SCHEME & SYLLABUS

OF

V & VI SEMESTERS

B.E.CHEMICAL ENGINEERING

2023 – 2024

[for 2021 admitted batch, 160 credit course, NEP 1.0]

About Institute:

Siddaganga Institute of Technology (SIT) was established in the year 1963 by Siddaganga Education Society, as a private self-financing institution with the following vision and mission.

Vision of the Institute:

To develop thoughtful and creative young minds in a learning environment of high academic ambience by synergizing spiritual values and technological competence.

Mission of the Institute:

- To continuously strive for the total development of students by educating them in state-of-the art technologies and managerial competencies providing best in class learning experience with emphasis on skills, values and learning outcomes and helping them imbibe professional ethics and societal commitment.
- To create research ambience that promotes interdisciplinary research catering to the needs of industry and society.
- To collaborate with premier academic and research institutions and industries to strengthen multidisciplinary education, applied research, innovation, entrepreneurship and consulting ecosystems.

Quality Policy:

Siddaganga Institute of Technology is committed to:

- Impart quality education by establishing effective learning-teaching – learning processes to produce competent engineers with high professional ethics and social responsibility.
- Create congenial environment and provide state-of-the-art infrastructure.
- Continually improve the effectiveness of the quality management system.
- Satisfy all applicable requirements.

Vision of the Department:

To be an internationally renowned department for chemical engineering education and research meeting the aspirations of society.

Mission of the Department:

M1. To impart quality education in chemical engineering at all levels.

M2. To foster cutting edge research and development in chemical engineering. M3. To produce responsible and ethical engineers to serve society.

Program Educational Objectives (PEOs)

The Program Educational Objectives of the program are:

The graduates shall possess

1. a sound knowledge of chemical engineering to pursue a successful professional career.
2. a spirit of inquiry and urge to pursue research in chemical engineering and thrust areas.
3. high ethical values and be socially responsible in discharging their duties.
4. knowledge of the latest developments in their field of activity and commit themselves to life-long learning.

Program Specific Outcomes (PSOs):

The following are the PSOs defined by the Chemical Engineering department:

PSO-1: Graduates will be able to apply the knowledge of science and transport process for production and separation of chemicals in chemical and allied industries

PSO-2: Graduates will be able to analyze processes/equipment taking into consideration, process safety, project engineering, economics and environmental aspects.

PSO-3: Graduates will be able to analyze processes using process control, process optimization and integration using modelling/simulation tools for process development

PSO-4: Graduates will be able to design chemical equipment for a given process.

Program Outcomes:

The following are the Program Outcomes:

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

2. **Problem analysis**: Identify, formulate, review research literature, and analyze 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 modeling 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, and 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**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

The above POs are achieved through curriculum that offers courses under mathematics and basic sciences, basic engineering courses, professional core, professional electives, laboratory courses, open electives, humanity courses, projects, technical seminar and the industrial training and mandatory courses. Each course under these course components have COs that are mapped to the POs. The attainment of POs is achieved through attaining the COs.

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A' grade & ISO 9001:2015 Certified)

B.E. in Chemical Engineering

SCHEME OF TEACHING AND EXAMINATION (160 Credits Scheme, NEP 1.0, 2021 admitted)

V Semester

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs/week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	IPCC	N5CHI01	Process Dynamics and Control	Chemical	3	0	2		3	50	50	100	4
2.	PCC	N5CH01	Chemical Reaction Engineering	Chemical	3	0	0		3	50	50	100	3
3.	PCC	N5CH02	Mass Transfer	Chemical	3	0	0		3	50	50	100	3
4.	PCC	N5CH03	Chemical Equipment Design	Chemical	3	0	0		3	50	50	100	3
5.	PCC	N5CH04	Chemical Technology	Chemical	3	0	0		3	50	50	100	3
6.	PCC	N5CHL01	Mass transfer Lab	Chemical	0	0	2		3	50	50	100	1
7.	HSMC	NSH04	Environmental Science		1	0	0		2	50	50	100	1
8.	AEC	N5CHAXX	**Respective Department to decide on the course**		If offered as Theory Course				3	50	50	100	2
					2	0	0						
					If offered as Integrated Course								
					1	0	2						
9.	NCMC	NSH07	Soft Skills	T&P	36 hrs. during the entire semester					100	--	100	0
			Total							**500**	**400**	**900**	**20**
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for the examination									

Note: **IPCC:** Integrated Professional Core Course; **PCC:** Professional Core Course, **HSMC:** Humanity and Social Science & Management Courses, **AEC** –Ability Enhancement Courses. **INT** –Internship, **UHV**- Universal Human Value Courses

L –Lecture, **T** – Tutorial, **P**- Practical/ Drawing, **S** – Self-Study Component, **CIE:** Continuous Internal Evaluation, **SEE:** Semester End Examination

Soft Skills Training Programme is a Non Credit Mandatory Course **for all the Programmes**. Dean Academic to schedule the even in the Academic Calendar.

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with Practicals of the same course. Credit for IPCC can be 04 and its Teaching – Learning hours (L:T:P) can be considered as (3:0:2) or (2:2:2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from practical part of IPCC shall be included in the SEE question paper.

Ability Enhancement Course – V (Offered by the Department)

N5CHA1	Process Simulation for Chemical Engineer	N5CHA3	Energy and Environmental Auditing
N5CHA2	Data Analytics	N5CHA4	Introduction to Process Technology

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B.E. in Chemical Engineering

SCHEME OF TEACHING AND EXAMINATION (160 Credits Scheme, NEP 1.0, 2021 admitted)

VI Semester

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs/week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	IPCC	N6CHI01	Computer Application and Modeling in Chemical Engg	Chemical	3	0	2		3	50	50	100	4
2.	HSMC	NHS06	Management and Entrepreneurship	ME, IM, MBA	3	0	0		3	50	50	100	3
3.	PEC	N6CHPE1X	Professional Elective Course-I	Chemical	3	0	0		3	50	50	100	3
4.	OEC	21OEXX	Open Elective Course-I		3	0	0		3	50	50	100	3
5.	PCC	N6CHL01	CRE Lab	Chemical	0	0	2		3	50	50	100	1
6.	MP	N6CHMP	Mini Project	Chemical	1 full day per week					100	--	100	2
7.	Internship	INT2	**INTERNSHIP –II** (4 weeks)	Chemical						100	--	100	3
8.	AEC	ARAS	Aptitude Related Analytical Skills	T&P	36 Hrs. for the entire semester				2	50	50	100	1
			Total							**500**	**300**	**800**	**20**
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for the examination									

Professional Elective - I

N6CHPE11	Material Science and Engineering	N6CHPE13	Organic synthesis
N6CHPE12	Advanced Mass Transfer Operations	N6CHPE14	Introduction to Risk Management in Process Industries

Note: **IPCC**: Integrated Professional Core Course; **PCC**: Professional Core Course, **HSMC**: Humanity and Social Science & Management Courses, **PEC** – Professional Elective Course; **OEC**- Open Elective Course; **MP**-Mini Project; **AEC** –Ability Enhancement Courses, **NCMC** – Non Credit Mandatory Course

L –Lecture, **T** – Tutorial, **P**- Practical/ Drawing, **S** – Self-Study Component, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Examination

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with Practicals of the same course. Credit for IPCC can be 04 and its Teaching – Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from practical part of IPCC shall be included in the SEE question paper.

Professional Elective Courses (PEC):

A Professional Elective Course (PEC) is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses are added to supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course out of four courses. The minimum students' strength for offering professional electives is 10.

Open Elective Courses:

Students belonging to a particular stream of Engineering and Technology are not entitled for the open electives offered by their parent Department.

However, they can opt an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor. Selection of an open elective shall not be allowed if,

i) The candidate has studied the same course during the previous semesters of the program.
ii) The syllabus content of open electives is similar to that of the Departmental core courses or professional electives.
iii) A similar course, under any category, is prescribed in the higher semesters of the program.

The minimum students' strength for offering open electives is 20.

Mini-project work:

Mini Project is a laboratory-oriented course which will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications.

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students. **Departments shall allocate one full day for Mini-project in the Time Table.**

CIE procedure for Mini-project:

(i) **Single discipline:** The CIE marks shall be awarded by a committee, DPEC - consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of Project Report, Project Presentation skill, Question & Answer session and Guide Assessment in the ratio of 40:20:20:20. The marks awarded for the project report shall be the same for all the batch mates.

(ii) **Interdisciplinary:** Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the project. The CIE marks awarded for the Mini-project be based on the evaluation of Project Report, Project Presentation Skill, Question & Answer session and Guide Assessment in the ratio 40:20:20:20. The marks awarded for the project report shall be the same for all the batch mates. **No SEE component for Mini-Project.**

VII semester Class work and Research Internship / Industry Internship (INT3)

Swapping Facility

Departments can swap VII and VIII Semester Scheme of Teaching and Examinations to accommodate research internship/ industry internship after the VI semester. Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether VII or VIII semester is completed during the beginning of IV year or later part of IV year of the program.

Elucidation:

At the beginning of IV year of the programme i.e., after VI semester, VII semester classwork and VIII semester Research Internship /Industrial Internship shall be

permitted to be operated simultaneously by the Department so that students have ample opportunity for internship. In other words, a good percentage of the students shall attend VII semester classwork and similar percentage of others shall attend to Research Internship or Industrial Internship.

Research/Industrial Internship shall be carried out at an Industry, NGO, MSME, Innovation centre, Incubation centre, Start-up, Centers of Excellence (CoE), Study Centre established in the parent institute and /or at reputed research organizations / institutes. The internship can also be rural internship.

The mandatory Research internship /Industry internship is for 24 weeks. There will be both CIE and SEE for the internship (INT3).

Those, who do not take up/complete the internship shall be declared fail and shall have to complete during the subsequent examination after satisfying the internship requirements.

INT3 Research Internship/ Industry Internship/Rural Internship

Research internship: A research internship is intended to offer the flavour of current research going on in the research field. It helps students get familiarized with the field and imparts the skill required for carrying out research.

Industry internship: Is an extended period of work experience undertaken by students to supplement their degree for professional development. It also helps them to learn how to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with contingencies helps students recognize, appreciate, and adapt to organizational realities by tempering their knowledge with practical constraints.

Rural internship: A long-term goal, as proposed under the AICTE rural internship programme, shall be counted as rural internship activity.

The student can take up Interdisciplinary Research Internship or Industry Internship.

The faculty coordinator or mentor has to monitor the students' internship progress and interact with them to guide for the successful completion of the internship.

The students are permitted to carry out the internship anywhere in India or abroad. Institute shall not bear any expenses incurred in respect of internship.

PROCESS DYNAMICS AND CONTROL

Contact Hours/ Week	2+2+2 (L+T+P)	Credits	4.0
Total Lecture Hours	26	CIE Marks	50
Total Tutorial Hours	26	SEE Marks	50
Practical contact hours	26		
Sub. Code	N5CHI01		

Course Objectives: This course will enable students to:

1. Introduce to the concept of process dynamics, laplace transformations and response of dynamic systems to step, pulse, ramp and sinusoidal inputs.
2. Learn about the single-loop feedback control systems and evaluation of the same under different input conditions for processes.
3. Acquaint with the concept of stability of control systems and its significance in operation of different type of control systems.
4. Introduce to the area of advanced control techniques and their significance in process industry

Unit – I

First-order systems: Transfer function, transient response, forcing functions, step response, impulse response, ramp response, sinusoidal response. **Examples of first-order systems:** Liquid level, liquid-level process with constant-flow outlet, mixing process, heating process; Linearization. Conceptual numerical. **6 + 6 Hrs**

Unit – II

First-order systems in series: Non-interacting system, several non- interacting systems in series**;** interacting system.

