AC –
Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1, 4 & 5		
Name of the Programme – B.E. (Chemical Engineering)		
Faulty of Engineering		
Board of Studies in Chemical Engineering		
U.G. Third Year Programme	Exit Degree	B.Sc. Tech Engineering- Chemical Engineering
Semester		V & VI
From the Academic Year		2026-27

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O:____________________	B.E. (Chemical Engineering)
2	Exit Degree	B.Sc. Tech Engineering- Chemical Engineering.
3	Scheme of Examination R: ____________	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	Standards of Passing R: ______________	40%
5	Credit Structure R: ______________	Attached herewith
6	Semesters	Sem. V & VI
7	Program Academic Level	5.5
8	Pattern	Semester
9	Status	New
10	To be implemented from Academic Year	2026-27

Sd/-
Dr. Parag Gogate
BoS-Chairman-Chemical Engineering
Faculty of Technology

Sd/-
Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-
Prof. Shivram S. Garje
Dean
Faculty of Science & Technology

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The third-year engineering course consists of a core and elective training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, program elective course, multidisciplinary minor, IKS, PCE and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program, elective program, communication skills and skills required for the Chemical Engineering branch of engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends. Elective courses are offered to the learners to understand the concepts of emerging technology. This will help with the holistic development of learners through interdisciplinary skills development and mobility among other departments as real-time solutions. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Chemical Engineering for open electives and multidisciplinary minor courses in sem V and VI. Essentially, to give a glimpse of trends in the industry under vocational and enhanced skill practices, the pool is offered to nurture and develop creative skills in contemporary industrial practices. Criteria met in the structure is the opportunity for learners to choose the course of their interest in all disciplines.

Program Core Course and Program Elective Courses Cover Chemical Engineering core and elective courses. Also, MDM is where a pool of subjects is given for selection. In addition to this learner will have IKS and PCE courses. Considering the present scenario, diverse choices need to be made available to fulfil the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. The IKS course will be program-specific, which can be achieved in Undergraduate training by giving an objective viewpoint to the learning technology, from ascent time and how it was learned and the process and transitioning a learner from a rote learner to a creative professional. For this purpose, PCE is introduced in the First Semester to orient a communication skills to become skilled professionals for placement and higher education entrance exams. Considering the NEP-2020 structure of award of Certificate after U.G. First Year, U. G. Diploma after the Second Year and B.Sc. Tech Engineering after the Third Year at multiple exit-point pools of Vocational skills, is arranged to give exposure to the current Industry practices.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every core and elective course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught to the learners, which will enhance the learners' learning process. NEP 2020 grading system enables a much-needed shift in focus from teacher-centric to continuous-based learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on the holistic development of the learners through mobility and continuous evaluation, which will enhance the quality of education. Credit assignment for courses is based on a 15-week teaching-learning process for NEP 2020; however, the content of courses is to be taught in 12-13 weeks, and the remaining 2-3 weeks are to be utilized for revision, self learning, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the third-year syllabus must not be heavily loaded for the learner and it is of utmost importance that the learner entering into the third year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a learner to get accustomed to the new environment of a college and to create a bond between the teacher and the learner. The present curriculum will be implemented for the Third Year of Engineering from the academic year 2026-27. Subsequently, this system will be carried forward for Final Year Engineering in the academic years 2027-28, respectively.

Sd/-	**Sd/-**	**Sd/-**
Dr. Parag Gogate **BoS-Chairman-Chemical Engineering** **Faculty of Technology**	**Dr. Deven Shah** **Associate Dean** **Faculty of Science & Technology**	**Prof. Shivram S. Garje** **Dean** **Faculty of Science & Technology**

B.Sc. Tech Engineering- Chemical Engineering.

Credit Structure (Sem. V & VI)

Level	Semester	Major: Mandatory	Major: Electives	Minor	OE	VSC, SEC (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC,RP	Cum. Cr. / Sem.	Degree/ Cum. Cr.
	R: ________________C									
5.5	V	2075111:3 2075112:3 2075113:3 2075115: 1 2075116:1 2075117:1	2075114X:3 2075118X:1	MDC501:3 MDL501:1	OEC L501: 2	--	2075511: IKS: 2	--	24	B.Sc. Tech Engineering 48
	R:_________________D									
	VI	2076111:3 2076112:3 2076115:1 2076116:1	2076113X:3 2076114X:3 2076117X:1 2076118X:1	MDC601: 3 MDL601:1	--	2076411 VSEC:2	2996511: AEC: 2	--	24	
	Cum Cr.	20	12	8	2	2	*2+2*	--	48	

Exit option: Award of UG Diploma in Major and MDM with 90 credits and additional 4 credits core **one** theory subject with 3 credits and **one** lab with 1 credit from one third year from where they want to take Exit degree. Along with theory and practical course student must compulsory do internship for **one month or 160 hours** which internship is equal to 4 credits.

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

T.E.Chemical Scheme

Program Structure for Third Year of Chemical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER V

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2075111	Transport Phenomena	3	--	--	3	--	--	3
2075112	Chemical Reaction Engineering-I	3	--	--	3	--	--	3
2075113	Mass Transfer Operations-I	3	--	--	3	--	--	3
2075114X	PEC-1	3	--	--	3	--	--	3
MDC501	Multidisciplinary minor	3	--	--	3	--	--	3
2075115	Transport Phenomena Lab	--	2	--	--	--	1	1
2075116	Chemical Reaction Engineering-I Lab	--	2	--	--	--	1	1
2075117	Mass Transfer Operations-I Lab	--	2	--	--	--	1	1
2075118X	PEL-1	--	2	--	--	--	1	1
MDL501	Multidisciplinary minor	--	2@	--	--	--	1	1
OECL501	To be taken from the bucket provided by the University from other Faculty	2#	--	---	2	--	--	2
2075511	IKS -II	--	2*+2	--	--	--	2	2
Total		**17**	**14**	**00**	**17**	**00**	**07**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Institute shall offer a course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

@ Institute shall offer a course for MDM from other Engineering Boards Group.

LIST of Program Elective Course-I (PEC-I) and Program Elective Lab-I (PEL-I)

Course Code	**Course Description**	
20751141	PEC-11	Piping Engineering
20751142	PEC-12	Advanced Material Sciences
20751143	PEC-13	Food Science & Engineering
20751144	PEC-14	Numerical Methods in Chemical Engineering
Lab Code	**Lab Description**	
20751181	PEL-11	Piping Engineering Lab
20751182	PEL-12	Advanced Material Sciences Lab
20751183	PEL-13	Food Science & Engineering Lab
20751184	PEL-14	Numerical Methods in Chemical Engineering Lab

SEMESTER V

course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral/ Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2075111	Transport Phenomena	20	20	40	60	2	--	--	100
2075112	Chemical Reaction Engineering-I	20	20	40	60	2	--	--	100
2075113	Mass Transfer Operations-I	20	20	40	60	2	--	--	100
2075114X	PEC-1	20	20	40	60	2	--	--	100
MDC501	Multidisciplinary minor	20	20	40	60	2	--	--	100
2075115	Transport Phenomena Lab	--	--	--	--	--	25	--	25
2075116	Chemical Reaction Engineering-I Lab	--	--	--	--	--	25	25	50
2075117	Mass Transfer Operations-I Lab	--	--	--	--	--	25	25	50
2075118X	PEL-1	--	--	--	--	--	25	25	50
MDL501	Multidisciplinary minor	--	--	--	--	--	25	25	50
OECL501	To be taken from the bucket provided by the University by other Faculty	--	--	--	--	--	50	--	50
2075511	IKS-II						50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**100**	**825**

SEMESTER VI

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2076111	Mass Transfer Operations-II	3	--	--	3	--	--	3
2076112	Chemical Reaction Engineering-II	3	--	--	3	--	--	3
2076113X	PEC-1	3	--	--	3	--	--	3
2076114x	PEC-2	3	--	--	3	--	--	3
MDC601	Multi-disciplinary minor	3	--	--	3	--	--	3
2076411	Chemical Engineering Software Skills	--	4	--	--	--	2	2
2996511	Professional Skill	--	2*+2	--	--	--	2	2
2076115	Mass Transfer Operations-II Lab	--	2	--	--	--	1	1
2076116	Chemical Reaction Engineering-II Lab	--	2	--	--	--	1	1
2076117X	PEL-1	--	2	--	--	--	1	1
2076118X	PEL-2	--	2	--	--	--	1	1
MDL601	Multi-disciplinary minor	--	2@	--	--	--	1	1
Total		**15**	**18**	**00**	**15**	**00**	**09**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

@ Institute shall offer a course for MDM from other Engineering Boards.

List of Program Elective Course-I & II (PEC-I&II) and Program Elective Lab-I &II (PEL-I &II)

Course Code	**Course Description**	
	PEC-I	
20761131	PEC-11	Pollution Control Technology
20761132	PEC-12	Biotechnology
20761133	PEC-13	Project Engineering and Management
20761134	PEC-14	Petroleum Refining
	PEC-II	
20761141	PEC-21	Industrial safety
20761142	PEC-22	Energy System Design
20761143	PEC-23	Plant Utility
20761144	PEC-24	Polymer Technology
Lab Code	**Lab Description**	
	PEL-I	
20761171	PEL-11	Pollution Control Technology Lab
20761172	PEL-12	Biotechnology Lab
20761173	PEL-13	Project Engineering and Management Lab
20761174	PEL-14	Petroleum Refining Lab
	PEL-II	
20761181	PEL-21	Industrial safety Lab
20761182	PEL-22	Energy System Design Lab
20761183	PEL-23	Plant Utility Lab
20761184	PEL-24	Polymer Technology Lab

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral/ Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2076111	Mass Transfer Operations-II	20	20	40	60	2	--	--	100
2076112	Chemical Reaction Engineering-II	20	20	40	60	2	--	--	100
2076113X	PEC-1	20	20	40	60	2	--	--	100
2076114x	PEC-2	20	20	40	60	2	--	--	100
MDC601	Multi-disciplinary minor	20	20	40	60	2	--	--	100
2076411	Chemical Engineering Software Skills.	--	--	--	--	--	50	--	50
2996511	Professional Skill	--	--	--	--	--	25	--	25
2076115	Mass Transfer Operations-II Lab	--	--	--	--	--	25	25	50
2076116	Chemical Reaction Engineering-II Lab	--	--	--	--	--	25	25	50
2076117X	PEL-1	--	--	--	--	--	25	25	50
2076118X	PEL-2	--	--	--	--	--	25	25	50
MDL601	Multi-disciplinary minor	--	--	--	--	--	25	25	50
Total		**100**	**100**	**200**	**300**	**10**	**200**	**125**	**825**

T.E Chemical

Semester - V

Vertical – 1
Major

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2075111	**Transport Phenomena**	**3**	-	-	**3**	-	-	**3**

Course Objectives:

Course Code	Course Name	Theory					Term work (TW)	Oral & Pract	Total
		Internal Assessment (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs.)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
2075111	**Transport Phenomena**	20	20	40	60	2	-	-	**100**

1. To introduce the fundamental principles of momentum, heat, and mass transfer using a unified transport phenomena approach.
2. To develop the ability to formulate governing transport equations using vector calculus, differential equations, and tensor notation.
3. To enable students to apply constitutive laws such as Newton's law of viscosity, Fourier's law of heat conduction, and Fick's law of diffusion to engineering problems.
4. To perform calculations and analyze problems related to laminar flow systems and determining velocity profiles using shell balance techniques and appropriate boundary conditions.
5. To analyze energy transport problems, including heat conduction with internal heat generation and composite systems.
6. To provide a strong foundation in mass transport analysis, enabling evaluation of concentration distribution and mass flux in diffusion and reaction-based systems relevant to chemical engineering applications.

Course Outcomes:

On completion of the course the students will be able to

1. Apply principles of vector calculus, differential equations, and tensor notation to formulate governing equations for transport processes.
2. Understand the fundamental concepts & molecular basis of momentum, heat, and mass transfer.
3. Solve laminar flow problems by determining velocity profiles and related flow parameters in practical chemical engineering systems
4. Apply momentum transfer principles and governing equations to analyze and solve industry-oriented chemical engineering flow problems.
5. Apply momentum transport principles to real chemical engineering flow problems.
6. Apply mass transfer principles to analyze **concentration distribution and mass flux** in steady-state diffusion problems.

