction of a given material
3. Choose suitable solid liquid separation equipment for a particular process

Indicative Experiments:

1.	Determination of screen Effectiveness
2.	Size reduction studies in Jaw crusher
3.	Determination of critical speed Ball mill
4.	Size reduction studies in Roll crusher
5.	Determination of terminal settling velocity of a sphere
6.	Filtration studies in plate and frame filter press
7.	Filtration studies in Leaf filter
8.	Determination of area of thickener
9.	Solid separation using Cyclone separator
10.	Effectiveness of mixing
Total Laboratory Hours	**30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE302L	**Mass Transfer II**	**3**	**0**	**0**	**3**
Pre-requisite	**BCHE207L**	**Syllabus version**			
		1.0			

Course Objectives:

1. Design the principles of staged and continuous contact separation equipment involved in mass transfer operations
2. Calculate the number of stages in staged and continuous contact separation operations
3. Identify modern separation methods for high purity products widely used in separation operations

Course Outcomes:

1. Determine the number of stages in mass transfer operations
2. Estimate the number of transfer units and height of transfer units in mass transfer operations
3. Compute the separation efficiency of single and multi-staged mass transfer operations
4. Select suitable equipment/process used for mass transfer operations
5. Discuss modern separation techniques applied in industries

Module:1	Introduction to Equilibrium Staged Operations	6 hours

Introduction to various equilibrium staged operations: Distillation, absorption, Extraction, leaching and adsorption - Vapour–liquid Equilibria - Types of distillation – Differential, Equilibrium, Steam, Azeotropic and Extractive distillations - Develop VLE data using Aspen Plus.

Module:2	Distillation	8 hours

Distillation column: Types of contact – Tray and Packed Column - Derivation of operating line equation for different section and parts of distillation column: rectification section, stripping section, feed tray location, condenser, reboiler and efficiency of distillation column - Determination of theoretical trays for continuous binary distillation using McCabe-Thiele method and Ponchon-Savarit graphical method - Case study of Industrial distillation column for multicomponent separation using Aspen Plus.

Module:3	Absorption	7 hours

Introduction to absorption, Continuous contact, co-current and counter-current multi-stage absorption (Tray absorber), Design of packed tower.

Module:4	Extraction	7 hours

Liquid–Liquid Equilibria – Determination of the number of theoretical stages in co-current, counter-current and cross-current contact operations - extraction equipment - Develop liquid-liquid equilibria using Aspen Plus.

Module:5	Leaching	5 hours

General principles of leaching - Factors influencing the rate of leaching –Co-current, Counter-current contact processes, Multi stage Processes, Equipment for leaching – Advanced industrial leaching processes

Module:6	Adsorption	6 hours

Adsorption theory- Structure of adsorbents - Adsorption isotherms – Langmuir and Freundlich isotherms – cross-current, counter-current contact operations -Adsorption in fixed beds – Breakthrough Curves.

Module:7	**Modern separation techniques**	**4 hours**
Membrane separation-microfiltration, ultrafiltration, nanofiltration and reverse osmosis, Chromatography techniques and other advanced separation techniques.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**45 hours**

Text Books:

1.	R.E. Treybal, Mass-Transfer Operations, 2017, 3rd ed., McGraw-Hill Inc., USA
2.	B.K. Dutta, Principles of Mass transfer and Separation Processes, 2010, 1st ed., PHI, India

Reference Books:

1.	D. Seader, and E.J Henley and D.K. Roper, Separation Process Principles, 2010, 3rd ed., John Wiley & Sons, USA.
2.	Christie J, Geankoplis, Transport processes and Unit Operations, 4th ed., Prentice Hall India Pvt.Ltd, 2003
3.	W.L. McCabe, J.C. Smith, and P. Harriott, Unit Operations of Chemical Engineering, 2005, 7th ed., McGraw-Hill Inc., USA.

Mode of Evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE302P	**Mass Transfer Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BCHE207L**	**Syllabus version**			
		1.0			

Course Objectives:

1. Understand the basic principles of staged and continuous contact separation equipments
2. Perform mass transfer experiments in teams
3. Study the performance of mass transfer equipment at lab scale

Course Outcomes:

1. Perform experiments of various equilibrium staged operations
2. Analyze mass transfer operations using simulation software such as Aspen Plus, MATLAB, PROSIM etc.
3. Write technical reports of performed experiments

Indicative Experiments:

1.	Diffusion in gas phase
2.	Diffusion in liquid phase
3.	Mass transfer studies in Wetted wall column
4.	Simple distillation by Rayleigh equation
5.	Rate of drying in a tray dryer
6.	Liquid-liquid Equilibria-Ternary system
7.	Liquid-liquid cross current Extraction
8.	Continuous distillation (using Aspen Plus or PROSIM)
9.	Adsorption (using Aspen Plus or PROSIM)
10.	Co-current Leaching
Total Laboratory Hours	**30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE303L	**Chemical Reaction Engineering I**	**3**	**0**	**0**	**3**
Pre-requisite	**BCHE202L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To impart the knowledge of chemical kinetics and reaction mechanisms
2. To explain isothermal and non-isothermal ideal reactors and their applications
3. To examine the problems related to multiple reactions and evaluate the selectivity, reactivity and yield

Course Outcomes:

1. Classify various reaction types and their applications
2. Apply the principles of reaction kinetics, formulate rate equations and analyse the batch reactor data
3. Compare and analyse ideal reactor designs (Batch, CSTR, PFR, recycle and autocatalytic) for simple chemical reaction schemes
4. Evaluate the choice of right reactor among single, multiple, recycle reactor, etc. with or without multiple reactions
5. Design non-isothermal reactors and explore steady-state multiplicity

Module:1	**Fundamental Concepts and Definitions**	**5 hours**

Classification of reactions, rate and stoichiometry, rate law, rate equation, rate constant, variables affecting the rate of reaction, activation energy, reactions at equilibrium

Module:2	**Chemical Kinetics**	**6 hours**

Interpretation of Batch Reactor Data - constant and variable volume batch reactor, Integral and Differential method of analysis - reaction mechanism, Half-life method, Analysis of data for Reversible and Irreversible Reactions

Module:3	**Design of Isothermal Ideal Reactors**	**6 hours**

Ideal Batch Reactor - space time, holding time and space velocity, Ideal Mixed Flow Reactor, Ideal Plug Flow Reactor for single reactions, Size comparison of single reactors for single reactions, Variable density systems

Module:4	**Multiple Reactors**	**6 hours**

Multiple Reactor Systems - equal size mixed flow reactors in series, plug flow reactors in series and parallel - mixed flow reactors of different sizes in series, reactors of different types in series

Module:5	**Design for Multiple Reactions**	**6 hours**

Reactions in parallel (simultaneous reactions) for CSTR- PFR, Reactions in series (Consecutive Reactions) for CSTR-PFR, Combined series and parallel reactions

Module:6	**Special Reactors**	**6 hours**

Semi batch reactor, Bio reactor, Recycle Reactor, Auto Catalytic Reactor

Module:7	**Non-isothermal Reactors**	**8 hours**
Steady state non-isothermal reactors-CSTR, PFR, Material balance, Energy balance, Adiabatic reactors – Batch reactor, CSTR, PFR, Multiple steady state, Multiple chemical reactions		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours	**45 hours**

Text Book:	
1.	O. Levenspiel, Chemical Reaction Engineering, 2006, 3rd ed., Wiley Publications, India
Reference Books:	
1.	H.S. Fogler, Elements of Chemical Reaction Engineering, 2016, 5th ed., Prentice Hall India Pvt. Ltd., New Delhi
2.	G. F Froment, K.B Bischoff and J.D Wilde, "Chemical Reactor Analysis and Design", 2010, Wiley Publications, New York
3.	J.M. Smith, Chemical Engineering Kinetics, 2014, 3rd ed., McGraw-Hill, India

Mode of Evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE303P	**Chemical Reaction Engineering Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BCHE202L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To expose the students to various experiments for obtaining experimental data and to predict reaction kinetics using appropriate rate law models
2. To analyse the performance of ideal reactors such as Batch, Semi batch ,CSTR and PFR
3. To impart knowledge about the behaviour of non-ideal reactors using Residence Time Distribution (RTD) analysis

Course Outcomes:

1. Apply the principles of reaction kinetics to formulate rate equations and analyse the reactor data
2. Design ideal reactors (Batch, Semi batch, CSTR, PFR) for simple chemical reaction schemes
3. Analyse the behaviour of non-ideal reactors for obtaining the RTD

Indicative Experiments:

1.	Analysis of Batch reactor – equimolar constant volume
2.	Analysis of Batch reactor - non-equimolar constant volume
3.	Assessment of Adiabatic batch reactor performance
4.	Performance of Plug flow reactor
5.	Performance of Mixed flow reactor
6.	Performance of Combined reactor in series
7.	Performance of packed bed reactor
8.	RTD studies in Plug flow reactor
9.	RTD studies in Mixed flow reactor
10	RTD studies in packed bed reactor
Total Laboratory hours	**30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE304L	**Chemical Process Technology and Economics**	**3**	**1**	**0**	**4**
Pre-requisite	**BCHE203L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To comprehend unit operations concepts in the Chemical Process industries.
2. To define the appropriate process flow diagram
3. To evaluate the economic viability of process industry projects.

Course Outcomes:

1. Outline organic and inorganic chemical processes in the industry.
2. Explain the manufacture of industrial gases used in the chemical industry.
3. Identify the manufacturing processes in the fertilizer industry
4. Describe Sugar, Soap manufacturing and Petroleum refining.
5. Understand the economic evaluation concepts as applied in the Chemical Process Industries.

Module	Title	Hours
Module:1	**Chloro-alkali and Cement Industries**	**10 hours**
Manufacture of soda ash - caustic soda - sulphur - sulphuric acid - Portland cement- glass.		
Module:2	**Industrial Gases**	**8 hours**
Manufacture of carbon-di-oxide – hydrogen - oxygen and nitrogen – producer gas – Syn-gas - natural gas - Clean energy technologies.		
Module:3	**Fertilizer Industries**	**8 hours**
Manufacture of nitric acid –Ammonia – Urea - phosphoric acid - Mono Ammonium Phosphate – Di-Ammonium Phosphate – Single super phosphate - Triple super phosphate.		
Module:4	**Cellulose, Sugar, Soap and Detergent Production Industries**	**6 hours**
Manufacture of pulp and paper- sugar- Oil and Fats - soaps and detergents		
Module:5	**Petroleum Industries**	**6 hours**
Petroleum refining processes - cracking - reforming - secondary refining processes		
Module:6	**Cost Estimation**	**12 hours**
Cash flow for industrial operations, financial sources, Equipment costs, materials transfer and handling costs, Estimation of capital requirements and operating expenses.		
Module:7	**Cost accounting and Depreciation**	**8 hours**
Cost and asset accounting, financial statements, Interest and Investment costs, Taxes and Insurance, Depreciation- Calculation methods		
Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**60 hours**

Text Books:

1.	M. Gopala Rao and Marshall Sittig, Dryden's Outlines of Chemical Technology, 2010, 3rd ed., East West Press, India.
2.	James R Couper: Process Engineering Economics, 2003, Marcel Dekker Inc., USA.
Reference Book:	
1.	Austin G.T., Shreve's Chemical Process Industries, 2017, 5th ed., McGraw Hill, USA.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE305L	**Process Dynamics and Control**	**3**	**0**	**0**	**3**
Pre-requisite	**BMAT102L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To introduce the fundamental concepts of control system and to understand the dynamic behaviour of the process
2. To impart knowledge on different modes of controllers, their general characteristics and analyse the stability of control systems
3. To develop basic understanding on advanced control strategies and implementation of computer control in industries

Course Outcomes:

1. Understand process measuring instruments and their operating principles
2. Apply the mathematical tools for modelling the dynamic behaviour of open loop process using different forcing functions
3. Identify the modes of control action required for closed loop control system and its stability in time domain
4. Analyze the stability of closed loop control system in frequency domain
5. Evaluate different advanced control schemes and various types of computer control in industries

Module:1	**Process Instrumentation**	**4 hours**

Measuring instruments, Components, Performance characteristics - Static and Dynamic, Principal measuring instruments in process industries- Temperature, Pressure, Flow Rate, Liquid Level, pH and Concentration

Module:2	**Linear Open Loop Systems**	**8 hours**

Introduction to Process Control, Laplace transformation - Transform of standard functions, Derivatives and integrals, Inversion theorems - Transfer functions - Forcing functions - step, pulse, impulse and sinusoidal - First order and Higher order system dynamics - First order systems in series, linearization of nonlinear systems, Transportation lag

Module:3	**Linear Closed Loop Systems**	**6 hours**

Components of closed loop control system – Pneumatic and Electronic controllers - Final control elements, Types of control valve- sizing & characteristics - Development of Block diagram - block diagram reduction rules, overall transfer function

Module:4	**Transient Response and Stability Analysis**	**7 hours**

Modes of control action- ON/OFF, P, PI, PD , PID and their characteristics – offset - Transient response of closed loop control systems - stability of closed loop systems - Routh's test

Module:5	Frequency Domain Analysis		8 hours
Frequency response analysis - substitution rule, Bode diagrams- Bode stability criteria, gain margin, phase margin, Nyquist plot, Controller tuning using Ziegler Nichols method, Cohen-Coon method			
Module:6	**Advanced Process Control**		**6 hours**
Advanced control strategies - Cascade control, Ratio control, Feed-Forward control, Inferential control, Introduction to Multivariable Control, Concept of Relative Gain Array			
Module:7	**Computer Process Control**		**4 hours**
Computer Process control and its implementation- Programmable Logic Controller, Distributed Control System, SCADA, Hardware for computer based control, Interfacing computer system with process			
Module:8	**Contemporary issues**		**2 hours**
Guest lecture from industry and R & D organizations			
		Total Lecture hours:	**45 hours**
Text Book:			
1.	Coughanowr C. R., Koppel L. M., Process System Analysis and Control, 2013, 3rd ed., McGraw Hill, New Delhi		
Reference Books:			
1.	Stephanopoulos G., Chemical Process Control, 2015, 1st ed., Pearson Education India, New Delhi		
2.	Seborg D.E., Edgar, T. F., Mellichamp D.A., Process Dynamics and Control, 2013, 3rd ed., Wiley India, New Delhi		
Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies		11-02-2022	
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE305P	**Process Dynamics and Control Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BMAT102L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To expose various types of controllers (ON/OFF, P, PI, PID) and their application in process industries
2. To explain different controller tuning methods
3. To introduce advanced control strategies and computer control employed in various control scenarios

Course Outcomes:

1. Identify appropriate modes of controller for a given process and apply right tuning method
2. Apply a suitable advanced control strategy appropriate for a given process
3. Compare the performance of controllers for a given process using PROSIM and DCS trainer

Indicative Experiments

1.	Automatic temperature control loop in a heating tank
2.	Automatic level control loop in a cylindrical tank
3.	Automatic flow control loop in a pipe line
4.	Automatic cascade control loop
5.	Dynamics of non-interacting tanks/interacting tanks
6.	Controller tuning using an open loop method (Cohen-Coon method) in Simulink
7.	Controller tuning using a closed loop method (Ziegler–Nichols method) in Simulink
8.	Control Valve Characteristics
9.	Dynamics of Ratio control using PROSIM
10.	Process control using DCS trainer

Total Laboratory Hours	**30 hours**		
Mode of assessment: Individual Experiment Assessment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE306L	**Chemical Reaction Engineering II**	**2**	**1**	**0**	**3**
Pre-requisite	BCHE303L, BCH303P	**Syllabus version**			
		1.0			

Course Objectives:

1. To introduce fundamentals of heterogeneous reactions
2. To facilitate understanding of non-ideal flow
3. To familiarize with critical parameters affecting the performance and design of heterogeneous and multi-phase reactors

Course Outcomes:

1. Predict the conversion in a non-ideal reactor using tracer information
2. Analyze the heterogeneous reaction systems in designing the reactors for fluid-solid reactions
3. Explain the role of catalyst in heterogeneous catalytic reactions
4. Characterize catalyst surface properties for better catalytic activity
5. Identify critical parameters affecting the performance and design of heterogeneous and multi-phase reactors

Module:1	Non-ideal Reactors	6 hours

Basics of non-ideal flow, Residence Time Distribution (RTD) - Relationship between C, E and F curves, Modelling of non-ideal reactors, one parameter and two parameter models - Conversion in real reactor systems.

Module:2	Introduction to Heterogeneous Reaction Engineering	6 hours

Introduction to heterogeneous reacting systems - Non-catalytic solid-fluid reactions - Sharp interface and volume reaction models, determination of rate-controlling steps and application to design of reactors.

Module:3	Introduction to Catalytic Reactions	5 hours

Definition and properties - Steps involved in catalytic reactions - Rate law mechanisms - Rate limiting step.