Second-order systems: Manometer, Damped vibrator, Transfer function, step response, terms used to describe an under-damped system, impulse response, sinusoidal response; Transportation lag. **5 + 5 Hrs**

Unit – III

The control system: Components of a control system, development of block diagram.

Controllers and final control elements: Control valve and controller mechanisms, ideal transfer function of control valve, Proportional control, on/off control, PI, PD, and PID control actions. **5 + 5 Hrs**

Unit – IV

Closed-loop transfer functions: Overall transfer function for single-loop and multi-loop control systems.

Transient response of simple control systems: Proportional control for set point and load changes, PI control for load and set point changes, Proportional control of system with measurement lag.

5 + 5 Hrs

Unit – V

Stability: Concept, criterion, and characteristic equation; Routh test for stability.

Frequency response: Substitution rule, Bode diagrams

Advanced control techniques: Cascade, feed-forward and ratio controls. **Controller tuning techniques:** Ziegler-Nicholas method and Cohen-Coon method. **5 + 5 Hrs**

TEXTBOOK:

Coughanowr, D. R. and LeBlanc, S. E	Process Systems Analysis and Control, McGraw Hill, New York, 3e, 2009, ISBN: 978-0-07-339789-4

REFERENCE BOOKS:

Seborg, D. E., Edgar, T. F., Mellichamp, D. A. and Doyle, F. J	Process Dynamics and Control", Wiley India Pvt Ltd, New Delhi, 3e, 2011, ISBN: 978-8-12-654126-3
Svrcek, W. Y., Mahoney, D. P. and Young, B. R	A Real-Time Approach to Process Control", John Wiley & Sons Ltd, Chichester, 3e, 2014, ISBN: 978-1-11-999388-9.

Course Outcomes: After the completion of the course, the student will be able to:

1. Demonstrate knowledge about dynamic control systems and their response to pulse, step, ramp and Sinusoidal inputs.
2. Illustrate single-loop feedback control of processes and evaluate the same for its performance for different types of inputs.
3. Estimate the stability limits for a system, with control.
4. Calculate and use the frequency response of a control system.

CHEMICAL REACTION ENGINEEING

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	------	SEE Marks	50
Sub. Code	N5CH01		

Course Objectives: This course will enable students to:

1. Introduce to the concepts of chemical reaction engineering along with importance of chemical kinetics, thermodynamics, mass and energy balances, and transport phenomena to the design of chemical reactors.
2. Learn about rates of chemical reaction, laws and theories governing temperature dependence, rate law, reaction order and activation energy.

3. Acquaint to predict the performance of common chemical reactors using simplified engineering models.
4. Learn to use the experimental data to determine the kinetic model of a multi-reaction system and based on results design a commercial reactor size.
5. Educate students to design ideal reactors (batch &continuous) for various operating requirements and compare their performance for multiple reactor systems

Unit – I

Kinetics of Homogeneous Reactions: Concentration-dependent term of a rate equation: (Single and Multiple reactions, Elementary and Nonelementary Reactions, Molecularity and order of reaction, Rate Constant, Representation of elementary reaction, Representation of Nonelementary reactions, Kinetic Models of Nonelementary Reactions, Testing Kinetic Models)

Temperature-dependent term of a rate equation: Temperature dependency from Arrhenius law, Collision theory, Transition state theory, Thermodynamic approach, Activation Energy. **8 Hrs**

Unit – II

Interpretation of Batch Reactor Data:

Constant-Volume batch Reactor: Analysis of Total pressure data, Integral Method of Analysis of Data(Irreversible I order Reactions, II order, nth order, Zero-order, Overall order of Irreversible reactions from the half-life, Irreversible Reactions in parallel, Homogeneous catalyzed reactions, Auto catalytic reactions, Irreversible Reactions in series, First order reversible reactions, Reactions of shifting order) Differential method of analysis of data.

Varying-Volume batch Reactor: Applications for Zero order, First order, Second order Reactions. **7 Hrs**

Unit – III

Ideal Reactors for a Single Reaction: Ideal Batch Reactor, Space-Time and Space-Velocity, Mixed flow reactor, Plug flow Reactor, Holding time and space time for flow reactors. General features of reactors, Numericals. **8 Hrs**

Unit – IV

Design for Single Reactions: Size comparison of single reactors, Multiple- Reactor systems (PFR in series and/or in parallel, Equal size MFR in series, Reactors of different types in series), Recycle Reactor, Numericals. **8 Hrs**

Unit – V

Multiple Reactions:

Design for Parallel Reactions: Qualitative Discussion about product distribution, Contacting patterns for reactions in parallel, Operating conditions for parallel reactions.

Design for Series Reactions: First order irreversible reactions in series, Qualitative discussion about product distribution,

Quantitative treatment, Plug flow or batch reactor, Quantitative treatment, mixed flow reactor.

Temperature and Pressure effects: Single reactions- heats of reaction from thermodynamics, heats of reaction and temperature, equilibrium constants from thermodynamics, equilibrium conversion, general graphical design procedure, optimum temperature progression, heat effects, adiabatic operations, non adiabatic operations, comments and extensions.

8 Hrs

TEXTBOOKS:

Octave Levenspiel	Chemical Reaction Engineering, Wiley Publishers, 3e, 2006, ISBN: 978-8126510009
Himadri Roy Ghatak	Reaction Engineering Principles, CRC Press, 1e, 2016, ISBN:978-1-4987-5858-1

REFERENCE BOOKS:

Fogler H Scott	Elements of chemical Reaction Engineering, Pearson Education India, 4e, 2015, ISBN:978-9332549326.
J.M. Smith	Chemical Engineering Kinetics, McGraw Hill, 3e, 2014, ISBN-13: 978-9332902633.

Course Outcomes: After the completion of this course, students will be able to:

1. Formulate stoichiometric relations and kinetic rate expression for elementary and non-elementary reactions considering thermodynamic consistency.
2. Apply the principles of reaction kinetics, formulate rate equations and analyze the batch reactor data
3. Solve chemical reaction engineering problems applying material and energy balance equations to batch, semi-batch and continuous type reactors for different reaction systems.
4. Calculate operating parameters (size, flow rates, conversion, etc.) for designing ideal type of reactors under isothermal conditions.
5. Analyse and select reactor type to achieve a desired reactant conversion/ selectivity/ yield.

MASS TRANSFER

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	N5CH02		

Course Objectives: This course will enable students to:

1. Develop familiarity with the basic principles of diffusion, mass transfer coefficients and Interphase mass transfer to enable selection of appropriate recovery process.
2. Introduce the fundamentals of molecular diffusion and convective diffusion in the context of distillation, drying and humidification processes.
3. Train students to apply mass transfer principles, material and energy balance to solve problems related to distillation, drying and humidification processes.
4. Facilitate the students to carry out selection of appropriate recovery process and perform basic design of the mass transfer equipment involved.
5. Enable students to demonstrate the knowledge and need for sustainable operations including distillation, drying and humidification in the context of environment and economics.

Unit - I

Introduction to Mass Transfer Operations: Classification of mass transfer operations, Diffusion: Molecular and Eddy diffusion, Diffusivity, Steady state molecular diffusion in fluids - molecular diffusion in gases and liquids, pseudo steady state diffusion, Diffusion in solids. **7 Hrs**

Unit - II

Mass transfer coefficients and Interphase mass transfer: Mass transfer coefficients, mass transfer theories: Film theory, Penetration theory, Surface renewal theory. Interphase mass transfer: Equilibrium, two-phase mass transfer, overall mass transfer coefficient. Types of operations: co- current process, counter-current process. **8 Hrs**

Unit - III

Distillation: Vapour liquid equilibria, relative volatility, computation of vapour liquid equilibria, types of distillation columns – batch column, continuous column, steam distillation, equilibrium distillation, simple distillation, Continuous rectification: McCabe Thiele Method: location of feed tray, reflux ratio.

8 Hrs

Unit - IV

Drying: Moisture content - wet and dry basis, equilibrium moisture, bound moisture, unbound moisture, free moisture, critical moisture content, constant rate drying period, falling rate drying period, classification of drying operations: batch and continuous drying. Parameters affecting drying rate during constant rate drying period. Drying Equipment: rotary dryer, drum dryer, spray dryer, freeze dryer. **8 Hrs**

Unit - V

Humidification: Molal absolute humidity, saturated absolute humidity, dry bulb temperature, relative humidity, percentage saturation, dew point, humid heat, enthalpy, humid volume, adiabatic saturation curves, wet bulb temperature, Equipment:

Types of cooling towers, spray chambers, spray ponds. **8 Hrs**

TEXTBOOKS:

Robert. E. Treybal	Mass Transfer Operations, Mc Graw Hill. NY, 3e, 2012, ISBN:978-1259029158
Narayanan and Lakshmikutty	Mass Transfer-Theory and Applications, CBS Delhi, 1e, 2005, ISBN:978-8123924212

REFERENCE BOOKS:

N Anantharaman and K M M S Begum	Mass Transfer: Theory and practice, PHI Learning Pvt., Ltd., 2013, ISBN:978-81-203-4169-2
Coulson J F	Chemical Engineering, Vol. I & II, Elsevier India, 6e, 2006, ISBN: 978-8181473868
Mc Cabe and J.M.Smith	Unit Operations in Chemical Engineering, McGraw Hill,7e, 2004, ISBN: 9780072848236
Geankoplis C.J.	Transport Processes and Unit Operations, Prentice Hall of India, New Delhi, 4e, 1993, ISBN: 978-0139304392

Course Outcomes: After the completion of the course, the student will be able:

1. Apply the concepts of diffusion and convection to vapor-liquid and solid-liquid processes to identify and formulate criteria for selecting appropriate separation processes.
2. Analyze problems related to mass transfer including humidification, drying, distillation and apply mass transfer concepts to calculate mass transfer rate.
3. Solve problems related to interfacial mass transfer, distillation, drying and humidification, analyze the data and infer the solution.
4. Utilize mass transfer concepts for basic design of mass transfer equipment.
5. Demonstrate life-long learning of emerging mass transfer operations and communicate the findings as an individual or as a part of a team.

CHEMICAL EQUIPMENT DESIGN

Contact Hours/ Week	2+2+0 (L+T+P)	Credits	3.0
Total Lecture Hours	26	CIE Marks	50
Total Tutorial Hours	26	SEE Marks	50
Sub. Code	N5CH03		

Course Objectives: This course will enable students to:

1. Learn about the standard design methodology for the design of double pipe heat exchangers, shell and tube heat exchanger, condenser and evaporator with mechanical design

of flanges, supports and enclosures for different heat load conditions
2. Learn about the standard design methodology for the design of mass transfer equipment such as bubble column distillation, packed bed absorption column and rotary dryer.

Unit-I

Detailed process and mechanical design of the following heat transfer equipment: Double-pipe heat exchanger, Shell and tube heat exchanger, Horizontal/Vertical condenser, and Single-effect evaporator. **13+13 Hrs**

Unit-II

Detailed process and mechanical design of the following mass transfer equipment: Bubble cap distillation column, Packed bed absorption column, and Rotary dryer.

