AC –
Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1 , 4, 5 & 6		
Name of the Programme – B.E. (Chemical Engineering)		
Faulty of Engineering		
Board of Studies in Chemical Engineering		
U.G. Second Year Programme	**Exit Degree**	**U.G. Diploma in Engineering- Chemical Engineering.**
Semester		**III & IV**
From the Academic Year		**2025-26**

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:**_____	**B.E. (Chemical Engineering)**
2	**Exit Degree**	**U.G. Diploma in 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. III & IV**
7	**Program Academic Level**	**5.00**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2025-26**

Sd/-	Sd/-	Sd/-
Dr. Parag R. Gogate	Dr. Deven Shah	Prof. Shivram S. Garje
BoS-Chairman-Chemical Engineering	Associate Dean	Dean
Faculty of Technology	Faculty of Science & Technology	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 second-year engineering course is a core training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, multidisciplinary minor, and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program 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 in technology. 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 in Engineering for open electives and multidisciplinary minor courses in the third and fourth semesters. 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 Cover Chemical Engineering core courses. Also, OE and MDM where a pool of subjects are given for selection. Considering the present scenario, diverse choices need to be made available to fulfill the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. Ability enhancement can be achieved in Undergraduate training by giving an objective viewpoint to the learning process and transitioning a learner from a rote learner to a creative professional. for the purpose Design Thinking is introduced in the First Semester to orient a journey learner to become a skilled professional. Considering the NEP-2020 structure of award of Certificate & Diploma at multiple exit-point pools of Vocational skills is arranged for giving exposure to the current Industry practices.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught, which will enhance the learner's learning process. NEP 2020 grading system enables a much-required 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 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, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the second-year syllabus must not be heavily loaded to the learner and it is of utmost importance that the learner entering into the second 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 Second Year of Engineering from the academic year 2025-26. Subsequently, this system will be carried forward for Third Year and Final Year Engineering in the academic years 2026-27, and 2027-28, respectively.

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

Under Graduate Diploma in Engineering- Chemical Engineering.

Credit Structure (Sem. III & IV)

	R: _____C								
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
	III	PCC301:3 PCC302:3 PCC303:3 PCC304:3 PCL301: 1 PCL302:1	--	--	OE:2	--	VEC: 2 HSL: 2	CEP: 2	22	
	R:_____D									
5.0	IV	PCC401:3 PCC402:3 PCC403:3 PCL401:1 PCL402:1	--	MDM: 4	OE:2	VSEC:2	VEC: 2 EEM:2	--	23	**UG Diploma 45**
	Cum Cr.	25	--	4	4	2	*2+2+2+2*	2	45	

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]

S.E.Chemical Engineering Scheme

Program Structure for Second Year of Chemical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER III

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2073111	Chemical Engineering Mathematics	2	--	1	2	1	--	3
2073112	Fluid Flow	3	–	--	3	--	--	3
2073113	Process Calculations	3	--	--	3	--	--	3
2073114	Chemical Engineering Thermodynamics-I	3	--	--	3	--	--	3
OEC301	Open Elective	2#	--	--	2	--	--	2
2073115	Fluid Flow Lab	--	2	--	--	--	1	1
2073116	Process Calculations Lab	--	2	--	--	--	1	1
2073611	Mini Project (group project)	--	2*+2	--	--	--	2	2
2993511	Entrepreneurship Development	--	2*+2	---	--	--	2	2
2993512	Environmental Science for Engineers	--	2*+2	--	--	--	2	2
Total		**13**	**16**	**01**	**13**	**01**	**08**	**22**

* 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.

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)					
2073111	Chemical Engineering Mathematics	20	20	40	60	2	25	--	125
2073112	Fluid Flow	20	20	40	60	2	--	--	100
2073113	Process Calculations	20	20	40	60	2	--	--	100
2073114	Chemical Engineering Thermodynamics-I	20	20	40	60	2	--	--	100
OEC301	Open Elective	20	20	40	60	2	--	--	100
2073115	Fluid Flow Lab	--	--	--	--	--	25	25	50
2073116	Process Calculations Lab	--	--	--	--	--	25	25	50
2073611	Mini Project-I (group project)	--	--	--	--	--	50	25	75
2993511	Entrepreneurship Development	--	--	--	--	--	50	--	50
2993512	Environmental Science for Engineers	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**75**	**800**

Program Structure for Second Year of Chemical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER IV

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2074111	Chemical Engineering Thermodynamics-II	2	--	1	2	1	–	3
2074112	Solid Fluid Mechanical Operations	3	–	--	3	–	–	3
2074113	Heat Transfer Operations	3	--	--	3	–	–	3
MDC401	Multidisciplinary minor	3	–	--	3	–	–	3
OEC401	Open Elective	2#	–	--	2	–	–	2
2074114	Solid Fluid Mechanical Operations Lab	–	2	–	–	–	1	1
2074115	Heat Transfer Operations Lab	–	2	–	–	–	1	1
MDL401	Multidisciplinary minor	–	2	–	–	–	1	1
2074411	Mini Project-II	–	2*+2	–	–	–	2	2
2994511	Business Model Development	–	2*+2	–	–	–	2	2
2994512	Design Thinking	–	2*+2	–	–	–	2	2
Total		**13**	**18**	**01**	**13**	**01**	**09**	**23**

* 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

Students must select 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.

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)					
2074111	Chemical Engineering Thermodynamics-II	20	20	40	60	2	25	--	125
2074112	Solid Fluid Mechanical Operations	20	20	40	60	2	--	--	100
2074113	Heat Transfer Operations	20	20	40	60	2	--	--	100
MDC401	Multidisciplinary minor	20	20	40	60	2	--	--	100
OEC401	Open Elective	20	20	40	60	2	--	--	100
2074114	Solid Fluid Mechanical Operations Lab	--	--	--	--	--	25	25	50
2074115	Heat Transfer Operations Lab	--	--	--	--	--	25	25	50
MDL401	Multidisciplinary minor	--	--	--	--	--	25	--	25
2074411	Mini Project-II	--	--	--	--	--	50	25	75
2994511	Business Model Development	--	--	--	--	--	50	--	50
2994512	Design Thinking	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**250**	**75**	**825**

Semester III

Vertical – 1
Major

Detail Syllabus

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2073111	Chemical Engineering Mathematics	2	-	1	2	-	1	3

		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)					
2073111	Chemical Engineering Mathematics	20	20	40	60	2	25	--	125

Rationale:

The goal of this course is to make the learner conversant with the basic tools of mathematics for application in Chemical engineering. The syllabus designed will help the learner build a foundation to model Chemical engineering problems mathematically, analyze and solve the same.

Course Objectives:

1. To develop proficiency in statistical techniques and familiarize with probability distributions, emphasizing their applications in engineering.
2. To introduce the concept and fundamentals of Matrix algebra.
3. To familiarize with the application of Numerical techniques for models yielding Ordinary Differential Equations.
4. To introduce Linear Finite Difference Equations and their solution.
5. To introduce partial differential equations and Numerical techniques to solve the same in context of chemical engineering.
6. To introduce the concept of Laplace Transform and its application in solving ODE.

Course Outcomes:

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

1. Analyze data related to Chemical Engineering problems and apply the concept of correlation and regression and curve-fitting.

2. Understand the matrix algebra and its applications in solving linear systems and related problems in engineering.
3. Apply numerical methods to solve ordinary differential equations arising in heat, mass transfer models.
4. Apply the concept of difference equations to Chemical Engineering problems and find solutions.
5. Apply numerical techniques to solve partial differential equations arising in Chemical Engineering.
6. Understand Laplace Transform and its application in solving ordinary differential equations related to Chemical Engineering.