Module:4	Transport Mechanisms in heterogeneous catalysis	8 hours

Transport effects in heterogeneous catalysis: Internal effectiveness, External transport limitations and overall effectiveness.

Module:5	Catalysts Preparation, Characterization	5 hours

Definition and types of catalysts – Industrial catalysts – Preparation and characterization of the catalysts, Surface area and pore volume determination.

Module:6	Catalyst Deactivation methods	5 hours

Types of catalyst deactivation – Determining the order of deactivation – Catalyst regeneration methods.

Module:7	Design of Reactors for Fluid-Solid and Fluid-Liquid reactions	8 hours

Reactor design fundamentals and methodology, rate data analysis - Overall view of Fluidized, Packed and Moving bed reactors- Fluid-liquid reactions: Film and Penetration theories - Fluid-solid catalytic reactions.

Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organisations		
	Total Lecture hours:	**45 hours**

Text Book:

1.	H. Scott Fogler, Elements of Chemical Reaction Engineering, 2015, 4th ed., Pearson, India.

Reference Books:

1.	G. T. Miller, Chemical Reaction Engineering, 2016, CBS Publishers, India.
2.	J.M. Smith, Chemical Engineering Kinetics, 2014, 3rd ed., McGraw-Hill, India.
3.	O. Levenspiel, Chemical Reaction Engineering, 2006, 3rd ed., Wiley Publications, India.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE307L	**Process Modelling and Simulation**	**2**	**0**	**0**	**2**
Pre-requisite	**BMAT201L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To study the modelling & simulation techniques of chemical processes
2. To discuss the importance of modelling and economic analysis to science and engineering
3. To identify and explain different types of models and simulations for hypothesis testing

Course Outcomes:

1. Explain the different modelling approaches for chemical processes
2. Develop mathematical models for various chemical processes
3. Analyze physical and chemical phenomena involved in various processes
4. Interpret the results of models obtained from the simulation

Module:1	Conservation Principles and Models	3 hours

Introduction to modelling and simulation, classification of mathematical models, Systematic approach to model building, Conservation principles, Constitutive relations

Module:2	Steady State Lumped Systems	5 hours

Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations

Module:3	Flow Sheeting and Solution	4 hours

Flow sheeting, sequential modular and equation oriented approach, partitioning and precedence ordering, Simulation of steady state lumped systems including simultaneous solution, modular solution

Module:4	Unsteady State Lumped Systems	5 hours

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, Isothermal and Non-isothermal reactors, flash and distillation column

Module:5	Dynamic Simulation of Unsteady State Lumped Systems	4 hours

Solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems

Module:6	Steady and unsteady State Distributed systems	3 hours

Analysis of compressible flow, heat exchanger, plug flow reactor, solution of ODE boundary value problems, sedimentation, heat conduction, heat transfer in packed bed, Diffusion.

Module:7	**Artificial Neural Network**	**4 hours**
Development of ANN based models-Architecture-identification of inputs-choice of the architecture-training the ANNs-Performance of ANN Models-Learning methods- Over fitting and under fitting Networks.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**30 hours**

Textbooks:	
1.	Ashok K., Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, 2015,1st ed., CRC press, New York.
2	Simant R.U., Process Modelling And Simulation for Chemical Engineers Theory and Practice, 2017, 1st ed., John Wiley & sons Ltd, Chichester, UK.
Reference Books:	
1.	Jana A.K., Chemical Process Modelling and Computer Simulation, 2018, 3rd ed., PHI Learning, Delhi.
2.	Nayef G., Modeling and Simulation of Chemical Process Systems, 2019,1st ed., CRC press, FL.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE307P	**Process Modelling and Simulation Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BMAT201L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To study the modelling & simulation techniques of chemical processes
2. To discuss the importance of modelling to science and engineering and the cost
3. To identify different types of models and simulations and explain the use of models and simulations for hypothesis testing

Course Outcomes:

1. Explain modelling approaches
2. Illustrate the mathematical models for various chemical processes

Indicative Experiments

1.	Solution of Algebraic equations
2.	Two Interacting Tanks in Series
3.	Jacketed stirred tank Heater
4.	Van de Vusse Reaction Mechanism
5.	Non-isothermal CSTRs in series
6.	Biochemical Reactor
7.	Mixing Tank
8.	1 D unsteady state heat conduction equation
9.	Elliptic PDE using PDE toolbox
10.	Parabolic PDE using PDE toolbox
	Total Laboratory Hours **30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE308L	**Chemical Process Equipment Design**	**3**	**0**	**0**	**3**
Pre-requisite	**BCHE302L, BCHE302P**	**Syllabus version**			
		1.0			

Course Objectives:

1. To summarize the concepts of unit operations and unit processes in chemical engineering.
2. To impart knowledge on the concepts of design of major equipment
3. To understand the energy requirements of the process and design network

Course Outcomes:

1. Understand flowcharts and ways to interpret the drawings
2. Explain the procedure practiced in the selection and design of fluid handling equipment, pressure vessels, heat transfer equipment
3. Use Standards and codes involved in the design process
4. Design separation equipment and ideal reactors using the fundamental principles
5. Apply Pinch Technology concept for energy recovery and design basic Heat Exchanger network

Module	Title	Hours
Module:1	**Introduction to Process Design**	**5 hours**
Introduction -Types of flowchart – Preparation and reading of flowcharts - Design of Fluid handling equipment – Pumps and pipes – pipe standards - pipe schedule- Gauges		
Module:2	**Pressure vessel**	**6 hours**
Mechanical design of pressure vessel – Concept of structural stability – Types of pressure vessel – Codes and standards – selection procedure - supports – Storage vessels for liquids and gasses-		
Module:3	**Heat transfer equipment**	**7 hours**
Basic design equation of heat transfer – Design of double pipe heat exchanger - Shell and tube heat exchanger – TEMA classification – Kern’s method – Condenser design		
Module:4	**Heat Exchanger Network**	**7 hours**
Introduction to Pinch Technology– Pinch point –Composite and Grand Composite curves - Heat exchanger network for simple processes		
Module:5	**Separation process equipment**	**7 hours**
Theory of distillation – McCabe –Thiele method - Design of separation column – Distillation and Absorbers– Plate type and Packed column		
Module:6	**Reactor Design**	**6 hours**
Concepts of the ideal reactor – reactor sizing with or without reaction – adiabatic and catalytic reactors - Reactor performance analysis		
Module:7	**Simultaneous Heat and Mass transfer Equipment**	**5 hours**
Introduction to heat and mass transfer operation – design of evaporators - single and multiple effect evaporators – design of dryer.		
Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organizations		

	Total Lecture hours:			**45 hours**
Text Books:				
1.	V.V. Mahajani and S.B. Umarji, Joshi's Process Equipment Design. Laxmi Publications, 2016, 5th ed., India.			
2.	Coulson J.M., Richardson J.F., Chemical Engineering, Volume 6, 2005, 4th ed., Butterworth – Heinemann Publishing Ltd., USA.			
Reference Books:				
1.	Joshi. M.V., Mahajani. V.V., Process Equipment Design, 2000, 3rd ed., Mc-Millan India Ltd., India.			
2.	Richard A. Turton, Richard C. Bailie, Wallace B.Whiting, Joseph A. Shaeiwitz, Debangsu Bhattacharyya - Analysis, Synthesis and Design of Chemical Processes, 4th ed., Prentice Hall, USA, 2014			
Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test				
Recommended by Board of Studies		11-02-2022		
Approved by Academic Council		No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE308P	**Chemical Process Equipment Design Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BCHE302L, BCHE302P**	**Syllabus version**			
		1.0			

Course Objectives:

1. To apply concepts to generate and read flowchart for processes
2. To sketch major equipment to given dimensions using Solid works
3. To understand and apply simulation tools to design

Course Outcomes:

1. Understand flowcharts and ways to interpret the drawings
2. Design and draw major equipment in involved in process industries
3. Apply simulation software for simple systems

Indicative Experiments

1.	Basics of 3D drawing and applications
2.	Extrusion of surfaces and geometries
3.	Design and drawing of Pressure vessel
4.	Design and drawing of Shell and Tube heat Exchanger
5.	Design and drawing of Bubble cap tray
6.	Design and drawing of Rotary Louvre dryer
7.	Analysis of the performance of Heat Exchanger using Aspen plus
8.	Design and analysis of Distillation Column using Aspen plus
9.	Cost Estimation of Distillation Column using Aspen plus
10.	Dynamic simulation on distillation column using Aspen Plus/Prosimulator
Total Laboratory Hours	**30 hours**

Mode of assessment: Individual Experiment Assessment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

DISCIPLINE ELECTIVE COURSES - 30 (15 CREDITS)

Course code	Course Title	L	T	P	C
BCHE309L	**Membrane Separation Processes**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To explain the basic membrane separation mechanisms, transport models, membrane materials and modules
2. To characterize and evaluate the membrane performance using membrane permeability parameters
3. To describe membrane fouling, cleaning and its applications

Course Outcomes:

1. Describe the membrane types, modules and membrane separation processes
2. Identify suitable techniques for membrane preparation and characterization
3. Derive various transport models for membranes
4. Compute flux, concentration polarization, fouling and operating parameters for various membranes
5. Examine the advanced membrane processes for a specific separation

Module:1	Overview, Classification and Membrane Materials	6 hours

Introduction, historical development, definition and types of membranes, basic principles of membrane separation, membrane processes and classifications, membrane materials - polymers used in membrane preparation and their properties, inorganic materials for membrane preparation, their advantages and disadvantages, membrane modules and selection, typical flow patterns.

Module:2	Membrane Preparation and Characterization	7 hours

Membrane preparation – phase inversion process, track-etching, sol-gel peptization, template leaching, interfacial polymerization, wet, dry and melt spinning, sintering, dip and spin coating methods, membrane modification; membrane characterization – visual methods (SEM and TEM), Hydraulic permeability, bubble point, liquid displacement, mercury porosimetry, permporometry, thermporometry, gas adsorption-desorption, molecular weight cut-off (MWCO), microbial challenge test.

Module:3	Membrane Transport Theory	6 hours

Description of transport process - passive and active, Transport through porous membrane and nonporous membrane, Membrane transport theory –solution-diffusion (SD) model, fouling model, concentration and gel polarization.

Module:4	Reverse Osmosis	6 hours

Concept of osmosis and reverse osmosis, Models for reverse osmosis transport - Kedem-Katchalsky, Spiegler-Kedem, Solution-Diffusion, Pore transport, Design and operating parameters, Design of RO module, Reverse osmosis for the non-aqueous system, Forward osmosis.

Module:5	Nanofiltration	5 hours

Principles of nanofiltration, transport mechanism in NF membranes, parameters affecting the performance of NF membranes, application of nanofiltration membranes.		
Module:6	**Microfiltration and Ultrafiltration**	**7 hours**
Basic principles, advantages of MF, cross-flow and dead-end MF, MF membranes and modules, Models for MF transport, plugging and throughput, fouling in MF, MF applications. Basic principles of UF, UF membranes and modules, UF configurations, Models for UF transport, mass transfer coefficient, membrane rejection and sieving coefficient, factors affecting UF performance, fouling & permeate flux enhancement, UF applications, Micellar-enhanced UF, affinity UF, UF based bio separation.		
Module:7	**Other membrane Processes**	**6 hours**
Pervaporation, gas separation, Liquid membranes, Ion exchange membranes, Dialysis and electrodialysis, Membrane contactor, Membrane distillation, Membrane chromatography, membrane bioreactors, membranes in bio-separation.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organisations.		
	Total Lecture hours:	**45 hours**

Text Books:	
1.	Kaushik Nath, Membrane Separation Processes, 2016, 2nd ed., PHI Learning Private Limited, New Delhi, India.
Reference Books:	
1.	R.W. Baker, Membrane Technology and Application, 2012, John Wiley and Sons Ltd. USA.
2.	B.K. Dutta, Mass Transfer and Separation Processes, 2007, 2nd ed., PHI Learning Private Limited, New Delhi, India.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE310L	**Polymer Technology**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To equip the students with the basic understanding of different types of polymers, preparation method and their applications.
2. To impart insights in relation to the structure and size of the polymers and their processing techniques.
3. To expose the students to different types of biopolymers and bio-nanocomposites and their applications.

Course Outcomes :

1. Explain the importance of different types of high polymeric systems and their applications.
2. Classify the different methods of polymerization processes and their mechanism.
3. Identify the different structures and sizes, and characterization of the polymers.
4. Summarize the rheological and morphological properties of different polymers.
5. Choose suitable polymer processing techniques for preparation of various polymers.

Module:1	**Basic Concepts of High Polymer Systems**	**4 hours**

Introduction and Historical Background, Macromolecular Concept, Structural Features of a Polymer, Length to Diameter Ratio, Classification of Polymers, Structure–Property Relationship – molecular forces and chemical bonding on polymers.

Module:2	**Classification of Polymerization**	**6 hours**

Functionality Principle, Types of Polymerization, Basic Characteristics of step-Growth Polymerization and addition polymerization, Relationship between Average Functionality, Extent of Reaction and Degree of Polymerization, Kinetics of Step-Growth Polymerization and chain polymerization, Comparison between Chain-growth and Step-growth Polymerization, Concept of Copolymerization

Module:3	**Polymer Characterization and properties of commercial polymers**	**8 hours**

Polymer Degradation, Concept of Average Molecular Weight, Polymer Fractionation and Molecular Weight Distribution, Crystallinity, Glass transition temperature and mechanical properties: testing of polymers, Gel Permeation Chromatography – PE- PP – PS – PVA – PMMA – PTFE – polyacrylamide – Nylon – PF – PU – Silicones.

Module:4	**Polymer Rheology and Morphology**	**7 hours**

Introduction - Stress and Strain - Ideal Elastic Solid - Non-Newtonian Fluid - Apparent viscosity - Viscosity as a Function of Molecular Weight - Weissenberg Effects, Rheological properties of polymers - Viscoelastic Behaviour, Stress Relaxation, Relaxation or Strain Enhancement under Constant Stress - Hysteresis - Creep and Relaxation of Typical Plastics - Development of Crystallinity - Crystallization of Rubber on Cooling - Mechanism of Crystallization - Melting of rubber – Spherulites.

Module:5	**Polymer Processing Techniques**	**6 hours**

Moulding techniques – compression – transfer moulding – injection moulding – reaction injection moulding – forming techniques – extrusion – spinning – calendaring – thermoforming – casting – slush – Roto moulding – powder coating – dip coating – friction coating.

Module:6	**Polymer Blends, Composites and Conducting Polymers**	**6 hours**

Polyblends – Types - Properties - Glass Transition of Polyblends, Polymer Composites, Bio-nano-composites, Protein-based polymers, Conducting Polymers, Inherently Conducting Polymers, Photoconducting Polymers, Carbon Black/Carbon Fibre Reinforced Conductive Polymer Composites		
Module:7	**Polymers in Wastes and their Environmental Impact**	**6 hours**
Natural Resources Scenario, Waste Items, Classified Waste Materials, Power Scenario, Municipal Solid Wastes (MSW), Waste Management, Recovery and Recycling of Organic Wastes, Composting, Integrated Waste Management for Sustainable Development		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry/ R&D organizations		
	Total Lecture hours:	45 hours

Text Book:	
1.	Ghosh P, Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, 2017, 3rd ed, McGraw Hill , India
Reference Books:	
1.	Gowariker V.R., Viswanathan N.V., Jayadev S, Polymer Science, 2015, 2nd ed, New Age Publishers, India
2	Young R.J., Lovell P.A., "Introduction to Polymers", 2011, 3rd ed, CRC Press, India.

Mode of Evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE311L	**Process Utilities and Pipeline Design**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To equip the students with a basic understanding of different types of utilities.
2. To impart insights into the selection of different utilities and their optimum utilization in process industries.
3. To expose students to understand the piping design, layout and insulation in process industries.

Course Outcomes:

1. Understand the importance of optimum usage of utilities in process industries.
2. Assess the quality, effective utilization and distribution of water and steam.
3. Compare different types of equipment used for air treatment, conditioning, refrigeration and transportation of industrial gases.
4. Select a suitable type of piping design, materials and standards used in industries.
5. Design a suitable piping layout and insulation system used in process industries.

Module:1	**Introduction to Process Plant Utilities**	**7 hours**

Compressed air for industrial use - selection of blowers and compressors - Purification and transportation of air - duct design - air blending - exhaust ventilation – flare systems - inert gases – properties and uses.

Module:2	**Process water treatment and recycling**	**5 hours**

Water and its characteristics - conditioning and treatment for process - recycling aspects of water from blowdowns and rejects -Wastewater treatment and recycling.

Module:3	**Steam generation and distribution**	**7 hours**

Steam generation and its application in chemical process plants – boiler types (Babcock Wilcox, Nestler, Cochran boilers) - boiler accessories - design of efficient steam heating systems - steam economy - condensate utilization - steam traps - steam distribution and waste heat utilization.