13+13 Hrs

Note for Semester End Examination:
The question paper shall contain two full design problems (100 Marks each) from each unit and the student is required to answer any one.
Perry's Chemical Engineers' Handbook and the relevant IS Codes shall be allowed in the examination as reference. The answer shall include detailed process design steps using the data given in the problem and mechanical design of the components

TEXTBOOKS:

V.V. Mahajani and S.B. Umarji	Joshi's Process Equipment Design, Laxmi Publications, 5e, 2016, ISBN: 978-9351380191
S. D. Dawande	Process Design of Equipment – Vol. 1, Central Techno Publications, 6e, 2012, ISBN: 978-8189904425

REFERENCE BOOKS:

Brownell and Young	Process Equipment Design, John Willey, 1e, 2009, ISBN: 978-8126524471.
Maloney, I.O	Perry's Chemical Engineers Handbook, McGraw Hill, Companies, Inc., 8e, 2008, ISBN: 978-0071542086.

Course Outcomes: After the completion of the course, the student will be able to:
1. Demonstrate skills for the design of double pipe heat exchangers, shell and tube heat exchanger, condenser and evaporator with mechanical design of flanges, supports and enclosures for different heat load conditions using standard design criteria and procedure.

2. Demonstrate skills for design of mass transfer equipment such

as bubble column distillation column, packed bed absorption and rotary dryer using standard design criteria and procedure.

CHEMICAL TECHNOLOGY

Contact Hours / Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	N5CH04		

Course Objectives: This course will enable students to:

1. Introduce to the process flow sheets of important chemical processes that are being adopted by the industry along with alternative process technologies in nutshell.
2. Learn about the availability of raw materials for a product, production trends, preparation of flow sheets, engineering problems associated with each of the processes.

Unit-I

Carbohydrate and fermentation industries: Manufacture of Sucrose, starch and Starch derivatives. Manufacture of Ethyl Alcohol, Citric Acid, Acetic acid and beer by fermentation.

8 Hrs

Unit-II

Edible and essential Oils, soaps and detergents: Production and extraction of vegetable oils, Hydrogenation of oils, refining of oils, production of fatty acids, glycerine and soap, Production of detergents.

Pulp and paper industries: Methods of pulping, Production of pulp, Production of paper. **7 Hrs**

Unit- III

Chlor - Alkali Industries: Manufacture of soda ash, Caustic soda and Chlorine.

Industrial gases: Manufacture of Carbon dioxide, Hydrogen, Oxygen and Nitrogen, Water gas, Producer gas.

Cement Industries: Manufacture of cement. **8 Hrs**

Unit-IV

Sulfur industry: Elemental sulphur mining and Manufacture of sulphur.

Acids: Manufacture of sulphuric acid, Hydrochloric acid, Phosphoric Acid and Nitric acid

Fertilizer industry: Manufacture of Ammonia, Urea, Calcium Phosphates, Ammonium Phosphates. **8 Hrs**

Unit – V

Polymer and Rubber industries: Polyethylene, Polypropylene,

PVC and Phenol-Formaldehyde resin, Urea-Formaldehyde resin, SBR, Viscose rayon, Nylon, Rubber Vulcanization. **8 Hrs**

Note: Unit Process and Unit operations involved, main / side reactions, raw materials / utility required and ratios flow sheet, major unit operations and equipment, engineering problems end uses and examples of such industries in India and reasons for their locations of the above industries are to be discussed.

TEXTBOOK:

M Gopal Rao	Dryden: Outlines of Chemical Technology, for 21st Century, EWP, 3e, 2010, ISBN: 9788185938790

REFERENCE BOOKS:

George T. Austin.,	Shreve's Chemical Process Industries, McGraw Hill Education, 5e, 2017, ISBN: 978-1259029455.
G.N. Pandey	A Textbook of Chemical Technology Vol.II, Sangam Books Ltd, New Delhi, 2e, 2018, ISBN: 978-0706986877

Course Outcomes: After the completion of the course, the student will be able to:

1. Demonstrate the knowledge about the manufacture of various inorganic and organic chemicals by various processes.
2. Interpret the given process flow diagram, unit operations and unit processes for a particular process.
3. Identify major engineering problems in the given process.

MASS TRANSFER LAB

Course Code	N5CHL01	CIE Marks	50
Teaching Hours /Week	0+0+2	SEE Marks	50
Total Lab Hours	2 Hrs/week	Credits	1.0

Course Objectives: This course will enable students to:

1. Demonstrate practical knowledge of the various mass transfer operations.
2. Carry out experiments on the different mass transfer operations like distillation, extraction, leaching, adsorption, and drying.
3. Analyze and interpret experimental data.
4. Learnt to communicate the findings through technical reports.

The experiment is based on the following topics.

1. Determine the diffusivity coefficient of a given liquid to air.

2. Verify application of Rayleigh's equation for simple distillation.
3. Estimate the HETP using Fenskey's equation and McCabe Thiele method under total reflux conditions
4. Estimate the vaporization efficiency and thermal efficiency for steam distillation.
5. Determine the Himus constants k and n for the given liquid under evaporation.
6. Determine the constants k and n of the Freundlich equation at room temperature, for the adsorption of acetic acid on activated carbon
7. Determine the percentage recovery of solute from a solution using a solvent and compare with theoretical relation (single stage extraction).
8. Determine the percentage recovery of solute from a solution using a solvent in each stage of multistage cross current extraction.
9. Determine the percentage recovery of solute by leaching for a given feed under single stage operation
10. Determine the percentage recovery by leaching for a given feed under each stage under multi stage operation.
11. Determine the percentage recovery by leaching for a given feed using counter current leaching by shank system.
12. Estimate the critical moisture content and equilibrium moisture content by drawing the rate of drying curve for a given sample.
13. Determine the diffusion co-efficient of an organic vapor in air and to study the effect of temperature on it [Virtual Lab].
14. Study the heat & mass transfer operation in Water Cooling Tower for different flow & thermodynamic conditions [Virtual Lab].
15. Study the dissolution of benzoic acid in aqueous NaOH solution and to compare the observed enhancement factor for mass transfer with those predicted by film and boundary layer model [Virtual Lab].

Course Outcomes: After the completion of the course, the student will be able to:

1. Conduct experiments on various mass transfer processes.
2. Analyse and interpret the data on diffusion coefficient, mass transfer coefficient, drying rate curve, adsorption isotherms and kinetics, cooling rates, HTU and NTU.
3. Write technical report effectively with proper conclusions.
4. Demonstrate the knowledge of mass transfer and its applications.

Environmental Science

Contact Hours / Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	NHS05	SEE Marks	50
		Duration SEE (Hrs)	1.5

Course Objectives: This course will enable students to:

1. The problems of depletion of natural resources due to deforestation, agricultural practices, and adverse environmental effects, pesticides, soil erosion, mining.
2. Different types of energy- renewable, non-renewable and energy conservation, impact of environmental pollution, solid waste management - disposal, treatment of different types of solid waste including MSW and e-waste.
3. Societal impacts of environmental issues - ozone layer depletion, GHG effects, and water conservation.

Unit I

Introduction: Components of Environment and their interactions **Natural Resources:** Forest Resources - Deforestation, Causes of deforestation, Environmental effects of deforestation and solutions Water resources, Types of water reserves Land resources, Land degradation. Soil erosion, Causes and prevention, Soil conservation and its types. **3 Hrs**

Unit II

Energy and resources: Types of Energy - Renewable, Non-renewable & sustainable energy & their advantages and disadvantages Renewable energy sources - Solar energy, Wind energy, Biomass energy, Thermal power - environmental impacts, Hydrogen energy Tips for conservation of energy. **3 Hrs**

Unit III

Environmental pollution: Sources of pollution- Natural and anthropogenic sources Pollutants - Classification & their effects on environment Air Pollution - Composition of clean air, Sources of air pollution, Effect of air pollution on human health and climate Water quality – Potable water, Wholesome water, Sources of water pollution Common impurities in water, Effects of impurities on human health Soil Pollution – Sources, effects and its control **3 Hrs**

Unit IV

Solid Waste Management: Definition of solid waste, refuse, garbage, rubbish, ash. Types of solid waste Municipal solid waste and the necessity of its safe disposal, Impacts on human health and environment Quantity and composition of MSW Disposal of solid waste E-waste – Types and health effects. **3 Hrs**

Unit V

Sustainable development: Global environmental issues: Population growth, Urbanization, Global warming, Acid rains, Ozone layer depletion &

controlling measures Issues on energy utilization, water conservation, concept of 3 Rs, Rainwater harvesting – methods. **3 Hrs**

Course Outcomes: After completion of the course, the student will be able to

1. Describe the interactions between components of environment, importance of water and land resources, effects of deforestation and land degradation.
2. Describe the need for renewable sources to address the present world's energy demand.
3. Describe the effects of pollution of air, water, soil, and its control.
4. Describe the composition of solid waste, its impact on environment and its safe disposal.
5. Describe the current environmental issues, the need for sustainable development, and its importance in the present world

TEXTBOOK:

Joseph, B. Environmental Studies. India: Tata McGraw-Hill, 2009, ISBN: 9781283922524

Tripathi, A. K. Environmental Studies. India: Energy and Resources Institute, 2016, ISBN:9788179935828

Reference Book:

Akitsu, T. Environmental Science: Society, Nature, and Technology. Singapore: Jenny Stanford Publishing. 2018, ISBN: 9780429468230

PROCESS SIMULATION FOR CHEMICAL ENGINEERS

Course Code	N5CHA1	CIE Marks	50
Teaching Hours /Week (L:T:P)	1+0+2	SEE Marks	50
Total Lab Hours	26	Credits	2.0

Course Objectives: This course will enable students to:

1. Learn about physical property estimation methods and its selection in UNISIM software
2. Learn skills for flow sheet development and estimate their degrees of freedom
3. Simulate flow sheets and analyze their results and validate.

Unit - I

Introduction to Process Simulation Software: Overview of process simulation software; Introduction to the graphical user interface (GUI) and software features; Familiarization with basic operations and functions of the software.

Simulation of Unit Operations: Modelling and simulation of

different unit operations such as distillation columns, reactors, heat exchangers, pumps, etc.; Understanding the principles and equations governing the behavior of each unit operation; Hands-on experience in setting up simulations and running different scenarios. **5 Hrs**

Unit – II

Process Flow sheet Development: Creating process flow sheets using the simulation software; Connecting various unit operations to build a complete process model; Defining process parameters, equipment specifications, and operating conditions.
Thermodynamic Models and Property Packages: Introduction to different thermodynamic models and property packages available in the simulation software; Understanding the selection and application of suitable models for different types of processes; Performing thermodynamic calculations and analyzing the impact of model selection on simulation results. **5 Hrs**

Unit – III

Simulation Analysis and Optimization: Analyzing and interpreting simulation results; Evaluating process performance and efficiency; Optimization techniques and sensitivity analysis using simulation software.
Troubleshooting and Error Handling: Identifying and resolving common errors and issues encountered during process simulation; Debugging simulation models and troubleshooting errors in simulation setups. **3 Hrs**

List of simulation experiments:

1. Using UniSim® Simulation Software for :
2. Simulation of Mixer, Heater and Pump.
3. Simulation of Two Stage Compression System
4. Simulation of Heat Exchanger
5. Simulation of Flash Drum for Binary Mixture
6. Simulation of Distillation Column
7. Simulation of Refrigeration Gas Plant
8. Simulation of Conversion Reactor
9. Simulation of Equilibrium Reactor
10. Simulation of Absorption Column
11. Oil Characterization / Introduction to Dynamic Simulation

TEXTBOOKS:

William. L Luyben	Process Modeling Simulation and Control for Chemical Engineering, McGraw Hill, 2e, 1990, ISBN : 978-0070391598
B. V. Babu	Process Plant Simulation, Oxford University Press, 1e, 2004, ISBN : 978-0195668056

Nayef Ghasem | Computer methods in Chemical engineering, 2e, 2021, CRC Press, ISBN : 978-0367765248

REFERENCE BOOKS:

R.W. Gaikwad and Dr. Dhirendra | Process Modelling and Simulation, Denett & Co., 2006, ISBN : 9788190322829

Amiya K. Jana, | Chemical Process Modelling and Computer Simulation, 3e, 2018, PHI Learning Pvt. Ltd. ISBN : 978-9387472075

Course Outcomes: After the completion of the course, the student will be able:

1. Demonstrate skill to simulate various model equipment such as mixers, settlers, distillation column, reactors, pumps and compressors
2. Perform simulation of refrigeration gas plant and analyse the performance under operating constraints
3. Perform simulation of absorption column and validate the results.