Prerequisite:

1. Engineering Mathematics: Ordinary and partial differential equations, Vector tensors.
2. Fluid Mechanics: Basic concepts of fluid properties.
3. Modes of heat transfer, Basic energy balance concepts.
4. Mass Transfer Fundamentals: Concept of diffusion, Basic mass balance equations.
5. Engineering Physics and Engineering Chemistry.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	Introduction to Transport Phenomena	1.1Introduction to differential equations (1^{st} and 2^{nd} order) 1.2 vector tensors (Gradient, Divergence and Curl) 1.3 Importance of Transport Phenomena (Macroscopic and Microscopic approach) 1.4 Introduction to analogies between momentum, heat and mass transfer, Defining Dimensionless numbers 1.6 Temperature and Pressure dependency of viscosity, thermal conductivity and mass diffusivity in gases and liquids. 1.7 Eulerian and Lagrangian approach, Equation of continuity, Equation of motion and Equation of energy. 1.8 AI & advanced computional techniques in transport phenomena (Numerical problem solving based on all the above topics) **Self-Learning Topic:** Application of AI/ML in predicting transport properties	07	CO1
2	Governing laws and fluxes for Transport Processes	2.1 Newton's law of viscosity 2.2 Fourier's law of heat conduction 2.3 Fick's law of diffusion 2.4 Momentum, heat, and mass flux concepts (Numerical problem solving based on all the above topics) **Self-Learning Topic:** Experimental methods for measurement of viscosity, thermal conductivity, and diffusivity	04	CO2
3	Mechanism of momentum transport: Velocity distribution in laminar flow	3.1Mechanism of momentum transport 3.2Newtonian & Non-Newtonian fluids 3.3 Velocity distribution in laminar flow: Shell momentum balances and boundary conditions 3.4 Flow of falling film (Vertical and Inclined) 3.5Flow through the circular tube	07	CO3

		(Numerical problem solving based on all the above topics) **Self-Learning Topic:** Application of non-Newtonian fluids in industries (food, pharmaceuticals, petrochemicals)		
4	Application of Momentum Balance to Special Flow Systems	4.1 Flow through an annulus 4.2 Flow in a narrow slit 4.3 Coaxial rod and cylinder (Numerical problem solving based on all the above topics) **Self-Learning Topic:** Flow behavior in packed beds and porous media	06	CO4
5	Mechanism of energy transport: Temperature distribution in solids and in laminar flow	5.1 Mechanism of energy transport: 5.2 Temperature distribution in solids and in laminar flow, shell energy balance and boundary conditions a) Heat conduction with electrical heat source b) Heat conduction with a viscous heat source c) Heat conduction in composite wall and cylinder d) Heat conduction in a cooling fin (Numerical problem solving based on all the above topics) **Self-Learning Topic:** Heat transfer enhancement techniques (fins, turbulators, nanofluids)	08	CO5
6	Mechanism of mass transport: Concentration distribution in solids and in laminar flow	6.1 Mechanism of mass transport: Definitions of concentrations, velocities. 6.2 Concentration distribution in solids and in laminar flow, Shell mass balances and boundary conditions a) Diffusion through stagnant gas film b) Diffusion with heterogeneous chemical reaction C) Solvent–Solid Concentration and Mass Flux in Leaching through a Pyrex Tube (Numerical problem solving based on all the above topics) **Self-Learning Topic**: Advanced separation processes (membrane separation, adsorption)	07	CO6
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject.				

Textbooks:

1. Bird, R.B., W.E. Stewart and E.N. Lightfoot, Transport Phenomena, Wiley, New York, 2nd ed., 2002

2. William J. Thomson, Introduction to Transport Phenomena, Prentice Hall, 2000

3. Ismail Tosun, Modelling In Transport Phenomena A Conceptual Approach, Elsevier Science B.V. 2002 1st Edition

References:

1. Christie J. Geankoplis, Transport Processes and Separation Process Principles, 4th Edition, 2004.

2. Brodkey, R.S. and H.C. Hershey, Transport Phenomena: A Unified Approach, McGraw-Hill, New York. 1988

3. Bodh Raj, Introduction to Transport Phenomena (Momentum, Heat and Mas), PHI Learning Pvt. Ltd, Eastern Economy Edition.

4. Grewal B.S., Higher Engineering Mathematics, Khanna Publisher 44th Edition

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc20_ch06/preview

Assessment:

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination:

Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus.**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2075112	Chemical Reaction Engineering-I	3	-	-	3	-		3

Course Code	Course Name	Theory					Term work (TW)	Oral & Pract	Total
		Internal Assessment (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs.)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
2075112	Chemical Reaction Engineering-I	20	20	40	60	2			**100**

Rationale: The goal of this course is to make the learner conversant with the fundamental principles of chemical reaction kinetics and reactor design for homogeneous reactions. The syllabus is designed to help learners develop the capability to model, analyse, and design chemical reactors, laying a foundation for understanding and optimising chemical processes.

Course Objectives:

1. To explain and classify homogeneous chemical reactions and reaction kinetics.
2. To formulate rate equations using reaction mechanisms and experimental kinetic data.
3. To analyze and model kinetic data for single and multiple homogeneous reaction systems.
4. To apply material balance principles to derive and design ideal chemical reactors such as Batch, CSTR, and PFR.
5. To evaluate and select suitable reactor configurations and combinations for various types of reactors.
6. To analyze and assess the effect of temperature and heat effects on reactor performance under adiabatic and non-adiabatic conditions.

Course Outcomes:

On successful completion, of course, the learner/student will be able to:

1) Classify reaction kinetics, rate laws, and reaction mechanisms for elementary and non-elementary homogeneous reactions.
2) Analyze experimental kinetic data using differential and integral methods to determine rate parameters and interpret pressure/concentration–time profiles for homogeneous systems..
3) Develop kinetic models for single and multiple homogeneous reaction systems.
4) Derive performance equations for Batch, CSTR, and PFR using material balance principles.
5) Asses reactor types and combinations for desired conversion levels.
6) Evaluate the effect of temperature and heat effects on reactor performance under adiabatic and non-adiabatic operation.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Types and classification of reactions. Stoichiometry, Chemical reaction balance, Material balance, Energy balance	0	
1	Introduction to Reaction Engineering and Kinetics of Homogeneous Reactions	Definitions of reaction rate, Variables affecting reaction rate, Speed of chemical reactions. Formulation of the rate equation. Molecularity and order of reaction. Rate constant k, temperature-dependent term of the rate equations from Arrhenius theory. Representation of an elementary and non-elementary reaction. Kinetic models for non-elementary reactions. Reaction mechanism and its influence on kinetics. Search for a plausible mechanism via reaction kinetics. ***Self Learning Topics :***Enzyme Kinetics and Michaleis Menten Model Temperature Dependence of Reaction Rates: Collision Theory and Transition State Theory	08	CO1
2	Methods of analysis of experimental data (constant volume)	a) Analysis of total pressure data. b) Integral method of analysis of experimental data. c) Differential method for analysing experimental data. d) Concept of Half Life/Fractional Life. Overall order of an irreversible reaction. ***Self Learning Topics :*** Determination of Reaction Order Using the Method of Initial Rates and Ostwald's Dilution Method	06	CO2
3	Methods of analysis of experimental data (multiple reaction system + variable volume)	Integral method of analysis for : a) First-order reversible reaction. b) Irreversible reaction in parallel and in series (first Order). c) Homogeneous catalysed reactions. d) Auto-catalytic reactions. e) Shifting order reactions. f) Variable volume reaction. ***Self Learning Topics :*** Analysis of Consecutive Homogeneous Reactions of Different Orders (Ex. Zero order followed by first order)	06	CO3
4	Design of Reactors: (Design for single reactions)	Ideal batch reactor and concept of batch time. Flow reactor and concept of space time/space velocity and holding time/residence time. Ideal Mixed Flow Reactor (MFR) and Plug Flow Reactor (PFR). Single reactor performance of irreversible and reversible first-order, pseudo-first-order, and second-order reactions for MFR and PFR. Graphical and analytical techniques. ***Self Learning Topics :*** Performance Comparison of Batch, CSTR, and PFR for Autocatalytic Homogeneous Reactions.	08	CO4

5	Design of Reactors: (Combination of Reactors)	Performance of the multiple reactors for the first-order reactions. a) PFR in series/ parallel. b) MFR in series/ parallel. c) Unequal size MFR in series. d) PFR-MFR in series Introduction to Semi-batch and Recycle Reactor. ***Self Learning Topics :***Design for Irreversible reactions in series and parallel with the same or different orders in various combinations**.**	06	CO5
6	Introduction to Heat Effects:	General graphical design procedure. Optimum temperature progression and Heat effects in adiabatic and non-adiabatic reactions. Exothermic reaction in mixed flow. ***Self Learning Topics :***Thermal Stability of Exothermic Homogeneous Reactions in Continuous Stirred Tank Reactors. Influence of Heat Removal on the Operation of Exothermic Homogeneous Reactors	05	CO6
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject.				

Text Books:

1) Levenspiel O., Chemical Reaction Engineering, John Wiley&Sons,3rd ed.,1999.
2) Smith J.M., Chemical Reaction Engineering, 3rd ed., Tata McGraw-Hill,1980.
3) Fogler, H.S. Elements of Chemical Reaction Engineering, 4th ed, PHI, 2008

References:

1) Hill C.G., Chemical Reaction Engineering.
2) Walas, Reaction Kinetics for Chemical Engineers, McGraw-Hill, 1959

Online References:

Sr. No.	Website Name
1.	nptel.ac.in/courses/103106116
2.	nptel.ac.in/courses/103103153
3.	Elements of Chemical Reaction Engineering

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test.

End Semester Theory Examination:

Question paper format

- The Question Paper will comprise a total of **six questions, each carrying 15 marks. Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus.**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3, then part (b) must be from any other Module randomly selected from all the modules.
- A total of **four questions** need to be answered.
- No questions will be asked in the **End Semester Examination (ESE)** from the **self-learning Topics.**

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2075113	Mass Transfer Operations-I	3	-	-	3	-		3

Course Code	Course Name	Theory					Term work (TW)	Oral & Pract	Total
		Internal Assessment (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs.)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
2075113	Mass Transfer Operations-I	20	20	40	60	2			**100**

Rationale:
To provide students with a **progressive and holistic understanding** of mass transfer principles

Course Objectives:

1. To provide students with a comprehensive understanding of molecular diffusion phenomena in gases, liquids, and solids
2. To enable students to develop a clear understanding of the concept and definition of mass transfer coefficients, with emphasis on F-type and K-type coefficients, their interrelationships, and their application in interphase mass transfer processes.
3. To provide students with a systematic understanding of the operation of various gas–liquid contacting equipment
4. To enable students to develop a clear understanding of gas absorption and impart the knowledge of single-component gas absorption operation with co-current and counter-current flow arrangements in packed and multistage columns.
5. To provide students with a fundamental understanding of drying, enable them to analyze batch and continuous operations and an understanding of the operations of various drying equipment.
6. To provide students with the fundamental knowledge of various properties of vapour gas mixtures and a systematic understanding of humidity charts and the operations of cooling towers

Course Outcomes:

1. Students will be able to analyze and explain molecular diffusion phenomena in gases, liquids, and solids, applying fundamental principles to calculate mass transfer rates in industrial mass transfer problems.
2. Students will be able to define and distinguish F-type and k-type mass transfer coefficients, explain their interrelationships, and apply them to analyze interphase mass transfer processes in industrial mass transfer problems.
3. Students will know various equipment for gas-liquid contacting and will be able to describe their operation and thereby evaluate their performance and suitability for different mass transfer applications.

4. Students will be able to explain the principles of gas absorption and analyze single-component absorption operations in packed and multistage columns with various flow arrangements.
5. Students will be able to explain the fundamentals of drying, analyze batch and continuous drying operations, and evaluate the performance and operation of various drying equipment used in industrial processes.
6. Students will be able to explain the properties of vapour–gas mixtures, interpret and apply humidity charts, and explain the operation of cooling towers.