Prerequisite:

Applied Mathematics-I
Applied Mathematics-II

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hrs	CO Mapping
01	**Probability and Statistics**	Discrete and Continuous random variables, Probability mass function, Correlation, Karl Pearson's Coefficient of Correlation Lines of regression, fitting of first-degree curves (use Chemical engineering examples.) **Self-Learning Topics:** **Conditional probability, Baye's Theorem, Spearman's Rank Correlation Coefficient**	**5**	**CO1**
02	**Matrices**	Eigen values and Eigen vectors, Properties of Eigen values and Eigen vectors. (No theorems/ proof) Similarity of matrices, Diagonalization of matrices. **Self -Learning Topics:** **Applications of Eigen values and eigen vectors in Chemical Engineering**	**4**	**CO2**
03	**Numerical Methods for Ordinary Differential Equations (ODE):**	Applying to chemical engineering problems related to momentum transfer, heat transfer, mass transfer and reaction engineering, Eulers method, Runge-Kutta second Order method **Self -Learning Topics:** **Applications of Runge-Kutta Fourth order Method and Adam Bashford Predictor - Corrector Method to chemical engineering problems**	**4**	**CO3**
04	**Finite Difference Equations**	Forward and Backward difference operators Δ , ∇, Shift operator E, Relation between E, Δ , ∇, Solution	**5**	**CO4**

		of Linear Difference Equations (up to order two) using Complimentary function & Particular Integral for F(n) = $coskn, sinkn, a^n (a\ is\ constant), polynomial\ in\ n$ Application to chemical engineering problems **Self -Learning Topics** **Introduction to Central Difference**		
05	**Numerical Techniques for Models Producing PDEs**	Introduction, Classification (Parabolic, Hyperbolic & Elliptic), Boundary and Initial Conditions, Bender Scmidt Method & Crank-Nicolsan Method **Self-Learning Topics: Characteristics of Linear Partial Differential Equations**	**4**	**CO5**
06	**Laplace Transform**	Laplace Transform & Inverse Laplace Transforms of Standard Functions like $e^{at}, \sin(at), \cos(at), \sinh(at), \cosh(at)$ and t^n, $where\ n \geq 0$ (without proof) First Shifting theorem, Laplace Transform of derivatives and integrals (Properties without proof) Inverse Laplace transform using First Shifting Theorem and Partial fractions method. Applications of Laplace Transforms for Solutions to ODE **Self -Learning Topics: Error Function, Properties of Error Function, and PDE problems related to chemical engineering**	**4**	**CO6**

Note: Tutorial shall be conducted batch wise
No Questions to be asked from Self-learning Topics.

References:

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication.
2. Rice R G. and. Do, D. D. "Applied Mathematics and Modeling for Chemical Engineers", John Wiley and Sons, New York, 1995.
3. Jenson. V.J. and Jeffereys, G. V, "Mathematical Methods in Chemical Engineering", 2nd Edition, Academic Press New York, 1977.
4. Probability, Statistics and Random Processes, T. Veerarajan, Mc. Graw Hill education.
5. Mickley. H.s., Sherwood, T. K. and Reed, c.E, "Applied Mathematics in Chemical

Engineering" 2nd Edition, Tata McGraw-Hill, New Delhi Publications, 1975.

Term Work:
General Instructions:

1. Batch wise tutorials are to be conducted. The number of students per batch should be as per the university pattern for practical.
2. Students must be encouraged to write at least 6 class tutorials on entire syllabus. A group of 4-6 students should be assigned a self-learning topic.
3. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Assessment:
Internal Assessment Test:

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.. Duration of each test shall be one hour.

End Semester Examination:

1. Question paper will comprise of total 06 questions, each carrying 15 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and should cover maximum content of the entire syllabus.
4. Remaining questions will be randomly selected from all the modules as per the weightage of each module (which is proportional to number of respective lecture hours mentioned in the syllabus).

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2073112	Fluid Flow Operations	3	-	-	3	-	-	3

		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)					
2073112	Fluid Flow Operations	20	20	40	60	2	--	--	100

Rationale:

Fluid flow operations is a basic/fundamental course of Chemical Engineering. This course is useful to determine the various types of flow rates (such as mass, volumetric), and also to determine pressure drops in the pipe, and mixing and agitation necessary for efficient unit operations. By understanding fluid behaviour, we (engineers) can improve reactor design, enhance heat transfer, and optimize mass transfer rates. The chemical engineers are involved in selecting, installing operating parameters that will be encountered in the chemical and process industries.

Course Objectives:

1. Students should be able to understand the scope of the subject in the chemical industry and pressure drop- flow rate relationship.
2. They should be able to understand the boundary layer conditions and types of flow.
3. They should be able to understand Bernoulli's equation and its applications in transportation of fluids.
4. They should be able understand the relationship between pressure drop and flow rates in conduits for incompressible fluids.
5. They should be able understand the types of velocities and stagnation properties for compressible flow and viscosity using Stokes law.
6. They should be able understand the purpose and need of power requirement in agitation and selection and importance of pumps and valves.

Course Outcomes:

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

1. Acquire basic concepts and pressure measurement methods.
2. Learn kinematics of flow, rheological behavior of fluid and boundary layer conditions.
3. Learn Bernoulli's equation and apply it in practical applications of various problems in Chemical Engineering.
4. Learn flow equations and evaluate the losses in incompressible flow.
5. Learn the behavior of compressible fluids and Stokes Law and also be able to apply these concepts for estimation of stagnation properties.
6. Gain the knowledge of various pumps, choice of pumps, valves and agitators and would be able to calculate power requirement for pumps as well as for agitators.

Prerequisite:

1. Students are assumed to have adequate background in physics, units and dimensions and thermodynamics
2. Introduction to Chemical Engineering

DETAILED SYLLABUS:

Sr. No	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	–	–	–
1	**Introduction and Basic Concepts**	Scope and applications of fluid flow, Properties of fluids, Types of Fluids. Pressure and Fluid Statics: Fluid pressure at a point, Pascal's Law, Pressure variation in a fluid at rest. Hydrostatic equilibrium. Measurement of pressure, Manometers – Piezometers, U- tube, Single column manometer, U – tube differential manometer, Inverted differential U – tube manometer, Inclined manometer.	07	CO1
2	**Fluid Flow Phenomena**	Newton's law of viscosity, Kinematic viscosity, Rheological behavior of fluid, Reynold's experiment and Reynold's number, Laminar and turbulent flow in boundary layer, Boundary layer formation in straight tube, Transition length for laminar and turbulent flow.	04	CO2
3	**Basic Equations of Fluid Flow**	Continuity equation, Bernoulli's equation, Euler's equation, Modified Bernoulli's equation. Practical Application of Bernoulli's Equation: Venturi meter: Horizontal and inclined, Orifice meter, Pitot tube. Differential area flow meter: Rotameter.	06	CO3
4	**Flow of Incompressible fluids: Laminar/Turbulent**	Shear stress distribution and velocity distribution, Relationship between skin friction and wall shear, Friction factor, Darcy-Weisbach equation, Local velocity, Maximum velocity, Average velocity, Kinetic energy correction factor, Hagen – Poiseullie equation, Moody diagram, Equivalent diameter for circular and non-circular ducts. Major and minor losses, Equivalent length, Frictional losses in different pipe fittings.	08	CO4