Module:4	**Humidification and refrigeration systems**	**6 hours**

Design of refrigeration and air-conditioning system - types of refrigerants - factors affecting the refrigeration cycle - operation and maintenance of refrigeration systems - concept of cryogenics and its characteristics - industrial coolants - thermal fluid systems.

Module:5	**Introduction to Piping Design**	**6 hours**

Process Auxiliaries - basic considerations and flow diagrams in chemical engineering plant design - piping design - pipe sizes - working pressure - basic principles - piping drawings- pipe fittings - pipe joints.

Module:6	**Piping Materials, Codes and Standards**	**6 hours**
Material properties of piping materials – Metallic materials – Degradation of materials in service. Piping codes and standards : ASME – BIS – ISO standards relevant to chemical engineering		
Module:7	**Piping Installation and Insulation**	**6 hours**
Pipe installations – Overhead installations - Piping insulation – Application of high, medium, low temperature and cryogenic insulation – Weather proof and fire-resisting pipe insulation jackets – Insulation materials and their effect on various materials of equipment piping.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Book:	
1.	Broughton J., Process Utility Systems, 2004, 3rd ed., Institution of Chemical Engineers, U.K.
2.	McAllister E.W., Pipeline Rules of Thumb Hand Book, 2009, 7th edition, Gulf Publications
Reference Books:	
1.	Mujawar B.A., A Textbook of Plant Utilities, 2007, 3rd ed., Nirali Prakashan Publication, India.
2.	Poling B.E., Prausnitz J.M., O'Connell J., The Properties of Gases and Liquid, 2008, 5th ed., McGraw Hill, USA.
3.	Nayyar M. L., Piping Handbook, McGraw Hill, 7 th Edition, 2000

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE312L	**Chemical Process Optimization**	**3**	**0**	**0**	**3**
Pre-requisite	**BCHE208L**	**Syllabus version**			
		1.0			

Course Objectives:

1. To provide an overview of state-of-the-art optimization algorithms
2. To impart the theoretical knowledge of Chemical Engineering principles that strengthens optimization techniques.
3. To enhance the modelling and formulation skills of practically relevant optimization problems in Chemical Engineering.

Course Outcomes :

1. Demonstrate the basic principles of Chemical Engineering Systems
2. Summarize the different types of optimization problems for process engineering
3. Evaluate single and multivariable optimization chemical engineering problems
4. Identify the different types of hypotheses for the model equations chemical system
5. Solve the optimization problems in real field applications.

Module:1	**Formulation of Optimization Problems**	**6 hours**

Nature and Organization of Optimization problem; Mathematical concepts of optimization; Gradient and Hessian matrix; Convex functions and sets; Degrees of freedom; Developing model for optimization; Constraints in the model; Fitting models to data, Method of least squares; Factorial experimental design

Module:2	**Single Variable Optimization – Unconstrained**	**6 hours**

One-dimensional search - Methods requiring derivatives (Newton, Quasi Newton, Secant method); Region elimination methods (Interval halving, Fibonacci search and Golden section) Polynomial approximations (Lagrange's, quadratic & Cubic)

Module:3	**Multivariable Optimization –Unconstrained**	**6 hours**

Unconstrained multivariable optimization - Graphical visualization (contour plots, 3D plots); Gradient-based methods – Steepest descent, conjugate direction, and Newton methods

Module:4	**Linear Programming**	**6 hours**

Linear programming (LP) - Graphical solution - Simplex method; Test for optimality –Sensitivity analysis; Introduction to interior-point method

Module:5	**Nonlinear Programming with constraints**	**6 hours**

Nonlinear programming (NLP) with constraints; Lagrange multipliers - Graphical illustration of NLP problems - KKT necessary and sufficient conditions; Quadratic programming - Successive linear and quadratic programming; Branch and bound methods; Minimum cost routing problems - Solution of separable nonlinear programming problem

Module:6	**Optimization of Chemical processes-I**	**6 hours**
Optimal pipe diameter- Minimum work of gas compression- Economic operation of fixed bed filter- Optimal design of gas transmission network- Optimum recovery of waste heat		
Module:7	**Optimization of Chemical processes-II**	**7 hours**
Optimal design and operation of staged distillation columns- Optimal design and operation of Chemical reactors- Optimum design of shell and tube heat exchanger - optimization of heat exchanger networks- optimization of multistage evaporators using MATLAB/Excel.		
Module: 8	**Contemporary issues**	**2 hours hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Book:	
1.	Edgar T.F., Himmelblau D.M., Lasdon L.S., Optimization of Chemical Processes, 2015, 2nd ed., McGraw-Hill Education, India.
Reference Books:	
1.	Dutta S., Optimization in Chemical Engineering, 2016, 1st ed., Cambridge University Press, India
2.	Rao S.S., Engineering Optimization: Theory and Practice, 2009, 4th ed., John Wiley & Sons Ltd., USA.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE313L	**Environmental Pollution Control**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To understand the different environmental standards related to air and water
2. To identify and design the equipments for air and water pollution control
3. To illustrate the effective methods of solid and hazardous waste management

Course Outcomes :

1. Understand basics of pollution parameters, standards and legislations on the environment
2. Apply the principles of process modification and use of alternative raw materials for pollution prevention
3. Design control equipments to meet appropriate requirement of environmental standards
4. Identify the techniques for solid and hazardous waste management
5. Analyze pollution control strategies in various process industries

Module:1	**Introduction**	**5 hours**

Environmental problems due to pollution - characterization of emission and effluents- Environmental standards (water standards for potable and agricultural streams, air standards)- MINAS.

Module:2	**Pollution Prevention**	**6 hours**

Process modification, alternative raw material, recovery of by-products from industrial emission/ effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization- Life cycle assessment (basic concepts).

Module:3	**Air pollution control**	**8 hours**

Principles and design of air pollution control equipments (particulate and gaseous pollutants) - gravity settling chamber – cyclone separator – electrostatic precipitators – fabric filters - wet scrubbers – adsorbers.

Module:4	**Water pollution control**	**10 hours**

Selection, design and performance analysis of waste water treatment processes: preliminary, primary (sedimentation, coagulation and flocculation) and secondary treatment processes (activated sludge process and trickling filter) – sludge separation and drying - tertiary treatment process (qualitative treatment)

Module:5	**Solid waste management**	**5 hours**

Classification of solid waste - collection, storage and transport of solid waste - 4R concept - waste disposal methods: composting, landfilling and incineration

Module:6	**Hazardous waste management**	**3 hours**

Hazardous waste classification - treatment methods: physical, chemical, biological and thermal - biomedical and e-waste management

Module:7	**Pollution control in chemical process industries**	**6 hours**

Sources – characteristics – pollution control strategies for selected industries: textile and

tanneries, electroplating, refineries and thermal power plants				
Module:8	**Contemporary issues**			**2 hours**
Guest lecture from industry and R & D organizations				
			Total Lecture hours:	**45 hours**
Text Book:				
1.	Rao C.S., Environmental Pollution Control Engineering, 2018, 3rd ed., New Age International Publishers, India.			
2.	Tchobanoglous G., Theisen H., Vigil S.A., Integrated Solid Waste Management, 2014, 1st ed., McGraw Hill Education, India.			
Reference Books:				
1.	Bhatia S.C., Environmental Pollution and Control in Chemical Process Industries, 2013, 2nd ed., Khanna publishers, India.			
2.	Pollution Control Law Series: PCLS/02/2010, Central Pollution Control Board, 2010, 6th ed., India.			
Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test				
Recommended by Board of Studies	11-02-2022			
Approved by Academic Council	No.65	Date	17-03-2022	

Course code	Course title	L	T	P	C
BCHE314L	Fuels and Combustion	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To introduce basic physical and chemical properties of fossil and alternative fuels.
2. To describe fuel characterization techniques for various types of fuels
3. To perform stoichiometric based combustion calculations

Course Outcomes:

1. Understand various types of fuels for firing in boilers and furnaces.
2. Select the right type of fuel based on availability, storage, handling, pollution and cost of fuel.
3. Describe the fuel properties for efficient use.
4. Analyse exhaust and flue gases.
5. Explain various combustion equipment.

Module:1	Classification and Properties of Fuels	6 hours

Fuels – Types and characteristics of fuels – Determination of properties of fuels - Fuel analysis - Proximate and ultimate analysis - Calorific value (CV) – Gross and net calorific values (GCV, NCV) – Bomb Calorimetry – Boye's Calorimetry - Orsat apparatus - empirical equations for CV estimation.

Module:2	Solid fuels	6 hours

Origin of coal- Ranking of coal- Washing and cleaning of coal - applications of the coal-comparative study of solid-liquid and gaseous fuels-selection of coal for different industrial applications-carbonization of coal.

Module:3	Liquid fuels	6 hours

Origin of crude oil- composition of crude petroleum - classification of crude petroleum – Desalting – Desulphurisation - processing of crude petroleum- Distillation - Cracking and Reforming.

Module:4	Gaseous fuels	6 hours

Rich and lean gas – Wobbe index - Natural gas - Dry and wet natural gas -Foul and sweet NG - LPG - LNG – CNG – Methane - Producer Gas - Water gas – oil gas.

Module:5	Combustion Calculations	7 hours

General principles of combustion – Flame and Flame dynamics-Types of combustion processes-combustion of solid, liquid and gaseous fuels - combustion calculations-air fuel ratio, Excess air calculations – emission and carbon Foot print calculation.

Module:6	Combustion Equipment	6 hours

Combustion of solid fuels-grate firing and pulverized - fuel firing system-Fluidized bed combustion-Circulating fluidized bed boiler – Combustion equipment for liquid and gaseous fuels.

Module:7	Alternative Fuels	6 hours

Bio fuels – Adsorbed Natural Gas (ANG) – Synthetic natural Gas (SNG) – Ethanol and Methanol

- Hydrogen Gas – Nuclear Fuels – Waste to fuel.				
Module:8	**Contemporary issues**			**2 hours**
Guest lecture from industry and R&D organizations				
			Total Lecture hours:	**45 hours**
Textbooks:				
1.	R.C. Gupta, Fuels, Furnaces and Refractories, 2016, Prentice-Hall Of India, India.			
2.	James G.Speight, The Chemistry and Technology of Coal, Third Edition, CRC Press. 2016.			
Reference Books:				
1.	Samir Sarkar, Fuels and combustion, 3rd Edition , Universities Press (India) Pvt. Ltd.(2009)			
2.	H. Joshua Phillips, "Fuels - solid, liquid and gases – Their analysis and valuation", General Books, 2010.			
3.	Kenneth K Kou, Principles of Combustion, Wiley & Sons Publications, 2012.			
Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test				
Recommended by Board of Studies	11-02-2022			
Approved by Academic Council	No.65	Date	17-03-2022	

Course code	Course title	L	T	P	C
BCHE315L	**Biochemical Engineering**	**3**	**0**	**0**	**3**
Pre-requisite	**BCHE303L, BCHE303P**	**Syllabus version**			
		1.0			

Course Objectives:

1. Impart the basic knowledge and overview of biotechnology covering the principles of cell and kinetics, bioreactor design, sterilization agitation and aeration
2. Understand the physical processes involved in bio-systems
3. Apply the knowledge of chemical engineering principles to biological processes

Course Outcomes :

1. Describe the significance and scope of biochemical processes with their metabolic pathways
2. Understand basic principles of enzyme and microbial growth kinetics
3. Apply basics of Chemical Engineering transport processes in designing bioprocess systems
4. Analyze bioreactor performance and their transient characteristics
5. Demonstrate downstream processing methods to fulfill separation requirements

Module:1	**Introduction to Biochemical Engineering**	**3 hours**

An overview of industrial biochemical processes with typical examples - comparing Chemical and Biochemical processes – Development and scope of biochemical engineering as a discipline.

Module:2	**Basic Microbiology and Biochemistry**	**5 hours**

Basics of Biology - overview of biotechnology - Diversity in microbial cells - Cell constituents - Chemicals for life - Examples of microbial synthesis - Major metabolic pathways – Bioenergetics - Glucose metabolism – Biosynthesis.

Module:3	**Enzymes & Enzyme kinetics**	**8 hours**

Enzymes - Classification of enzymes - Mechanism of enzymatic reactions – Michaelis Menten kinetics – Enzyme inhibition - Inhibition kinetics - Enzyme denaturation and inactivation- Factors affecting the reaction rates - Enzyme immobilization – kinetics of immobilized enzymes - Mass transfer effects on immobilization.

Module:4	**Kinetics of Cell Growth**	**6 hours**

Typical growth characteristics of microbial cells - Factors affecting growth - Unstructured models of microbial growth - Monod model - Modelling of batch and continuous cell growth –inhibition on cell growth - Immobilized whole cells and their characteristics.

Module:5	**Transport in Microbial Systems**	**7 hours**

Rheological behaviour of broth - Agitation and mixing - Power consumption - gas/liquid transport in cells - Mass transfer coefficients and its measurement – Oxygen transfer –Factors affecting oxygen transfer rate - Heat transport in microbial systems – Thermal death kinetics of microorganism - batch and continuous sterilization - air and media sterilization.

Module:6	**Bioreactors**	**8 hours**

Classification of bioreactors - Batch and continuous types - Fed-batch reactors - Free and immobilized whole-cell and enzyme reactors - Reactors in series with and without recycle – Transient behaviour of bioreactors - Design of reactors and scale up with examples.

Module:7	**Downstream processes**	**6 hours**
Different unit operations in down streaming with special reference to filtration - centrifugation - - extraction - membrane separations - crystallization - chromatographic techniques – drying – cell desruption technologies.		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Book:

1.	Rao D.G., Introduction to Biochemical Engineering, 2012, 2^{nd} ed., Tata McGraw Hill, India.
2.	Harvey W.Blanch and Douglas S. Clark, Biochemical Engineering, 1997, 2^{nd} ed., CRC Press, USA.

Reference Books:

1.	Doran P.M., Bioprocess Engineering Principles, 2013, 3^{rd} ed., Academic Press, United Kingdom
2	Bailey J.B., Ollis D.F., Biochemical Engineering Fundamentals, 2010, 4^{th} ed., McGraw Hill, USA.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course Code	Course Title	L	T	P	C
BCHE316L	**Pharmaceutical Technology**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus Version**			
		1.0			

Course Objectives:

1. To explain the different techniques employed in the production of tablets and capsules.
2. To outline the different drug delivery systems.
3. To illustrate the various pharmaceutical packaging materials and their quality control.

Course Outcomes:

1. List the methods of tablet preparation and the types of tablet coating processes.
2. Classify the types of capsules, their quality control tests, and packaging.
3. Explain the different techniques of microencapsulation and the evaluation of microcapsules.
4. Describe the general manufacturing process of parenteral products and the relevant quality control tests.
5. Elucidate the different drug delivery systems and Categorize the various pharmaceutical packaging materials.

Module:1	Tabletting Technology	8 hours

Introduction - types and classes of tablets - formulation of tablets – granulation - methods of tablet preparation - advances in granulation - operations involved in tablet manufacturing - tablet compression - auxiliary equipment – packaging - problems in tablet manufacturing - tablet coating - types of tablet coating processes - specialized coatings - tablet coating equipment - process parameters - problems and remedies for tablet coating - In Process Quality Control (IPQC) tests for tablets.

Module:2	Capsules Technology	6 hours

Introduction - hard gelatin capsules (HGC) - soft gelatin capsules (SGC) - quality control tests for capsules - special types of hard gelatin and soft gelatin capsules – packaging - capsules manufacturing techniques

Module:3	Microencapsulation	5 hours

Introduction - core materials - coating materials - techniques of microencapsulation - evaluation of microcapsules.

Module:4	Parenteral Products	6 hours

Introduction - formulation requirements - general manufacturing process – freeze drying - quality control tests for parenteral products – packaging – tray drying – fluidised bed drying.

Module:5	Novel Drug Delivery Systems	6 hours

Oral controlled release drug delivery systems - parenteral controlled drug delivery systems - targeted drug delivery systems – nanoparticles - transdermal drug delivery systems – wound healing systems.

Module:6	Packaging Techniques	6 hours

Introduction - packaging and stability of products - containers for pharmaceutical use - pharmaceutical packaging materials - qualification and quality control of packaging components – packaging machinery.

Module:7	**Packaging Technology**	**6 hours**
Introduction - BFS Technology - Anti-Counterfeit Packaging Technologies – Quality Analysis - Packaging designs		
Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture Hours:	**45 hours**

Text Books:

1.	Kushwaha P., Handbook of Pharmaceutical Technology, 2015, 1st ed., Jaypee Brothers Medical Publishers Private Limited, India.
2.	Prager G, Practical Pharmaceutical Engineering, 2019, Ist ed., John Wiley and Sons, Inc., USA

Reference Books:

1.	Bharath S., Pharmaceutical Technology: Concepts and Applications, 2013, 1st ed., Pearson Education India, India.
2.	Agarwal G., Kaushik A., Pharmaceutical Technology, Volume I, 2017, 1st ed., CBS Publishers & Distributors, India.
3.	Murthy R.S.R., Kar A., Pharmaceutical Technology, Volume II, 2017, 2nd ed., New Age International Private Limited, India.

Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignments, and Final Assessment Test.

Recommended by Board of Studies:	11-02-2022		
Approved by Academic Council:	No.65	Date:	17-03-2022

Course code	Course Title	L	T	P	C
BCHE317L	**Petroleum Refining Technology**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To understand the importance of crude oil as fuel and the operation of petroleum refinery
2. To interpret the challenges involved in crude oil refining from the viewpoint of feedstock properties, product specifications, economic considerations, and environmental regulations
3. To integrate chemical engineering principles in petroleum refining

Course Outcomes:

1. Explain the crude oil formation, exploration, extraction and classification
2. Illustrate various crude oil refining processes
3. Analyze safe, economic, and environment-friendly refinery operations
4. Evaluate the fuel additives for improvement of product quality
5. Choose the better purification and conversion of petroleum products for end-users application

Module	Title	Hours
Module: 1	**Overview on crude oil and upstream processes**	**7 hours**

Formation of crude oil - exploration practices - oil reservoir types – reservoir rock properties – oil extraction techniques - transportation of crude oil – crude oil composition - classification and constituents of petroleum – selection criteria for crude oil - list of petroleum products - properties of crude oil and petroleum products

Module	Title	Hours
Module: 2	**Distillation**	**7 hours**

Desalting-dehydration of crude oil - Pre-fractionation column - components of crude oil distillation column - various types of oil distillation units – ADU – VDU - factors influencing the performance of distillation column - crude distillation curves - uses of petroleum products

Module	Title	Hours
Module: 3	**Cracking, visbreaking and coking**	**8 hours**

The necessity of cracking - Thermal cracking - Catalytic cracking - classification of catalytic cracking process based on catalyst mobility - Fixed bed catalytic cracking - fluid bed catalytic cracking- Steam Cracking - Hydrocracking - advantages and disadvantages of different types of cracking process – Visbreaking - Delayed coking - Flexi coking - uses of petroleum coke

Module	Title	Hours
Module: 4	**Quality improvement of light end petroleum products**	**7 hours**

Knocking - causes of knocking - feedstock, catalyst, and products of different octane boosting techniques - Catalytic reforming – Polymerization - Hydrofluoric acid and Sulfuric acid Alkylation - Isomerization

Module	Title	Hours
Module: 5	**Purification of petroleum products**	**6 hours**

Sweetening processes – Claus sulfur recovery - Merox treatment – Hydrodesulphurization – Hydrotreating - Dewaxing - Deasphalting - Lube oil processing - Hydrofinishing

Module	Title	Hours
Module: 6	**Fuel additives**	**4 hours**

Types of oil additives - selection of additives based on fuel type - anti-oxidants - metal deactivators - corrosion inhibitors - anti-knocking agents/oxygenates – fuel dyes		
Module: 7	**Liquid fuel storage and effluent treatment plant**	**4 hours**
Storage and handling of liquid fuels - types of storage tanks - selection criteria of fuel storage tanks based on fuel types - overview of an effluent treatment plant		
Module: 8	**Contemporary issues**	**2 hours**
Guest lecture from industry/R&D organizations		
	Total Lecture hours:	**45 hours**

Textbooks:	
1.	Kaiser M.J., Klerk A.D., Gary J.H., Handwerk G.E., Petroleum Refining: Technology, Economics, and Markets, 2019, 6th ed., CRC Press, USA.
2.	Bhaskara Rao B.K., Modern Petroleum Refining Processes, 2018, 6th ed., OXFORD & IBH Publishing, India.
Reference Books:	
1.	Meyers R. A., Handbook of Petroleum Refining Processes, 2016, 4th ed., McGraw-Hill Education, Europe.
2	Gupta O.P, Elements of Petroleum Refinery Engineering, 2019,1st ed., Khanna Book Publishing, India.

Mode of Evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE318L	Safety and Hazard Analysis	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To assess the significance of the chemical safety analysis
2. To identify the occupational hazards in the work environment
3. To determine the root cause of the failure events in the workplace

Course Outcomes:

1. Develop work safety protocols for the individual tasks
2. Implement safety framework at the workplace
3. Analyse the root cause of the work-related accidents using safety analysis
4. Apply Hazard and Operability Study (HAZOP) for Hard and Soft Industries
5. Identify hazard and conduct a safety audit

Module:1	Introduction to Safety in Industry	7 hours

Safety consciousness in the workplace - Hazard, Risk, Danger and Accident, Chemical safety, Industry safety, Safe operating conditions and drafting safety protocols for accidents, and Importance of the safety/communication training

Module:2	Safety Programmes in Industry	7 hours

Safety Analysis in industries: Fault tree analysis, event tree analysis, and Reliability analysis, Elements of the safety program, Economic, Social Benefits from safety program, disaster management, occupational and industrial health hazards; and fail-safe systems.

Module:3	Hazard analysis in the workplace	7 hours

Hazard identification, Hazop table, keyword in Hazop analysis, Creating HAZOP table for Chemical plants; High pressure and Temperature Operations; Dangerous and Toxic work environment; Routes of entry, layer of protection analysis, and personal protective equipment.

Module:4	Risk Assessment	6 hours

Application of risk assessment, Difference in risk assessment, Identifying risk in radiation, vapour cloud explosions, and toxic work environment, chemical storage and security, safety in plant layout, Risk management, Emergency planning, On-site & offsite workplace emergency planning, and ISO certifications.

Module:5	Safety Models and behaviour-based safety	7 hours

Occupational health and safety effects of toxicants and their elimination. Toxic release and dispersion models. Radioactive decay models, Gaussian plume models, What-if analysis, Vulnerability models, Resilience engineering models, FRAM models, Bayesian regression models, Safety audits, behaviour-based analysis for the workplaces, Involvement of Human factors and Errors, safety checklist, and use of regression methods in safety.

Module:6	Safety in manufacturing and service industries	6 hours

Formulation of the safety committee, the legal framework in safety committee, Safe handling of high energy material; tools; machinery, ergonomic safety, and safety in workplaces

Module:7	**Case studies**	**3 hours**
Dominos' effect, Worst case scenario, Chemical release, and Natural disasters		
Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Books:

1.	Ericson C.A., Hazard Analysis Techniques for System Safety, 2015, 2nd ed., Wiley, USA.
2.	Lars Harms-Ringdahl, Safety Analysis, Principles, and practices in occupational safety, 2001, 1st ed., Taylor and Francis.

Reference Books:

1.	Gupta A., Industrial Safety and Environment, 2015, 2nd ed., Laxmi Publications, India.
2.	Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with Applications, 2019, Pearson Education, India.

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE319E	Process Plant Design and Simulation	2	0	2	3
Pre-requisite	BCHE202L	Syllabus version			
		1.0			

Course Objectives:

1. To emphasize the basic concepts of steady-state process plant simulation
2. To impart knowledge and awareness to understand the validity and physicochemical interpretation of thermodynamic models and their limitations
3. To develop skills for plant simulation and optimization, solve chemical engineering problems encountered in chemical industries using professional software's

Course Outcomes:

1. Explain the principles for developing a Process flow sheet and its execution
2. Illustrates the approaches to follow in plant simulation
3. Utilize commercial software's for a complete simulation of refineries
4. Interpret steady-state process plant simulation
5. Improve the debottleneck existing in the process plant and have maximum productivity

Module:1	Introduction	3 hours

Introduction to Process Synthesis, Flow sheeting & simulation, Degrees of freedom, Process flow sheet

Module:2	Approaches to process simulation	4 hours

Sequential modular approach and Simultaneous modular approaches, Equation solving approach used in process plant simulation.

Module:3	Equation solving Approach	4 hours

Partitioning, Decomposition, Probabilistic Transformation ***Method*** **(**PTM), slow-wave structure(SWS), Steward, and Rudd-Algorithms, Direct Methods, Iterative methods, Block triangular form (BTF), Bordered block transformation (BBTF), Block Back Substitution, Beecham-Titchener-Simpson (BTS).

Module:4	Decomposition of Networks	5 hours

Tearing Algorithms in the decomposition of networks, digraph, signal flow graph, Boyer Moore (BM) Algorithm, Binary Tree Algorithm (BTA), Kennard-Stone (K&S) Algorithm, Metropolis-Hastings (M&H) Algorithms, and related problems.

Module:5	Convergence promotion	4 hours

Linear equation – nonlinear equation, Convergence Promotion scheme Newton's method, Direct substitution, Wegstein's method, Dominant eigen value method, Quasi-Newton methods, Acceleration criterion.

Module:6	Application of flow sheeting software	4 hours

Flow sheeting software: Aspen Plus-Steady state simulation, Aspen Hysys-dynamic simulation

Module:7	Case studies: process plant simulation	4 hours

Process plant steady-state and dynamic simulation: Any process such as Ammonia plant, Biodiesel plant, NG liquefaction.

Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry/ R&D organizations		
	Total Lecture hours:	**45 hours**

Textbook(s)p

1.	Robin S., Chemical Process Design and Integration, 2016, 2nd ed., Wiley, USA
2	Jana A.K., Process Simulation and Control using Aspen, 2012, 1st ed., PrenticeHall, New Delhi

Reference Books

1.	Nishanth G.C, Chien H.C, Denny N.K.S, Rafil E, Cheng L.C, Lung C.I, Hao Y.L, Rene E.D., Chemical Engineering Process Simulation, 2017, 1st ed., Elsevier Science, USA
2	B.V.Babu, Process Plant Simulation, 2004, Oxford University Press, India

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test

Indicative Experiments

1.	Simulation of Binary Distillation using Aspen plus/ Hysys	
2.	Simulation of Heat Exchanger using Aspen plus/ Hysys	
3.	Simulation of CSTR using Aspen plus/ Hysys	
4.	Simulation of PFR using Aspen plus/ Hysys	
5.	Simulation of Adsorption process using Aspen plus/ Hysys	
6.	Simulation of Absorption process using Aspen plus/ Hysys	
7.	Simulation of Ammonia refrigeration cycle using Aspen plus/ Hysys	
8.	Simulation of Ammonia production process using Aspen plus/ Hysys	
9.	Simulation of NG liquefaction process using Aspen plus/ Hysys	
10.	Simulation of HEN analysis using Aspen Energy Analyser	
	Total Laboratory Hours	**30 hours**
	Mode of assessment: Individual Experiment Assessment, Final Assessment Test	

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE320L	Chemical Product Design	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To train the students in identifying the needs and converting needs to product specifications
2. To facilitate generation of innovative ideas for chemical products and select among the ideas
3. To familiarize the student with intellectual property issues and manufacture and design of speciality products

Course Outcomes:

1. Understand the needs of the customer
2. Apply engineering knowledge to convert the needs to product specifications
3. Generate innovative ideas for chemical products
4. Evaluate ideas to satisfy the product specifications
5. Analyze the implementation of ideas in practice for the manufacture of products

Module:1	Introduction	1 hour
Introduction to chemical product design - Product examples		

Module:2	Needs of chemical product	6 hours
Customer needs - interviewing customers - lead users - interviews - alternatives to interviews - consumer products - needs examples		

Module:3	Needs to specifications	6 hours
Consumer assessments - simple comparison test - relative grading test - test for assessing ratios - Converting needs to specifications - revising product specifications - examples		

Module:4	Ideas	8 hours
Human sources of ideas - brainstorming - problem-solving styles - chemical sources of ideas - natural product screening - random molecular assembly - combinatorial chemistry - sorting the ideas - screening the ideas - examples		

Module:5	Selection of ideas	8 hours
Selection using thermodynamics - ingredient substitutions - substitutions in consumer products - ingredient improvements - selection using kinetics - less objective criteria - risk in product selection - examples		

Module:6	Product manufacture	6 hours
Intellectual property - patents and trade secrets - requirements for patents - supplying missing information - final specifications - micro structured products - device manufacture - examples		

Module:7	Speciality chemical manufacture and Economic Concerns	8 hours
First steps towards production - extending laboratory results - reaction engineering - separations - heuristics for separations - speciality scale-up - Product versus process economics - Gantt chart - cash flow - time value of money - examples		

Module:8	Contemporary Issues	2 hours

Guest Lecture from Industry and R&D Organizations		
	Total Lecture hours:	45hours

Text Book:

1.	Cussler E.L., Moggridge G. D., Chemical Product Design, 2011, 2nd ed., Cambridge University Press, UK.

Reference Books:

1.	Seider W.D., Seader J D., Lewin D.R., Product and Process Design Principles, 2016, 4th ed., Wiley , USA.
2.	Wei J., Product Engineering: Molecular Structure and Properties, 2007, 1st ed., Oxford University Press, UK.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE321L	**Natural Gas Engineering**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To impart design experiences essential for graduates to enter the practice of Gas Engineering and pursue lifelong professional development
2. To summarize the necessary theory, application to case studies and engineering project design
3. To implement research that generates, communicates and applies new knowledge for the betterment of society

Course Outcomes :

1. Emphasize fundamentals of mathematics and integrates them in application to traditional Natural Gas Engineering to improve further needs
2. Recognize the changes and practices followed in offshore platforms
3. Develop an ability to revamp and retrofit a system, process to meet desired needs within realistic constraints such as environmental, health, safety, manufacturability and sustainability in the field of Natural Gas
4. Apply natural gas refining principles and practices for optimizing resource development and management
5. Evaluate project economics and resource valuation methods for design and decision making under conditions of risk and uncertainty

Module:1	**Properties and Composition of Natural Gas**	**6 hours**

Natural gas origin – Composition of Natural Gas – Source of Natural Gas – Thermodynamic properties – Compressibility factor for Natural Gas – Heating value and flammability limit of Natural Gas

Module:2	**Natural Gas Extraction**	**5 hours**

Onshore Extraction - Offshore Extraction- Techniques and Principles

Module:3	**Natural Gas Offshore Production and Handling**	**6 hours**

Drilling Deepwater Reservoir – Deepwater production systems – Mooring Systems – Gas Terminals

Module:4	**Natural Gas Onshore Production and Handling**	**6 hours**

Sucker rod pumping – separation, storage and transportation of Natural Gas

Module:5	**Natural Gas Processing**	**8 hours**

Dehydration – Desulphurization processes (Sour gases, Toxicity of H_2S, Physical and Chemical Absorption process, Carbonate process, sulphur recovery) – Low-temperature processes (Joule Thompson effect, Turbo expander, Refrigeration, Low-temperature Heat Exchanger)

Module:6	**Liquid Recovery**	**6 hours**

Natural Gas Liquids(NGL), LPG, C_3 and C_2 fraction recovery from Natural Gas				
Module:7	**Economics of Natural Gas**			**6 hours**
Current status in India – Trade & selection of port location – Economics of gas processing				
Module:8	**Contemporary issues**			**2 hours**
Guest Lecture from Industry and R&D Organizations				
			Total Lecture hours:	**45 hours**
Text Books:				
1.	Arthur J. Kidnay, William R. Parrish., Fundamentals of Natural Gas Processing, 2018, 5th ed.,Taylor and Francis, CRC Press, UK.			
2.	Alireza Bahadori, Natural Gas Processing Technology and Engineering Design, 2014, Elsevier, Gulf Professional Publishing, UK.			
Reference Books:				
1.	S. Mokhatab, William A. Poe, James G. Speight., Handbook of Natural Gas Transmission and Processing, 2014, 1st ed., Gulf Professional Publishing, USA.			
2.	G. Ghalambor, Natural Gas Engineering Handbook, 2014, 2nd ed., Gulf Publishing Company, USA.			
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test				
Recommended by Board of Studies	11-02-2022			
Approved by Academic Council	No.65	Date	17-03-2022	

Course code	Course Title	L	T	P	C
BCHE322L	Nanoscience and Nanotechnology	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To understand nanotechnology and nanoscience phenomena
2. To provide an insight into the chemical materials and fabrication techniques used in nanotechnology
3. To emphasize the design concepts and strategies to build molecular machines

Course Outcomes:

1. Distinguish between micro/nano systems based on their properties
2. Explain the nanoscale paradigm in terms of properties at the nanoscale dimension
3. Describe major top-down and bottom-up strategies in making the stable nanomaterials
4. Discuss various nanoscale device fabrication techniques
5. identify various characterization techniques for estimating the properties of nanomaterials

Module:1	Introduction	5 hours

Definition of Nano and history of nanotechnology, Scientific revolution-Atomic Structure and atomic size, the influence of nano over micro/macro, size effects and crystals, large surface to volume ratio, surface effects on the properties.