Prerequisite:

The learners should know about the following domains.

1. Mathematics, physics, and physical chemistry.
2. System of units.
3. Process calculations (Mass and Energy Balance)
4. Fundamentals of thermodynamics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	• System of units • Fundamentals of differential and integral calculus. • Laws of conservation of mass, energy and momentum, • Concept of thermodynamic equilibrium	1	
1	Molecular diffusion (Gases, liquids, and solids)	• Definition of molecular diffusion • Definition of molar flux and types. • Fick's first law of molecular diffusion • Steady-state molecular diffusion in binary gas mixtures: ✓ One component diffusing in a non-diffusing second component, ✓ Equimolal counter diffusion of two components. ✓ Numerical example • Steady-state molecular diffusion in binary liquid solutions ✓ One component diffusing in a non-diffusing second component. ✓ Equimolal counter diffusion of two components. ✓ Numerical examples • Theoretical estimation of diffusivities for gases and liquids. • Fick's-law diffusion through solids. • Types of solid diffusion	8	CO1

		Self-Learning Topics • Molecular diffusion through multicompartment gas mixtures. • Derivation of the equation of continuity		
2	Mass transfer coefficients	• Definition of mass transfer coefficient. • F-type and k-type mass transfer coefficients. • Relations between F-type and k-type mass transfer coefficients, for binary gas and liquid mixtures, for the following cases ✓ One component diffusing in a non-diffusing second component ✓ Equimolal counter diffusion of two components. • Prediction of mass transfer coefficients in laminar flow. • Theories of mass transfer for predicting mass transfer coefficients in turbulent flow. • Introduction to interphase mass transfer • Two-film theory for interphase mass transfer. • The concept of individual and overall mass transfer coefficients. • The relation between individual and overall mass transfer coefficients for mass transfer between gas and liquid phases. • Numerical examples • Methods of contacting two insoluble phases **Self-Learning Topics** • Comparison of molecular with turbulent diffusion • Various dimensionless groups in mass transfer • Steady-state material balance for different types of processes.	8	CO2
3	Equipment for gas-liquid contacting.	• Classification of equipment for gas-liquid contacting. • Equipment in which the gas phase is dispersed and the liquid phase is continuous. ✓ Sparged vessels (Bubble columns) ✓ Mechanically agitated vessels/ ✓ Tray columns • Equipment in which the liquid phase is dispersed, and the gas phase is continuous. ✓ Venturi Scrubber ✓ Wetted wall column ✓ Spray column ✓ Packed column • Comparison between packed and tray columns	4	CO3

		Self-Learning Topics • Various types of tray efficiencies • Advanced equipment for gas-liquid contact.		
4	Gas Absorption	• Fundamentals of gas absorption ✓ Definition ✓ Equilibrium solubility of gases in liquids ✓ Effect of temperature and pressure on the equilibrium solubility. ✓ Ideal and non-ideal solutions ✓ Choice of a suitable solvent for gas absorption. • Single-component absorption ✓ Equations of operating line for co-and counter-current operations. ✓ Minimum liquid to gas ratio. ✓ Counter-current multistage operation with numerical examples based on the estimation of the number of stages. ✓ Absorption in a packed column with numerical examples based on the estimation of NTU, HTU and height of packed bed. **Self-Learning Topics** • Absorption with chemical reaction	8	CO4
5	Drying	• Fundamentals of drying ✓ Definition ✓ Equilibrium ✓ Definitions of different types of moisture contents. • Batch drying ✓ Rate of drying. ✓ Drying curve ✓ Typical rate of drying curve ✓ Time of batch drying and numerical examples based on it. • Equipment for batch and continuous drying Batch Drying a. Tray Dryers b. Vacuum Dryer c. Fluidized Bed Dryer Continuous Drying b. Spray Dryer c. Rotary Dryer **Self-Learning Topics** • Material and Energy Balance for Continuous Dryers • Green and Sustainable Drying	6	CO5
6	Humidification and dehumidification	• Fundamentals	5	CO6

		✓ Definition of humidification and dehumidification. ✓ Vapour-pressure curve ✓ Definitions of various properties of vapour-gas mixtures. • Wet-bulb temperature theory. • Derivation of the equation of adiabatic saturation curves. • Humidity charts. • Various cooling tower arrangements **Self-Learning Topics** • Design of cooling towers • Non-Adiabatic Operation: Evaporative Cooling		
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject.				

Textbooks:

1. Treybal R.E., Mass transfer operation, 3 Ed., McGraw-Hill Hill New York, 1980.
2. Datta B.K., Mass Transfer and separation processes, Eastern economy edition, PHI learning private ltd, New Delhi, 2009
3. G. K. Roy, Fundamentals of Heat and Mass Transfer, Khanna Publication, New Delhi

References:

1. McCabe W.L. and Smith J.C., Unit operations in chemical engineering, 5 Ed., McGraw-Hill, New York, 1993
2. Geankoplis C.J., Transport Processes and Unit Operations, Prentice Hall, New Delhi, 1997
3. Coulson J.M. Richardson J.F., Backhurst J.R. and Harker J.H., Coulson and Richardson chemical engineering, vol 1 & 2, Butterworth Heinmann, New Delhi, 2000
4. R.K. Sinnott (Ed), Coulson and Richardson chemical engineering, vol 6, Butterworth Heinemann, New Delhi, 2000

Online References:

Sr. No.	Website Name
1.	Swayam - NPTEL

Assessment:

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in the First IA Test, and the remaining 40% to 50% of syllabus content must be covered in the Second IA Test

End Semester Theory Examination:

Question paper format

- The Question Paper will comprise of a total of **six questions, each carrying 15 marks. Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus.**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3, then part (b) must be from any other Module randomly selected from all the modules.
- A total of **four questions** need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
20751141	**Piping Engineering**	**3**	-	**-**	**3**	**-**		**3**

Course Code	Course Name	Theory					Term work (TW)	Oral & Pract	Total
		Internal Assessment (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs.)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
20751141	**Piping Engineering**	20	20	40	60	2			**100**

Rationale:

Piping systems are an essential part of all process industries, including chemical, petroleum, power plants, pharmaceuticals, water treatment, and refineries. Efficient transfer of fluids, safe operation, proper design, and accurate installation of piping networks form the backbone of industrial infrastructure.

This course provides a comprehensive understanding of piping fundamentals, materials, Codes and standards, components, system design, and technical drawings required in industry.

Course Objectives:

1. To introduce the fundamental concepts of piping systems, pipe classifications, manufacturing processes, terminology, and basic functional features used in industrial piping.
2. To develops understanding of piping materials, their desirable properties, metallurgical concepts, corrosion behavior, coatings, insulation and color-coding standards
3. To provide knowledge of national and international codes and standards governing piping design, fabrication, installation, and safety requirements.
4. To familiarize students with various piping components, their specifications, fittings, valves, joints, supports, and quality inspection methods used in piping systems.
5. To provide understanding of pipe flow behavior, energy losses, water hammer, line sizing, stress analysis, and flexibility considerations for designing safe and efficient piping systems.
6. To develop the ability to understand and interpret various piping drawings, symbols, plot plans, GA drawings, PFDs, and P&IDs used in engineering documentation.

Course Outcomes:

On completion of the course the students will be able to:

1. Explain the basics of piping systems, pipe classifications, key definitions, vents/drains, and the responsibilities of a piping field engineer.
2. Select suitable piping materials based on properties, temperature/pressure conditions, corrosion resistance, and interpret coating, insulation, and color-coding standards (IS 2379).
3. Identify, interpret, and apply relevant piping codes and standards (such as ASME, ASTM, API, ANSI, ISO) required for proper design and safety compliance in piping systems.
4. Identify, classify, and select appropriate piping components, fittings, valves, joints, supports, and apply NDT knowledge for defect detection.
5. Apply flow principles, calculate losses, perform line sizing, evaluate stresses, conduct flexibility analysis, and understand pipeline designation in piping design.
6. Read, interpret, and prepare basic piping drawings including PFDs, and P&IDs using standard symbols and conventions.

Detailed Syllabus:

Sr. No	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	• Basics of Chemical Engineering Process • Fluid flow fundamentals	–	–
1	**Introduction to Piping**	• Introduction to piping • Pipe and tube • Pipe classification • Manufacturing processes of pipe • Pipe sizes and schedule number • Concept of high point vent and low point drain. • Duties & responsibilities of piping field engineer • **Self-Learning Topics:** Advanced and application-based study of concepts such as fluid flow calculations, pipe standards and materials, manufacturing methods, valves & fittings, piping layout and supports, corrosion prevention, and basic	**6**	CO1

		industrial design practices.		
2	**Materials of Piping**	• Selection of material for piping, • Desirable properties of piping materials • Iron Carbide Diagram • Materials for various temperature and pressure conditions, • Materials for corrosion resistance. • Pipe coating and insulation • Color coding of piping as per types fluid passing through piping (IS 2379:1990) • **Self-Learning Topics:** Advanced study of material selection based on temperature–pressure conditions, corrosion mechanisms and protection methods, interpretation of the iron–carbon diagram, coating/insulation techniques, and industrial standards (like IS 2379) used in real piping systems.	**4**	CO2
3	**Codes and Standard**	• Codes and standards such as, ANSI codes for pressure piping 31.1 and 31.3. International standards, DIN and API. • **Self-Learning Topics:** Detailed study of major piping codes and standards such as ASME B31.1 & B31.3, API and DIN standards, their applications in design, material selection, safety requirements, and comparison between different international standards used in industry	**2**	CO3
4	**Piping Components**	• Pipe fittings • Pipes joints & bending (Cold & Hot Bending) • Welding defect (NDT) • Valves: Types of valves and selection • Strainers & traps, sight glass, • Flame arresters, • Piping Surge Analysis	**8**	CO4

		• Jacketed piping • Expansion joints • Threaded joints • Types of piping support and Pipe rack • **Self-Learning Topics:** In-depth study of selection, design, and practical applications of piping components such as fittings, valves, supports, expansion joints, surge analysis, NDT methods for weld defects, and special systems like jacketed piping used in industrial operations.		
5	**Piping System Design**	• Flows through Pipes. • Loss of energy / head in pipes, Loss of head due to friction. • Minor energy losses, • Water hammer in pipes • Design Principles and Line Sizing • Miter Joint Calculation. • Stress intensification factor • Various stresses in piping and stress analysis • Pipeline designation **Self-Learning Topics:** Advanced analysis of pipe flow and head losses, water hammer effects, line sizing and miter calculations, stress analysis (including SIF), and application of design standards for safe and efficient piping system design.	**12**	CO5
6	**Piping Drawing**	• Piping drawing symbols and abbreviations • Classification/Types of drawing • Introduction to simple piping drawings • Plot Plan • Introduction to G.A. Drawing • Process flow diagram (P.F.D) • Piping and instrumentation diagram (P&ID) / Engineering flow diagram.	**7**	CO6

		Self-Learning Topics: Advanced interpretation and preparation of piping drawings such as PFD, P&ID, GA and plot plans, including symbols, abbreviations, and real industrial drawing practices using basic CAD tools.		
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject.				

Text Books:

1. Deutsch D. J. Process piping systems, Chemical engineering magazine. Mc-Graw hill.
2. Ed Bausbacher and Roger Hunt, 'Process Plant Layout and Piping Design', First Edition, Prentice Hall, 1993
3. Robert A. Rhea, Roy A Parisher, "Pipe Drafting and Design", Second Edition, Gulf Professional Publishing, 2003

References:

1. Handbook of piping design- S.K. Sahu Elsevier Publishers
2. Piping/mechanical hand book- Mohinder L. Nayyar. Peter H. O. Fischer, Manager, Pipeline Operations, Bechtel
3. Piping Design Handbook by John J. Mcketta, by Marcel Dekker, Inc, New York.