5	**Flow of Compressible Fluids**	Introduction, Mach number, Sonic, Supersonic and Subsonic flow, Continuity equation and Bernoulli's equation, Stagnation properties, Acoustic velocity. Adiabatic flow, Isothermal flow. Flow past immersed bodies: Drag Forces, Coefficient of Drag, One dimensional motion of particle through fluid, Terminal Settling Velocity, Stoke's law, Stagnation Point.	06	CO5
6	**Pumps, Valves and Agitators**	Classification and types, Centrifugal Pumps – Construction and Working, Power Requirement, Definitions of Heads and Efficiency, Specific Speed, Minimum Speed, Characteristic Curves,Cavitation, NPSH, NPSHA, NPSHR, Priming. Reciprocating Pump: Classifications and Working. Power Consumption in Agitation: Purpose of Agitation, Types of Impellers, Prevention of Swirling, Power Curves, Power Number Introduction to Compressors, Fans and Blowers. Types of Valves: Globe valve, Gate valve, Butterfly valve and Non – Return valve.	08	CO6

Text Books:

1. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.
2. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and 2.
3. Dr. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications Pvt.Ltd.

References:

1. Cengel, Y. A. (2006). Fluid mechanics: fundamentals and applications. New Delhi, India: Tata McGraw-Hill Publishing.
2. Darby, R. (2001). Chemical Engineering Fluid Mechanics (2nd ed., rev.). New York: Marcel Dekker.
3. Douglas, J. F. (2001). Fluid mechanics (5th ed.). New Delhi, India: Pearson Education
4. Batchelor, G. K. (1999). Introduction to Fluid Dynamics. New Delhi, India:Cambridge University Press.
5. Rajput, R. K. (1998). A Textbook of Fluid Mechanics. New Delhi, India: S Chand and co
6. Mohanty, A. K. (2009). Fluid Mechanics (2nd ed.). New Delhi, India: PHI Learning.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc25_ch25/course (Course by Prof. Subrata Kumar Majumder, IIT Guwahati)
2.	https://archive.nptel.ac.in/courses/103/104/103104044/ (Course by Prof. V. Shankar, IIT Kanpur)

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 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
2073113	Process Calculation	3	-	-	3	-	-	3

		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)					
2073113	Process Calculation	20	20	40	60	2	--	--	100

Rationale :

Course covers the basics of chemical engineering also the material balance with chemical reaction and without chemical reaction calculations. Heat capacity, enthalpy change of system calculate by energy balance calculations

Course Objectives:

1. Learn about material balance of various unit operations for both steady and unsteady state operations.
2. Understand the material balance of various unit processes with and without chemical reactions.
3. To have the knowledge of recycle, bypass and purge operations.
4. Understand the energy balance calculations over various processes.
5. Understand the concept associated with combustion and humidification operation.
6. Development of the material balance and energy load of a binary distillation column.

Course Outcomes:

Students will apply the material balance for various unit operations for both steady and unsteady state operations.

1. Students will apply the material balance for various unit operations for both steady and unsteady state operations.
2. Students will compute the material balance of various unit processes with and without chemical reactions.
3. Students will evaluate recycle, bypass and purge operations and its streams.
4. Student will perform energy balance calculations over various processes.
5. Student will perform calculations of combustion.
6. Student will assess the material balance and energy load of a binary distillation column.

DETAILED SYLLABUS :

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Units and dimensions, various systems of units, conversion of units. Density, specific volume, specific gravity, concentration & composition of mixtures and solutions. Ideal Gas law, Dalton's law, Amagat's law and Raoult's law.		
1	**Material Balance without Chemical Reactions**	Introduction, general material balance equation, degree of freedom analysis for individual units, solving material balance problems for various unit operations under steady and unsteady state conditions.	**08**	**CO1**
2	**Material Balance with Chemical Reactions**	Concept of limiting and excess reactants, conversion and yield, selectivity and degree of completion of reaction.	**08**	**CO2**
3	**Recycle, Bypass and Purge Operations**	Material Balance calculations for both with and without chemical reactions.	**06**	**CO3**
4	**Energy Balance**	Heat capacity, sensible heat, latent heat, calculation of enthalpy changes. General energy balance equation. Energy balances for process involving chemical reaction including adiabatic reactions.	**08**	**CO4**
5	**Combustion**	Combustion theory and equations, Theoretical excess air and equivalence ratio, Proximate and ultimate analysis of coal, Numerical related to calorific values of fuel_from composition, air requirement and composition of flue gases. Introduction of humidification, theory of wet bulb and dry bulb temperature.	**07**	**CO5**
6	**Combined Material and Energy Balance**	Material and energy balance for binary distillation.	**02**	**CO6**

Text Books:

1. Narayan, K. V. and Lakshmikutty, B. "Stioichiometry and Process Calculations", 1st edition, Prentice Hall of India Pvt. Ltd., New Delhi (2006)

2. Bhatt, B. I. and Thakore, S. B., "Stoichimetry, 5th edition, Tata McGraw Hill Education Private Limited, New Delhi

3. Ch. Durga Prasad Rao and D. V. S. Murthy, "Process Calculations for Chemical Engineers", McMillan India Ltd. (2010)

4. O. A. Hougen, K. M. Watson, and R. A. Ragatz., "Chemical process principles-part 1, Material and Energy Balances". Second Edition. John Wiley & Sons, Inc., New York (1954).

References:

1. Himmelblau, D. M. and Riggs, J. B., "Basic Principles and Calculations in Chemical Engineering, 7th edition, Prentice Hall of India Pvt. Ltd., New Delhi (2009)

Online References:

Sr. No.	Website Name
1.	https://archive.nptel.ac.in/courses/103/103/103103165/ NPTEL: BASIC PRINCIPLES AND CALCULATIONS IN CHEMICAL 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 First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 15 marksQ.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
2073114	Chemical Engineering Thermodynamics-I	3	-	-	3	-	-	3

		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)					
2073114	Chemical Engineering Thermodynamics I	20	20	40	60	2	--	--	100

Rationale:

The laws of thermodynamics, which govern energy and the direction of energy flow, are amongst the most important fundamentals of chemical engineering that students learn during their course. This subject revises and expands the students' understanding of the 1st and 2nd laws of thermodynamics, from both classical perspectives. Students learn about the concepts of entropy and equilibrium in detail, which form the basis for the topics of phase equilibrium, mixture properties, mixture equilibrium, and reaction equilibrium in chemical engineering thermodynamics-II.

Course Objectives:

The course aimed:

1. To apply the first and second law of thermodynamics to chemical engineering systems.
2. To apply the second law of thermodynamics to chemical engineering systems.
3. To explain thermodynamic concepts such as Entropy, Exergy.
4. To predict the P-V-T behavior of ideal gases and real gases.
5. To demonstrate the use of thermodynamic charts and diagrams, the applications of enthalpy and entropy departure functions and the concept of fugacity.
6. To perform calculations involving the applications of the laws of thermodynamics.

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

1. Apply the First Law of Thermodynamics to flow and non-flow Chemical Engineering processes.
2. Compute the thermal efficiencies of various engines and machines using Second Law of Thermodynamics.
3. Calculate changes in entropy using thermodynamic relationships.
4. Compute the properties of real fluids using different equations of state.
5. Compute property changes of non-ideal gas systems using departure functions and use thermodynamic charts and diagrams for estimation of various thermodynamic properties.
6. Apply the laws of thermodynamics to analyze the chemical processes.