DATA ANALYTICS

Course Code	N5CHA2	CIE Marks	50
Teaching Hours/Week (L:T:P)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	26	Total Marks	100
Credits	2	Exam Hours	2

Course objective: This course will enable students to:

1. Identify and classify various types of data and its significance
2. Analyze the data quality
3. Clustering the data for convince of handling and mining
4. Understand various data prediction technique
5. Binary classification of data and predictive method

Unit I

Introductory Background, Big Data and Data Science, Big Data Architectures, Small Data , A Short Taxonomy of Data Analytics Examples of Data Use, A Project on Data Analytics , The KDD Process The CRISP-DM Methodology

Descriptive Statistics, Scale Types,Descriptive Univariate Analysis, Univariate Frequencies, Univariate Data Visualization ,Univariate Statistics,Common Univariate Probability Distributions, Descriptive Bivariate Analysis, Two Quantitative Attributes, Two Qualitative Attributes, at Least one of them Nominal, Two Ordinal Attributes. **5 Hrs**

Unit II

Descriptive Multivariate Analysis: Multivariate Frequencies, Multivariate Data Visualization , Multivariate Statistics ,Location Multivariate Statistics Dispersion Multivariate Statistics, Infographics and Word Clouds, Infographics , Word Clouds , Final Remarks

Data Quality: Missing Values, Redundant Data, Inconsistent Data, Noisy Data, Outliers, Converting to a Different Scale Type Converting Nominal to Relative, Converting Ordinal to Relative or Absolute, Converting Relative or Absolute to Ordinal or Nominal, Converting to a Different Scale, Data Transformation, Dimensionality Reduction Attribute Aggregation, Principal Component Analysis, Independent Component Analysis, Multidimensional Scaling, Attribute Selection, Filters, Wrappers, Embedded. **5 Hrs**

Unit III

Clustering: Distance Measures, Differences between Values of Common Attribute Types, Distance Measures for Objects with Quantitative Attributes, Distance Measures for Non-conventional Attributes, Clustering Validation, Clustering Techniques,K-means, Centroids and Distance Measures,How K- means Works,DBSCAN, Agglomerative Hierarchical Clustering Technique, Linkage Criterion, Dendrograms, **Frequent Pattern Mining:** Frequent Itemsets, Setting the *min_sup* Threshold, Apriori – a Join-based Method, Eclat, FP-Growth, Maximal and Closed Frequent Itemsets, Association Rules, Behind Support and Confidence, Cross-support Patterns , Simpson's Paradox Other Types of Pattern, Sequential patterns, Frequent Sequence Mining, Closed and Maximal Sequences. **5 Hrs**

Unit IV

Predicting the Unknown Regression, Predictive Performance Estimation, Generalization , Model Validation, Predictive Performance Measures for, Regression, Finding the Parameters of the Model, Linear Regression, Empirical Error, The Bias-variance Trade-off , Shrinkage Methods, Ridge Regression, Lasso Regression, Methods that use Linear Combinations of Attributes, Principal Components Regression, Partial Least Squares Regression, Technique and Model Selection. **5 Hrs**

Unit V

Binary Classification, Predictive Performance Measures for Classification, Distance-based Learning Algorithms, K-nearest Neighbor Algorithms, Case- based Reasoning, Probabilistic Classification Algorithms, Logistic Regression Algorithm, Naive Bayes Algorithm, **Additional Predictive Methods***:* Search- based Algorithms, Decision Tree Induction Algorithms, Decision Trees for Regression, Model Trees, Multivariate Adaptive Regression Splines, Optimization-based Algorithms, Artificial Neural Networks, Backpropagation, Deep Networks and Deep Learning Algorithms. **5 Hrs**

TEXTBOOK

Moreira, J., Carvalho, A., Horvath, T.	General Introduction to Data Analytics, Wiley, 2018, ISBN 1119296269

REFERENCE BOOK:

B. Dwarakanath, R. M. Rani, D. Usha,	Fundamentals of data science, Notion Press, 2022, ISBN9798885915717
Denis Constales, Gregory S.Yablonsky, Dagmar R. et. al.	Advanced Data Analysis and Modelling in Chemical Engineering, Elsevier, 2017, ISBN: 978-0-444-59485-3

Course out comes: At the end of the course, the student will be able to:

1. Appreciate the classification of data and using descriptive statistics fordata handling.
2. Carry out multivariate data analysis and appreciate the quality of thedata.
3. Apply data clustering as a tool for efficient data mining.
4. Perform data prediction, for predicting missing data.
5. Analyse the algorithm for predicting missing data.

ENERGY AND ENVIRONMENT AUDITING

Course Code	N5CHA3	CIE Marks	50
Teaching Hours / Week(L:T:P)	2:0:0	SEE Marks	50
Total Lecture Hours	26	Total Marks	100
Credits	2.0	Exam Hours	2.0

Course Learning Objectives: This course will enable students to:

1. Introduce to the fundamentals of energy sources, energy use, energy efficiency, and resulting environmental implications of various energy supplies.
2. Learn about various aspects of environmental pollution and its control.
3. Acquaint with the causes and remedies related to social issues like global warming, ozone layer depletion, climate change etc.
4. Learn about the various acts related to prevention and control of pollution of water and air, forest protection act, wild life protection act etc.

Unit-I

Basic Introduction to Energy: Energy and power, forms of energy,

primary energy sources, energy flows, world energy production and consumption, Key energy trends in India: Demand, Electricity, Access to modern energy, Energy production and trade, Factors affecting India's energy development: Economy and demographics Policy and institutional framework, Energy prices and affordability, Social and environmental aspects, Investment. **5 Hrs**

Unit-II

Energy storage systems: Thermal energy storage methods, Energy saving, Thermal energy storage systems Energy Management: Principles of Energy Management, Energy demand estimation, Energy pricing Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries. **5 Hrs**

Unit-III

Environment: Introduction, Multidisciplinary nature of environmental studies- Definition, scope and importance, Need for public awareness. Ecosystem: Concept, Energy flow, Structure and function of an ecosystem. Food chains, food webs and ecological pyramids, Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystems, Ecological succession. **5 Hrs**

Unit-IV

Environmental Pollution: Definition, Cause, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, Solid waste Management, Disaster management Role of an individual in prevention of pollution, Pollution case studies. **5 Hrs**

Unit-V

Environmental Audit - Scope & Requisites: Environmental Audit: Definition; Objectives; Scope, Coverage - GOI Notification on Environmental Audit - Benefits to Industry. Reporting Environmental Audit Findings - Importance of Environmental Audit Report to industry, public and the governments. **5 Hrs**

TEXTBOOKS:

Erach Bharucha	Textbook for Environmental Studies for Undergraduate Courses, University Press, Hyderabad, 1e, 2013, ISBN: 9788173718625
Barun Kumar De	Energy Management, Audit & Conservation- Vrinda Publications Pvt. Ltd. New Delhi, 2e, 2014, ASIN : B00K0N7KCI
K.R. Gupta	Environmental Education in India, Atlantic Publishers & Distributors Pvt Ltd, New Delhi, 2010

ISBN:9788126913312,9788126913312

Web resources	https://parivesh.nic.in/ https://www.cpcb.nic.in/ https://www.free-ebooks.net/environmental-studies-academic

Course Outcomes: At the end of the course, the student will be able to:

1. Demonstrate knowledge about energy sources, energy use, energy efficiency, and environmental implications of various energy supplies.
2. Illustrate about various aspects of environmental pollution and its control.
3. Distinguish between causes and remedies related to social issues like global warming, ozone layer depletion, climate change etc.
4. Illustrate about the various acts related to prevention and control of pollution of water and air, forest protection act, wild life protection act etc.

INTRODUCTION TO PROCESS TECHNOLOGY

Course Code	N5CHA4	CIE Marks	50
Teaching Hours/Week (L:T:P)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	26	Total Marks	100
Credits	2	Exam Hours	3

Course objectives: This course will enable students to:

1. Introduce to the nature and application of process drawing with their significance in the process industries
2. Introduce to the functions and uses of various types of pipes and valves and maintenance of them in industries
3. Learn about the types and functions of various types of vessels, types of cooling towers with their significance, safety practice procedures in process industries
4. Learn about boilers, components of a boiler, types of boiler and their role and maintenance in process industries.
5. Introduce to the various process auxiliaries, their function and their need in industry.

Unit I

Process Drawings: Purpose of Process drawings, Common Components and Process Drawings Information: Symbols, Legend, Title Block, Application Block. Types of Process Drawing and their uses: Block flow diagrams (BFDS), Process Flow Diagrams, Piping and Instrumentation Diagrams (P& IDS), Engineering Flow Diagrams, Plot Plan Diagrams (PPDS), Utility Flow Diagram , Electrical Diagrams, Isometric Drawings, Other Drawings. **5 hrs**

Unit II

Piping and Valves: Purpose and Function of Piping and Valves,

Construction Materials in Piping and Valves, Connecting Methods for Piping and Valves: Threaded, Flanges, Welds, Bends; Fitting types, Valve Types: Ball Valve, Plug valve, Butterfly valve, Check valve, Diaphragm Valve, Gate Valve, Globe Valve, Relief and Safety Valves, Valve actuators, Operational hazards, Monitoring and Maintenance Activities; Piping and Valve symbols.

5 hrs

Unit III

Vessels: Purpose of Vessels, Types of Tanks, Common Components of Vessels, Containment Walls, Dikes, Firewalls, Reactors: Purpose and Types; Operational Hazards, Monitoring and maintenance activities, Symbols for vessel and Reactors

Cooling Towers: Purpose of Cooling Towers, Types of Cooling Towers, Component Parts of an Open Cooling Tower, Principles of Operation of Open Circuit Cooling Towers, Factors that affect cooling tower performance, Cooling Tower Applications, Operational Hazards, Monitoring and maintenance activities, Cooling Tower Symbols. **5 hrs**

Unit IV

Boilers- Introduction, Purpose of Boilers, Parts of a Boiler, How a Boiler Works, Fuels used in Boilers, Water and Fire tube boilers, Operational hazards, Monitoring and Maintenance activities, Boiler symbols. **5 hrs**

Unit V

Process Auxiliaries: Types of Process auxiliaries, Flare Systems and associated equipment, Refrigeration Systems and associated components, Components of Mechanical Refrigeration System, Lubrication Systems and Associated Components, Hot Oil Systems and Associated Components, Other common auxiliary systems: Amine, Fluidized Bed Systems, Nitrogen Header, Operational Hazards, Monitoring and Maintenance Activities.