Online References:

Sr. No.	Website Name
1.	nptel.ac.in/courses/103105210 (Principles and Practices of Process Equipment and Plant Design, IIT Kharagpur. Prof. Gargi Das, Prof. S Ray)
2.	nptel.ac.in/courses/103105166 (Plant Design and Economics, IIT Kharagpur Prof. Debasis Sarkar)

Assessment:

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

End Semester Theory Examination: Question paper format

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules
- Total of four questions need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
20751142	Advanced Material Sciences	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment (IAT)			End Sem Exam	End Sem Exam Duration (Hrs)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
20751142	Advanced Material Sciences	20	20	40	60	2	--	--	100

Rationale:

The goal of Advanced material sciences are crucial for Chemical Engineering because they enable Engineers to move beyond the limitations of traditional materials, tackle complex global challenges, and drive innovation across various industries.

Course Objectives

1) To Understand crystal structure and various metallic advanced materials.
2) To Outline the Structure, preparation, and application of the Advanced Polymeric Materials used in Chemical engineering.
3) To Explore the Properties, Classification, Engineering applications of Ceramic Materials.
4) To Explain the Fiber Reinforced Plastic Processing.
5) To Understand the various fabrication methods of Metal Composites and Ceramic Composites.
6) To learn the properties and applications of nanomaterials.

Course Outcomes:

On completion of the course the learner would be able to :

1) Study crystal structure and various advanced metallic materials.
2) Outline the Structure, preparation, and application of the Advanced Polymeric Materials used in Chemical engineering.
3) Discuss the Properties, Classification, Engineering applications of Ceramic Materials.
4) Explain the Fiber Reinforced Plastic Processing.
5) Familiarize with the various fabrication methods of Metal Composites and Ceramic Composites.

6) Describe the properties and applications of nanomaterials.

Prerequisite:

1. Basic knowledge of Material Science.
2. Mechanical, Electrical, Magnetic and Optical Properties of Materials.
3. Commonly used Materials of Construction and their Selection.
4. Corrosion in Materials

DETAILED SYLLABUS:

Sr. No	Name of Module	Detailed Content	Hours	CO Mapping
1	**Crystal Structure and Advanced Metallic Materials**	Crystal Structure: Unit Cell, Bravais Lattices and Miller Indices with examples Stainless Steels: Types, properties of stainless steels, failure of stainless steels. High Temperature Alloys: Properties and types. Titanium Alloys and Cobalt-Chromium Alloys: Composition, properties and applications. Nitinol as Shape Memory Alloy and its applications. **Self-Learning** Component: Metallic Glasses	**7**	CO1
2	**Advanced Polymeric Materials**	Structure, preparation, and application of various conducting polymers, high temperature polymers and liquid crystal polymers. Biomedical applications of polymers such as hydrogels, polyethylene, polyurethanes, polyamides and silicone rubber. **Self-Learning** Component: Smart Polymers	6	CO2
3	**Ceramic Materials**	Properties of ceramic materials, classification of ceramic materials, ceramic crystal structures. Preparation and application of ceramic materials: Alumina, Partially Stabilized Zirconia, Sialon, Silicon Nitride, Silicon Carbide. Processing of Ceramics. **Self-Learning** Component: Bioceramics	6	CO3
4	**Composite Materials and**	Composite Materials: Necessity of composite materials, classification of composite materials,	7	CO4

	Fiber Reinforced Plastic Processing	types of matrix materials and reinforcements, reinforcement mechanism. Fiber Reinforced Plastic Processing: Open Moulding Processes : Filament Winding Process Closed Moulding Processes : Pultrusion and Pulforming, Sheet Moulding Compound Process **Self-Learning Component**: Self-Healing FRPs		
5	**Metal Composites and Ceramic Composites**	Metal Composites : Advantage of metal composite over metal, types of reinforcement and matrix fabrication types, properties, various fabrication processes: diffusion bonding process, in-situ process. Ceramic Composites : Matrices and reinforcements, properties, fabrication methods: slurry infiltration process, chemical vapour infiltration process. **Self-Learning Component**: Hybrid Composites	7	CO5
6	**Carbon Nanotubes, Nanoshells and Nanosensors**	Carbon Nanotubes: Synthesis, properties and applications. Nanoshells : Types, properties and applications. Nanosensors : Assembly methods, nanosensors based on optical, quantum size, electrochemical and physical properties. **Self-Learning Component:** Application of Smart Nanosensor-Integrated Carbon Nanotube Systems for in Environmental Monitoring	6	CO6
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject				

Textbooks:

1. V. Raghavan, Material Science and Engineering, PHI Learning Pvt. Ltd., 5^{th} Edition 2011.

2. B.K. Agrawal, Introduction to Engineering Materials, Tata McGraw Hill Education Pvt. Ltd., 1988.

3. A.K. Bhargava, Engineering Material: Polymers, Ceramics and Composites, PHI Learning Pvt. Ltd., 2nd Edition 2012.

References:

1. William Smith, Javed Hashemi, Ravi Prakash, Material Science and Engineering, 5th Edition, Tata McGraw Hill Education Company Ltd., 2013.
2. Kenneth G. Budinski, Engineering Materials : Properties and Selection, 4th Edition, Prentice Hall,1992.
3. James A. Jacob and Thomas F. Kilduff, Engineering Materials Technology : Structures, Processing, Properties, and Selection, 5th Edition, Pearson/Prentice Hall, 2005.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc25_mm19/preview
2.	https://www.mdpi.com/2079-4991/14/20/1649
3.	https://www.youtube.com/watch?v=hgk0TiN6Ov4

Assessment:

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination:

Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus.**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
20751143	**Food Science & Engineering**	3	-	-	3	-	-	**3**

Course Code	Course Name	Theory					Term work	Practical & Oral	Total
		Internal Assessment (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
20751143	**Food Science & Engineering**	20	20	40	60	2		--	100

Course Objectives:

1. Various unit operations involved in Food processing.
2. The role of heat transfers in Food processing.
3. The laws to prevent adulteration.
4. Proper packaging & storage of materials.
5. The importance of microorganisms in food processing
6. Food quality management and its techniques

Course Outcomes:

The student will be able to:

1. Identify the various food constituents and evaluate the D and Z values.
2. Identify the size reduction equipment for solid and liquid food and evaluate the mixing index and power requirement for size reduction.
3. Apply the various thermal processing in food technology.
4. Acquire the knowledge about freezing and refrigeration.
5. Analyze the Food Adulteration, Quality Management and food safety techniques.
6. Demonstrate the manufacturing of various food products.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Knowledge of Chemical Engineering, Food Technology, Food microbiology	0	
1	**Food Biochemistry and Food Microbiology**	Food Constituents: Carbohydrates, Proteins, Enzymes, Vitamins, Lipids and Minerals, Flavors, Nutritional & sensory characteristics, Food fortification.: Types and Importance, Water activity, role of microorganisms, D & Z values, TDT curve, Indian laws regulating Foods and Food processing. Numerical on D & Z value **Self-Learning:** Emerging Preservation technologies.	5	CO1
2	**Size reduction of solid, liquid foods**	Size reduction in solid and liquid foods, Mixing and Forming, Mechanical Operation and expressions (Mechanical operations), Size reduction effects on food. Numerical on Mixing Index, Size reduction. **Self-Learning**: Extrusion technology in food processing used in noodles, snacks, breakfast cereals	8	CO2
3	**Thermal Processing**	Blanching, extrusion, pasteurization, Heat Sterilization, In container Ultra high Temperature (UHT)/aseptic processes. **Self-Learning**: Food dehydration technology	7	CO3
4	**Freezing and Refrigeration**	Effects of low temperature on quality, chilling, freezing, freeze drying and freeze concentration. **Self-Learning**: Cold storage engineering: Shelf-life improvement techniques in fruits and vegetables	5	CO4
5	**Food Storage & Packaging**	Modified Atmosphere Storage (MAS), Hurdle Technology, Modified atmosphere packaging (MAP) Food Adulteration & Quality Management: food safety., HACCP, GMP, GHP, GLP.	6	CO5

		Self-Learning: Smart packaging, Biodegradable packaging materials		
6	**Food Processing**	Manufacturing and processing of food products: Fruit juice processing, Alcoholic beverages, Milk and Milk Products; Milk powder, cheese, Ice cream, Tea coffee, cocoa, Bread, Biscuits, confectionary (hard boiled sweets & chocolates) **Self-Learning**: Automation in food processing industries like Sensors, PLC (Programmable Logic Controllers) systems in food processing industry.	8	CO6
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject				

Textbooks:

1. Fellows. P. Food Processing Technology: principles and practice. Woodhead publishing Ltd, England

2. B. Sivasankar. Food processing and Preservation, Prentice Hall of India pvt ltd

References:

1. Toledo R. Fundamentals of Food process Engineering, CBS publishers, New Delhi

2. D.G.Rao.Fundamentals of Food engineering, PHI Learning pvt ltd

3. Sukumar Dey. Outlines of Dairy Technology (free download available)

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/126105548
2.	NPTEL : NOC:Food Science and Technology (Agriculture)

Assessment:

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination:

Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus.**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
20751144	Numerical method in Chemical Engineering	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment (IAT)			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
20751144	Numerical method in Chemical Engineering	20	20	40	60	2	-	-	100

Rationale:

In chemical engineering, challenges in areas like heat and mass transfer, fluid mechanics, chemical reaction engineering, thermodynamics, and modeling and simulation often require the application of linear algebra, nonlinear algebraic equations, ordinary and partial differential equations, among others. When conventional analytical methods fall short, numerical methods offer effective solutions to these problems. The growing significance of numerical methods has led to an increased demand for courses focused on numerical analysis techniques. As a result, a well-rounded Engineering education would be incomplete without a thorough understanding of these methods. Students must be equipped with the skills to choose the appropriate numerical technique for solving specific engineering problems.

Course Objectives:

1. To understand the concepts of errors, approximations, and numerical solutions of algebraic and transcendental equations used in chemical engineering problems.
2. To develop the ability to solve systems of linear equations using matrix methods and iterative techniques relevant to engineering applications.
3. To apply numerical methods for differentiation and integration to analyze engineering data and process variables.
4. To understand and implement interpolation techniques for estimating unknown data points in chemical engineering processes.
5. To introduce numerical techniques for solving partial differential equations arising in heat transfer, diffusion, and wave phenomena.
6. To apply numerical methods for solving ordinary differential equations (initial value problems) in dynamic chemical systems.

Course Outcomes

After successful completion of the course, students will be able to:

1. Analyze errors and apply appropriate numerical methods (e.g., Newton-Raphson, fixed-point iteration) to solve nonlinear equations.
2. Solve linear algebraic systems using direct and iterative methods such as LU decomposition, Gauss-Seidel, and Jacobi methods.
3. Perform numerical differentiation and integration with error estimation for Chemical Engineering applications.
4. Apply interpolation methods (Newton's, central difference, spline techniques) to estimate and model engineering data.
5. Solve basic partial differential equations numerically for applications in heat transfer and fluid flow problems.
6. Solve ordinary differential equations using Euler methods, predictor-corrector techniques, and analyze system behavior in Chemical processes.