Prerequisite:

1. Basic thermodynamic properties, laws and equations.
2. Engineering Mathematics: Differential and Integral Calculus, Linear Algebraic Equations.

   Engineering Physics and Engineering Chemistry.

DETAILED SYLLABUS: Total six module for each subject (13 Weeks)

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisites.	--	--	--
1	**First law of Thermodynamics.**	1.1 First law of Thermodynamics for non-flow processes. 1.2 First law of Thermodynamics for flow processes (steady state processes). 1.3 Calculation of heat and work for various types of processes. 1.4 Transient Flow Processes - Charging & discharging tanks.	08	**CO1**
2	**Second Law of Thermodynamics.**	2.1 Second Law of Thermodynamics. 2.2 Concepts of heat engine, heat pump and refrigerator. 2.3 Carnot Cycle and Carnot Principle.	05	**CO2**
3	**Entropy.**	3.1 Clausius Inequality 3.2 Concept of Entropy and estimation of entropy change of various processes	06	**CO3**

		3.3 Concept of Exergy		
4	**Equations of state.**	4.1 Equations of state for non-ideal gases : Virial equation of state, van der Waals equation of state, Redlich- Kwong, Redlich-Kwong-Soave and Peng-Robinson equations of state	08	**CO4**
5	**Thermodynamic Properties of Pure Fluids.**	5.1 Maxwell's Equations 5.2 Enthalpy and Entropy departure functions (van der Waals and Redlich-Kwong EOS) 5.3 Fugacity and fugacity coefficient (van der Waals and Redlich-Kwong EOS) 5.4 Thermodynamic Charts, Diagrams and their applications	08	**CO5**
6	**Applications of Thermodynamics to Flow Processes.**	Applications of Thermodynamics to Flow Processes: Throttling Process (Joule- Thomson Expansion) and Compressors.	04	**CO6**

Text Books:

1. J.M. Smith, H.C. Van Ness, M.M. Abbot, M.T. Swihart, Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw-Hill Education, 2017.
2. K.V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2013.
3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997

References:

1. M.J. Moran, H.N. Shapiro, D.D. Boettner, M.B. Bailey, Fundamentals of Engineering Thermodynamics, 9th Edition, Wiley, 2018.
2. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2014.
3. J. Richard Elliot and Carl T. Lira, Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, 2012.
4. S. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 5th Edition, John Wiley and Sons, 2017.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc19_ch17/preview
2.	https://ocw.mit.edu/courses/10-40-chemical-engineering-thermodynamics-fall-2003/resources/suppnote_ch01_03/
3.	https://libraryguides.missouri.edu/thermodynamics

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 First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **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
2073115	Fluid Flow Operations Lab	–	2	–	–	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment(IAT)			End Sem. Exam	Term Work	Prac / Oral	Total
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
2073115	Fluid Flow Operations Lab	--	--	--	--	25	25	50

Lab Objectives:

Students should be able to:

1. Understand the basic properties and concepts of the fluid behavior in the chemical industry.
2. Understand various flow patterns and boundary layer conditions.
3. Understand applications of flow and pressure measuring devices.
4. Understand various pipe fittings, valves and its applications.
5. Understand working and operations of various pumps.
6. Understand Working and application of agitated vessels and use of different impellers in process industries.

Lab Outcomes:

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

1. Determine viscosity by Stokes law.
2. Distinguish different flow patterns and calculations involving Reynolds number.

3. Find coefficient of discharge for various flow measuring devices.
4. Evaluate minor losses and frictional losses for various pipe fittings and networks.
5. Calculate power required and efficiency for various pumps.
6. Find power requirements for various impellers in agitated vessels.

Prerequisite:

1. Knowledge of physical sciences and units and dimensions.
2. Knowledge of properties of fluids, law of conservation of mass and law of momentum.
3. Knowledge of flow and pressure measurement devices.
4. Knowledge of different flow patterns and pumps.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	–	–	–
1	Viscosity	Properties of fluids, Viscosity and its Measurement. Various units of viscosity.	**02**	CO1
2	Fluid Flow Phenomena	Types of flow (Laminar/Turbulent), Reynolds experiment.	**02**	CO2
3	Flow measuring devices	Bernoulli's theorem and its applications, Venturimeter and Orificemeter and its discharge coefficient. Pitot tube	**02**	CO3
4	Flow of Incompressible fluids	Flow through pipe, Major and Minor losses in pipe and pipe fittings	**02**	CO4
5	Pumps	Classification and types, power required and efficiency of various pumps. Characteristics of a pump.	**02**	CO5
6	Power Consumption in Agitation	Purpose of Agitation, Types of Impellers, Prevention of Swirling, Power Curves, Power Number	**02**	CO6

Text Books:

1. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.
2. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and 2.
3. Dr. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications Pvt.Ltd.

References:

1. Cengel, Y. A. (2006). Fluid mechanics: fundamentals and applications. New Delhi, India: Tata McGraw-Hill Publishing.
2. Darby, R. (2001). Chemical Engineering Fluid Mechanics (2nd ed., rev.). New York: Marcel Dekker.
3. Douglas, J. F. (2001). Fluid mechanics (5th ed.). New Delhi, India: Pearson Education
4. Batchelor, G. K. (1999). Introduction to Fluid Dynamics. New Delhi, India:Cambridge University Press.
5. Rajput, R. K. (1998). A Textbook of Fluid Mechanics. New Delhi, India: S Chand and co
6. Mohanty, A. K. (2009). Fluid Mechanics (2nd ed.). New Delhi, India: PHI Learning.

Online Resources:

Sr. No.	Website Name (Virtual Lab details)
1.	https://ce-iitb.vlabs.ac.in/ (IIT Bombay)
2	https://uorepc-nitk.vlabs.ac.in/ (NITK Surathkal)

List of Experiments:

Sr No	List of Experiments (Minimum Eight to be performed)	Hrs
1	Determination of flow behavior by Reynolds Apparatus	2
2	Verification of Bernoulli's theorem experimentally	2
3	Venturimeter - Determination of Coefficient (C_V)	2
4	Orifice meter - Determination of Coefficient (C_0)	2
5	Pitot Tube - Measurement of local/point velocity	2
6	Flow through Helical Coil	2
7	Flow through Annulus	2
8	Flow through Circular Pipe	2
9	Losses in Pipe Fittings (Minor Losses)	2
10	Flow through Pipes (Major Losses)	2
11	Study the characteristics of a centrifugal pump	2
12	Power Consumption in Agitated Vessel	2
13	Viscosity by Stokes Law	2
14	Rotameter - Calibration and flow rate measurement	2
15	Experiments using Virtual Labs* (https://ce-iitb.vlabs.ac.in/) - IIT Bombay	–

Sr No	List of Assignments	Hrs
01	Module 1 - Introduction and Basic Concepts	–
02	Module 2 - Fluid Flow Phenomena	–
03	Module 3 - Basic Equations of Fluid Flow	–
04	Module 4 - Flow of Incompressible fluids: Laminar/Turbulent	–
05	Module 5 - Flow of Compressible Fluids	–
06	Module 6 - Pumps, Valves and Agitators	–

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 Examination/Orals - 25 Marks:

Practical Examination will be based on experiments performed in the laboratory.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2073116	Process Calculations Lab	–	2	–	–	1	–	1

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment(IAT)			End Sem. Exam	Term Work	Prac / Oral	Total
		IAT-I	IAT-II	Total (IAT-I + IAT-II)				
2073116	Process Calculations Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To study material balance without chemical reaction of various unit operations.
2. To study material balance with chemical reaction of various unit operations.
3. To learn about the knowledge of recycle, bypass and purge operations.
4. Understand the energy balance calculations over various processes.
5. Understand the concept associated with combustion and humidification operation.
6. Development of the material balance and energy load of a binary distillation column.