6 hrs

TextBooks:

Martha McKinlley, Ed.	Introduction to Process Technology, Pearson Education Inc., USA, 2e, 2018, ISBN: 978-0-13-480824-6

Reference Books:

Charles E. Thomas	Introduction to Process Technology, Cengage Learning, USA, 3e, 2010, ISBN: 13-978-1-4354-5425-5
Charles E. Thomas	Process Technology and Equipment Systems, Cengage Learning, USA, 4e, 2015 ISBN: 978-1-285-44458-1

Course Outcomes: On successful completion of the course, the student will be able to:

1. Identify the various types of process diagrams and identify the various components through the symbols denoted on them.
2. Identity different types of pipes and valves by their symbols and regular maintenance schedules adopted in work place.
3. Identify different types of vessels and cooling towers and avoid the hazards associated with them in work place
4. Illustrate about the various components of boiler their operation and

maintenance

5 Describe about the various process auxiliaries and exhibit awareness about operational hazards and maintenance practices to be adopted in industry

SOFT SKILLS

Contact Hours/ semester	: 36+0+0 (L+T+P)	Credits :	0.0
Total Lecture Hours	: 36	CIE Marks :	50
Sub. Code	: HSS08	SEE Marks :	50

Course Objectives:

This course will enable students:

1. To make the students aware of the importance of soft skills in the present-day business world and work environment
2. To Learn the science behind picking up any skill quickly
3. To help students realize as well as develop key soft skills interviewers look for – such as change management, professionalism, inter- and intra-personal skills, adaptability etc.
4. To develop effective resumes (paper-based as well as video)
5. To understand the importance of and create an effective digital footprint
6. To provide simulated Group Discussion and Personal Interview experience based on the models adopted by reputed companies.
7. To understand professional etiquette to be displayed in workplaces.
8. To learn to introspect over one's strengths and weaknesses, and apply them effectively for career growth

Methodology:

Interactive instructor led session with audio-visual aids / case studies

Day	#	Topic	Sub-topics covered	Duration (Hrs)
1	1	How to pick up skills faster?	i) Knowledge v/s. skill ii) Skill introspection iii) Skill acquisition iv) "The 10,000 hours rule" and the converse	2
	2	Interpersonal and Intrapersonal skill building	Social Interaction i) Interpersonal Communication ii) Peer Communication iii) Bonding iv) Types of social interaction Emotional Management Responsibility i) Types of responsibilities ii) Moral and personal responsibilities	2
	3	Professional etiquette	Workplace etiquette - meeting room, pantry, cubicle Dining etiquette; Telephone etiquette; Email and Business correspondence etiquette	2
2	4	Change Management	i) Who moved my Cheese? ii) Tolerance of change and uncertainty iii) Joining the bandwagon iv) Adapting change for growth – overcoming inhibition	2

			v) Adapt to changes (tolerance of change and uncertainty) vi) Adaptability Curve vii) Survivor syndrome	
	5	Creating a digital footprint	i) How what you post online / information online can affect people's and recruiter's perception about you ? ii) Usage of LinkedIn to further one's career prospects iii) Managing content that one posts on platforms like Twitter, Facebook, Instagram etc. to create positive footprint about oneself iv) Why is it important to leave a digital footprint?	2
	6	Time Management	i) Prioritization - Time Busters ii) Procrastination iii) Scheduling iv) Multitasking v) Monitoring vi) Working under pressure and adhering to deadlines	2
3	7	Group Discussion - Basics	i) Importance of GD round ii) Skills assessed in a GD iii) How to ace a GD? iv) Do's and Don'ts in a GD v) Idea generation techniques vi) One mock GD involving 12 volunteers, facilitated by the trainer	2
	8	Personal Interview - Basics	i) Self-introduction practice. ii) Body language especially grooming for personal interview. iii) Personal interview – FAQs discussion.	2
	9	Building a resume from scratch	i) How to write a good and impressive Resume? ii) Important aspects of an impressive resume. iii) Sample template and formatting ideas.	2
4	10	Group Discussion - Advanced	i) GD sample Video with analysis and discussion. ii) GD Do's and Don'ts – Worksheet practice. iii) Role plays for Do's and Don'ts. iv) Idea generation – worksheet practice.	3
	11	Personal Interview - Advanced	i) Extensive discussion on PI FAQs. ii) Interview questions from based on resume – discussion iii) PI Videos - discussion and analysis. iv) Highlighting successful answers for PI-questions. v) Body language during a personal interview. vi) Unconventional types of interviews (Stress panel, MR, Guesstimation)	3
5	12	Resume Writing -	i) Resume writing – Worksheet practice.	3

		Workshop (Drafting a paper-based as well as a video resume)	ii) 3 stage Resume drafting iii) Rough draft-1. iv) Rough draft -2. v) Fair draft. vi) Discussion on specific aspects of an impressive Resume. vii) Creating a video resume	
	13	Setting and achieving targets	i) Ambition, goal, passion and career objective –difference ii) SMART goals and Action plans iii) Obstacles -Failure management (case studies)	1.5
	14	Introspection	i) Identify your USP - Unique Selling Proposition ii) Recognize your strengths and weakness (SWOT) iii) Nurture strengths iv) Fixing weakness v) Overcoming your complex vi) Confidence building	1.5
6	15	Group Discussion - Mock	i) Mock Group Discussions featuring groups of 10 people, with each GD lasting for 15 minutes. ii) Detailed feedback for each participant iii) Introspection by the audience to add value to the GD	3
	16	Personal Interview - Mock	i) Mock personal interview for a sample set of candidates ii) Simulate the real personal interview experience. iii) Individual feedback and areas of improvements are shared.	3

ASSESSMENTS PROVIDED

The following assessments are integrated into the training programme to best judge a student's proficiency on soft skills.

1. Team building tasks (Inside training hours)
2. Participation in group activities (Inside training hours)
3. Psychometric test
4. Creating a resume
5. Creating an effective LinkedIn profile
6. Mock Group Discussion (Inside training hours)

REFERENCE MATERIAL

1. 'Who moved my Cheese?' by Spencer Johnson
2. 'Outliers' by Malcolm Gladwell
3. 'Emotional Intelligence' by Daniel Goleman
4. 'Road Less Travelled' by Scott Peck M.
5. 'How to win friends and influence people' by Dale Carnegie

COURSE OUTCOMES: On successful completion of this course, students will be able to:

1. Display key soft skills expected by recruiters
2. Be able to apply scientific methods to learn any skill quickly
3. Participate in Group Discussions and Personal Interviews effectively
4. Create effective resumes that impress interviewers (paper-based as well as video)
5. Apply professional etiquette to be displayed in various workplace scenarios
6. Set and achieve targets – work-place based as well as personal

VI SEMESTER

COMPUTER APPLICATIONS AND MODELLING IN CHEMICAL ENGINEERING

Course Code	N6CHI01	CIE Marks	50
Teaching Hours/Week (L:T:P)	3+0+2	SEE Marks	50
Total Lecture Hours	39	Credits	4
Total Practical Contact Hours	26		

Course Objectives: This course will enable students to:

1. Introduce to the different numerical techniques to solve non-linear algebraic, transcendental equations, ordinary differential equations and definite integral expressions.
2. Learn to write C program to solve mathematical equations using numerical techniques, estimation of thermodynamic properties and reactor parameters and validate the results achieved
3. Acquaint with writing C program to design heat exchangers and distillation column, and validate the results achieved.
4. Learn to formulate, solve and analyse chemical engineering problems using mathematical modeling to obtain an appropriate solution.
5. Execute using simulation softwares (MATLAB and UNISIM) for solving given chemical engineering problems.

Unit - I

Numerical Techniques: (Algorithm and C program) Non-linear algebraic equation-Newton Raphson (Specific volume of binary mixture using real gas equations); Ordinary Differential Equation- R-K Method ($dCA/dt = K\ Ca^2$); Numerical Integration-Simpson's $1/3^{rd}$ Rule (Batch Reactor to find time).

8 Hrs

Unit - II

Applications: (Algorithm and C program) Calculation of Bubble Point and Dew Point for Ideal multi-component system. Flash Vaporization for multi-component system, Design of Adiabatic Batch Reactor, PFR, CSTR.

8 Hrs

Unit - III

Design: (Algorithm and C Program) Double pipe Heat Exchanger (Area, Length and Pressure drop), Shell Tube Heat Exchanger (Area, Number of tubes, Pressure drop), Distillation Column (Number of stages). **8 Hrs**

Unit - IV

Modelling: Models and model building, principles of model formulations, precautions in model building, Fundamental laws: Review of shell balance approach, continuity equation, energy equation, equation of motion, transport equation of state equilibrium and Kinetics, classification of mathematical models. **8 Hrs**

Unit - V

Mathematical modeling and solutions to the following: Basic tank model - level v/s time, multi component flash drum , Batch distillation - Vapor composition with time, Batch reactor, Three CSTR in series, Heat exchanger (co-current and counter current)- Steady state energy balance. **7 Hrs**

COMPUTER APPLICATIONS AND SIMULATION LAB

PART A: C Program **30 marks**

1. Application of Newton Raphson method for determining Specific volume of binary mixture.
2. Application of Runge-Kutta Method to find the concentration profile in a reactor.
3. Application of Simpson's $1/3^{rd}$ for determining the time required for the given reaction in a Batch Reactor.
4. Estimation of Curve fitting by least square method (Nre V/s f).
5. Application of Newton Raphson method to find Bubble Point and Dew Point for Ideal multi-component system.
6. Application of Newton Raphson method to determine Flash Vaporization for multi-component system.
7. Application of Newton Raphson method to Design of Adiabatic Batch Reactor, PFR.
8. Application of Newton Raphson method to evaluate the Adiabatic Flame Temperature.
9. Design of Double pipe Heat Exchanger (Area, Length and Pressure drop).
10. Design of Distillation Column (Bubble cap).

Part B: MATLAB **20 Marks**

1. Determination of specific volume using Equation of state.
2. Estimation of the rate constants in a series reaction $A \rightarrow B \rightarrow C$,

each of first order kinetics.

3. Determination of heat to be removed in a crystallizer.
4. Solution to the system of linear equations using matrix inversion and matrix left division.

Simulation software

5. Introduction to suggested software available (flow sheeting)
6. Simulation Studies of flash drum, Distillation Column, CSTR, PFR
7. Process simulation study involving mixing, reactor, Distillation, Heat Exchanger for any of the following process:
   a. Ethylene Glycol from Ethylene oxide
   b. Atmospheric distillation of crude oil

NOTE:

- One question from PART – A Excluding Numerical Techniques – 30 marks
- One question from PART – B (Simulation of any above process) – 20 marks

SOFTWARE'S SUGGESTED:

1) DESIGN-II
2) DWSIM
3) MATLAB
4) PROSIM

TEXTBOOKS:

Pradeep Ahuja	Introduction to Numerical Methods in Chemical Engineering, PHI Learning, 2010, ISBN: 9788120340183
Myers, A.L and Seider. W.D	Introduction to Chemical Engineering and Computer Calculations, 1976, ISBN: 9780134792385
William. L. Luyben	Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 2e, 1990 ISBN: 9780071007931.

REFERENCE BOOKS:

H. Scott Fogler	Elements of Chemical Reaction Engineering, Prentice Hall, 5e, 2015, ISBN: 9780133887518.
Smith J.M and H. C. Vanness	Introduction to Chemical Engg. Thermodynamics, McGraw Hill, 8e, 2017, ISBN: 9781259696527.