Prerequisite:

1. Differential Calculus.
2. Integral Calculus.
3. Differential Equations.
4. Linear Algebraic Equations

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	**Introduction & Approximations, Algebraic and Transcendental equations**	Motivation and Applications Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation, fixed point iteration method, Newton Raphson Method Applications in Chemical Engineering. **Self-learning Topics:** Bisection, Regula, Falsi Method/false position.	4	CO1
2	**Linear Systems and Equations**	Matrix representation; Cramer's rule; Gauss Siedal, Gauss Jacobi method; Matrix Inversion; LU Decomposition; TDMA Method. (Numericals based on application in Chemical Engineering)	8	CO2

		Self-learning Topics: Gauss-Jordan Method, Gauss Elimination method.		
3	**Numerical Differentiation and Integration.**	Numerical differentiation- Newton's method; error analysis; higher order formulae. (Numericals based on application in Chemical Engineering) **Self-learning Topics:** Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule.	8	CO3
4	**Interpolation**	(Finite difference operators, difference tables, Newton's Forward/Backward, Central difference; (Central difference formula's i.e. Bessel and Stirling's interpolation formulae Cubic Splines. (Numericals based on application in Chemical Engineering) **Self-learning Topics:** Lagrange's Interpolation	8	CO4
5	**Partial differential equation**	Laplace equation, Heat equation, wave equation, (Numericals based on application in Chemical Engineering) **Self-learning Topics:** Crank-Nicolson method, Bender Schmidt Method.	3	CO5
6	**ODEs: Initial Value Problems**	Introduction to ODE-IVP, Modified Euler's and Improved Euler's method. Predictor-corrector methods, Extension to multi-variable systems; Adaptive step size; Stiff ODEs. Over/Under Relaxation (SOR). (Numericals based on application in Chemical Engineering) **Self-learning Topics:** Adam Bashford Method to solve chemical engineering problems	8	CO6
Note: No questions will be asked in the end-semester exam from self-study topics. However, students are encouraged to explore these topics for a better understanding of the subject				

Textbooks:

1. S C Chapra and R P Canale, Numerical Methods for Engineers, McGraw Hill International Edition.

2. John H Mathews, Numerical Methods for mathematics & science, 2nd Edition, Prentice Hall.

3. Numerical methods in chemical engineering **Author** : Pradeep Ahuja **Publisher** : PHI learning

4. Pushpavanam S, Mathematical Methods in Chemical Engineering, Prentice Hall of India.

5. N W Loney, Apllied Mathematical Methods for Chemical Engineers, CRC Press.

6. R G Rice, D D Do, Applied Mathematics and Modeling for Chemical Engineers, Wiley.

7. A Varma, M Morbidelli, Mathematical Methods in Chemical Engineering, Oxford University Press.

References:

1. V G Jenson, G V Jeffreys, Mathematical Methods in Chemical Engineering, Elsevier.

2. Mickley, Reid, Sherwood, Apllied Mathematics in Chemical Engineering, Tata McGraw Hill.

3. S K Gupta, Numerical Methods for Engineers, New Academic Science.

4. M K Jain, S R K Iyengar and R K Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern.

5. S S Shastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.

6. B S Grewal, Numerical Methods in Engineering & Science, Khanna Publishers.

7. Kenneth J Beers, Numerical methods for chemical engineering, Cambridge University Press.

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/ (https://nptel.ac.in/courses/127106019)
2.	https://nptel.ac.in/ (https://onlinecourses.nptel.ac.in/noc21_ma45/preview)
3.	https://www.atozmath.com/default.aspx

Assessment:

Internal Assessment (IA) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination:

Question paper format

- Question Paper will comprise of a total of **six questions each carrying 15 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus.**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2075115	Transport Phenomena Lab	-	2	-	-	1		1

Course Code	Course Name	Theory					Term work (TW)	Oral & Practical	Total
		Internal Assessment (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs.)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
2075115	Transport Phenomena Lab	-	-	-	-	-	25	-	25

Lab Objectives: Students should be able……

1. To introduce computational tools for modeling and analysis of momentum, heat, and mass transfer phenomena.
2. To apply governing transport equations (Navier–Stokes, Fourier's law, Fick's law) to solve practical engineering problems numerically.
3. To develop the ability to validate theoretical models and empirical correlations using computational simulations.
4. To analyze the effect of dimensionless parameters such as Reynolds, Prandtl, Nusselt, Schmidt, and Sherwood numbers on transport processes.
5. To understand coupled transport phenomena involving simultaneous momentum, heat, and mass transfer.
6. To enhance skills in data analysis, visualization, and technical reporting using spreadsheet and open-source computational tools.

Lab Outcomes: On completion of the course the students will be able to……

1. Apply governing equations of momentum, heat, and mass transfer to formulate numerical models for transport phenomena problems.
2. Compute velocity, temperature, and concentration profiles for laminar flow, conduction, and diffusion systems using computational tools.
3. Analyze the effect of dimensionless parameters such as Reynolds, Prandtl, Nusselt, Schmidt, and Sherwood numbers on transport processes.
4. Validate theoretical models and empirical correlations by comparing numerical results with analytical solutions and standard correlations.

5. Investigate coupled momentum, heat, and mass transfer problems through simulation and sensitivity analysis.
6. Interpret and present computational results through graphs, tables, and technical laboratory reports with appropriate engineering conclusions.

Prerequisite:

Engineering Mathematics, Fluid Mechanics, Heat and Mass Transfer fundamentals, basic Transport Phenomena theory, and introductory knowledge of computational tools such as Excel and Scilab.

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**LO Mapping**
1	Fundamentals of Momentum Transport	1.1Numerical Solution of Laminar Pipe Flow 1.2 Friction Factor Prediction and Moody Chart Recreation 1.3 Verification of Bernoulli's Equation	02	LO1
2	Momentum Transport Applications & Scaling	2.1 Scaling and Dimensional Analysis 2.2 Advanced / Optional CFD Experiments (Pipe Flow)	02	LO2
3	Heat Conduction and Thermal Systems	3.1 1D Steady-State Heat Conduction (Plane & Composite Wall) 3.2 Heating Liquids in Tank Storage	02	LO3
4	Convective Heat Transfer Applications	4.1 Forced Convection Correlation Validation 4.2 Double-Pipe Heat Exchanger Simulation 4.3 Shell-and-Tube Heat Exchanger Simulation	02	LO4
5	Mass Transfer by Diffusion	5.1 Molecular Diffusion in 1D 5.2 Convective Mass Transfer Coefficients	02	LO5
6	Interphase & Coupled Transport Phenomena	6.1 Gas Absorption Modeling 6.2 Coupled Heat and Mass Transfer	02	LO6

Text Books:

1. Bird, Stewart, and Lightfoot, *Transport Phenomena* (2nd Ed., Wiley) – Core theory , 2000

2. William J. Thomson, Introduction to Transport Phenomena, Prentice Hall, 2000
3. Ismail Tosun, Modelling In Transport Phenomena A Conceptual Approach, Elsevier Science B.V. 2002 1st Edition

References:

1. Supplementary: Patankar, *Numerical Heat Transfer and Fluid Flow* (for numerical methods).

Online Resources:

Sr. No.	Website Name
1.	Scilab Documentation: scilab.org/tutorials (focus on differential equations modules).
2.	OpenFOAM User Guide: openfoam.org/docs (tutorials on pipe flow).
3.	Flowsquare Manual: flowsquare.com/manual.
4.	Online Resources: YouTube channels for Scilab/OpenFOAM simulations; Excel templates from engineering forums.
5.	Python & C language

List of Experiments:

Sr. No	Name of Experiment	Concepts Covered	Computational Tool	Hrs.
1	To numerically determine the velocity profile, wall shear stress, and pressure drop for laminar flow in a circular pipe using Excel or Scilab, and to validate the numerical results with the Hagen–Poiseuille equation.	Relevance of Re, viscosity, diameter	Excel / Scilab	02
2	To compute friction factors for laminar, transitional, and turbulent flow regimes using standard correlations and the Colebrook equation, and to computationally recreate the Moody chart using Microsoft Excel.	Correlation implementation & iteration	Excel	02
3	To determine temperature distribution and heat transfer rate for one-dimensional steady-state heat conduction through plane and composite walls using computational methods.	Thermal circuit modeling	Excel	02
4	To predict the Nusselt number for forced convection using standard heat transfer correlations and to study the effect of Reynolds and Prandtl numbers on heat transfer performance through computational analysis using Microsoft Excel.	Correlation selection & limitations	Excel	02

5	To study unsteady-state molecular diffusion in one dimension by numerically solving Fick's second law using Scilab and to estimate the diffusivity from transient concentration profiles.	Diffusion dominance regimes	Scilab	02
6	To estimate convective mass transfer coefficients using Sherwood number correlations and to study the applicability of heat–mass transfer analogies through computational analysis using Microsoft Excel.	Transport Analogy mastery	Excel	02
7	To model gas absorption based on the two-film theory, compute individual and overall mass transfer coefficients using Microsoft Excel or Scilab, and evaluate the effect of gas and liquid flow rates on the overall mass transfer performance.	Interphase transport understanding	Excel / Scilab	02
8	To apply the Buckingham π theorem to derive dimensionless groups for a given transport phenomena problem and establish similarity criteria for model–prototype scaling using Microsoft Excel.	Design scale-up fundamentals	Excel	02
9	To model and simulate coupled heat and mass transfer processes, such as evaporation or drying, by solving simultaneous energy and mass balance equations using Scilab, and to analyze the effects of operating conditions on heat and mass transfer rates.	Multiphysics coupling	Scilab	02
10	To analyze fluid flow and heat transfer in a pipe using numerical simulations and validate results against analytical solutions.	Mesh generation	Open FOAM/ flow square	02
11	To experimentally investigate the heat transfer characteristics of a double-pipe heat exchanger operating under parallel-flow and counter-flow arrangements, evaluate overall heat transfer performance using Microsoft Excel, and validate experimental results with theoretical heat transfer correlations.	Design	Excel	02
12	To model and simulate the transient heating of liquids in a storage tank using Scilab by applying unsteady-state energy balance equations and numerical solution techniques.	Unsteady-state (transient) heat transfer	Scilab	02
13	To verify Bernoulli's equation for incompressible fluid flow through a pipe by analyzing pressure, velocity, and elevation head using experimental data and	Total energy head in flowing fluids	Excel/ Scilab	02

	validating results through Scilab or Microsoft Excel calculations.			
14	To simulate the thermal performance of a shell-and-tube heat exchanger using Microsoft Excel by applying heat transfer correlations, energy balance equations, and LMTD/NTU methods, and to analyze the effect of operating parameters on heat exchanger performance.	Design	Excel	02

Assessment:

Term Work: Term Work shall consist of at least 8 practicals' based on the above list. Also, Term work Journal must include at least 3 assignments**.**

Term Work - 25 Marks: Distribution of marks will be as follows:

● Experiments/Laboratory work: 15 marks

● Assignments: 05 marks

● Attendance: 05 marks

Course Code	Course Name	Teaching Scheme (Contact Hours)	Credits Assigned

		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2075116	**Chemical Reaction Engineering -I Lab**		2			1		**1**

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work Marks	Practical/ Oral Marks	Total
		Internal Assessment (IAT)			End Sem. Exam Marks			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
2075116	**Chemical Reaction Engineering -I Lab**	--	--	--	--	25	25	**50**

Lab Objectives:

1. Understand the importance of reaction kinetics in chemical engineering.

2. Analyse the effect of temperature on the rate of a homogeneous reaction

3. Selection of an appropriate analysis technique depending on the type of homogeneous reaction

4. Visualise the operation of various reactor types

5. Evaluating the performance of single and multiple reactors

6. Choose an appropriate reactor set-up for various types of homogeneous reactions.

Lab Outcomes:

On successful completion of the lab, the learner /student will be able to:

1. Employ various methods to determine the kinetics of homogeneous reaction.

2. Acquire analytical skills for the Analysis of varying concentration and temperature data

3. Analyse experimental data to determine reaction kinetics and interpret the results.

4. Evaluate the operational principles, design parameters, and performance of batch and flow reactors

5. Compare the performance of different reactor types.

6. Select an appropriate reactor set-up for different homogeneous reactions

Prerequisite:

- Basic knowledge of chemistry and reaction kinetics.
- Concepts of molarity and normality.
- Basic knowledge of data fitting and regression.
- Knowledge of laboratory safety rules and good laboratory practice.

Detailed Syllabus

Sr. No.	Module	Detailed Content	Hours	LO mapping
0	Prerequisites	Basic concepts of chemistry,like Molarity,Normality. Basic knowledge of data fitting , laboratory safety rules and practices.		
1	Determination of Reaction Kinetics using Experimental Methods	Concepts of rate law, reaction order and rate constant for homogeneous reactions. Determination of kinetics using integral, differential and initial rate methods from experimental data.	**2**	**1**
2	Analysis of Concentration and Temperature Data	Effect of concentration and temperature on reaction rate and rate constant. Analysis of experimental data to estimate activation energy and related kinetic parameters.	**2**	**2**
3	Experimental Data Interpretation & Kinetic Modeling	Techniques for processing and interpreting experimental data using basic regression methods. Identification and validation of suitable kinetic models with error analysis.	**2**	**3**
4	Batch Reactor – Operation and Design Analysis	Principles of batch reactor operation and relation between conversion and time. Evaluation of reactor performance and design aspects using experimental results.	**2**	**4**
5	Flow Reactors – CSTR and PFR Performance Evaluation	Operational features of CSTR and PFR and concept of space time and conversion. Comparative analysis of reactor performance under identical conditions.	**2**	**5**
6	Reactor Selection for Homogeneous Reaction Systems	Criteria for selection of reactors based on reaction kinetics and desired conversion. Comparison of batch and flow reactors with basic introduction to selectivity considerations.	**2**	**6**

List of Experiments.