Lab Outcomes:

1) Students will apply the material balance for various unit operations.
2) Students will compute the material balance of various unit processes with and without chemical reactions.
3) Students will evaluate recycle, bypass and purge operations and its streams.
4) Students will perform energy balance calculations over various processes.
5) Students will perform calculations of combustion.
6) Students will assess the material balance and energy load of a binary distillation column.

List of Experiments.

Sr No	List of Experiments	Hours	LO Mapping
01	Evaluation of unknown Normality / Molarity / Molality of solutions using titrimetric analysis.	02	1
02	Material balance over different unit operations.	02	1
03	Limiting reactant and excess reactant for chemical reaction.	02	2
04	Material balance Calculation of Recycle in EXCEL.	02	3
05	Material balance Calculation of Purge in EXCEL.	02	3
06	Energy balance over different unit operations.	02	4
07	Heat of reaction and Hess's law of heat summation.	02	4
08	To calculate the heat of reaction.	02	4
09	To calculate the heat of combustion.	02	4
10	Measurement of Dew Point Temperature.	02	5
11	Estimation of properties of Water and Steam from Psychrometric Chart.	02	5
12	Excess air calculation in hydrocarbon fuel oil fired furnace.	02	5
13	Calculating boiler and process thermal heater efficiency by input-output and heat loss method in EXCEL	02	5
14	Material and energy balance calculation over the binary distillation in EXCEL.	02	6

Note: All the Experiments (Minimum eight) can be performed either in laboratory or using MS EXCEL **or** any open source software.

Sr No	List of Assignments / Tutorials	Hrs
01	Material Balance without Chemical Reactions	02
02	Material Balance with Chemical Reactions	02
03	Recycle, Bypass and Purge Operations	02
04	Energy Balance	02
05	Combustion	02

Assessment:

Term Work: Term Work shall consist of at least eight practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

SEMESTER III

Vertical - 5

Detail Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2993511	Entrepreneurship Development		2*+2	-	-	-	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II				
2993511	Entrepreneurship Development	--	--	--	--	50	--	50

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

Lab Objectives:

1. To introduce students to entrepreneurship concepts and startup development.
2. To develop business idea generation, validation, and business model preparation.
3. To provide hands-on experience in market research, financial planning, and business pitching.
4. To enhance problem-solving and decision-making skills in entrepreneurial ventures.
5. To familiarize students with government schemes and support systems for entrepreneurs.
6. To develop communication and presentation skills required for business pitching.

Lab Outcomes:

Upon successful completion of this course, students will be able to:

1. Understand the fundamental concepts of entrepreneurship and business models.
2. Conduct market research and develop business plans.
3. Utilize financial planning and cost analysis for startups.
4. Apply entrepreneurial skills to identify and solve business challenges.
5. Develop prototypes using open-source software for business operations.
6. Pitch business ideas effectively with structured presentations.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Fundamentals of communication and leadership skills.	01	--
I	**Introduction to Entrepreneurship**	Definition, Characteristics, and Types of Entrepreneurs. Entrepreneurial Motivation and Traits. Start-up Ecosystem in India. Challenges in Entrepreneurship	**02**	**LO1**
II	**Business Idea Generation & Validation**	Ideation Techniques: Design Thinking, Brainstorming, Mind Mapping. Business Model Canvas (BMC). Market Research & Customer Validation. Minimum Viable Product (MVP) Concept.	**04**	**LO2**
III	**Business Planning & Strategy**	Writing a Business Plan. SWOT Analysis and Competitive Analysis. Financial Planning and Budgeting. Risk Assessment and Management	**04**	**LO3**
IV	**Funding and Legal Framework**	Sources of Funding: Bootstrapping, Angel Investors, Venture Capital Government Schemes & Start-up India Initiatives. Business Registration & Legal Formalities. Intellectual Property Rights (IPR) & Patents	**05**	**LO4**
V	**Marketing & Digital Presence**	Branding and Digital Marketing. Social Media Marketing & SEO. Customer Relationship Management (CRM). E-commerce & Online Business Models	**05**	**LO5**
VI	**Business Pitching & Prototype Development**	Pitch Deck Preparation & Presentation Techniques. Prototyping with Open-source Tools. Elevator Pitch & Investor Pitch. Case Studies of Successful Start-ups	**05**	**LO6**

Text Books:

1. "Entrepreneurship Development and Small Business Enterprises" – Poornima M. Charantimath, Pearson, 3rd Edition, 2021.
2. "Innovation and Entrepreneurship" – Peter F. Drucker, Harper Business, Reprint Edition, 2019.
3. "Startup and Entrepreneurship: A Practical Guide" – Rajeev Roy, Oxford University Press, 2022.

4. "Essentials of Entrepreneurship and Small Business Management" – Norman Scarborough, Pearson, 9th Edition, 2021.
5. "The Lean Startup" – Eric Ries, Crown Publishing, 2018.

References:

1. "Disciplined Entrepreneurship: 24 Steps to a Successful Startup" – Bill Aulet, MIT Press, 2017.
2. "Zero to One: Notes on Startups, or How to Build the Future" – Peter Thiel, 2014.
3. "The $100 Startup" – Chris Guillebeau, Crown Business, 2019.
4. "Business Model Generation" – Alexander Osterwalder & Yves Pigneur, Wiley, 2020.
5. "Blue Ocean Strategy" – W. Chan Kim & Renée Mauborgne, Harvard Business Review Press, 2019.

Online Resources:

Website Name
1. Startup India Portal – https://www.startupindia.gov.in 2. MIT OpenCourseWare – Entrepreneurship – https://ocw.mit.edu/courses/sloan-school-of-management/ 3. Coursera – Entrepreneurship Specialization – https://www.coursera.org/specializations/entrepreneurship 4. Harvard Business Review – Entrepreneurship Articles – https://hbr.org/topic/entrepreneurship 5. Udemy – Startup & Business Courses – https://www.udemy.com/courses/business/entrepreneurship/

List of Experiments.

Sr No	List of Experiments	Hrs
01	Business Idea Generation using Mind Mapping.	02
02	Conducting Market Research & Customer Validation.	02
03	Preparing a Business Model Canvas for a Startup Idea.	02
04	Developing a Financial Plan & Break-even Analysis.	02
05	Creating a Website using WordPress/Wix.	02
06	Social Media Marketing Campaign using Open-source Tools.	02
07	Digital Prototyping using Figma/Inkscape.	02
08	Business Pitch Deck Preparation & Presentation.	02
09	Exploring Government Schemes for Startups.	02
10	Legal Compliance & IPR Basics (Case Study).	02

Sr No	List of Assignments / Tutorials	Hrs
01	a. Write a report on any successful entrepreneur and their startup journey. b. Conduct SWOT analysis for a real-life startup.	02
02	Develop a business idea and create a one-page business plan.	02
03	Conduct market research using surveys & present findings.	02
04	Design a simple logo and branding strategy for a startup.	02
05	Create a financial model and cost estimation for a startup.	02
06	Make a case study report on startup failure analysis.	02

List of Open-Source Software
1. Canva – Designing pitch decks, social media posts, and branding materials. 2. Trello / Asana – Project management for startups. 3. GIMP / Inkscape – Graphic design and logo creation. 4. WordPress / Wix – Website development for startups. 5. OpenCart / PrestaShop – E-commerce website setup. 6. Figma – UI/UX design and prototyping. 7. LibreOffice Calc – Financial planning and budgeting. 8. Google Suite (Docs, Sheets, Slides) – Documentation and presentations. 9. Python (Pandas, Flask, Django) – Data analytics and web application development. 10. MailChimp – Email marketing and customer engagement.