Module:2	Types of nanostructure and their properties	6 hours

One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

Module:3	Synthesis and stability of nanomaterials	7 hours

Top-down and bottom-up methods, chemical methods, physical methods, electrostatic stabilization, steric stabilization, Depletion stabilization

Module:4	Metal, semiconductor and magnetic nanoparticles	6 hours

Size, properties and shape control of metal, semiconductor and magnetic nanoparticles, Core-Shell structured and semiconductor nanoparticles – alloy nanostructure – Janus nanoparticles.

Module:5	Nano scale device fabrication	6 hours

Lithography techniques –Photo – UV – X-ray – inferometric techniques – inkjet printing – nano scale coating techniques – dip-coating – spin coating – spray coating – CVD – plasma coating – atomic layer deposition.

Module:6	Nano scale characterization techniques	7 hours

Optical properties – surface and bulk morphological properties – phase purity – surface characterization – nano mechanic properties – electromagnetic properties.

Module:7	Application of nanomaterials	6 hours

Ferroelectric materials, molecular electronics and nanoelectronics, biological, environmental, membrane-based application, polymer-based application.

Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Book:

1.	Chris Binns, Introduction To Nanoscience And Nanotechnology, 2010, 1st edition, John Wiley & Sons Inc, USA.

Reference Books:

1.	Sulabha K Kulkarni, Nanotechnology: Principles and Practices, 2019, 3rd edition, Springer International Publishing, USA.
2.	CNR Rao, Achim Müller and Anthony K. Cheetham , The Chemistry of nanomaterials: Synthesis, properties and applications, 2004, Wiley-VCH Verlag GmbH & Co. KGaA.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE323L	Fertilizer Technology	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To introduce the production of various NPK fertilizers and their importance
2. To impart knowledge of bio fertilizers, fluid fertilizers and controlled release fertilizers
3. To identify pollutants in fertilizer industries and their controlling strategies

Course Outcomes:

1. Understand the role of essential elements for plant growth.
2. Identify reactions and unit operations involved in the manufacturing of various fertilizers
3. Categorize the major engineering problems associated with the fertilizer manufacturing processes
4. Explain the importance of bio fertilizers, fluid fertilizers and controlled release fertilizer
5. Analyse the impact of pollution from the fertilizer industry based on pollution standards

Module:1	Overview of Fertilizers	6 hours

Introduction - Plant Nutrients - Fertilizer grade - Terminology and Definitions - Status of fertilizer industry – Fertilizer production and consumption- Raw materials – Availability and Sources- Productivity and energy efficiency.

Module:2	Nitrogenous Fertilizers	7 hours

Nitrogenous fertilizers – Ammonia - Nitric acid – Urea - Ammonium sulphate - Ammonium chloride – Ammonium nitrate - Methods of production - characteristics and specification - Storage and handling.

Module:3	Phosphatic Fertilizers	7 hours

Phosphatic Fertilizers - Raw materials – phosphate rock, sulphur, pyrites etc. - Production of sulphuric and phosphoric acids - Ground rock phosphate - Bone meal – Single superphosphate - Triple superphosphate - Thermal phosphates – Methods of production - characteristics and specifications.

Module:4	Potassic Fertilizers	6 hours

Potassic fertilizers – Potassium Chloride - Potassium sulphate - Potassium magnesium sulphate - Potassium hydroxide - Potassium nitrate – Methods of production - characteristics and specifications.

Module:5	Complex Fertilizers	6 hours

Complex fertilizers - Ammonium phosphate - Urea ammonium phosphate - Ammonium phosphate sulphate – Nitrophosphates - Calcium ammonium nitrate - Grades of complex fertilizers.

Module:6	Other Fertilizers	5 hours

Fertilizers and granulated mixtures – Biofertilizers - Fluid fertilizers - Granular fertilizers - Controlled-release fertilizers - Slow-release fertilizers- Statistics and economic analysis.

Module:7	Pollution Control in Fertilizer industry	6 hours

Pollution from fertilizer industry – Solid, liquid and gaseous pollution – MINAS standards- Controlling techniques

Module:8	Contemporary issues	2 hours
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	45 hours

Text Book:	
1.	Austin T.G., Shreve's Chemical Process Industries, 2017, 5th ed., Tata McGraw-Hill Education Pvt. Ltd, India.
Reference Books:	
1	Rao G., Sittig M., Dryden's Outlines of Chemical Technology, 2019, 3rd ed., East West Press, India.
2.	Shukla S.D., Pandey G.N., A Text Book of Chemical Technology, 2018, 1st ed., Vikas Publishing House Pvt. Ltd, India.
3.	Fertilizer Manual, United Nations Industrial Development Organization, New York, 1967, United Nations.
4.	Handbook of Fertilizer Technology, Fertilizer Association of India, 1977, New Delhi.

Mode of Evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE324L	**Fermentation Technology**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To recognize the basics of the various aspects of microbiology and bio-systems
2. To impart experimental design thinking capability in relation to various fermenter configurations, modes of operation, growth kinetics and product recovery
3. To employ the design thinking skills to bio-related processes with a chemical engineering background

Course Outcomes:

1. Understand the fermentation processes as applied for various bio-transformations
2. Summarize kinetics prevalent in microbial processes
3. Recognize the classification of microorganisms to select and manage microorganisms from a natural source to fermentation
4. Apply the fermenter configuration for different types of cells and enzymes
5. Design downstream processing of fermentation products

Module:1	**Introduction and history of fermentation processes**	**4 hours**

Development of fermentation process – range of processes under fermentation, Types of fermentation

Module:2	**Microbial growth kinetics**	**6 hours**

Microbial growth - Batch, Continuous and fed-batch – kinetics studies – structured and unstructured models of culture

Module:3	**Microbial Strain Management**	**5 hours**

Industrial microorganisms – isolation - preservation of strains - Storage methods - improvement strategies

Module:4	**Media for industrial fermentations**	**5 hours**

Media formulation – energy - carbon and nitrogen sources - micro nutrients - oxygen requirements; Other non-nutrient and functional components - Effects of media composition on penicillin production - Media optimization

Module:5	**Aseptic fermentation process**	**8 hours**

Preparation of media and air for pure culture fermentation; Media sterilization - Batch and continuous sterilization; Sterilization of fibrous filters and design; Development of inocula - processes involving yeast, bacterial, fungi; Inoculation of plant fermentation.

Module:6	**Fermenters**	**8 hours**

Basic functions – Aeration and agitation – process requirements and mechanical design - Maintenance of aseptic conditions - Foam control - Types and design of fermenters for industrial applications - stirred & sparred tanks fermenters, Tower fermenter, Packed tower, Air lift and rotating disc fermenters - Solid State fermentation.

Module:7	**Process technology for bulk products**	**7 hours**

Downstream processing - Bulk products; Production of alcohols- organic acids-enzymes, and

antibiotics – flow sheet and process description of modern processes.		
Module:8	**Contemporary Issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Books:	
1.	Stanbury P.F., Whitaker A., Steve H., Principles of Fermentation Technology, 2008, 3rd ed., Butterworth-Heinemann, USA.
2.	El-Mansi E., Bryce C.F.A, Arnold L.D., Allman A.R., Fermentation Microbiology and Biotechnology, 2007, 2nd ed., CRC Press, USA.
Reference Books:	
1.	Ashok P, Christian L, Carlos R.S., Advances in Fermentation Technology, 2008, 1st ed., Asiatech Publishers Inc., India.
2.	Rhodes A and Pletcher. D.L: Principles of Industrial Microbiology, 1977, 3rd ed., Pergamon Press, UK.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE391J	Technical Answers to Real Problems Project	0	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To gain an understanding of real-life issues faced by society.
2. To study appropriate technologies in order to find a solution to real-life issues.
3. Students will design system components intended to solve a real-life issue.

Expected Course Outcome:

1. Identify real-life issue(s) faced by society.
2. Apply appropriate technologies to suggest a solution to the identified issue(s).
3. Design the related system components/processes intended to provide a solution to the identified issue(s).

Module Content (Project duration: Two semesters)

Students are expected to perform a survey and interact with society to find real-life issues.

Logical steps with the application of appropriate technologies should be suggested to solve the identified issues.

Subsequently, the student should design the related system components or processes which is intended to provide the solution to the identified real-life issues.

General Guidelines:

1. Identification of real-life problems
2. Field visits can be arranged by the faculty concerned
3. 3 – 4 students can form a team (within the same/different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modelling/product design/process design/relevant scientific methodologies
7. Consolidated report to be submitted for assessment
8. Participation, involvement, and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed
11. The project component to have three reviews with the weightage of 20:30:50

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE392J	Design Project	0	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. Students will be able to upgrade a prototype to a design prototype.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Expected Course Outcome:

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.

Module Content	(Project duration: one semester)

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototypes or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE393J	Laboratory Project	0	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. The student will be able to conduct experiments on the concepts already learnt.
2. Analyse experimental data.
3. Present the results with appropriate interpretation.

Expected Course Outcome:

1. Design and conduct experiments in order to gain hands-on experience on the concepts already studied.
2. Analyse and interpret experimental data.
3. Write clear and concise technical reports and research articles

Module Content	(Project duration: one semester)

Students are expected to perform experiments and gain hands-on experience on the theory courses they have already studied or registered in the ongoing semester. The theory course registered is not expected to have laboratory component and the student is expected to register with the same faculty who handled the theory course. This is mostly applicable to the elective courses. The nature of the laboratory experiments (wet lab / dry lab) is depended on the course.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE394J	**Product Development Project**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to translate a prototype to a useful product.
2. Apply relevant codes and standards during product development.
3. The student will be able to present his results by means of clear technical reports.

Expected Course Outcome:

1. Demonstrate the ability to translate the developed prototype/working model to a viable product useful to society/industry.
2. Apply the appropriate codes/regulations/standards during product development.
3. Write clear and concise technical reports and research articles

Module Content (Project duration: Two semesters)

Students are expected to translate the developed prototypes/working models into a product that has application to society or industry. Evaluation involves periodic reviews by the faculty with whom the student has registered.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the product – Mark weightage of 20:30:50 – project report to be submitted, presentation and demonstration reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE395J	**Computer Project**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to analyse complex engineering processes.
2. Describe the applications and limitations of a given engineering process.
3. Present the results in written reports and oral presentations.

Expected Course Outcome:

1. Utilize programming skills/modelling to analyse complex engineering processes/problems.
2. Demonstrate the ability to evaluate the applicability and limitations of the given engineering process.
3. Communicate effectively through written reports, oral presentations, and discussion.

Module Content (Project duration: One semester)

Students are expected to use programming skills or modelling to analyse complex engineering processes. The student should be able to evaluate the application and limitations of the said engineering processes. Evaluation involves periodic reviews by the faculty with whom the student has registered.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE396J	**Reading Course**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Expected Course Outcome:

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.

Module Content (Project duration: One semester)

This is oriented towards reading published literature or books related to niche areas or focused domains under the guidance of a faculty. It is expected to have at least 10 students to form a group and come up with a specific topic. Assessments will be as per the academic regulations slated for the theory course.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE397J	**Special Project**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to identify and solve problems in a time-bound manner.
2. Describe major approaches and findings in the area of interest.
3. Present the results in a clear and concise manner.

Expected Course Outcome:

1. To identify, formulate, and solve problems using appropriate information and approaches in a time-bound manner.
2. To demonstrate an understanding of major approaches, concepts, and current research findings in the area of interest.
3. Write clear and concise research articles for publication in conference proceedings/peer-reviewed journals.

Module Content	(Project duration: not more than three semesters)

This is an open-ended course in which the student is expected to work on a time-bound research project under the supervision of a faculty. The result should be a tangible output in terms of publication of research articles in a conference proceeding or in a peer-reviewed Scopus indexed journal.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE398J	**Simulation Project**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to simulate a real system.
2. Identify the variables which affect the system.
3. Describe the performance of a real system.

Expected Course Outcome:

1. Demonstrate the ability to simulate and critically analyse the working of a real system.
2. Identify and study the different variables which affect the system elaborately.
3. Evaluate the impact and performance of the real system.

Module Content (Project duration: one semester)

The student is expected to simulate and critically analyse the working of a real system. Role of different variables which affect the system has to be studied extensively such that the impact of each step in the process is understood, thereby the performance of each step of the engineering process is evaluated. Evaluation involves periodic reviews by the faculty with whom the student has registered.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE401L	Petrochemical Technology	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To outline the basics of organic synthesis and the processes that goes along with it
2. To distinguish between the various unit operations and unit processes involved in the polymerization of monomers
3. To interpret the analytical approaches used in different types of application-oriented challenges encountered in the chemical industry

Course Outcomes:

1. Demonstrate the basic methods for converting monomers to polymers
2. Compare different types of polymers for diverse applications
3. Develop an understanding of the major industrial polymerization processes
4. Summarize applications of plastics and fibres
5. Analyse the economics of the Petroleum industry

Module:1	Petrochemicals and Precursors	2 hours

Introduction – Precursors –Selection of precursors- properties – petrochemical from precursors

Module:2	Alkanes and Alkenes	7 hours

Introduction - Manufacture of Petrochemical Derivatives from C_1, C_2, C_3, C_4 compounds

Module:3	Aromatics	6 hours

Introduction - Manufacture of Petrochemical Derivatives from Benzene, Toluene, Xylene and Styrene.

Module:4	Petrochemical Derivatives	8 hours

Manufacture of vinyl chloride (VCM) by thermal cracking, Dimethyl Terephthalate, Poly TA, maleic anhydride, cumene, diphenylcarbonate.

Module:5	Polymers	8 hours

Production of - poly butadiene rubber, Styrene-Butadiene Rubber (SBR), Styrene Acrylonitrile (SAN), Polyalkylene Terephthalate, Alpha Olefins(Linear), Octenes.

Module:6	Plastics and Fibres	7 hours

Production of Polyacrylonitrile resins – Melamine - Formaldehyde resins – Solidified Nitro Glycerine(SNG) – explosives.

Module:7	Economics of Petrochemical Industry	5 hours

Current status in India – Trade - Selection of Petrochemical products - Economics of Petrochemical derivatives.

Module:8	Contemporary Issues	2 hours

Guest Lecture from Industry and R&D Organizations

	Total Lecture hours:	45 hours

Text Books:			
1.	I. D. Mall, Petrochemical Process Technology, 2017, 2nd ed., Macmillan Publishers, India.		
2.	S. Maitra and O. P. Gupta, Elements of Petrochemical Engineering, 2018, Khanna Publishers, India.		
Reference Books:			
1.	V. Patel, Advances in Petrochemicals, 2015, Intech Open Publications, India.		
2.	I.D. Mall, Petroleum Refining Technology, 2017, CBS Publishers, India.		
Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE402L	Food Process Engineering	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To familiarize with the constituents of food and importance of microorganisms and additives in food processing.
2. To emphasize on the basic concepts of unit operations in Chemical Engineering with an application to food processing.
3. To impart necessary knowledge required for food processing technology, food quality and packaging.

Course Outcomes

1. Explain the constituents and nutritive aspects of food and the importance of microorganisms and food additives.
2. Develop material and energy balances on unit operations involved in food processes.
3. Compare the unit operations involved in food processing and their integration to actual process design.
4. Identify the appropriate preservation techniques for various food items.
5. Explain different processing technology to produce quality food products and their packaging.

Module:1	Introduction to food	4 hours

Constituents of food - Carbohydrates, Proteins, Lipids, Enzymes, Vitamins and minerals, Water, role and functional properties in food, contribution to organoleptic and textural characteristics

Module:2	Food microbiology and food additives	4 hours

Importance of micro-organisms in foods, Food borne diseases and food spoilage Functional characteristics of additives in food processing; food colourants – natural and artificial; food flavours; enzymes as food processing aids.

Module:3	Food process calculations	4 hours

Material balance calculations with and without reaction, recycle and bypass, Material and energy balances in food processing (mixing, evaporation and drying)

Module:4	Unit operations in food processing	10 hours

Concept of food rheology and viscoelastic foods; Size reduction – Equipments and energy and power requirements, Mixing and agitation – Agitated vessels – Impellers for high viscosity liquids; Mechanical separations – Filtration: Constant rate and constant pressure filtration – filtration equipments – filter press – rotary drum filters – sedimentation and centrifugal separations; Heat exchangers – types of heat exchangers – enthalpy balance; Evaporators – single and multiple-effect – evaporator economy – enthalpy balance of single-effect evaporator – multiple-effect evaporator – methods of feeding; Dryers – drying rate – types of dryers – fluidized bed – Spray drier – vacuum shelf dryer – freeze dryer

Module:5	Food preservation techniques	10 hours

Heat and cold dehydration, irradiation, microwave heating, sterilization and pasteurization (thermal death curves of microorganisms)

Food canning technology (batch and continuous), application of infrared, microwaves, sterilization of canned food, canning procedures for fruits, vegetables, meats, poultry marine products.