Sr No	List of Experiments	Hrs
01	Differential Analysis (To find rate parameters)	2
02	Integral Analysis of Rate Data	2
03	Determination of Arrhenius Constants – Verification of Arrhenius Law.	2
04	Determination of Order and Rate Constant using the Half-Life Method.	2
05	Verification of Pseudo-First-Order Reaction	2
06	Kinetic Study of Homogeneous Catalytic Reaction	2
07	Determination of Reaction Order and Rate Constant Using the Method of Initial Rates	2
08	Kinetic Study of an Autocatalytic Reaction	2
09	Plug Flow Reactor (PFR)– performance evaluation.	2
10	Continuous Stirred Tank Reactor (CSTR)– performance evaluation.	2
11	Continuous Stirred Tank Reactors Series – performance evaluation.	2
12	PFR – CSTR in series combination– performance evaluation.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Integral Method of Analysis	2
02	Differential Method of Analysis	2
03	Half-life and fractional life Method	2
04	Design of a reactor for single/multiple reactions	2
05	Recycle reactor	2
06	Semi-batch Reactor	2
07	Heat effects in an adiabatic reactor	2
08	Virtual lab	2
09	Simulation of Batch, CSTR, and PFR using MATLAB/Python	2

Reference Books :

4) Levenspiel O., Chemical Reaction Engineering, John Wiley&Sons,3rd ed.,1999.
5) Smith J.M., Chemical Reaction Engineering, 3rd ed., Tata McGraw-Hill,1980.
6) Fogler, H.S. Elements of Chemical Reaction Engineering, 4th ed, PHI, 2008

Online References:

Sr. No.	Website Name
3.	Welcome to Virtual Labs (https://uorepc-nitk.vlabs.ac.in/)
4.	https://www.olabs.edu.in/
5.	Kinetics and Reactor Design Simulations - LearnChemE (https://learncheme.com/simulations/kinetics-reactor-design/)

Assessment :

Term Work: Term Work shall consist of at least 8 to 10 practicals based on the above list. Also, the term work Journal must include at least 3 assignments**.**

Term Work - 25 Marks: Distribution of marks will be as follows:

- Experiments/Laboratory work: 15 marks
- Assignments: 05 marks
- Attendance: 05 marks

End Semester Practical /Oral Examination - 25 Marks:

Practical/Oral Examination will be conducted based on above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
2075117	Mass Transfer Operations-I Lab	-	2	-	-	1		1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment (IAT)			End Sem. Exam			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
2075117	Mass Transfer Operations-I Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To enable students to experimentally determine and analyze diffusion coefficients of gases and liquids.
2. To equip students with the ability to experimentally determine and evaluate mass transfer coefficients.
3. To develop students' ability to experimentally plot drying curve and typical rate-of-drying curves,
4. To enable students to effectively use humidity charts and experimentally determine the properties of vapour–gas mixtures.
5. To enable students to experimentally determine and evaluate the operational characteristics of gas–liquid contact equipment
6. To enable students to experimentally determine NTU, HTU, and HETP for packed bed absorption systems

Lab Outcomes:

1. Students will be able to experimentally determine diffusion coefficients of gases and liquids, interpret experimental data, and validate results against theoretical models.
2. Students will be able to experimentally determine mass transfer coefficients, critically evaluate experimental data, and relate findings to theoretical models.
3. Students will be able to experimentally plot drying curves and the rate-of-drying curves, and interpret drying behaviour.
4. Students will be able to effectively use humidity charts and experimentally determine the properties of vapour–gas mixtures, interpret psychrometric data, and apply results to analyze mass transfer operations.
5. Students will be able to experimentally determine and evaluate the operational characteristics of gas–liquid contact equipment and analyze their performance.
6. Students will be able to experimentally determine NTU, HTU, and HETP for packed bed absorption systems, and analyze the obtained data.

Prerequisite:

The students should have knowledge in the following domains

1. Mathematics, physics, and physical chemistry.
2. System of units.
3. Process calculations (Mass and Energy Balance)
4. Fundamentals of thermodynamics
5. Standard operating procedures
6. Dos and Don'ts in a Chemical Engineering Laboratory.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	• System of units • Fundamentals of differential and integral calculus. • Laws of conservation of mass, energy and momentum, • Concept of thermodynamic equilibrium		
1	Diffusivities of gases and liquids	Diffusivities of gases and liquids	**02**	LO1
2	Mass transfer coefficients	Prediction of mass transfer coefficients	**02**	LO2
3	Batch drying	Drying curve and the typical rate of drying curve	**02**	LO3
4	Properties of vapour gas mixtures	Use of humidity charts for determining properties of vapour-gas mixtures	**02**	LO4
5	Gas-liquid contacting equipment	Operational characteristics of equipment used for gas-liquid contact	**02**	LO5
6	Packed bed absorption systems	Calculation of NTU, HTU, and HETP	**02**	LO6

Textbooks:

1. Treybal R.E., Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. Datta B.K., Mass Transfer and separation processes, Eastern economy edition, PHI learning private ltd New Delhi, 2009
3. G. K. Roy, Fundamentals of Heat and Mass Transfer, Khanna Publication, New Delhi

References:

1. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill, New York 1993
2. Geankoplis C.J., Transport processed and unit operations, Prentice Hall, New Delhi 1997
3. Coulson J.M. Richardson J.F., Backhurst J.R. and Harker J.H., Coulson and Richardson chemical engineering, vol 1 & 2, Butterworth Heinmann, New Delhi, 2000

4. R.K. Sinnott (Ed) Coulson and Richardson chemical engineering, vol 6, Butterworth Heinemann, New Delhi, 2000

Online Resources:

Sr. No.	Website Name
6.	Swayam - NPTEL
7.	Virtual Lab - IIT Guwahati

List of Experiments.

Sr No	List of Experiments	Hrs
01	Determination of diffusion coefficient of liquid vapor in air by Winkelmann Experiment	2
02	Determination of F-type mass transfer coefficient by the surface evaporation of a liquid.	2
03	Determination of diffusion coefficient for Liquid-in-liquid diffusion	2
04	Determination of mass transfer coefficient for solid-in-air diffusion	2
05	Determination of mass transfer coefficient for dissolution of benzoic acid in water.	2
06	Determination of efficiency of a natural and mechanical draft cooling tower.	2
07	Determination of the equilibrium moisture content by plotting the typical rate of drying cure for drying in atmospheric tray dryer	2
08	Determination of loading and flooding velocities by studying the hydrodynamics of a packed column	2
09	Determination of mass transfer coefficients in a wetted wall column	2
10	Determination of NTU, HTU, and HETP for absorption in a packed bed	2
11	Study of humidification and dehumidification and determine the properties of air-water vapor mixture using humidity charts	2
12	Determination of the equilibrium moisture content by plotting the typical rate of drying cure for drying in vacuum tray dryer	2
13	To study the operation of a fluidized bed dryer and plot the drying curve	2
14	To investigate the absorption of carbon dioxide in water or sodium hydroxide solution	2
15	Self-learning activity- Preparation of prototype for any one mass transfer operation based on Mass Transfer Operation I Syllabus	2

Assessment:

Term Work: Term Work shall consist of at least 8 to 10 practicals based on the above list. Also, Term work Journal must include **at least 3 assignments covering all six modules.**

Term Work - 25 Marks: Distribution of marks will be as follows:

- Experiments/Laboratory work: 15 marks
- Assignments: 05 marks
- Attendance: 05 marks

End Semester Practical /Oral Examination - 25 Marks:

Practical/Oral Examination will be conducted based on above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract	Tut.	Theory	Pract	Tut.	Total
20751181	Piping Engineering Lab	–	2	–	–	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT -I	IAT- II	Total (IAT-I + IAT-II)				
20751181	Piping Engineering Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To understand crucial role of piping engineer in chemical engineering projects
2. To understand the piping fundamentals, codes and standards
3. To understand materials used for piping and fittings
4. To understand the control valve sizing, line hydraulics, pump head calculations, pipe rack design
5. To create piping layout, P & ID, isometric drawings and plot plan
6. To understand stress analysis, network analysis, flexibility analysis and surge analysis for chemical plants

Lab Outcomes:

On completion of the course the students will be able to:

1. Apply piping standards in design of complex piping networks.
2. Solve complex engineering problem of selection of appropriate material for pipes and fittings for chemical plants
3. Identify, analyze and solve pipe sizing, pump sizing, valve sizing and pipe-valve-pump selection Problem.
4. Design and draw piping networks, piping layout, P & ID, isometric drawings and plot plan by considering legal, environmental, societal and ethical aspects
5. Use modern IT tools such as MS Excel/Libre office Calc/WPS spreadsheets, DWSIM,

AutoCAD 2D and 3D, CAE demo and Edraw Fluid flow for design and analysis of piping networks E

6. Carry out stress analysis, network analysis, flexibility analysis and surge analysis for chemical plants which will benefit society and environment by following strict ethical standards.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	• Basic computer skills including MS EXCEL is essential. • Basic Knowledge of Fluid Flow Operation • Process Equipment design material Selection	--	--
1	Piping Codes, Standards & Materials	• Study of Codes & Standards	**02**	LO1, LO2
2	Pipe Flow, Hydraulics & Water Hammer	• Equivalent Diameter Calculations • Line Hydraulics & Network Analysis • Water Hammer / Surge Analysis	**02**	LO3, LO6
3	Pipe Sizing, Thickness, Pumps & Valves	• Control Valve Sizing • Pipe Sizing, Thickness & Pump Head Calculation	**02**	LO3, LO5
4	Pipe Stress Analysis & Flexibility	• Pipe Stress Analysis using CAE • Flexibility Analysis	**02**	LO5, LO6
5	Piping Components, Layout & Supports	• Pipe Rack Design • Piping of Standard Process Modules	**02**	LO4
6	P&ID, Plot Plan & CAD Drawing	• Piping Layout in AutoCAD • Preparation of P&ID (AutoCAD/DWSIM) • Plot Plan Development	**02**	LO4, LO5

Text Books

1. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.

Reference

1. The Engineer's guide to plant layout and piping design in oil and gas industries by Geoff Barker, Gulf professional publishing

Online Resources:

Sr. No.	Website Name
1	https://www.pipeflow.com
2	vlab.amrita.edu (Fluid Mechanics)
3.	https://online.visual-paradigm.com

List of Experiments:

Sr No	List of Experiments	Hrs
01	Introduction to Code and Standards: IS, AWWA, IWWA, ASME, ANSI, BS, HIS, CPHEEO Manual, ISO, DIN and Material selection of pipes and fittings.	2
02	Equivalent diameter calculations of pipelines	2
03	Pipe sizing, thickness calculation and Pump head calculations	2
04	Line hydraulics and network analysis: Flow rate and Pressure drop calculations	2
05	Pipe stress analysis for piping and piping support using software	2
06	Preparation of Process Flow Diagram for a given chemical process on Visual Paradigm /DWSIM	2
07	Preparation of Piping and Instrument Diagram for a given chemical process on Visual Paradigm /DWSIM	2
08	Developing plot plan from given data using software	2
09	Piping layouts for a given chemical process using software	2
10	Piping engineering of standard piping modules like distillation column piping, heat exchanger piping, tank piping, vessel / drum piping, reformers piping. Any one of this module should be given to students.	2
11	Pipe rack design	2
12	Control valve sizing and selection of valves	2
13	Water hammer /surge analysis for piping	2

Note: All the Experiments (Minimum eight) should perform using any open-source software (Such as MS Excel/Libre office Calc /WPS spreadsheets, DWSIM, Visual Paradigm, CAEPIPE etc.,) or any paid software (PDMS, CAESAR, Smart Plant 3D, Smart Plat Review, Revit, Plant 3D, SP3D, Navisworks, Smart Plant Review, Smart P&ID etc. if available in institute.