Assessment :

Term Work: Term Work shall consist of at least 10 practicals' based on the above list. Also, Term work Journal must include at least 6 assignments.

Term Work Marks: 50 Marks (Total marks) = 20 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2993512	Environmental Science	-	2*+2	-	2*	2	-	2

		Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2993512	Environmental Science	--	--	--	--	--	50	--	50

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

Rationale:

Most of the engineering branches are offspring of applied sciences, and their practices have a significant impact on the environment. Understanding environmental studies is essential for engineers to develop sustainable solutions, minimize ecological footprints, and promote responsible resource management. This course equips students with the knowledge of ecosystems, biodiversity, pollution control, and environmental laws, enabling them to integrate sustainability into engineering practices.

Lab Objectives:

1. To understand the scope, importance, and role of environmental studies in public awareness and health.
2. To study different natural resources, their issues, and sustainable conservation.
3. To understand ecosystem types, structures, and functions.
4. To explore biodiversity, its importance, threats, and conservation.
5. To learn about pollution types, causes, effects, and control measures.
6. To understand environmental challenges, sustainability, and ethics.

Lab Outcomes:

1. Explain the significance of environmental studies and the role of IT in environment and health.
2. Describe resource types, associated problems, and conservation methods.
3. Classify ecosystems and explain their role in ecological balance
4. Analyze biodiversity levels and conservation strategies, especially in India.
5. Explain pollution impacts and suggest preventive measures.
6. Discuss environmental issues and propose sustainable solutions.

DETAILED SYLLABUS:

Unit Name	Topic Name	Topic Description	Hours	LO Mapping
I	**The Multidisciplinary Nature of Environmental Studies**	Definition, scope and importance. Need for public awareness, Role of information technology in environment and human health. Human population and the environment: Population growth, variation among nations. Population Explosion- family welfare program. Environment and human health Women and child welfare	**03**	LO1
II	**Natural Resources**	Renewable and non-renewable resources. Natural resources & associated problems: a) Forest resources: b) Water resources: Natural resources & associated problems c) Mineral resources: d) Food resources: e) Energy resources: Role of an individual in conservation of natural resources: f) Equitable use of resources for sustainable lifestyles.	**04**	LO2
III	**Ecosystems**	Concepts of an ecosystem. Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries). Case study on various ecosystems in India.	**05**	LO3
IV	**Biodiversity and its Conservation**	Introduction-Definition: genetic species and ecosystem diversity. Bio-geographical classification of India Value of biodiversity : Consumptive use, productive use, social, ethical, aesthetic and option values, Bio-diversity at global, national, local levels India as a mega diversity nation Case study on Bio diversity in India.	**05**	LO4

V	**Environmental Pollution Definition**	Causes, effects and control measures of: a) Air pollution b) Water pollution c) Soil pollution. Solid waste management: Causes, effect and control measures of urban and industrial wastes. Role of an individual in prevention of pollution, Case study on Pollution Disaster management: floods, earthquake, cyclone and landslides. Carbon Credits for pollution prevention	**05**	LO5
VI	**Social Issues and Environment**	From unsustainable to sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management. Environmental ethics: issues and possible solution. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies. Consumerism and waste products. Environment protection act. Public awareness Case study on Environmental Ethics	**04**	LO6

Textbooks

1. Environmental Science: Towards a Sustainable Future, G. Tyler Miller and Scott Spoolman, 13th Edition, Cengage Learning 2021
2. Environmental Management: Text and Cases, Bala Krishnamoorthy, 3rd Edition, PHI Learning, Publication Year: 2016
3. Green IT: Concepts, Technologies, and Best Practices, Markus Allemann, Springer 2008
4. Sustainable IT: Slimming Down and Greening Up Your IT Infrastructure, David F. Linthicum, IBM Press 2009
5. Environmental Modelling: Finding Solutions to Environmental Problems, David L. Murray, Cambridge University Press 2016
6. Remote Sensing and Image Interpretation, Thomas M. Lillesand, Ralph W. Kiefer, and Jonathan W. Chipman, 9th Edition, John Wiley & Sons 2020
7. Business Ethics: Concepts and Cases, Manuel Velasquez, Pearson 2012

Reference Books

1. Environmental Law and Policy in India, Shyam Divan and Armin Rosencranz, 2nd Edition, Oxford University Press 2018
2. The International Handbook of Environmental Laws, David Freestone and Jonathon L. Rubin, Edward Elgar Publishing 2000

3. E-Waste Management: Challenges and Opportunities in Developing Countries, Ruediger Kuehr and Ram K. Jain, Springer 2008
4. The E-Waste Handbook: Managing Electronic Waste, Klaus Hieronymi, Ruediger Kuehr, and Ram K. Jain, Earthscan 2009
5. Environmental Ethics: An Introduction, J. Baird Callicott, University of Georgia Press1999

Online References:

Sr. No.	Website Name
4.	Centre for Science and Environment (CSE), Website: cseindia.org
5.	Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India
3.	CSIR-National Environmental Engineering Research Institute (NEERI)

List of Experiments.

Sr No	List of Experiments	Hrs
01	Study of Environmental Components and Ecosystems.	2
02	Visit and Report on Solid Waste Management Plant.	2
03	Study of Renewable Energy Sources (Solar, Wind, Biogas).	2
04	Analysis of Air and Water Quality Parameters.	2
05	Study of Local Biodiversity and Conservation Methods.	2
06	Awareness Activity on Environmental Issues.	2
07	Rainwater Harvesting System Design	2
08	Case Study on Environmental Pollution & Control Measures.	2
09	Report on Climate Change Impact and Adaptation.	2
10	Study of Environmental Laws and Acts.	2
11	Study of Disaster Management Techniques.	2
12	Report on Role of IT in Environmental Protection.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Prepare a report on Renewable and Non-Renewable Resources.	2
02	Write a case study on Ecosystem Types in India	2
03	Write a report on Biodiversity in India.	2
04	Prepare a report on Pollution Types and Control Measures.	2
05	Prepare a report on Environmental Ethics and Sustainability.	2
06	Prepare a case study report on Global Warming and Climate Change.	2
07	Report on Role of an Individual in Environmental Protection.	2
08	Write a report on Disaster Management Techniques.	2
09	Prepare a report on Environmental Laws and Acts in India.	2
10	Case Study on E-waste Management and Recycling Techniques.	2

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practical's based on the above list. Also, Term work Journal must include at least 8 to 10 assignments.

Term Work Marks: 50 Marks (Total marks) = 20 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report)

SEMESTER III

Vertical - 6

Detail Syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2073611	Mini Project-I	–	2*+2	–	–	2	–	2

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pral/ Oral	Total
		Internal Assessment (IAT)			End Sem Exam			
		IAT-1	IAT-II	Total (IAT-I + IAT-II)				
2073611	Mini Project-I	–	–	–	–	50	25	75

Course Objectives :

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To provide knowledge of unit operation and unit process.
3. To familiarize the process of solving the problem in a group.
4. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
5. To inculcate the process of self-learning and research.
6. Design and development of Small project based on various process and software

Course Outcome: Learner will…

1. Identify problems based on societal /research needs.
2. Reproduce, improve and refine technical aspects for engineering projects.
3. Draw the proper inferences from available results through theoretical/ experimental / simulation
4. Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
5. Students will be able to practice acquired knowledge within the chosen area of technology for project development.
6. Work as an individual or in a team in development of technical projects, which leads to lifelong learning.