Amiya K. Jana	Chemical Process Modelling and Computer Simulation, PHI Learning Private Limited, 1e, 2017, ISBN-13: 978-9387472075
Kamal I. M. Al-Malah	MATLAB Numerical Methods with Chemical Engineering Applications, McGraw-Hill Education, 2013, ISBN: 9780071831291

Course Outcomes: After the completion of the course, the student will be able to:

1. Apply numerical methods and computer programming for solving chemical engineering problems.
2. Develop an algorithm and program to evaluate bubble and dew point values, design of heat exchangers and distillation column
3. Demonstrate knowledge about types of models and model building techniques adopted for chemical engineering applications
4. Build mathematical models for process systems using modelling concept and physical laws.
5. Demonstrate skills of C programming, MATLAB and UNISIM usage for solving given chemical engineering problems

MANAGEMENT AND ENTREPRENEURSHIP

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	00	SEE Marks	50
Course Code	NHS06		

Course Objectives: This course will enable students to:

1. Introduce to the principles and functions of management.
2. Learn about the importance of planning, organizing, staffing, leading and controlling in a organization.
3. Acquaint with role of engineering design and quality in a process/product
4. Inculcate entrepreneurial qualities and understand the need of rural entrepreneurship
5. Learn about funding agencies, procedure in applying for funds and analyze the cases of successful entrepreneurs

Unit-I

Introduction to Management: Definition of management, management skills, productivity and effectiveness, efficiency, functions and principles of management.

Planning: Nature of planning, types of plans- purpose of vision, mission, goals, objectives strategies, policies; steps in planning, MBO, Strategic planning

Organizing: Formal and informal organization, span of management, the structure and Process of organizing, Organizational structure: line and staff organization, Functional organization, matrix organization. **8 Hrs**

Unit-II

Staffing: Definition, systems approach to HRM, factors affecting staffing, recruitment and selection, job design, skill and characteristics of a manager, selection process and techniques.
Leading: Human factors in managing, motivation, Theory X and Y, the hierarchy of needs theory, leadership behavior and styles.
Controlling: Basic control process, critical control points and standards, Benchmarking requirements for effective control.
9 Hrs

Unit - III

Managing Engineering Design and Development: Product and Technology Life Cycles, Nature of Research and Development, Research Strategy and organization, Nature of Engineering Design, Systems Engineering / New Product Development.
Managing Production/Operations: Types of production processes, Forecasting, Work measurement, Maintenance and Facilities (Plant) Engineering, Total Quality Management, Lean Manufacturing
Engineers in Marketing and service activities: Marketing and the Engineer, Engineers in Service organizations. **8 Hrs**

Unit – IV

Entrepreneur & Entrepreneurship: Introduction, concept of Entrepreneur, characteristics of an entrepreneur, and qualities of an entrepreneur, functions of an entrepreneur, characteristics of entrepreneurship, factors affecting entrepreneurial growth. Entrepreneurship and economic development-rural, woman and social entrepreneurship
Financing and Institutional Support for Entrepreneurship: Startups, business plans, venture capitalists, angel investors, funding agencies - commercial banks, development banks, NBFCS and incubation centres. Innovations and project trends.
8 Hrs

Unit – V

Taxation benefits: Depreciation allowances, rehabilitation allowance, investment allowance and other tax concession benefits to an entrepreneur. **Case Studies from Stay Hungry and Stay Foolish – Rashmi Bansal, IIM Ahmedabad:**

1) Success story of naukri.com by Sanjeev Bikhchandani
2) Success story of Make My Trip by Deep Kalra. **6 Hrs**

TEXTBOOKS:

Harold Koontz, Heinz Weihrich — Essentials of Management, McGraw Hill Education, 10e, 2015, ISBN: 978-9339222864

Lucy C. Morse	Managing Engineering and Technology, Pearson Education, 6e, 2015, ISBN : 978-9332550124
S.S. Khanka	Entrepreneurial Development, S. Chand Publishing, 4e, Reprint 2020. ISBN 978-81-219-1801-5

REFERENCE BOOKS:

James A.F. Stoner, R. Edward Freeman, Daniel R. Gilbert	Management, Pearson Education, 6e, 2018, ASIN : B07DFHYYSZ
Rashmi Bansal	Stay Hungry Stay Foolish, IIM Ahmedabad, 1e, 2008, ISBN: 978-8190453011
Rashmi Bansal	Connect the Dots, Bushfire Publishers, 1e, 2019, ISBN: 978-8193182178

Course Outcomes: After the completion of this course, students will be able to:

1. Demonstrate knowledge about types of management and its various functions.
2. Apply the knowledge of management principles and strategies in various functional areas.
3. Manage engineering design and product development.
4. Describe importance of entrepreneurship, its characteristics, and benefits and identify various funding sources for starting a business venture.
5. Illustrate various types of taxation, its benefits enjoyed by an entrepreneur and analyze the characteristics and strategies adopted by successful entrepreneurs.

MATERIALS SCIENCE AND ENGINEERING

Course Code	N6CHPE11	CIE Marks	50
Teaching Hours/Week (L:T:P)	3+0+0	SEE Marks	50
Total Lecture Hours	39	Credits	3

Course Objectives: This course will enable students to:

1. Introduce to the material engineering fundamentals, phase transformations and phase diagrams, material processing problems in nucleation and crystal growth through TTT and CCT curves.
2. Learn about types of deformation in materials, mechanism of deformation, and different heat treatment methods.
3. Acquaint with the selection and the use of Engineering

Materials.

4. Introduce to the field of Nanomaterials, processing principles and methods of synthesis.
5. Introduced to advanced Materials and Smart materials and their applications.

Unit – I

Introduction: Introduction to material science, classification of engineering materials, Level of structure, Structure property relationships in materials.

Phase Diagram and Phase Transformations: Phase rule, Single component systems, Binary phase diagrams, Lever rule, Typical phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron – Carbon systems, Nucleation and growth, solidification, Allotropic transformation, Cooling curve for pure iron, Iron-carbon equilibrium diagram, Isothermal transformations (TTT Curves). **8 Hrs**

Unit – II

Deformation Of Materials And Fracture: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture. **Heat Treatment**: Annealing, Normalizing, Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Carburising, Cyaniding, Nitriding, Flame hardening. **8 Hrs**

Unit – III

Typical Engineering Materials: Ferrous metals, Non ferrous metals and alloys – Aluminum and its alloys, Copper and its alloys, Lead and its alloys, Tin, Zinc and its alloys, Alloys for high temperature service, Ceramic materials, Mechanical, electrical and thermal properties of ceramic phase, Refractories, Glasses, Abrasives. Organic materials, Organic protective coatings. **8 Hrs**

Unit – IV

Nano Materials: Classification, synthesis, characterisation and application of Nano materials – Fullerenes, Buckyballs, carbon nano tubes, fullerites. Applications of Nano materials. **7 Hrs**

Unit – V

Advanced Materials: composite materials, definition, classification, types of matrix materials and reinforcements, fundamentals of production of FRP's and MMC's, advantages and applications of composites. **Smart Materials :** Introduction, classification, definition of each type of smart material. **8 Hrs**

TEXTBOOKS:

Raghavan V	Materials Science and Engineering - A First Course, Prentice Hall of India. New Delhi, 3e 2015, ISBN:978-8120350922
Charles P Poole, Frank J Owens	Introduction to Nanotechnology, Wiley Publications, 1e, 2007,

ISBN: 978-0471079354

REFERENCE BOOKS:

Van Vlack H.L.	Elements of Materials Science, Addison – Wesley Publishing Company, New York, 2e, 2002, ISBN: 978-8131706008.
Guazhong Cao.	Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, Imperial College Press, 1e, 2011, ISBN: 978-9814324557.

Course Outcomes: After completion of this course, students will be able to:

1. Apply the knowledge of materials engineering fundamentals, phase transformations, transformation curves, and different heat treatment methods to materials development.
2. Identify, formulate, and analyze materials processing problems in nucleation and crystal growth through TTT and CCT curves.
3. Select appropriate material for a given application.
4. Demonstrate the knowledge of nanomaterials processing, principles, and methods.
5. Illustrate about composite and advanced materials and their applications

ADVANCED MASS TRANSFER OPERATIONS

Course Code	N6CHPE12	CIE Marks	50
Teaching Hours/Week (L:T:P)	3+0+0	SEE Marks	50
Total Lecture Hours	39	Credits	3

Course Objectives: The objectives of this course are to:

1. Train students to apply advanced mass transfer principles, material and energy balance to solve problems related to absorption, extraction, adsorption, crystallization and novel separation processes.
2. Facilitate the students to carry out selection of appropriate recovery process and perform basic design of the mass transfer equipment involved.
3. Enable students to demonstrate the knowledge and need for sustainable operations including absorption, extraction, adsorption, crystallization and novel separation processes in the context of environment and economics.

Unit - I

Absorption: Gas solubility in liquids at equilibrium, ideal and non-ideal liquid solutions, choice of solvent for absorption,

design of isothermal absorption towers, overall transfer units, desorption, design of Packed tower absorber. **8 Hrs**

Unit - II

Extraction: Equilibria, Equilateral-triangular coordinates, partially soluble system, Operations: single stage operation, multistage cross-current operation, multistage counter-current operation, insoluble systems: single stage operation, multistage cross-current operation. Extraction Equipment: mixer-settler, rotating disc contactor, pulsed column extractor. **8 Hrs**

Unit - III

Adsorption: Types of adsorption, equilibria, hysteresis, adsorption isotherms, operation: single stage operation, multistage cross-current operation, multistage counter-current operation, Adsorption Equipment: fluidised beds, moving bed adsorber.

Unit - IV

Crystallization: Classification of crystals, invariant crystal, principles of crystallization – purity of product, equilibria and yield, enthalpy balance, super-saturation, nucleation, crystal growth, crystallizers: agitated tank crystallizer, Swenson-walker crystallizer, vacuum crystallizer and draft tube baffle crystallizer. **8 Hrs**

Unit - V

Novel Separation Processes: Membrane separation process; solid and liquid membranes; reverse osmosis; electro dialysis; their applications; Azeotropic distillation, extractive distillation. **7 Hrs**

TEXTBOOKS:

Robert E. Treybal	Mass Transfer Operations, McGraw Hill, NY, III Edition, 1980, ISBN: 0-07-65176-0
Narayanan and Lakshmikutty	Mass Transfer – Theory and Applications, CBS Publishers, New Delhi, 1e, 2014, ISBN: 978-81-239- 2421-2

REFERENCE BOOKS:

Coulson J. and Richardson J. F.	Chemical Engineering, Elsevier India, Vol I and Vol II, Butterworth Heinemann, 6e, 1999
Mc Cabe & Smith, et.,	Unit Operations in Chemical Engineering, Mc Graw Hill, New York, 7e, 2019, ISBN:978-9355321084

Course Outcomes: After completion of this course, students will be able to:

1. Apply advanced concepts of diffusion and convection to liquid-liquid, vapor-liquid and solid-liquid processes to identify and formulate criteria for selecting appropriate separation processes.
2. Analyze problems related to mass transfer including absorption, adsorption, extraction, crystallization and novel separation processes and apply advanced mass transfer concepts to calculate mass transfer rate.
3. Solve problems related to absorption, adsorption, extraction, crystallization and novel separation processes, analyze the data and infer the solution.
4. Utilize advanced mass transfer concepts for basic design of mass transfer equipment.
5. Demonstrate life-long learning of emerging mass transfer operations and communicate the findings as an individual or as a part of a team.