Module:6	Food processing and food quality	8 hours

Processing of Cereal grains, Vegetables, Spices, Bakery, Confectionary Products, Soft and Alcoholic Beverages, Dairy Products, Meat Products. Food quality parameters and their evaluation - FSSAI and safety concepts in food processing, Quality control and Food standard organizations		
Module:7	**Food packaging**	**3 hours**
Basic packaging materials, Types of packaging, Packaging design, packaging for different types of foods, retort pouch packing, costs of packaging and recycling of materials		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organizations		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Berk, Z., Food Process Engineering and Technology, 2018, 3rd ed., Academic press, USA.
2.	Sivasankar, B., Food Processing and Preservation, 2009, 1st ed., Prentice-Hall of India Pvt. Ltd. New Delhi.
Reference Books	
1.	Smith, P.G., Introduction to Food Process Engineering, 2011, 2nd ed., Springer, USA.
2.	Rao, D.G., Fundamentals of Food Engineering, 2010, 1st ed., PHI Learning Private Limited, New Delhi.
3.	Saravacos, G. D., Maroulis, Z.B., Food Process Engineering Operations, 2011, 1st ed., CRC press, USA.

Mode of Evaluation: CAT, Quiz, Seminar, FAT			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE403L	**Process Intensification**	**3**	**0**	**0**	**3**
Pre-requisite	**BCHE208L, BCHE208P**	**Syllabus version**			
		1.0			

Course Objectives:

1. To understand the concept of process intensification.
2. To apply the techniques of intensification to chemical processes
3. To infer alternative solutions considering economic viability, environmental and social acceptance

Course Outcomes:

1. Explain the scientific background, techniques of intensification in the process industries
2. Apply process intensification in chemical processes
3. Classify the various methodologies adopted for process intensification
4. Identify scale up issues in the chemical processes
5. Evaluate the feasibility of the process intensification

Module:1	Introduction	6 hours

Techniques of Process Intensification (PI) - Applications, The philosophy and opportunities of Process Intensification, benefits from process intensification, Process intensifying Equipment, Process intensification toolbox

Module:2	Process intensification through micro reaction technology	6 hours

Effect of miniaturization on unit operations and reactions, Implementation of Micro reaction Technology, From basic Properties, Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Module:3	Mixing and flow patterns	8 hours

Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer, Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, High intensity inline mixers reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Module:4	Combined chemical reactor with heat exchange and reactor/separators	6 hours

Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes.

Module:5	Compact heat exchangers	8 hours

Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Module:6	Enhanced fields	6 hours

Energy based intensifications in distillation, Sono-chemistry, Cavitation Reactors, Flow over a

rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, Sono crystallization, Reactive separations		
Module:7	**Case studies**	**3 hours**
Reaction separation of Plastic/Biomass pyrolysis; Petrochemicals and Fine Chemicals, Refineries, Bulk Chemicals, Nuclear Industry		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry/ R&D organizations		
	Total Lecture hours:	**45 hours**

Textbooks:	
1.	Reay D, Ramshaw C, Harvey A., Process Intensification Engineering for Efficacy, Sustainability and Flexibility, 2013, 2nd ed., Butterworth Heinemann, USA.
2	Dominic C. Y.F, Halwagi-EI M.M., Process Intensification and Integration for Sustainable Design, 2021, 1st ed., Wiley-VCH, USA.
Reference Books:	
1.	Hernández S, Gabriel J, Petriciolet B, Adrián., Process Intensification in Chemical Engineering Design Optimization and Control, 2016, 1st ed., Springer, Switzerland
2.	Boodhoo K, Harvey A., Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, 2013, 1st ed., Wiley, USA.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course Title	L	T	P	C
BCHE404L	**Colloids and Interfacial Science**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To describe the theories of colloids and interfacial phenomena
2. To explain solution thermodynamics, stability of colloids, light scattering,capillary effects
3. To expose the importance of colloidal phenomena through real-life examples

Course Outcomes:

1. Describe the concept of non-covalent colloidal forces
2. Explain different methods of measuring liquid surface tension and contact angle
3. Apply the knowledge of thermodynamics for micellization in surfactant solutions
4. Interpret the kinetic and thermodynamic stability of emulsions and interfaces
5. Calculate colloidal parameters using light scattering spectrum

Module	Title	Hours
Module:1	**Introduction to Colloid & Interface Science**	**6 hours**
Fundamentals of Colloid Science-Colloids definition-Van der Waals interactions-The Hamaker constant-Electrostatic Interactions in Colloids-The electrical double layer (EDL) theory-Zeta potential-Gibbs energy of electrostatic interactions		
Module:2	**Surface Tension and Contact Angle**	**6 hours**
Surface tension of liquids-definition-Lewis Acid-Base interactions-Surface tension & contact angle-Measuring contact angles – Du Noüy ring method – Wilhelmy plate method – effect of temperature on surface tension – Young – Laplace equation – Kelvin equation		
Module:3	**Interactions at Interfaces**	**5 hours**
Surfactants Types – Cationic surfactant – Anionic surfactant: Zwitterionic, Gemini and Bio-surfactants – Definitions - applications -thermodynamics - Surface excess, Micellization of surfactant - Hydrophilic-lipophilic balance (HLB).		
Module:4	**Emulsions**	**6 hours**
Definitions and applications - Types of emulsions - Thermodynamics of emulsification-Emulsion stability – Ostwald ripening – phase inversion – micro emulsion – foams.		
Module:5	**Design of Interfaces**	**7 hours**
Adsorption-Models of adsorption-Adsorption at the solid-liquid interface-Adsorption at the liquid-air interface-Adsorption at the solid-air interface – applications – calculation of free energy of adsorption.		
Module:6	**Principles of Light Scattering**	**6 hours**
Fundamentals of light scattering-Static light scattering-Dynamic light scattering – applications – Rayleigh scattering – polydispersity index – average particle size calculation.		
Module:7	**Application of Colloids and Interfacial phenomena**	**7 hours**
Colloidal and interfacial phenomena in biology- food technology– Photovoltaic – Water treatment-Medicine-Tribology-Engineering		

Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R&D organisations.		
	Total Lecture hours:	**45 hours**

Text Books:

1. Pallab Ghosh, Colloid and Interface Science, 2009, 1st edition, PHI, India

Reference Books:

1. Hiemenz P.C., Rajagopalan R., Principles of Colloid and Surface Chemistry, 1997, 3rd ed., CRC Press, USA.
2. Wang C., Leblanc R.M., Recent Progress in Colloid and Surface Chemistry, 2016, 1st ed., Oxford University Press Inc., UK.

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE405L	**Fluidization Engineering**	**3**	**0**	**0**	**3**
Pre-requisite	**NiL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To understand the physical and chemical aspects of the fluidization process
2. To identify the various fluidization regimes and describe their behaviour
3. To design the various types of fluidized bed widely used in industrial practice

Course Outcomes:

1. Identify the behavior of fluidization process under various operating conditions
2. Determine minimum fluidization velocity and terminal velocity in fluidized bed
3. Design suitable distributor for fluidized beds
4. Apply various models for designing the fluidized bed systems
5. Analyze the performance of fluidized bed reactor systems

Module:1	**Introduction**	**5 hours**

Concept of Fluidization - Special Features of Fluidization - Comparison with other Contacting Methods - Advantages and Disadvantages of Fluidized Beds - Industrial Applications of Fluidized Beds - Historical Highlights - Physical Operation - Chemical Operations.

Module:2	**Characteristics of solids**	**5 hours**

Geldart Classifications of Particles - Flow characteristics and its outline in the different types of fluidizations – Gas-solid system - Liquid-solid system

Module:3	**Characterization of Fluidization I**	**5 hours**

Mapping of Fluidization Flow pattern – Transition regime - Behaviour of Fluidized Beds – Minimum and Terminal Velocities in Fluidized Beds

Module:4	**Characterization of Fluidization II**	**7 hours**

Frictional pressure drop and its model – analysis - Solid movement, mixing, segregation and Staging - Gas distribution - small and large scale industries - Design of Distributors – Power Consumption

Module:5	**Entrainment and Elutriation**	**8 hours**

Free Board Behaviour - Entrainment from Tall and Short Vessels - Constant Approach - Flow Pattern of Gases through Fluidized Beds - Solid Movement - Mixing, Segregation and Staging

Module:6	**Heat Transfer in Fluidized Beds**	**6 hours**

Fluid-solid heat transfer - Determination and Interpretation of Heat Transfer. Calculation of overall Heat Transfer coefficient

Module:7	**Miscellaneous systems**	**7 hours**

Conical fluidized bed - Inverse fluidized bed – Draft tube systems; Semi fluidized bed systems - Design of fluidized bed reactors

Module:8	**Contemporary issues**	**2 hours**

Guest lecture from industry and R & D organizations

		Total Lecture hours:	**45 hours**

Textbook:

1. Kunii D and Levenspiel O., Fluidization Engineering, 2013, 2nd ed., Butterworth Heinemann, USA.

Reference Books:

1. Yang W.C., Handbook of Fluidization and Fluid – Particle System, 2003, 1st ed., CRC Press, USA.
2. Grace J.R., Avidan A.A., Knowlton T.M., Circulating Fluidized Beds, 2011, 1st ed., Springer, USA.
3. John Grace, Xiaotao Bi, Naoko Ellis, Essentials of Fluidization Technology, 2020, Wiley-VCH Verlag GmbH & Co, Germany

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Course title	L	T	P	C
BCHE406L	**AI in Chemical Engineering**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To introduce Artificial Intelligence (AI) as an advanced approach to automation in process to industries
2. To impart knowledge on various AI techniques employed to address complex chemical engineering problems
3. To analyse the issues and limitations of AI methods

Course Outcomes:

1. Understand the scope of Artificial Intelligence (AI) in simulating the human behaviour
2. Analyze the components of AI and its capability to address the nonlinear chemical processes
3. Apply AI approaches to model different chemical processes
4. Assess the suitability of various AI approaches to solve optimization problems
5. Develop AI-based models for fault detection and diagnosis in process plants and control systems

Module:1	**Artificial Intelligence in Chemical Engineering**	**2 hours**

Scope of AI in Chemical Engineering - background - phases of AI - expert systems - neural network - deep learning and data science - merits and demerits.

Module:2	**Artificial Neural Networks (ANN)**	**6 hours**

History of ANN - biological neuron - artificial neuron - activation function - neural network architecture - learning methods - single layer perceptron - multi layer perceptron - back propagation algorithm - applications – clustering – classification - function approximation and prediction - familiarize neural network tool box in MATLAB.

Module:3	**Introduction to Fuzzy logic**	**6 hours**

History of fuzzy logic- fuzzy sets and concepts - operation on fuzzy sets - fuzzy relations – fuzzification - defuzzification- fuzzy membership functions - Adaptive Neuro Fuzzy Inference System (ANFIS) - familiarization of fuzzy logic and ANFIS tool box in MATLAB

Module:4	**AI in Process Modelling**	**8 hours**

Mathematical versus AI based process models - AI approaches to process modelling - ANN models - fuzzy logic models - hybrid models, case study - ANN modelling of wastewater treatment process

Module:5	**AI in Process Optimization**	**8 hours**

Classical optimization approaches versus evolutionary algorithms - genetic algorithm - swarm

optimization, case study - optimization of chemical process		
Module:6	**AI in fault detection and diagnosis**	**8 hours**
Fault detection and diagnosis in process plants - methods of fault diagnosis - neural network method - fuzzy logic method, case study - fault diagnosis using genetic fuzzy system		
Module:7	**AI in Process Control**	**5 hours**
Conventional versus AI based process control – ANN - Fuzzy logic – ANFIS, Case study: Online genetic-ANFIS temperature control in reactors		
Module:8	**Contemporary issues**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Book:	
1.	Quantrille, T.E. and Liu, Y.A., Artificial Intelligence in Chemical Engineering, 1991, 1st ed., Academic Press, USA
Reference Books:	
1.	Michael L. Mavrovouniotis, Artificial Intelligence in Process Engineering, 1990, 1st ed, Academic Press, USA
2.	Boullart, L., Krijgsman, A., Vingerhoeds, R.A., Application of Artificial Intelligence in Process Control, 1992, Pergamon Press Ltd., UK
3.	Zhang, Huaguang, Liu, Derong, Fuzzy modelling and Fuzzy control series: Control Engineering, 2006, Birkahauser, Swiss

Mode of evaluation: Continuous Assessment Test, Quiz, Assignment, Final Assessment Test			
Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

PROJECTS AND INTERNSHIP COURSES-3 (9 CREDITS)

<table>
<tr><th>Course code</th><th colspan="3">Title of the course</th><th>L</th><th>T</th><th>P</th><th>C</th></tr>
<tr><td>BCHE399J</td><td colspan="3">Summer Industrial Internship</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Pre-requisite</td><td colspan="3">Nil</td><td colspan="4">Syllabus version</td></tr>
<tr><td></td><td colspan="3"></td><td colspan="4">1.0</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td colspan="8">The course is designed so as to expose the students to the industry environment and to take up on-site assignments as trainees or interns.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">Expected Course Outcome:</td></tr>
<tr><td colspan="8">• Demonstrate professional and ethical responsibility.
• Understand the impact of engineering solutions in a global, economic, environmental, and societal context
• Develop the ability to engage in research and to involve in lifelong learning
• Comprehend contemporary issues</td></tr>
<tr><td colspan="3">Module Content</td><td colspan="5">4 Weeks (28 days)</td></tr>
<tr><td colspan="8">Four weeks of work at the industry site.
Supervised by an expert in the industry.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">Mode of Evaluation: Continuous Assessment - Internship Report, Presentation and Project Review</td></tr>
<tr><td>Recommended by Board of Studies</td><td colspan="7">11-02-2022</td></tr>
<tr><td>Approved by Academic Council</td><td>No.65</td><td>Date</td><td colspan="5">17-03-2022</td></tr>
</table>

Course code	Title of the course	L	T	P	C
BCHE497J	**Project - I**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development, and analysis of suitable product/process so as to enhance the technical skill sets in the chosen field.

Expected Course Outcome:

1. Demonstrate professional and ethical responsibility.
2. Evaluate evidence to determine and implement best practices.
3. Mentor and support peers to achieve excellence in the practice of the discipline.
4. Work in multi-disciplinary teams and provide solutions to problems that arise in multi-disciplinary work.

Module Content (Project duration: one semester)

The project may be a theoretical analysis, modelling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research, and any other related activities.

Can be individual work or a group project, with a maximum of 3 students.

In the case of group projects, the individual project report of each student should specify the individual's contribution to the group project.

Carried out inside or outside the university, in any relevant industry or research institution.

Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

Course code	Title of the course	L	T	P	C
BCHE498J	Project – II /Internship	0	0	0	5
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development, and analysis of suitable product / processes so as to enhance the technical skill sets in the chosen field.