1. **Guidelines for Mini Project**

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- Mini Projects should focus on self-learning, innovation, solving societal problems, and developing entrepreneurial skills, and it is preferred that a single, meaningful project be continued over the semester for deeper learning and better outcomes.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;

- Marks awarded by guide/supervisor based on log book: 20
- Marks awarded by review committee: 20
- Quality of Project report: 10

Assessment Criteria for Term Work (Internal Assessment):

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

Semester IV

Vertical – 1 Major

Detail Syllabus

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2074111	Chemical Engineering Thermodynamics-II	2	-	1	2	-	1	3

		Theory					Term Work (TW)	Oral and Pract	Total
		Internal Assessment Test (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
2074111	Chemical Engineering Thermodynamics-II	20	20	40	60	2	25	--	125

Rationale:

Thermodynamics is a fundamental subject in Chemical Engineering and knowledge of thermodynamics is required in the study of various unit operations and unit processes. The course Chemical Engineering Thermodynamics-I covers the basics of thermodynamics. In Chemical Engineering Thermodynamics-II more emphasis is given to the study of the properties of solutions, phase equilibria, vapour-liquid equilibria and chemical reaction equilibria. The topics covered in this course will serve as a foundation for the students in the study of courses on Mass Transfer Operations and Chemical Reaction Engineering in the subsequent semesters.

Course Objectives:

1. To compute the thermodynamic properties of ideal and non-ideal solutions and mixtures.
2. To explain thermodynamic concepts such as activity, chemical potential and excess property for solutions
3. To perform calculations and analyze problems related to phase equilibria.
4. To predict and analyze vapour-liquid equilibrium data for various systems.
5. To perform calculations and analyze problems related to chemical reaction equilibria.
6. To outline various types of refrigeration cycles and predict their performance.

Course Outcomes:

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

1. Evaluate the thermodynamic properties of ideal and non-ideal solutions and mixtures.

2. Perform calculations related to solution thermodynamics.

3. Analyze and solve the problems of phase equilibria.

4. Analyze and solve the problems of vapour-liquid equilibria.

5. Analyze and solve the problems of chemical reaction equilibria.

6. Describe various types of refrigeration cycles and evaluate their performance.

Prerequisites:

1. Chemical Engineering Thermodynamics-I.
2. Applied Mathematics and Engineering Mathematics.
3. Applied Physics and Elective Physics.
4. Applied Chemistry and Elective Chemistry.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisites	-	-	-
1	**Ideal and Non-Ideal Solutions**	1.1 Ideal solutions and mixtures 1.2 Non-idealities of solutions and mixtures 1.3 Partial molar properties 1.4 Chemical potential	**03**	**CO1**
2	**Properties of Solutions**	2.1 Activity and activity coefficients 2.2 Gibbs-Duhem equation 2.3 Property changes of mixing 2.4 Excess properties	**04**	**CO2**
3	**Phase Equilibria**	3.1 Concept of equilibrium between phases 3.2 Review of Raoult's law and Henry's law 3.3 Phase diagrams for binary solutions	**03**	**CO3**
4	**Vapour-Liquid Equilibria**	4.1 Vapour-liquid equilibria in ideal and non-ideal solutions 4.2 Estimation of activity coefficients using Margules equations, van Laar equation and Wilson equation 4.3 Introduction to UNIQUAC equation and UNIFAC method 4.4 Consistency tests for VLE data	**05**	**CO4**
5	**Chemical Reaction Equilibria**	5.1 Representation of reaction stoichiometry 5.2 Concept of reaction equilibrium in single and multiple reactions 5.3 Estimation of standard Gibbs free energy change and equilibrium constant of a reaction 5.4 Estimation of degree of conversion and composition of reactor effluents for single and multiple reactions 5.5 Degrees of freedom for single and multiple reactions	**07**	**CO5**
6	**Refrigeration**	6.1 Theory of Refrigeration 6.2 Vapour compression refrigeration system 6.3 Vapour absorption refrigeration system 6.4 Estimation of COP, refrigerant flow rate and power consumption	**04**	**CO6**

Text Books:

1. J.M. Smith, H.C. Van Ness, M.M. Abbot, M.T. Swihart, Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw-Hill Education, 2017.

2. K.V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2013.

3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997.

References:

1. M.J. Moran, H.N. Shapiro, D.D. Boettner, M.B. Bailey, Fundamentals of Engineering Thermodynamics, 9th Edition, Wiley, 2018.

2. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2014.

3. S. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 5th Edition, John Wiley and Sons, 2017.

4. J. Richard Elliot and Carl T. Lira, Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, 2012.

Online References:

Sr. No.	Website Name
1.	https://archive.nptel.ac.in/courses/103/101/103101004/

Term Work:

1. Batch-wise tutorials are to be conducted. The number of students per batch should be as per University pattern for practicals.
2. The tutorial questions should consist of numerical problems and mathematical derivations based on all the six modules of the syllabus covered in the theory lectures.
3. Each student must submit a minimum of ten tutorials as term work.

The distribution of Term Work marks will be as follows:-

1.	Attendance (Theory Lectures and Tutorials)	05 Marks
2.	Class Tutorials (minimum ten) on entire syllabus	20 Marks

Assessment:

Internal Assessment Test (IAT) for 20 marks:

- 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	Prac.	Tut.	Theory	Prac.	Tut.	Total
2074112	Solid Fluid Mechanical Operations	3	-	-	3	-	-	3

		Theory					Term Work (TW)	Oral and Pract	Total
		Internal Assessment Test (IAT)			End Sem Exam Marks	End Sem Exam Duration (Hrs)			
		IAT-I	IAT-II	Total (IAT-I + IAT-II)					
2074112	Solid Fluid Mechanical Operations	20	20	40	60	2	-	--	100

Rationale:

A "solid-fluid mechanical operation" refers to a set of industrial operations that involve the handling and processing of solid particles, either in the presence or absence of a fluid, utilizing mechanical methods like size reduction, separation, mixing, and conveying, often used in chemical engineering and related fields to evaluate particle size, composition, and flow characteristics within a system; essentially, it's the science and technology of working with powders and granular materials, including their interactions with fluids. Solid-fluid operations are widely used in industries like pharmaceuticals, mining, food processing, chemical manufacturing, and waste management. Common solid fluid mechanical operations are size reduction, size separation, mixing, fluidization, filtration, flotation etc.