ORGANIC SYNTHESIS

Contact Hours / Week	3+0+0 (L+T+P)	Credits :	3.0
Total Lecture Hours	39+0+0	CIE Marks :	50
Sub. Code	N6CHPE13	SEE Marks :	50

Course Objectives: After the completion of this course, Students will be able to

1. Teach the students regarding the basic concepts of different types of isomers, stereoisomers, D-L configurations and conformational analysis.
2. Educate the students about the oxidation and reduction reactions and their mechanism. Also teach the students to use different types of reagents for oxidation and reduction reactions.
3. Learn about different types of reagents used in organic synthesis and also teach them how to select the appropriate reagents for the organic synthesis.
4. Learn the concepts of ionic liquids and solid supported organic synthesis.
5. Introduce to the students the chemistry used in our daily life such as food chemistry, pigments and vitamins.

Unit - I

Stereochemistry – I : Nomenclature and conformations of fused rings and bridged ring systems. Fischer, Newman, Sawhorse and flying wedge projections and their interconversions. **Optical isomerism**: Elements of symmetry and chirality. D-L conventions. CIP rules, R-S and M-P conventions. Chirality in compounds with a stereogenic centre, allenes, biphenyls, alkylidene cycloalkanes, hemispiranes and spiranes (with a stereogenic axis). Cram's and Prelog's rules. **Conformational analysis**: Conformational analysis of cycloalkanes, cyclobutane, cyclopentane, cychexane (monosubstituted e.g., methyl, *iso*-propyl, *tert*-butyl and di- substituted cyclohexanes e.g., dialkyl,

dihalo, diols), and cycloheptane. Effect of conformation on reactivity. **8 Hrs**

Unit - II

Oxidation and Reduction Reactions: Oxidation reactions: Introduction, oxidation by potassium permanganate - alcohols, alkenes, alkynes, aldehydes, and ketones. Oxidation by manganese dioxide: allylic and benzylic alcohols. Oxidation of alcohols and phenols by chromic acid and potassium dichromate, Jones reagent, chromium trioxidepyridine complex, pyridinium chlorochromate (PCC), pyridinium dichromate (PDC), oxidation of alkanes, alkenes, aromatic side chains and aromatic rings. **Reduction reactions**: Catalytic hydrogenation; Classifications, reactions and their applications. Homogeneous and Heterogeneous hydrogenation, Hydrogenolysis and their applications. Introduction to Pt, Pd, Ni, catalysts, reduction of alkenes, alkynes and Nitro compounds. Reduction with metal hydrides LiAlH4, NaBH4, and NaBH3C. **8 Hrs**

Unit – III

Reagents in Organic Synthesis: Use of following reagents in organic synthesis and functional group transformations: Lithium diisopropylamide (LDA), Gilmann reagent, dicyclohexyl carbodimide (DCC), dichlorodicyanoquinone (DDQ), Silane reagentstrialkylsilyl halides, trimethylsilyl cyanide, trimethyl silane, phase transfer catalyst, crown ethers, cyclodextrins, Ziegler-Natta catalyst, diazomethane, Woodward and Prevost hydroxylation, Stark enamine reaction, phosphorous ylides - Wittig and related reactions, sulphur ylides – reactions with aldehydes and ketones, 1,3-dithiane anions – Umpolung reaction, Peterson reaction. **8 Hrs**

Unit– IV

Green Chemistry: Ionic-liquids: Introduction, structure, synthesis and applications of some important ionic liquids in organic synthesis. **Polymer supported reagents in organic synthesis.** Introduction- properties of polymer support, advantages of polymer supported reagents and choice of polymers. Applications: Substrate covalently bound to the support: Synthesis of oligosaccharides, Dieckmann cyclisation. Preparation of polymer bound aldehyde and application in aldol reactions. Synthesis of polystyryl boronic acid and use in diol protection reaction. Reagent linked to a polymeric material: Preparation of sulfonamide polymer and application in diazo transfer reaction. Synthesis of polymer bound per acid and its applications. Polymer supported catalytic reactions: Preparation of polymer supported AlCl3 and application in etherification and acetal formation reactions. **8 Hrs**

Unit – V

Chemistry of Daily Life: Food additives properties & uses: classification of food additives, Antioxidants (Ascorbic acid, Citric acid, Tocopherols, Butylated hydroxyl anisole (BHA), Tertiary butyl hydro quinine, colouring agents (Chlorophyll, Caramel, Curcumin or turmeric, Indigo carmine), flavours (Diacetyl,

Vanilla extracts, Vanillin, Ethyl vanillin), emulsifiers (Methyl cellulose, Carboxymethyl cellulose, Gellan gum), Artificial sweeteners (Aspartame, Acesulfame K, Sucralose), leavening agents (Baking powder, Ammonium bi-carbonate, Ammonium carbonate), thickeners (Alginic acid and their salts) and preservatives (Sorbic acid and its sodium, potassium and calcium salts, Benzoic acid). Pigments and colours: Importance & perception of color in foods, Chlorophylls, myoglobin and haemoglobin, anthocyanins, flavonoids, tannins, betalains, quinones, xanthones, carotenoids properties & uses. Vitamins: Classification, functions requirements, distribution in foods, loss during processing, effects of deficiency and characteristic properties of vitamins – B1(Thiamine), B2(Riboflavin), B3 (Pantothenic acid), B6 (pyridoxine), B12 (Cyanocobalamin), H(Biotin), P(Ruti), C (ascorbic acid), A (Retinol), D (Calciferol), E (Tocopherol), K (naphthoquinone), Folic acid (PGA) and Niacin.

8 Hrs

TEXTBOOKS:

J. Clayden, S. Warren, N. Greeves, S. Warren	Organic Chemistry, Oxford University Press, UK, 1e, 2001, ISBN: 978-0198728719
	Organic Chemistry – Solution Mannual, Oxford University Press, UK, 2009, ISBN: 978-0199663347
Francis A. Carey, Richard J. Sundberg	Advanced Organic Chemistry, Part-A: Structure and Mechanisms, Springer, New York, 5e, 2007, ISBN: 978-0387683431
R.O.C. Norman, J.M. Coxon	Principles of Organic Synthesis,(Indian Reprint), Taylor & Francis, UK, 3e, 2012, ISBN: 978-0748761623
Jerry March	Advance Organic Chemistry– Reactions, mechanisms and structure, Wiley India Pvt. Ltd., New Delhi, 4e, 2008, ISBN: 978-9971512576
V.K. Ahluwalia, R.K. Parashar	Organic Reaction Mechanisms, Narosa Publishing House, New Delhi, 3e, 2009, ASIN: BOBHDNMVF7
T W Graham Solomons, et. al.	Solomons' Organic Chemistry, (Wiley Student Edition), Brijbasi Art Press Ltd., Noida, India, 8e, 2004, ISBN: 978-8126568116
G. Marc Loudon	Organic Chemistry, Oxford University Press, UK, 4e, 2000, ISBN: 978-0195119992
R.T. Morrison, R.N. Boyd	Organic Chemistry, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 6e, 2005, ISBN: 978-8131211514
L.G. Wade, JR.	Organic Chemistry, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 6e, 2004, ISBN: 978-8177587395

Course Outcomes: On successful completion of this course, the student will be able to:

1. Illustrate about the different types of isomer, stereoisomers, D-Lconfiguration of organic molecules.
2. Distinguish oxidation and reduction reactions in the synthesis of target molecule.
3. Identify by different types of reagents and talent to select suitable reagent required for organic synthesis.
4. Demonstrate knowledge about ionic liquids and polymers and their role and support in organic synthesis.
5. Demonstrate knowledge about the chemistry and its usage in daily life.

INTRODUCTION TO RISK MANAGEMENT IN PROCESS INDUSTRIES

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39+0+0	CIE Marks	50
Sub. Code	N6CHPE14	SEE Marks	50

Course Objectives: This course will enable students to:

1. Introduce to the risk management aspects in process industries
2. Learn about the hazard identification and risk analysis techniques
3. Teach about the consequence occurrence and its estimation techniques applied in process industries
4. Introduce to the concept and application of likelihood analysis and Independent layer of protection to achieve safety.

Unit – I

Risk Management Overview: Terminologies, Key differences between Risk, Consequence, Hazards, Personal Safety, Occupational Safety and Process Safety. Project Safety Lifecycle Concept (Concept, Front End Engineering, Design, Construction, Commissioning, Operations and Decommissioning) Governing standards for risk management (ISO 31000, Safety Management Systems - Energy Institute, Operations Integrity Management Systems (OIMS – ExxonMobil), BP SMS, Oil and Gas Producers SMS, CCPS RBPS) Learning from industrial incidents – Key Incidents that shaped the world of Process Safety (Bhopal, Piper Alpha, Pasadena, Seveso, Flixborough, Valdez, BP Texas, Chernobyl, Fukushima and BP Mocondo) Regulatory requirements (OSHA CFR 1910, Indian Factories Act, UN C 124 – Major Accident Prevention Policy, RIDDOR, UK, Norwegian PSA, Safety Case Approach, etc.) Key Industry Standards and Codes (NFPA, ISO, IEEE, ISA, EEMUA, API – Key standards used in process industries). **10 Hrs**

Unit – II

Hazard Identification and Risk Analysis Techniques (Process

Hazard and Risk Analysis Methodologies): Introduction to Qualitative, Semi- Quantitative and Quantitative What-If, Checklist, Hazard and Operability (HAZOP), Failure Modes and Effects Analysis, Fault Tree Analysis, Event Tree Analysis, Layer of Protection Analysis, Dow Fire and Chemical Index, Dow Chemical Exposure Index, Quantitative Risk Assessment (including Markov Analysis), Human Reliability Analysis. **6 Hrs**

Unit– III

Consequence estimation: Consequence types (Fire, Explosion and Toxic), The fire triangle, distinction between fires and explosions, definitions, flammability characteristics of liquids and vapors. Limiting oxygen concentration and inerting, flammability diagram, ignition energy, auto-ignition, auto-oxidation, adiabatic compression, ignition sources, sprays and mists, explosions. Consequence end points (Heat radiation levels, Explosion Over pressure levels and Toxic end points). Occupational Exposure Levels (Chemical Exposure Levels, Electrical Radiation level, Cariogenic exposures, Noise levels and other Occupational hazards associated in industries). Emergency Exposure Levels (IDLH, ERPG and other thresholds for Pre-Incident Planning and Emergency Responses). **4 Hrs**

Unit – IV

Likelihood analysis: Concepts of equipment, reliability and process safety implications, Reliability, Availability and Maintainability, Equipment reliability (Failure frequency and failure data for equipment), Concepts of Safety Integrity Levels, Human Reliability (High Reliability Organization). **6 Hrs**

Unit – V

Industrial concepts of Safeguards and Independent Layer of Protection (Process Safety in Design): Process Safety Information, Facility Siting, Pressure relief devices, Control System Design, Safe systems of plant shutdown (Interlock systems), Automation, Artificial Intelligence, and Big Data Analytics, Industry 4 and growth areas, Pre-Incident Planning, Emergency Preparedness, Risk Matrix, Risk Acceptance Criteria, Risk As Low As Reasonably Practicable (ALARP) – decision making process, Leading and Lagging Performance Indicators, Human Factors (Skillsets and mindsets for risk professionals). **13 Hrs**

TEXTBOOKS:

Crowl, D. A. and Louvar, J. F.,	Chemical Process Safety: Fundamentals with Applications, Prentice Hall, Upper Saddle River, NJ, 2e, 2001, ISBN: 0132440555, 9780132440554

American Institute of Chemical Engineers	Guidelines for Risk Based Process Safety CCPS (Center for Chemical Process Safety) ISBN: 978-1-118-20963-9

REFERENCE BOOKS:

Sam Mann an	Lee's Loss Prevention in the Proces Industries, 3e, ISBN: 0-7506-7555-1

Course outcomes: On successful completion of the course, the student will be able to

1 Illustrate the concepts of process safety, benefits of process safety to an organization and to society.
2 Demonstrate knowledge about risk assessment, hazards and principles of process safety risk assessment including layers of protection, threats, consequences , etc. for a given situation.
3 Perform hazard identification/ risk assessment for a process safety case study using the concepts of process hazard analysis and distinguish qualitative and quantitative risk assessment techniques, their uses, benefits and limitations.
4 Apply the Knowledge of regulations, standards, risk Assessment techniques, inherent safety techniques and risk-based decisions during design projects.