Expected Course Outcome:

1. Formulate specific problem statements for ill-defined real-life problems with reasonable assumptions and constraints.
2. Perform literature search and/or patent search in the area of interest.
3. Conduct experiments / Design and Analysis/solution iterations and document the results.
4. Perform error analysis / benchmarking/costing
5. Synthesize the results and arrive at scientific conclusions/products/solution
6. Document the results in the form of a technical report/presentation

Module Content (Project duration: one semester)

1. Project may be a theoretical analysis, modelling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for one or two semesters based on the completion of the required number of credits as per the academic regulations.
3. Can be individual work or a group project, with a maximum of 3 students.
4. In the case of group projects, the individual project report of each student should specify the individual's contribution to the group project.
5. Carried out inside or outside the university, in any relevant industry or research institution.
6. Publications in peer-reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Evaluation involves periodic reviews by the evaluation Team. (No FAT)
Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

<table>
<tr><th>Course code</th><th>Title of the course</th><th>L</th><th>T</th><th>P</th><th>C</th></tr>
<tr><td>BCHE499J</td><td>One Semester Internship</td><td>0</td><td>0</td><td>0</td><td>14</td></tr>
<tr><td>Pre-requisite</td><td>Nil</td><td colspan="4">Syllabus version</td></tr>
<tr><td></td><td></td><td colspan="4">1.0</td></tr>
<tr><td colspan="6">Course Objectives:</td></tr>
<tr><td colspan="6">To provide sufficient hands-on learning experience related to the design, development, and analysis of suitable product / processes so as to enhance the technical skill sets in the chosen field.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Expected Course Outcome:</td></tr>
<tr><td colspan="6">1. Formulate specific problem statements for ill-defined real-life problems with reasonable assumptions and constraints.
2. Perform literature search and/or patent search in the area of interest.
3. Conduct experiments / Design and Analysis/solution iterations and document the results.
4. Perform error analysis / benchmarking/costing
5. Synthesize the results and arrive at scientific conclusions/products/solution
6. Document the results in the form of a technical report/presentation</td></tr>
<tr><td colspan="2">Module Content</td><td colspan="4">(Project duration: one semester)</td></tr>
<tr><td colspan="6">This is a capacity-linked opportunity during which the students are expected to take up research / industrial internship for a period of 5 – 6 months duration. These students are expected to complete all other academic commitments. The outcome is expected to be exceptional quality with tangible outcomes more than that expected of an undergraduate student. Evaluation will be either at the industry and / or by the school level committee constituted for this purpose. Student generally registers for the 5 credit internship and is escalated to 14 credits depending on the performance.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Mode of Evaluation: Evaluation involves periodic reviews by the evaluation Team. (No FAT) Continuous Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews</td></tr>
</table>

Recommended by Board of Studies	11-02-2022		
Approved by Academic Council	No.65	Date	17-03-2022

NON GRADED DISCIPLINE CORE COURSE – 1 (1 CREDIT)

Course code	Course Title	L	T	P	C
BCHE101N	**Introduction to Engineering**	**0**	**0**	**0**	**1**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objective:

1. To make the student comfortable and get familiarized with the facilities available on campus
2. To make the student aware of the exciting opportunities and usefulness of engineering to society
3. To make the student understand the philosophy of engineering

Expected Course Outcome:

1. To know the infrastructure facilities available on campus
2. To rationally utilize the facilities during their term for their professional growth
3. To appreciate the engineering principles, involve in life-long learning and take up engineering practice as a service to society

General Guidelines

1. Student should observe and involve in the activities during the induction programme. Both general activities and those which are discipline-specific should be included here.
2. Student should get familiarized with the infrastructure facilities available on campus during the general induction, school induction programme and also from the institutional website.
3. Student should attend the lecture by industries, including those on career opportunities, organized by the School and probably involve in 'Do-it-yourself' projects or projects involving reverse-engineering.
4. Activities under 'Do-it-Yourself' will be detailed by the School.
5. Student should prepare a report on the activities and observations, as per the specified format, and submit the same in institutional LMS, VTOP for further evaluation

General instruction on formatting: Document to be prepared with the titles given in the template; Arial type with font size of 12 to be used; photographs can be included in the document as per the requirement; 1.5 line spacing to be used.

Mode of Evaluation: Evaluation of the submitted report and interaction with the students

Recommended by Board of Studies	yes		
Approved by Academic Council	No. 62	Date	15-07-2021

SHORT SYLLABUS

SCHOOL OF CHEMICAL ENGINEERING - SCHEME

B.Tech in Chemical Engineering

Discipline-Linked Engineering Sciences :

BCHE201L Computational Methods in Chemical Engineering (3 - 0 - 0 - 3)

Single Algebraic and Transcendental Equations - Computers and error analysis, mathematical model formulation; Linear and Nonlinear System of Equations - solution for single and simultaneous equations; Interpolation and Regression Analysis - Interpolation and regression analysis; Optimization - unconstrained and constrained optimization; Integration and Differentiation - numerical integration and differentiation ; Ordinary Differential Equations - Ordinary differential equations, Initial and boundary value problems; Partial Differential Equations - partial differential equations: Implicit and explicit methods.

BCHE201P Computational Methods in Chemical Engineering Lab (0 – 0 – 2 – 1)

Experiments related to computational methods - MATLAB code for bisection / Regula falsi method, Newton Raphson / Secant method, Gauss Elimination / Gauss Jordan method, Gauss Jacobi / Gauss Seidel method, Develop MATLAB code for ODE: Euler / Modified Euler method, ODE: Runge-Kutta method, Liebmann's method - Aspen Plus simulation/ MS Excel package.

BCHE204L Transport Phenomena (3 - 1 - 0 - 4)

Introduction - Concepts in chemical engineering, Transfer of momentum, mass, and energy; Momentum Transport - Phenomenological laws; Vector and Tensor analysis - Molecular and Convective Transport; 1D Viscous Flow: Shell Balance - viscous

Flow, shell Balance; Equations of Change - Equations of Change, Applications to isothermal flow of Newtonian and non-Newtonian fluids; Steady state Heat Transfer – Shell Balance - energy transport; Mass Transfer- Shell Balance - mass transport, mechanisms.

BCHE206L Materials Science and Engineering (3 – 0 – 0 – 3)

Basics of Materials and Structure – Classification of materials, atomic structure, chemical Bonds, structures of metals, ceramics, polymers, and amorphous materials; Crystal Systems - frenkel and schottky defects; Phase Diagrams of the engineering materials - chemical alloying; Evaluation of engineering materials – preparation of nano materials, microstructure; Characterization of materials - physicochemical properties; Electrochemical Characterization of the materials - evaluation of electrochemical, thermal and optical properties of materials, stress-strain response, polarization curves, electrolytic/electrochemical systems; Nano materials - Preparation of nano-materials, Heat treatment, sintering.

Discipline Core :

BCHE202L Chemical Engineering Thermodynamics (3 – 1 – 0 – 4)

Fundamental Concepts and Definitions - Volumetric properties of pure fluids, P-V-T relationships ; Laws of Thermodynamics - first law of thermodynamics, second law of thermodynamics; Thermodynamic Properties of Pure Fluids - thermodynamic properties of pure fluids, Maxwell's relations, fugacity, activity ; Thermodynamic Properties of Solutions - partial molar properties, residual properties , excess property relations; Phase Equilibria - Vapour-Liquid Equilibria for ideal solutions; Vapour-Liquid Equilibria – Non-ideal Solutions – azeotropic systems, P-x-y and T-x-y diagrams, consistency test for VLE data, Chemical Reaction Equilibria - criteria for chemical equilibrium, equilibrium constant.

BCHE203L Chemical Process Calculations (3 – 1 – 0 – 4)

Introduction to Basic Concepts - Unit conversion, mass and mole fractions; Vapor pressure and Humidity calculations - Vapor pressure of liquids, humidity and saturation; Material Balance without Chemical Reaction - steady state material balances for unit operations; Material balance with Chemical Reaction -

Stoichiometric equation, material balance with single and multiple chemical reactions; Recycle and Bypass Operation - Recycle, purge and bypass calculations in unit operations; Combustion calculations - theoretical and excess air requirement; Energy balance - steady state energy balance equation.

BCHE205L Momentum Transfer (3 – 0 – 0 – 3)

Basic Concept of Momentum Transfer - Characteristic properties of fluids; Fluid Flow Phenomena - Kinematics and Dynamics of fluid flow; Flow Measuring Devices – Classification and working principle; Flow through Pipes - Velocity Profile, Fluid friction; Dimensional and Model Analysis - Dimensional homogeneity, Similitude; Flow through Packed and Fluidized Bed - Flow past immersed bodies, Pressure drop across packed beds; Transportation of Fluids - Pumps, Pump Characteristics.

BCHE205P Momentum Transfer Lab (0 – 0 – 2 – 1)

Experiments related to Momentum Transfer - Flow through Venturi meter, Orifice meter, circular pipe, non-circular pipe, Reynolds Experiment, Bernoulli's theorem, Characteristics of Centrifugal pump, Packed bed, Fluidized bed.

BCHE207L Mass Transfer-1 (2 – 1 – 0 - 3)

Diffusion - Steady state molecular diffusion; Molecular diffusion in fluids - Diffusivity in solids and fluids; Mass transfer coefficients - Correlation for convective mass transfer coefficient; Theories of mass transfer - Penetration and surface theory; Humidification - Psychrometric Charts, Cooling Towers ; Drying - Rate of Drying, Drying Equipment's; Crystallization - Super saturation, Types of Crystallizers used in practice.

BCHE208L Heat Transfer (3 - 0 - 0 - 3)

Conduction - Steady state and unsteady state conduction; Extended Surfaces and Unsteady state conduction - Fin efficiency and effectiveness, Lumped parameter system; Convection (without phase change) - Convective heat transfer coefficients; Convection (with phase change) - Drop wise and Film wise condensation, Boiling, Condensation; Radiation - Blackbody concepts, Gray bodies ; Heat Exchangers - LMTD, NTU, Effectiveness, Special type of heat exchangers; Evaporators - Design of single and multiple effect evaporators.

BCHE208P Heat Transfer Lab (0 - 0 - 2 -1)

Experiments related to Heat Transfer - Thermal conductivity of metal rod and liquids, Transient Heat Conduction, Fin efficiency & effectiveness, Natural Convection heat transfer, Forced Convection heat transfer, Emissivity, Double Pipe Heat Exchanger, Plate type Heat Exchanger, shell and tube Heat Exchanger , Aspen Plus – EDR and PROSIM software.

BCHE301L Mechanical Operations (3 - 0 - 0 - 3)

Properties and Storage of Solids - Storage and transportation of bulk solids; Size Reduction of Solids - Laws of Crushing, Size Reduction Equipment; Size separation of solids - Screen analysis; Separation of solids based on specific Properties - Wet scrubber, Elutriator; Settling and Sedimentation - free and hindered settling; Filtration – Constant Pressure Filtration, Constant Rate Filtration; Agitation and Mixing - Power Consumption in Agitated vessel, Mixing index.

BCHE301P Mechanical Operations Lab 0 0 2 1

Experiments related to mechanical operations- Screen Effectiveness, Size reduction studies in Jaw crusher, Ball mill, Size reduction studies in Roll crusher, terminal settling velocity of a sphere, Plate and frame filter press, Leaf filter, Determination of area of thickener, Cyclone separator, Effectiveness of mixing.

BCH302L Mass Transfer-II (3 – 0 – 0 – 3)

Introduction to Equilibrium Staged Operations - Vapour–liquid Equilibria, Types of distillation; Distillation - McCabe-Thiele and Ponchon - Savarit graphical method; Absorption - Continuous contact, co-current, counter-current; Extraction- Liquid – Liquid equilibria, extraction equipment; Leaching - rate of leaching, Equipment for leaching; Adsorption – isotherms, Breakthrough Curves; Modern separation techniques - Membrane separation, Chromatography techniques.

BCH302P Mass Transfer Lab (0 – 0 – 2 – 1)

Experiments related to Mass Transfer - Diffusion in gas phase, liquid phase, Wetted wall column, Simple distillation, Tray dryer, Liquid-liquid Equilibria ternary system, cross current Extraction, Continuous distillation , Adsorption (using Aspen Plus or PROSIM), Leaching.

BCHE303L Chemical Reaction Engineering I (3 – 0 – 0 – 3)

Fundamental Concepts and Definitions - rate and stoichiometry; Chemical Kinetics - reaction mechanism, Half-life method; Design of Isothermal Ideal Reactors - Ideal Mixed Flow and plug flow reactor; Multiple Reactors - mixed flow and plug flow reactors in series and parallel; Design of Multiple reactions - simultaneous reactions, Consecutive Reactions; Special Reactors - Semi batch reactor, Bio reactor; Non-isothermal Reactors - Material balance, Energy balance, Adiabatic reactors.

BCHE303P Chemical Reaction Engineering Lab (0 – 0 - 2 -1)

Experiments related to reaction Engineering - equimolar and non-equimolar constant volume batch reactor, Adiabatic batch reactor, Plug flow reactor, Mixed flow reactor , reactor in series, packed bed reactor, RTD studies in Mixed flow reactor, RTD studies in plug flow reactor, RTD studies in packed bed flow reactor.

BCHE304L Chemical Process Technology and Economics (3 – 1 – 0 - 4)

Chloro-alkali and Cement Industries - Manufacture of sulphur, sulphuric acid, Portland cement, glass; Industrial Gases - carbon-di-oxide, hydrogen, oxygen and nitrogen; Fertilizer Industries - NPK Fertilizers; Cellulose, Sugar, Soap and Detergent Production Industries - paper, sugar, soap; Petroleum Industries - Petroleum refining processes; Cost Estimation - Cash flow for industrial operations, financing sources, capital requirements estimation; Cost accounting and Depreciation - Cost and asset accounting, financial statements, Depreciation.

BCHE305L Process Dynamics and Control (3 – 0 - 0 – 3)

Process Instrumentation - Principal measuring instruments in process industries; Linear Open Loop Systems - Forcing functions, first order and second order systems; Linear Closed Loop Systems - Development of Block diagram, controllers and final control elements; Transient Response and Stability Analysis – characteristics of controllers, offset, Routh’s test; Frequency Domain Analysis - Bode stability criteria, Nyquist plot, Controller tuning; Advanced Process Control - Cascade control, Feed-Forward control; Computer Process Control - Distributed Control System, SCADA.

BCHE305P Process Dynamics and Control Lab (0 – 0 – 2 – 1)

Experiments related to process control - Temperature control system, level control system, flow control system, Cascade control loop, Non-interacting tanks/interacting tanks, controller tuning using cohen and coon, controller tuning Ziegler–Nichols method in Simulink, control Valve Characteristics, Ratio control using PROSIM, control using DCS trainer.

BCHE306L Chemical Reaction Engineering II (2 – 1- 0 - 3)

Non-ideal Reactors - Residence Time Distribution, C, E and F curves; Introduction to Heterogeneous Reaction Engineering - Non catalytic fluid-solid reactions, rate-controlling steps; Introduction to Catalytic Reactions - Rate law mechanisms, Rate limiting step; Transport Mechanisms in heterogeneous catalysis - Internal effectiveness, External transport limitations; Catalyst preparation and characterization - Surface area and pore volume determination; Catalyst Deactivation methods - order of deactivation, Catalyst regeneration; Design of Reactors for Fluid-Solid and Fluid-Liquid reactions - Overall view of Fluidized, Packed and Moving bed reactors.

BCHE307L Process Modelling and Simulation (2 – 0 - 0 – 2)

Conservation Principles and Models - Mathematical models, Conservation principles, Constitutive relations; Steady state lumped systems - linear and non-linear algebraic equations; Flow Sheeting and Solution - partitioning and precedence ordering, simultaneous solution, modular solution; Unsteady State Lumped Systems - matrix differential equations, simulation of closed loop systems; Dynamic Simulation of

Unsteady State Lumped Systems - matrix differential equations, simulation of closed loop systems; Steady and unsteady State Distributed systems - Analysis of compressible flow, ODE boundary value problems; Artificial Neural Network - development of ANN based models, Performance of ANN Models.

BCHE307P Process Modelling and Simulation Lab (0 – 0 – 2 – 1)

Experiments related to modeling and simulation - Solution of Algebraic equations, Interacting Tanks in Series, Jacketed stirred tank Heater, Van de Vusse Reaction Mechanism, Non-isothermal CSTRs in series, Biochemical Reactor, Mixing Tank, 1D unsteady state heat conduction, Elliptic PDE and Parabolic PDE using Matlab PDE toolbox.

BCHE308L Chemical Process Equipment Design (3 – 0 – 0 - 3)

Introduction to Process Design - Flowchart and interpretation; Pressure vessel - Codes and standards, mechanical design of pressure vessel, storage vessels; Heat transfer equipment – heat Exchanger design, Condenser design; Heat Exchanger Network - Pinch Technology, Heat exchanger with energy network design; Separation process equipment - Distillation and Absorbers design; Reactor Design - ideal and adiabatic reactors; Simultaneous Heat and Mass transfer Equipment – Design of evaporators and dryers.

BCHE308P Chemical Process Equipment Design Lab (0 - 0 - 2 - 1)

Experiments related process equipment design - 3D drawing and applications, surfaces and geometries, Design and drawing of Pressure vessel, Shell and Tube heat Exchanger, Bubble cap tray, Rotary Louvre dryer, performance of Heat Exchanger using Aspen plus, Distillation Column using Aspen plus, Cost Estimation of Distillation Column using Aspen plus, Dynamic simulation on distillation column using Aspen Plus/Prosimulator

Discipline Elective:

BCHE309L Membrane Separation Processes (3 - 0 - 0 - 3)

Overview, Classification and Membrane Materials - classification, types of membrane processes, membrane material; Membrane Preparation and Characterization - phase inversion process, visual methods; Membrane Transport Theory - Transport through porous membrane and nonporous membrane, fouling model; Reverse Osmosis - Models for reverse osmosis transport, Design of RO module; Nanofiltration - transport mechanism in NF membranes; Microfiltration and Ultrafiltration – MF and UF membranes and modules, membrane rejection and sieving coefficient; Other membrane Processes - Liquid membranes, membrane bioreactors.

BCHE310L Polymer Technology (3 – 0 – 0 – 3)

Basic Concepts of High Polymer Systems - Structural Features of a Polymer, Classification of Polymers; Classification of Polymerization- step-Growth Polymerization, addition polymerization; Polymer Characterization and properties of commercial polymers - Polymer Fractionation, Molecular Weight Distribution, Crystallinity, testing of polymers; Polymer Rheology and Morphology - Stress and Strain, Rheological properties of polymers, Crystallization of Rubber on Cooling; Polymer Processing Techniques - Moulding technique, forming techniques; Polymer Blends, Composites and Conducting Polymers - Bio-nano-composites, Protein-based polymers; Polymers in Wastes and their Environmental Impact - Waste Management, Recovery and Recycling of Organic Wastes.