Sr No	List of Assignments	Hrs
01	Introduction to Piping & Materials of Piping	2
02	Codes and Standard	2
03	Piping Components	2
04	Piping System Design	2
05	Piping Drawing	2

Assessment:

Term Work: Term Work shall consist of at least 8 to 10 practicals' based on the above list. Also, Term work Journal must include at least 3 assignments.

Term Work - 25 Marks: Distribution of marks will be as follows:

● Experiments/Laboratory work: 15 marks

● Assignments: 05 marks

● Attendance: 05 marks

End Semester Practical /Oral Examination - 25 Marks:

Practical/Oral Examination will be conducted based on above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
20751182	Advanced Material Sciences Lab		2	--		1	--	1

Lab Objectives:

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment (IAT)			End Sem. Exam			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
20751182	Advanced Material Sciences Lab	--	--	--	--	25	25	50

1. To familiarize learner with Bravais lattices.
2. To study the microstructures of metals / alloys.
3. To introduce a learner to various advanced materials used in Chemical Engineering.
4. To acquire the knowledge of Composite Materials.
5. To understand the FRP (Fiber Reinforced Plastic) Processing.
6. To define the fundamental concepts to students in the area of polymers and nanomaterials.

Lab Outcomes:

On completion of the course the learner would be able to :

1. Understand Bravais lattices with the help of models.
2. Know the microstructures of metals / alloys.
3. Describe the properties of the advanced materials used in Chemical Engineering.
4. Recognize the Composite Materials by Matrix.
5. Outline the FRP (Fiber Reinforced Plastic) Processing.
6. State the applications of Polymers and nanomaterials.

Prerequisite:

1. Basic knowledge of Material Science.
2. Mechanical, Electrical, Magnetic and Optical Properties of Materials.
3. Commonly used Materials of Construction and their Selection.

Detailed Syllabus:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
1	Crystal Structure and Advanced Metallic Materials	Study of Bravais lattices models and various metallic alloys.	**2**	**LO1**
2	Advanced Polymeric Materials	Understanding classes of polymers with their applications.	**2**	**LO2**
3	Ceramic Materials	Properties and preparation of ceramic materials.	**2**	**LO3**
4	Composite Materials and Fiber Reinforced Plastic Processing	Understanding of Composite Materials by Matrix and Fiber Reinforced Plastic Processing.	**2**	**LO4**
5	Metal Composites and Ceramic Composites	Discussion of fabrication methods of ceramic composits.	**2**	**LO5**
6	Carbon Nanotubes, Nanoshells and Nanosensors	Interpreting the applications of Nanoshells, Nanosensors and Carbon Nanotubes.	**2**	**LO6**

List of Experiments:

Sr No	List of Experiments	Hrs
01	To study Bravais lattices with the help of models.	2
02	To study heat treatment processes (hardening and tempering) of steel specimen.	2
03	To study microstructures of metals / alloys.	2
04	To study the mechanism of chemical corrosion and its protection.	2
05	To study the various properties of Ceramics.	2
06	To study the microstructure of Aluminium.	2
07	To study the Jominey Quench Test	2
08	To study the microstructure of Stainless Steel	2
09	To study the FRP (Fiber Reinforced Plastic) Processing	2
10	To study the primary classes of polymers.	2
11	To study the Composite Materials by Matrix.	2
12	To study the applications of Nanoshells and Nanosensors.	2

List of Assignments:

Sr. No.	List of Assignments / Tutorials	Hrs
01	Draw a few cubic unit cells and draw the following lattice planes within them: (0 0 1), (1 0 1), (0 1 1), (0 2 1), (2 1 0)	1
02	What are liquid crystal polymers? State their properties and applications.	1
03	Give the applications of Partially Stabilized Zirconia and silicon nitride.	1
04	What is mean by composite materials? Explain with classification.	1
05	Explain Slurry infiltration of manufacturing Ceramic Matrix Composites.	1
06	Explain properties and applications of Carbon Nanotubes	1

References:

1. William Smith, Javed Hashemi, Ravi Prakash, Material Science and Engineering, 5th Edition, Tata McGraw Hill Education Company Ltd., 2013.

2. James A. Jacob and Thomas F. Kilduff, Engineering Materials Technology : Structures, Processing, Properties, and Selection, 5th Edition, Pearson/Prentice Hall, 2005.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc25_mm19/preview
2.	https://www.mdpi.com/2079-4991/14/20/1649
3.	https://www.youtube.com/watch?v=hgk0TiN6Ov4

Assessment:

Term Work: Term Work shall consist of at least 8 to 10 practicals' based on the above list. Also, Term work Journal must include at least 3 assignments**.**

Term Work - 25 Marks: Distribution of marks will be as follows:

● Experiments/Laboratory work: 15 marks

● Assignments: 05 marks

● Attendance: 05 marks

End Semester Practical /Oral Examination - 25 Marks:

Practical/Oral Examination will be conducted based on above syllabus.

Lab Objectives:

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
20751183	**Food Science & Engineering Lab**		2			1		**1**

1 To analyze the physico-chemical and nutritional properties of food materials.

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work Marks	Practical/ Oral Marks	Total
		Internal Assessment (IAT)			End Sem. Exam			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
20751183	**Food Science & Engineering Lab**	--	--	--	--	25	25	**50**

2 To apply food processing and preservation techniques and study their effect on food quality.

3 To evaluate microbiological quality and food safety parameters of food products.

4 To assess sensory and quality attributes of foods using standard methods.

5 To understand the role of food additives, packaging, and storage in shelf-life extension.

6 To develop skills in laboratory instrumentation, data analysis, and quality control standards

Lab Outcomes:

1. Demonstrate the ability to manufacture dairy products such as cottage cheese, cheese, curd, butter, and ice cream using standard processing techniques.
2. Apply principles of bakery and confectionery processing in the preparation of cake, biscuits, jam, and jelly.
3. Prepare and evaluate fruit and vegetable-based beverages including mixed fruit juice, orange juice, and carrot juice, and assess their quality attributes.
4. Analyze the processing methods of plantation and beverage products such as tea, coffee, cocoa, and alcoholic beverages through practical work and case studies.
5. Analyze food constituents, food fortification practices, and labeling requirements through experiments and case studies in compliance with food regulations.
6. Correlate laboratory experiments with industrial food processing practices through food industry visits, observation, and report preparation.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Knowledge of Chemical Engineering, Food Technology, Food microbiology		
1	Food Biochemistry and Food Microbiology	The study of food constituents and microbial aspects, including fermentation processes involved in products such as curd and cheese, along with food labeling practices.	02	LO1
2	Size reduction of solid, liquid foods	The principles of size reduction and mixing operations as applied in the preparation of bakery products like cakes and biscuits, as well as in beverage processing.	02	LO2
3	Thermal Processing	Thermal preservation techniques such as pasteurization and their application in the preparation of products like jam and jelly.	02	LO3
4	Freezing and Refrigeration	The principles of low-temperature preservation and their application in the manufacturing of products such as ice cream.	02	LO4
5	Food Storage & Packaging	Food packaging methods, labeling requirements, and techniques for enhancing shelf life and maintaining food quality during storage. Case Study on Labels of Food Products	02	LO5
6	Food Processing	practical exposure to the processing of dairy products, beverages, and plantation products, along with industrial exposure through visits and case studies.	02	LO6

List of Experiments:

Sr No	List of Experiments	Hrs
01	Manufacturing of Cottage cheese	02
02	Manufacturing of Cheese	02
03	Manufacturing of Curd	02
04	Manufacturing of Butter	02
05	Manufacturing of cake	02
06	Manufacturing of Biscuits	02
07	Manufacturing of Mixed fruit Juice	02
08	Manufacturing of Orange Juice	02
09	Manufacturing of Carrot Juice	02
10	Manufacturing of Ice-Cream	02
11	Case study on labels of food products	02
12	Visit to a food Industry	02
13	Manufacturing of Jam or jelly	02
14	Case study of Alcoholic beverages	02
15	Manufacturing of Coffee & Cocoa	02
16	Manufacturing of Tea	02
17	Question on food constituents, food fortification	02

Sr No	List of Assignments / Tutorials	Hrs
01	Questions based on Module 1	02
02	Questions based on Module 2	02
03	Questions based on Module 3	02
04	Questions based on Module 4	02
05	Questions based on Module 5	02
06	Questions based on Module 6	02
07	Numerical based Modules	02

Assessment:

Term Work: Term Work shall consist of at least 8 to 10 practical based on the above list. Also, Term work Journal must include at least 3 assignments.

Term Work - 25 Marks: Distribution of marks will be as follows:

- Experiments/Laboratory work: 15 marks
- Assignments: 05 marks
- Attendance: 05 marks

End Semester Practical /Oral Examination - 25 Marks:

Practical/Oral Examination will be conducted based on above syllabus.

LAB Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
20751184	Numerical method in Chemical Engineering Lab	-	2	-	-	1	-	1

LAB Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment (IAT)			End Sem. Exam			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
20751184	Numerical method in Chemical Engineering Lab	-	-	-	-	25	25	50

Lab Objectives:

1. To understand the implementation of numerical methods for solving algebraic and transcendental equations using computational tools.
2. To develop skills in solving systems of linear equations using matrix-based numerical techniques and iterative methods.
3. To apply numerical techniques for differentiation and integration in analyzing chemical engineering data.
4. To implement interpolation methods for estimating intermediate values in experimental and process data.
5. To gain practical exposure to solving partial differential equations relevant to heat transfer and transport phenomena.
6. To solve ordinary differential equations (initial value problems) using numerical methods for modeling dynamic systems in chemical engineering.

Lab Outcomes:

After completing the laboratory work, students will be able to:

1. Implement numerical methods like Newton-Raphson and fixed-point iteration using programming tools (e.g., MATLAB, Python, Excel).
2. Solve linear systems using numerical techniques such as Gauss-Seidel, Jacobi, and LU decomposition through computational approaches.
3. Perform numerical differentiation and integration with proper error analysis using software tools.
4. Apply interpolation techniques (Newton's, central difference, spline methods) to real-life chemical engineering datasets.

5. Solve basic partial differential equations numerically and interpret results in the context of physical systems.
6. Model and solve ordinary differential equations using Euler and predictor-corrector methods for chemical process simulations.