CHEMICAL REACTION ENGINEERING LAB

Contact Hours/ Week	0+0+2 (L+T+P)	Credits	1.0
Sub. Code	N6CHL01	CIE Marks	50
		SEE Marks	50

Course Objectives: This course will enable students to:

1. Introduce to the practical aspect of reaction engineering fundamentals.
2. Learn to carry out experiments to obtain kinetic and RTD data.
3. Acquaint with analysis and interpretation of experimental data and determine the order of reaction and specific rate constant.
4. Learn to write effective technical reports based on results obtained and arrive at appropriate conclusions.

The experiments are based on the following topics.

1. To estimate order and rate constant for a reaction in a batch reactor- I (equi-molar) and non-equimolar)
2. To estimate order and rate constant for a reaction in a batch

reactor- II (non-equimolar)
3. To estimate the rate constant of a reaction at different temperatures in a batch reactor
4. To estimate order and rate constant for a reaction in a CSTR
5. To determine order and rate constant for a reaction in a PFR
6. Effect of addition of reactant on conversion in a Semi-batch reactor
7. Estimation of rate constant of a saponification reaction in a packed bed reactor
8. RTD studies in a CSTR
9. RTD studies in a PFR-I (pulse input)
10. RTD studies in a PFR-II (step input)
11. Determine rate constant and order in a combined flow reactor (PFR + MFR)

TEXTBOOKS:

Octave Levenspiel	Chemical Reaction Engineering, Wiley Publishers, 3e, 2006, ISBN: 978-8126510009
Himadri Roy Ghatak	Reaction EngineeringPrinciples, CRC Press, 1e, 2016, ISBN:978-1-4987-5858-1

REFERENCE BOOKS:

Fogler H Scott	Elements of chemical Reaction Engineering", Pearson Education India, 4e, 2015, ISBN:978-9332549326.
J.M. Smith	Chemical Engineering Kinetics", McGraw Hill, 3e, 2014, ISBN-13: 978-9332902633.

Course Outcomes: After the completion of the course, the student will be able to:
1. Conduct the experiments to acquire the kinetics and RTD data.
2. Analyse and interpret the experimental data to obtain the reaction rate expression (order of reaction and specific rate constant)
3. Write appropriate technical report with proper conclusions.
4. Demonstrate the knowledge of Chemical Reaction Engineering and its applications.

MINI PROJECT

Contact Hours / Week	0+0+7 (L+T+P)	Credits	2.0
Sub. Code	N6CHMP	CIE Marks	0.0
		SEE Marks	0.0

Course Objectives: This course will enable students to:

1. Educate the students to identify unmet societal needs and train

them to apply basic sciences and chemical engineering principles to solve them.

2: Guide the students to use latest research methods and modern engineering and design tools to provide valid conclusions.

3: Create awareness about importance of professional ethics and implications of the proposed solution.

4: Guide the students to function effectively as an individual or in a team to solve a problem.

5: Educate the students to effectively communicate the unmet need and their proposed solution.

6: Introduce the need for further knowledge and continuous development of competencies including innovation and entrepreneurship.

Guidelines for Mini Project:

The project can be taken by group of 4 students and mini project can be carried out in the dept. under a guide or outside the department/institute/ company under a guide from the dept. and co guide from the outside department/institute/ company.

Mini project is evaluated over 2 semesters (V & VI) and is evaluated at the end of each semester. With no credit in the V sem., mini project is evaluated for 100 marks at the end of VI semester (50% CIE & 50% SEE)

Evaluation procedure: (CIE)

1	Report	Abstract, Introduction, Literature survey, And parameters planned to study	05 marks
2	PPT Presentation	Evaluation by the DPEC	10 marks

Course Outcomes: On successful completion of the course, the student will be able to:

1. Identify the issues prevailing in areas where chemical engineering is applied.
2. Demonstrate sound technical knowledge of the selected project topic and apply the knowledge of basic sciences and chemical engineering to meet the unmet needs.
3. Use of research methods including design of experiments and data analysis to provide valid conclusions after conducting investigations.
4. Develop process engineering solutions and/or design process equipment to the selected problem.

5. Demonstrate knowledge about implications of the proposed solution with respect to finance, environment and sustainability and society.
6. Demonstrate the ability to apply modern engineering tools including process modelling, simulation and optimization to the selected topic with an understanding of the constraints.
7. Display ethical behavior in the context of conduction of experiments, data analysis and reporting.
8. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings to solve problems within the area of expertise.
9. Evaluate and critically assess one's own and others' results and be able to document and present one's own work for a given target group, with requirements on structure, format, and language usage.
10. Demonstrate the need for further knowledge and continuously develop competencies including innovation and entrepreneurship.

INTERNSHIP - II

Lab Hours/ Week	: --	Credits :	3.0
Sub. Code	: INT2	CIE Marks :	100
		SEE Marks :	0

Course Objectives:
This course will enable students to:

1. Explain the process and the technical details about process in the industry.
2. Educate students about the process flow diagram and its interpretation.
3. Understand the concepts of material and energy balances to a given process.
4. Prepare a technical report and presentation about the given industrial process.

Guidelines:
Students have to undergo for a period of 4 weeks minimum during the vacation between even and odd semesters of II or III year. Those students who are unable to complete during these period will have to undergo training after VIII semester and the VIII semester results will be announced only after the successful completion of Industrial Training.

Course Outcomes: After the completion of the course, the student will be able to:

1. Demonstrate the knowledge of the given process learnt in the industry.
2. Demonstrate the knowledge of process flow diagram and its

interpretation.
3. Apply the concepts of material and energy balances to a given process.
4. Prepare a technical report and presentation about the given industrial process.

APTITUDE RELATED ANALYTICAL SKILLS

Contact Hours/ semester	36+0+0 (L+T+P)	Credit :	1.0
Total Lecture Hours	36	CIE Marks :	50
Sub. Code	ARAS	SEE Marks :	50

MODULES COVERED:

Sl. No.	Module covered	Duration (in hrs.)
1	Quantitative Aptitude	16
2	Verbal Reasoning	08
3	Logical Reasoning	08
4	Test taking strategies to crack recruiter tests	02
5	Post-Training Assessment along with a debrief	02
	Total Course Duration	**36**

Methodology : Instructor led – Concepts with guided question solving, assignments and homework assessments

Detailed syllabus:

1.Quantitative Aptitude (with focus on questions from top recruiters) **16 hrs**

- Number System
- Classification of numbers
- Divisibility tests
- Power cycles and remainders
- Factors and multiples
- Applications of HCF and LCM

b) Profit and Loss, Partnerships and Averages

- Basic terminology in Profit and Loss
- Partnerships
- Averages and weighted averages
- Mixtures and alligations

c) Time and Work

- Working with different efficiencies
- Pipes and cisterns
- Work equivalence
- Division of wages

d) Time, Speed and Distance

- Basics of Time Speed and Distance
- Relative Speed
- Problems based on trains
- Problems based on boats and streams
- Problems based on Races

e) Percentages, Simple and Compound Interest

- Percentages as fractions and decimals
- Percentage increase / decrease
- Simple interest and compound interest
- Relationship between simple and compound interest

f) Permutation, Combination and Probability

- Fundamental counting principle
- Basics of permutation and combination
- Computation of permutation
- Circular permutation
- Computation of combination
- Probability

g) Logarithms, Progressions, Geometry and Quadratic Equations

- Logarithms
- Progressions – Arithmetic, Geometric and Harmonic
- Geometry
- Mensuration
- Quadratic equations

2.Verbal Reasoning (with focus on questions from top recruiters) – 8 hrs

a) Reading Comprehension –

- Eyespan
- Speed reading techniques
- Types of questions
- Comprehension strategies

b) Sentence Correction –

- Subject-Verb Agreement
- Parallelism
- Modifiers
- Pronoun Antecedent Agreement
- Verb Time Sequence
- Comparison
- Determiners
- Prepositions

c) Vocabulary –

- Etymology of words
- Prefix and suffix
- Memory techniques to remember words
- Synonyms and antonyms
- Analogy

d) Sentence Completion and Para Jumbles –

- Sentence completion – single blank and double blank questions
- Parajumbles – Moving and anchored jumbles

3.Logical Reasoning (with focus on questions from top recruiters)-
8hrs

a) Coding and Decoding, Series, Analogy, Odd Man Out and Visual Reasoning
- Coding and decoding
- Number and alphabet series
- Analogy
- Odd man out
- Visual Reasoning

b) Data Arrangements and Blood Relations
- Linear, circular and distribution arrangements
- Blood Relations

c) Data interpretation and Data Sufficiency
- Tables
- Pie Charts
- Bar Graphs
- Data Sufficiency

d) Clocks, Calendars, Direction sense and Cubes
- Clocks
- Calendars (Conventional and shortcut methods to find day of a date)
- Cubes
- Direction Sense

4.Test taking strategies – 2 hrs

This module will focus on:
- Understanding patterns of tests (Adaptive, non adaptive, navigation – intra sectional, inter sectional)
- Best strategies to maximize scores and clear cut-offs
- Shortcut strategies on Quantitative Aptitude, Logical Reasoning as well as Verbal Ability to ace sections

5.Post Training Assessment with debrief – 2 hrs

An assessment that tests a student on all three sections of Aptitude, followed a detailed student-wise analysis based on:
- Cut-off
- Percentile w.r.t the batch
- Percentile w.r.t. the college
- Corrective measures to be taken to improve the score

In class, there will be a debrief on how the test should have been taken by an ideal test taker to navigate through the difficulties and ace the cut-off.

6.Tests outside training schedule

An ideal aptitude training course is a mix of classroom learning / guided question solving, followed by self-practice. The 'training duration' focuses mainly on laying strong foundations on concepts and ability to solve questions on major aptitude topics. Significant amount of practice is also provided to students through online tests in the form of:

1.Pre-Assessment test
2.Full-length practice tests
3.Company specific tests (patterns and question types of major

recruiters should be given exposure to)

REFERENCE BOOKS:

Face Wiley India	Aptipedia, Aptitude Encyclopedia, Wiley India Ltd. 2017, 2e, ISBN:978-8126569502
R S Agarwal	Quantitative Aptitude for Competitive Examinations, S Chand Publishing, 2022, New Delhi, ISBN:978-9355012326
Nisht K Sinha	The Pearson Guide to Verbal Ability and Logical Reasoning for the CAT, 1e, Pearson Education, 2012, ISBN:978-8131774137