BCHE311L Process Utilities and Pipeline Design (3 - 0 - 0- 3)

Introduction to process plant utilities - selection of blowers and compressors, Purification and transportation of air; Process water treatment and recycling - recycling aspects of water from blowdowns and rejects; Steam generation and distribution - boiler types, boiler accessories, steam distribution and waste heat utilization; Humidification and refrigeration systems - types of refrigerants, concept of cryogenics and its characteristics; Introduction to Piping Design - Process Auxiliaries, piping drawings, pipe fittings, pipe joints; Piping Materials, Codes and Standards - Metallic materials, ASME – BIS – ISO standards; Piping Installation and Insulation - Overhead installations Weather proof and fire-resisting pipe insulation

BCHE312L Chemical Process Optimization (3 – 0 – 0 – 3)

Formulation of Optimization Problems - Mathematical concepts of optimization; Single Variable Optimization - Unconstrained - Region elimination methods, Polynomial approximations; Multivariable Optimization – Unconstrained - Graphical visualization, Gradient-based methods; Linear Programming - Simplex method, Sensitivity analysis; Nonlinear Programming with constraints - Lagrange multipliers, Quadratic programming; Optimization of Chemical processes-I - Minimum work of gas compression, Optimum recovery of waste heat; Optimization of Chemical processes-II - optimization of heat exchanger networks, optimization of multistage evaporators using MATLAB/Excel.

BCHE313L Environmental Pollution Control (3 - 0 - 0 – 3)

Introduction - Environmental standards, MINAS; Pollution Prevention - Process modification, alternative raw material, energy recovery and waste utilization; Air pollution control - Principles and design of air pollution control equipments; Water pollution control – Selection, design and performance analysis of waste water treatment processes; Solid waste management - Classification of solid waste, 4R concept, waste disposal methods; Hazardous waste management - Hazardous waste classification, e-waste management; Pollution control in chemical process industries - textile and tanneries, electroplating, refineries and thermal power plants.

BCHE314L Fuels and combustion (3 – 0 – 0 – 3)

Classification and Properties of Fuels – Types and characteristics of fuels, Calorific value (CV), Orsat apparatus; Solid fuels - Origin of coal, applications of the coal; Liquid fuels - classification of crude petroleum, processing of crude petroleum; Gaseous fuels - Dry and wet natural gas, LPG, LNG, CNG; Combustion Calculations - Flame and Flame dynamics, air fuel ratio, and carbon Foot print calculation; Combustion Equipment - fuel firing system, Fluidized bed combustion; Alternative Fuels - Adsorbed Natural Gas (ANG), Synthetic natural Gas (SNG), Waste to fuel.

BCHE315L Biochemical Engineering (3 – 0 – 0 – 3)

Introduction to Biochemical Engineering - Scope of biochemical engineering; Basic Microbiology and Biochemistry - overview of biotechnology, diversity in microbial cells, Glucose metabolism; Enzymes & Enzyme kinetics- mechanism of enzymatic reactions, enzymes inhibition, enzyme immobilization; Kinetics of Cell Growth - growth characteristics of microbial cells, inhibition on cell growth; Transport in Microbial Systems - Newtonian and non-Newtonian behavior of broth, gas/liquid transport in cells, heat transport in microbial systems; Bio reactors – Design of bio reactor, Scale up studies; Downstream processes – centrifugation, extraction, membrane separations, cell desruption technologies.

BCHE316L Pharmaceutical Technology 3 0 0 3

Tabletting Technology - Types and classes of tablets, formulation of tablets, tablet coating; Capsules Technology – hard gelatin and soft gelatin capsules; Microencapsulation - core materials, coating materials, evaluation of microcapsules; Parenteral Products - general manufacturing process; Novel Drug Delivery Systems - targeted drug delivery systems, nanoparticles; Packaging Techniques – packaging and stability of products, packaging machinery; Packaging Technology – BFS Technology, Quality Analysis, Packaging designs.

BCHE317L Petroleum Refining Technology (3 - 0 – 0 – 3)

Overview on crude oil and upstream processes - exploration practices, crude oil composition, selection criteria for crude oil; Distillation – Desalting, ADU, VDU; Cracking, visbreaking and coking - Thermal cracking, Catalytic cracking, Hydrocracking; Quality improvement of light end petroleum products - Knocking, Catalytic reforming, Polymerization; Purification of petroleum products - Sweetening processes, Dewaxing , Deasphalting; Fuel additives - Types of oil additives, corrosion inhibitors, fuel dyes; Liquid fuel storage and effluent treatment plant - types of storage tanks , overview of an effluent treatment plant.

BCHE318L Safety and Hazard Analysis (3 – 0 – 0 – 3)

Introduction to Safety in Industry - Hazard, Risk, Danger and Accident, Chemical safety, Industry safety; Safety Programmes in Industry - Safety Analysis in industries, Economic, Social Benefits from safety program; Hazard analysis in the workplace - Hazard identification, Creating HAZOP table for Chemical plants, , Layer of Protection Analysis (LOPA); Risk Assessment - Difference in risk assessment, Risk management, Emergency planning; Safety Models and behaviour-based safety

- Gaussian plume models, What-if analysis, Vulnerability models, Safety audits, safety checklist; Safety in manufacturing and service industries - Formulation of the safety committee, ergonomic safety; Case studies - Dominos' effect, Chemical release.

BCHE319E Process Plant Design and Simulation (2 – 0 - 2 - 3)

Introduction - Process synthesis, flow sheeting & simulations; Approaches to process simulation - Equation solving approach used in process plant simulation; Equation solving approach - Partitioning, Decomposition, Direct Methods, Iterative methods; Decomposition of Networks - digraph, signal flow graph, Boyer Moore (BM) Algorithm; Convergence promotion - Linear equation, nonlinear equation, Convergence Promotion scheme Newton's method, Wegstein's method; Application of flow sheeting software - Aspen Plus-Steady state simulation, Aspen Hysys-dynamic simulation; Case studies: Process plant steady-state and dynamic simulation.

BCHE320L Chemical Product Design (3 - 0 – 0 – 3)

Introduction - Introduction to chemical product design; Needs of chemical product - Customer needs, lead users, interviews; Needs to specifications - Consumer assessments, Converting needs to specifications; Ideas – brainstorming, Chemical sources of ideas, sorting the ideas, screening the ideas; Selection of ideas - ingredient substitutions, selection using kinetics, risk in product selection; Product manufacture - patents and trade secrets, supplying missing information, micro structured products; Speciality chemical manufacture and Economic Concerns - extending laboratory results, heuristics for separations, Product versus process economics, time value of money.

BCHE321L Natural Gas Engineering (3 – 0 – 0 – 3)

Properties and Composition of Natural Gas - Natural Gas origin, Thermodynamic properties; Natural Gas Extraction - Onshore Extraction, Offshore Extraction; Natural Gas Offshore Production and Handling - Drilling Deep-water Reservoir, Mooring Systems; Natural Gas Onshore Production and Handling- Sucker rod pumping; Natural Gas Processing – Dehydration, Desulphurization processes, Low-temperature processes; Liquid Recovery – Natural Gas Liquids(NGL), LPG, C3 and

C2 fraction recovery from Natural Gas; Economics of Natural Gas - Trade & selection of port location, Economics of gas processing.

BCHE322L Nanoscience and Nanotechnology (3 – 0 – 0 – 3)

Introduction - Scientific revolution, influence of nano over micro/macro; Types of nanostructure and their properties - Quantum Dots shell structures, mechanical-physical-chemical properties; Synthesis and stability of nanomaterials - Top-down and bottom-up methods, electrostatic stabilization; Metal, semiconductor and magnetic nanoparticles - Core-Shell structured and semiconductor nanoparticles, Janus nanoparticles; Nano scale device fabrication - Lithography techniques, inferometric techniques, nano scale coating techniques; Nano scale characterization techniques - surface and bulk morphological properties, nano mechanic properties; Application of nanomaterials - molecular electronics and nanoelectronics, membrane-based application.

BCHE323L Fertilizer Technology (3- 0 – 0 - 3)

Overview of Fertilizers - Plant Nutrients, Fertilizer production and consumption, Raw materials; Nitrogenous Fertilizers - Ammonium sulphate, Ammonium chloride, Ammonium nitrate; Phosphatic Fertilizers - Production of sulphuric and phosphoric acids, Single superphosphate, Triple superphosphate, Thermal phosphates; Potassic Fertilizers - Potassium Chloride, Potassium sulphate, Potassium magnesium sulphate; Complex Fertilizers - Urea ammonium phosphate, Ammonium phosphate sulphate; Other Fertilizers – Biofertilizers, Controlled release fertilizers; Pollution from fertilizer industry - Solid, liquid and gaseous pollution.

BCHE324L Fermentation Technology (3 – 0 – 0 - 3)

Introduction and history of fermentation processes - Development of fermentation process; Microbial growth kinetics - Batch, Continuous and fed-batch, structured and unstructured models of culture; Microbial Strain Management - Industrial microorganisms, isolation, preservation of strains; Media for industrial fermentations - Media formulation, oxygen requirements, Media optimization; Aseptic fermentation process - Media sterilization, Development of inocula; Fermenters - Aeration and agitation, Foam control, stirred & sparred tanks fermenters; Process technology for bulk products - Downstream processing, flow sheet and process description of modern processes.

BCHE391J Technical Answers to Real Problems Project (0 – 0 – 0 – 3)

Students are expected to perform a survey and interact with society to find out the real life issues. Logical steps with the application of appropriate technologies should be suggested to solve the identified issues. Subsequently the student should design the related system components or processes which is intended to provide the solution to the identified real-life issues.

BCHE392J Design Project (0 – 0 - 0 – 3)

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

BCHE393J Laboratory Project (0 – 0 – 0 – 3)

Students are expected to perform experiments and gain hands-on experience on the theory courses they have already studied or registered in the ongoing semester. The theory course registered is not expected to have laboratory component and the student is expected to register with the same faculty who handled the theory course. This is mostly applicable to the elective courses. The nature of the laboratory experiments (wet lab / dry lab) is depended on the course

BCHE394J Product Development Project (0 – 0 – 0 – 3)

Students are expected to translate the developed prototypes / working models into a product which has application to society or industry. Evaluation involves periodic reviews by the faculty with whom the student has registered.

BCHE395J Computer Project (0 – 0 – 0 – 3)

Students are expected to use programming skills or modelling to analyse complex engineering processes. The student should be able to evaluate the application and limitations of the said engineering processes. Evaluation involves periodic reviews by the faculty with whom the student has registered.

BCHE396J Reading Course (0 – 0 – 0 – 3)

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty. It is expected to have at least 10 students to form a group and come up with a specific topic. Assessments will be as per the academic regulations slated for the theory course.

BCHE397J Special Project (0 – 0 – 0 – 3)

This is an open-ended courses in which the student is expected to work on a time bound research project under the supervision of a faculty. The result should be a tangible output in terms of publication of research articles in a conference proceeding or in a peer-reviewed Scopus indexed journal.

BCHE398J Simulation Project (0 – 0 – 0 – 3)

The student is expected to simulate and critically analyse the working of a real system. Role of different variables which affect the system has to be studied extensively such that the impact of each step in the process is understood, thereby the performance of each step of the engineering process is evaluated. Evaluation involves periodic reviews by the faculty with whom the student has registered.

BCHE401L Petrochemical Technology (3 – 0 – 0 – 3)

Petrochemicals and Precursors - Selection of precursors; Alkanes and Alkenes - Manufacture of Petrochemical Derivatives from C1, C2, C3, C4 compounds; Aromatics - Manufacture of Petrochemical Derivatives from Benzene, Toluene, Xylene and Styrene; Petrochemical Derivatives - Dimethyl Terephthalate, cumene, diphenyl carbonate; Polymers - poly butadiene rubber, Styrene-Butadiene Rubber (SBR); Plastics and Fibres – Melamine, Formaldehyde resins; Economics of Petrochemical Industry - Selection of Petrochemical products, Economics of Petrochemical derivatives.

BCHE402L Food Process Engineering (3 – 0 – 0 – 3)

Introduction to food - Constituents of food, contribution to organoleptic and textural characteristics; Food microbiology and food additives - Food borne diseases and food spoilage, Functional characteristics of additives in food processing; Food process calculations - Material and energy balances in food processing; Unit operations in food processing - Concept of food rheology and viscoelastic foods, Mechanical separations, Heat exchangers, Evaporators, Dryers; Food preservation techniques - sterilization and pasteurization, Food canning technology, microwaves, sterilization of canned food; Food processing and food quality - Processing of Cereal grains, Vegetables, Food quality parameters and their evaluation; Food packaging - Types of packaging, Packaging design.

BCHE403L Process Intensification (3 – 0 – 0 – 3)

Introduction - Techniques of Process Intensification (PI), Applications, benefits from process intensification; Process intensification through micro reaction technology - Implementation of Micro reaction Technology, Microfabrication of Reaction and unit operation Devices, Wet and Dry Etching Processes; Mixing and flow pattern - Scales of mixing, Flow patterns in reactors, Mixing in intensified equipment, Ultrasound Atomization, High intensity inline mixers reactors, Static mixers; Combined chemical reactor with heat exchange and reactor/separators - Reactive absorption, Reactive distillation; Compact heat exchangers - Plate heat exchangers, Spiral heat exchangers, Selection of heat exchanger technology; Enhanced fields - Cavitation Reactors, Sono crystallization; Case studies - Petrochemicals and Fine Chemicals, Nuclear Industry.

BCHE404L Colloids and Interfacial Science (3 – 0 – 0 – 3)

Introduction to Colloid & Interface Science - Fundamentals of Colloid Science, Electrostatic Interactions in Colloids, The electrical double layer (EDL) theory; Surface Tension and Contact Angle - Lewis Acid-Base interactions, Du Noüy ring method , Wilhelmy plate method; Interactions at Interfaces - Surfactants Types, Micellization of surfactant, Hydrophilic-lipophilic balance (HLB); Emulsions - Thermodynamics of emulsification, micro emulsion, foams; Design of Interfaces - Models of adsorption, calculation of free energy of adsorption; Principles of Light Scattering - Static light scattering, Dynamic light scattering; Application of Colloids and Interfacial phenomena – Colloidal and interfacial phenomena in biology, Medicine, Tribology.

BCHE405L Fluidization Engineering (3 – 0 – 0 – 3)

Introduction - Concept of Fluidization, Industrial Applications of Fluidized Beds; Characteristics of solids - Geldart Classifications of Particles, Gas-solid system , Liquid-solid system; Characterization of Fluidization I - Mapping of Fluidization Flow pattern, Behaviour of Fluidized Beds; Characterization of Fluidization II - Frictional pressure drop and its model, Design of Distributors; Entrainment and Elutriation - Entrainment from Tall and Short Vessels, Flow Pattern of Gases through Fluidized Beds; Heat Transfer in Fluidized Beds - Fluid-solid heat transfer, Determination and Interpretation of Heat Transfer; Miscellaneous systems - Conical fluidized bed, Inverse fluidized bed, Draft tube systems, Design of fluidized bed reactors.

BCHE406L AI in Chemical Engineering (3 – 0 – 0 – 3)

Artificial Intelligence in Chemical Engineering - phases of AI, expert systems, neural network; Artificial Neural Networks (ANN) - neural network architecture, learning methods, clustering, classification; Introduction to Fuzzy Logic - fuzzy sets and concepts, fuzzy relations, Adaptive Neuro Fuzzy Inference System (ANFIS); AI in Process Modelling - ANN models, fuzzy logic models, hybrid models; AI in Process Optimization - genetic algorithm, swarm optimization; AI in fault detection and diagnosis - neural network method, fuzzy logic method; AI in Process Control - Conventional versus AI based process control, ANN, Fuzzy logic, ANFIS.

Project and Internship :

BCHE399J Summer Industrial Internship (0 – 0 – 0 – 1)

Four weeks of work at industry site. Supervised by an expert at the industry.

BCHE497J Project – I (0 – 0 – 0 – 3)

Carried out inside or outside the university, in any relevant industry or research institution. Publications in peer-reviewed journals / International Conferences will be an added advantage

BCHE498J Project - II/Internship (0 – 0 – 0 – 5)

Carried out inside or outside the university, in any relevant industry or research institution. Publications in peer-reviewed journals / International Conferences will be an added advantage

BCHE499J One Semester Internship (0 – 0 – 0 – 14)

Carried out inside or outside the university, in any relevant industry or research institution. Publications in peer-reviewed journals / International Conferences will be an added advantage

Date : 21-02-2022

Signature Dean, SCHEME

Dean
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