Prerequisite:

1. Basic computer skills is essential.
2. Knowledge of programming language
3. Differential Calculus.
4. Integral Calculus.
5. Differential Equations.
6. Linear Algebraic Equations

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
1	**Introduction & Approximations, Algebraic and Transcendental equations.**	Motivation and Applications Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation, fixed point iteration method, Newton Raphson Method Applications in Chemical Engineering.	02	CO1
2	**Linear Systems and Equations**	Matrix representation; Cramer's rule; Gauss Siedal, Gauss Jacobi method; Matrix Inversion; LU Decomposition; TDMA Method. **(Numericals based on application in Chemical Engineering)**	**02**	CO2
3	**Numerical Differentiation and Integration.**	Numerical differentiation- Newton's method; error analysis; higher order formulae. **(Numericals based on application in Chemical Engineering)**	**02**	CO3
4	**Interpolation**	(Finite difference operators, difference tables, Newton's Forward/Backward, Central difference; (Central difference	**02**	CO4

		formula's i.e. Bessel and Stirling's interpolation formulae Cubic Splines. **(Numericals based on application in Chemical Engineering)**		
5	**Partial differential equation**	Laplace equation, Heat equation, wave equation, **(Numericals based on application in Chemical Engineering)**	**02**	CO5
6	**ODEs: Initial Value Problems**	Introduction to ODE-IVP, Modified Euler's and Improved Euler's method. Predictor-corrector methods, Extension to multi-variable systems; Adaptive step size; Stiff ODEs. Over/Under Relaxation (SOR).	**02**	CO6

Note: Practical's can be performed using Python, Scilab, Matlab or any other programming language

Text Books:

1. Introduction to Scilab: A Mathematical Tool by Dr Jitendra Singh, Sh. Jogendra Singh

2. Numerical method using Scilab by Dr. Santosh Ingle

Numerical Methods using Python by Dhananjay R. Mishra

3. Numerical Methods using Python by Dhananjay R. Mishra

References:

1. Numerical methods in chemical engineering **Author** : Pradeep Ahuja **Publisher** : PHI learning

2. S C Chapra and R P Canale, Numerical Methods for Engineers, McGraw Hill International Edition.

Online Resources:

Sr. No.	Website Name
8.	www.thechemicalengineers.com/

List of Experiments

Sr No	List of Experiments	Hrs
01	Solve Algebraic and Transcendental equations using newton raphson method. method.	02
02	Solve Algebraic and Transcendental equations using iteration method.	02
03	Solve linear algebraic equations using Gauss Elimination method (or LU Decomposition method).	02
04	Numerical integration/differentiation (any method)	02
05	Solve numerical using Newton's Forward difference formula.	02
06	Solve heat equations based on applications in Chemical Engineering.	02
07	Solving ordinary differential equation using Eulers method.	02
08	Solving ordinary differential equation using improved Eulers method.	02
09	Solve linear equations based on applications in Chemical Engineering.	02
10	Assignment 1- Solve ordinary differential equations based on applications in Chemical Engineering.	02
11	Assignment 2- Solve Linear Systems and Equations based on applications in Chemical Engineering.	02
12	Assignment 3- Solve Algebraic and Transcendental equations based on applications in Chemical Engineering.	02

Assessment :

Term Work: Term Work shall consist of at least 8 practical's based on the above list Also, Term work Journal must include at least 3 assignments**.**

Term Work - 25 Marks: Distribution of marks will be as follows:

- Experiments/Laboratory work: 15 marks
- Assignments: 05 marks
- Attendance: 05 marks

End Semester Practical /Oral Examination- 25 Marks:

Practical/Oral Examination will be conducted based on above syllabus

TE Chemical
Sem V

Vertical - 5
IKS

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2075511	Indian Knowledge System-II	--	2*+2	-	--	2	--	2

*** Two hours of practical class to be conducted for full class as demo/discussion.**

Rationale: India has ancient Indian knowledge systems (IKS) that have significantly contributed to mathematics, science and engineering etc. NEP 2020 visualizes a framework where students can apply traditional knowledge with contemporary approaches to suggest sustainable solutions and

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg.					
2075511	Indian Knowledge System-II	--	--	--	--	--	50	--	50

innovative practices. This subject aims to integrate the IKS into present-day engineering education, research, and practice to cultivate well-rounded individuals grounded in India's great intellectual traditions

Course Objectives: To impart necessary knowledge and skills so as to enable students to

1. Understand the premise of Indian Knowledge System (IKS) in the domain of town planning and governance
2. Appreciate the ancient technologies used in Irrigation planning and transport systems, astronomy and Vastu shastra (The science of architecture) for fulfilling basic human needs.
3. To introduce students to traditional Indian chemical engineering knowledge and chemical processes related to metallurgy, pharmaceuticals.

   To understand traditional chemical engineering practices, rasashastra apparatus, and to compare traditional processes with modern chemical engineering processes.
5. To enable students to understand India's rich Indigenous Knowledge Systems (IKS) in metals and metal processing.
6. To introduce the early development of transmission systems in India.

Course Outcomes:

After completion of this course, learner will be able to

CO1: Compare the ancient knowledge in the domain of town planning, governance, and traditional principles in residential (Vastu) construction.

CO2: Evaluate the developments in irrigations systems, transport systems and astronomy.

CO3: Explain traditional Indian chemical engineering knowledge and their scientific principles.

CO4: Describe classical chemical processes, rasashastra apparatus, and indigenous material processing techniques and compare traditional chemical engineering processes with modern chemical engineering processes.

CO5: Evaluate India's indigenous metal and metal-processing heritage.

CO6: Analyze early Indian transmission technologies

Prerequisite: Basic concepts of Science and Technology

Detailed Syllabus:

Module No.	Unit no	Detailed Content	Hours	CO Mapping
1	**Title: Town Planning and Governance, Vastu shastra – The science of Architecture**		**5**	**CO1**
	1.1	Development of ancient text, principles, Terminologies, Indic languages, various typologies, social infrastructure- places for gathering, worship, entertainment, cremation etc. Perspective of Arthaśāstra on town planning.		
	1.2	Governance systems and Principles of Town Planning: Principles of land management, local and global trade routes and trade centres; the establishment and decay of urban settlements. Ancient India urbanization, layouts in terms of geometry, population, geography, and various communities. Evolution of the cities, planning principles in urban centres. interconnection between ancient knowledge of town planning and present planning practices.		
	1.3	Eight limbs of Vastu, Ancient literature and archaeological evidence of building and building materials, Fortification and Forts.		
	1.4	Structural Principles in worship places Architecture. marvelous stone architecture for eternity, Iconography Use of bricks or dressed stone based on logical principals of structural engineering.		
2	**Irrigation planning, transport systems and Astronomy**		**4**	**CO2**
	2.1	Irrigation and water management. Ancient irrigation systems, dams, reservoirs, sluices, canals, embankments, wells, water-lifting devices, etc. from a historical point of view. Irrigation systems and practices in South India		
	2.2	Ancient transport systems during various periods : Indus valley, Buddhist period, Mauryan period, Gupta period, etc. Shipbuilding: Indigenous shipbuilding, materials and methods-Use of local materials: teak, bamboo, coir, and		

		lac- Construction techniques: -Innovations in hull design, masts, and rigging.		
	2.3	Indian Astronomy: Planetary System. Motion of the Planets; Velocity of Light; Eclipse. Astronomy. Navagrahas. Important works in Indian Astronomy. Aryabhata and Nilakantha: Contribution to Astronomical Studies		
3	**Traditional Chemical Processes and Industrial Advancements**		**4**	**CO3**
	3.1	Overview of ancient Indian scientific texts related to chemicals, Arthashastra – mining techniques and metallurgy,		
	3.2	Charaka Samhita – pharmaceutical preparations and fermentation, Sushruta Samhita – preparation of alkali and mineral medicines, traditional chemical operations and processes such as manual metal extraction methods and herbal extraction techniques, small-scale batch production methods,		
	3.3	production of natural alkali from plant ash, comparison of traditional metallurgy with modern metallurgical processes, herbal extraction with solvent extraction and chromatography, natural alkali production with chlor-alkali industry, batch processing with continuous processing.		
4	**Rasashastra – Ancient Indian Chemical Science and Classical Apparatus**		**4**	**CO4**
	4.1	Introduction, scope of rasashastra in traditional Indian alchemy and medicine, development of rasashastra, contributions of Nagarjuna in metallurgical and alchemical practices, role of mercury (Parada) and metals in classical medicinal formulations,		
	4.2	Various apparatus used in rasashastra such as Dolayantra (boiling and heating setup), Patana Yantra (distillation apparatus), Puta (system for controlled heating), Musha (crucible) used for melting and calcination, Khalva Yantra (grinding and mixing of materials), rasashastra processes such as Shodhana (purification), Marana (calcination), Jarana (roasting)		

		and Bhavana (levigation).		
	4.3	Comparison of Dolayantra with modern jacketed reactors, Patana Yantra with distillation columns, Marana process with rotary kiln or muffle furnace, mercury purification methods with modern hydrometallurgical refining techniques.		
5		**Indigenous Metal and Metal Processing Techniques**	**5**	**CO5**
	5.1	Early Metals in India Use of copper, bronze, gold, silver, tin, and lead in Harappan and Vedic periods. Indigenous mining, ore beneficiation, furnace designs, and smelting practices.		
	5.2	Landmark Indian Metallurgical Achievements Wootz Steel: crucible steelmaking, carbon control, carbide banding, global influence as Damascus steel. Zawar Zinc Distillation: world's earliest large-scale zinc production; downward distillation furnaces. Chola Bronze Metallurgy: alloy design (Cu–Sn–Pb), precision lost-wax casting for sculptures. Aranmula Metal Mirror: high-tin bronze polishing technology with mirror-grade reflectivity. Konark Temple Iron Beams & Clamps: structural iron demonstrating marine corrosion resistance.		
	5.3	Scientific Insights Behind Traditional Metallurgy Delhi Iron Pillar: natural formation of a passive protective layer; high-phosphorus wrought iron. Microstructure evolution through traditional forming and heat-treatment cycles. Traditional Indian blacksmiths (Lohar, Vishwakarma, Asari, Kammalar communities)		
6		**Development of Transmission in India**	**4**	**CO6**
	6.1	Transmission in Early Indian Civilizations Indus Valley Civilization: evidence of wheel technology, carts, pottery wheels, and early bearing surfaces. Use of pulleys, levers, and inclined planes in construction and material handling.		

	6.2	Traditional gear and motion Conversion systems Sugarcane crushers, oil ghanis, temple clocks, and granaries		

Textbooks

1. Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi.
2. Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.
3. Kak, S.C. (1987). "On Astronomy in Ancient India", Indian Journal of History of Science, 22(3), pp. 205–221.
4. Bag, A.K. (1997). History of Technology in India, Vol. I, Indian National Science Academy, New Delhi.
5. Acarya, P.K. (1996). Indian Architecture, Munshiram Manoharlal Publishers, New Delhi.
6. Banerjea, P. (1916). Public Administration in Ancient India, Macmillan, London.
7. Gagan Bansal, Indian Knowledge System: Integrating Heritage with Engineering
8. Prafulla Chandra Ray, A History of Hindu Chemistry –
9. R. Balasubramaniam – Wootz Steel: An Advanced Material of the Ancient World
10. K.T.M. Hegde – Indian Archaeometallurgy
11. T.R. Anantharaman – The Rustless Wonder: The Iron Pillar of Delhi
12. AICTE – IKS Division Publications

References

1. Kapoor Kapil, Singh Avadhesh (2021). "Indian Knowledge Systems Vol – I & II", Indian Institute of Advanced Study, Shimla, H.P.
2. Subbarayappa, B.V. and Sarma, K.V. (1985). Indian Astronomy: A Source Book, Nehru Centre, Mumbai.
3. R.T.V. Ramachandra – History of Indian Metallurgy
4. A. Ghosh - Encyclopedia of Indian Archaeology
5. Research papers on Zawar zinc distillation, Chola bronzes, and Aranmula mirror metallurgy.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.swayam2.ac.in/e-learning/preview/imb23_mg54
2.	https://iksindia.org

3.	https://iks.iitk.ac.in

The experiential learning sessions may include:

- Field Visits to historical sites, museums.
- Arranging students' discussions with experts in various fields of IKS.
- Providing the students with online lectures by distinguished experts in the field.
- Students' participation in activities related to understand the practical aspects of Indian knowledge systems.
- Traditional practices of arts, crafts, agriculture, Vastu Shastra etc.,
  Herbal extraction using decoction or distillation methods.
  Preparation of lime mortar (calcination, slaking, carbonation).
  Natural dye extraction and mordanting process.
  Herbal soap preparation through saponification.
  Comparative study of batch vs continuous processing.

Sr No	Details of Activities
01	Project-based activities
02	Presentation
03	Case studies
04	Visit Museum/historical places and write a report
05	Flip class mode
06	Quiz with MCQ
07	Comparative Study of IKS & other scientific systems around the world
08	Group Discussions
09	Roleplay
10	Self-study activities

The faculty can choose any of these activities for continuous assessment

Assessment:

Term work Assessment for 50 marks:

- Suggested Pedagogy and assessment criteria:
  1. Assignment as per the modules. 06
  2. Project-based activities.
  3. Presentation, Group Discussions, and Case studies.
  4. Visit historical places.
  5. Flip class mode/ Roleplay

6. Quiz MCQ

7. Assessment through flipped class and PowerPoint presentation along with documentation

Term Work:

Assignments	10 Marks
Presentation	20 Marks
Quiz /MCQ	15 Marks
Attendance	05 Marks