Course Objectives:

1. Familiarize particle size distribution
2. Learn size reduction principles
3. Understand solid fluid mixing
4. Understand fluidization and filtration
5. To have knowledge of solid fluid separation
6. Understand storage and handling of solids

Course Outcomes:

1. Apply the concept of particle size distribution and identify the equipment

2. Explain size reduction principles
3. Explain solid fluid mixing
4. Compute the fluidization and filtration parameters
5. Design solid fluid separation equipment
6. Discuss the techniques for storage and handling of solids

Prerequisite:

1. Fluid flow operations
2. Engineering mechanics
3. Introduction to Chemical Engineering
4. Differential equations

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	**Particle size**	Particle size measurement and distribution using sieve analysis. Capacity and effectiveness of screen. (Numericals) Screening equipment – Vibrating screen, Grizzlies and Trommels.	05	1
2	**Size Reduction**	Size reduction of solids. Mechanism of size reduction and method of operation. Energy requirement for size reduction and crushing laws. (Numericals) Size reduction equipment – Jaw crusher, Hammer mill, Ball mill and Roll crusher. (Numericals)	07	2
3	**Mixing**	Solid mixing – Introduction to solid mixing, degree of mixing and rate of mixing. (Numericals) Mixing equipment for cohesive solids: Muller mixer and kneaders. Mixers for free flowing solids: Ribbon blender and internal screw mixer.	05	3
4	**Fluidization and Filtration**	Flow of a single fluid through a packed bed, Ergun's equation. Fluidization: conditions for fluidization. Minimum fluidization velocity. Types of fluidization. Applications of fluidization. Filtration: Mechanism of filtration. Types of filtration: constant rate and constant pressure filtration. Filter aids, washing of filter cake, flow of filtrate through the cloth and cake combined. (Numericals) Filters: Rotary drum vacuum filter, plate and frame filter press.	10	4
5	**Solid fluid separation**	Sedimentation: Batch sedimentation. Kynch theory of sedimentation. Derivation of area and depth of thickener. (Numericals) Particle separation by flotation and elutriation.	08	5

		Gas solid separation equipment: Cyclone separator, fabric filter and electrostatic precipitator.		
6	**Storage and handling of solids**	Storage of solids: Properties of particulate masses. Pressure in bins and silos, Jansen's equation. Conveying, of solids: Belt conveyer, bucket conveyer, screw conveyer and pneumatic conveyer.	05	6

Text Books

1. W. McCabe, J.C. Smith and P. Harriot, Unit operations of chemical engineering, 7th edition, McGraw Hill, 2004.
2. J .M Coulson and J. F Richardson, Chemical Engineering, vol 2, Pergamon Press, 1974.
3. A.S. Foust and L.A. Wenzel, Principles of unit operation, 2nd edition, Wiley, 1980.

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Reference

1. Perry's Chemical Engineers' Handbook , Robert H. Perry & Don W. Green, 8th edition, McGraw Hill

Online References:

Sr. No.	Website Name
2.	https://onlinecourses.nptel.ac.in/noc23_ch47/preview#
3.	https://archive.nptel.ac.in/courses/103/103/103103155/
3.	https://www.scribd.com/document/386040724/103107090-pdf

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 First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **Question paper format**
- Question Paper will comprise of a total of **six questions each carrying 15 marksQ.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
2074113	Heat Transfer Operations	3	-	-	3	-	-	3

		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)					
2074113	Heat Transfer Operations	20	20	40	60	2	--	--	100

Rationale:

A basic course that deals with heat transfer, heat exchangers and their design is typically called "Heat Transfer Fundamentals" within a Chemical Engineering curriculum, which are crucial for understanding and designing various chemical processes and equipment, making it a vital component of chemical engineering education.

Course Objectives:

1. To learn basic concepts of heat transfer and study steady and unsteady heat conduction.
2. To study Natural and Forced convection with its empirical correlations.
3. To develop heat transfer system with phase change i.e. condensation & boiling.
4. To understand various laws and rate of heat transfer by radiation.
5. To study preliminary design, construction, working of heat exchangers.
6. To understand construction and working of evaporators.

Course Outcomes:

1. Understand conductive heat transfer and calculate temperature profiles at steady state.
2. Comprehend natural and forced convection and calculate the heat transfer coefficients.
3. Interpret condensation and boiling phenomena and calculate heat duty in both the processes.
4. Acknowledge the radiative heat transfer.
5. Recognize the rate performance using NTU method and calculate heat duty /outlet/Temperatures / pressure drops / area required for various heat exchangers.
6. Know the process design aspects of evaporators.

Prerequisite: Applied mathematics-I & II, Material and Energy balance Calculations, Units and Dimensions, Laws of Thermodynamics

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
1	**Conduction**	Basic Fundamentals and Modes of Heat Transfer with its rate expressions. Concept of Thermal Resistance and Heat Transfer Coefficient **Steady State Conduction:** Fourier's Law, thermal conductivity, conduction through a flat slab, composite slab, conduction through a cylinder wall, composite cylinder, Conduction through hollow sphere, composite sphere. Critical radius of insulation. **Unsteady state conduction:**-Lumped Parameter Analysis – systems with negligible internal resistance. Biot number. Fourier number, Numericals.	**8**	**CO1**
2	**Convection: Heat Transfer without Phase Change:**	**Natural Convection:** Introduction, Natural convection currents. Heat transfer correlations. Numericals. **Forced Convection:** Introduction, thermal and hydrodynamic boundary layer, Heat transfer in laminar and turbulent boundary layers. Significance of various dimensionless numbers. Empirical correlations. Various analogies. Numericals.	**7**	**CO2**
3	**Condensation & Boiling: Heat Transfer with Phase Change**	**Condensation:** Introduction, types of condensation, Nusselt's theory of condensation, correlations for vertical and horizontal tube, plate. Numericals. **Boiling:** Heat transfer to boiling liquids, Pool Boiling Curve, Correlations for estimating the boiling heat transfer coefficients.	**3**	**CO3**
4	**Radiation**	Introduction, Radiation Fundamentals, Laws of radiations. Radiative heat exchange between surfaces, Multiple reflection method, Radiation shield. Heat Transfer in Furnaces. Numericals.	**4**	**CO4**
5	**Heat Exchangers**	Introduction, Types of flow, energy balance, rate of heat transfer, individual and Overall Heat Transfer Coefficients, LMTD, Wilson plot and fouling factors. Classification of Heat Exchangers. Preliminary process design of Double pipe heat exchangers. TEMA exchanger types, their nomenclature, choice of exchanger type, Design of Shell & tube heat exchangers: by Kerns method. Bell Delaware method.	**14**	**CO5**

		Effectiveness-NTU method. Heat transfer in agitated vessels and correlations, Extended surface heat exchangers, Fin efficiency and fin effectiveness, calculation of rate of heat transfer. Plate Heat Exchanger, Spiral Heat Exchanger. Numericals.		
6	**Evaporators**	Types of Evaporators, Performance, Capacity and Economy, Boiling Point Elevation, Methods of Feeding for MEE. Process design aspects of evaporators.	**3**	**CO6**

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Text Books:

1. MaCabe W. L., Smith J. C., Harriot P., Unit Operations of Chemical Engineering, 5th edition, McGraw Hill,1993.
2. Cengel, Y. A. (2006). Fluid mechanics: fundamentals and applications. New Delhi, India: Tata McGraw-Hill Publishing.
3. D. Q. Kern, Process Heat Transfer, McGraw hill, 1997.
4. R. K. Sinnot, Coulson & Richardsons Chemical Engineering Design, Vol 1 & 6, Elsevier Science & Technology Books.

References:

1. Holman J. P., Heat Transfer, 9th Edition, McGraw Hill, 2008.
2. B. K. Datta, Heat Transfer: Principles and applications, PHI learning

Online References:

Sr. No.	Website Name
4.	NPTEL
5.	SWAYAM
3.	Udemy

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 First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **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
2074114	Solid Fluid Mechanical Operation 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)				
2074114	Solid Fluid Mechanical Operation Lab	--	--	--	--	25	25	50

Lab Objectives:

1. Understand the importance of various mechanical operations used in process industry
2. Apply principles of basic sciences and chemical engineering for designing various size reduction and separation equipment.
3. Understand particulate solid characterization.
4. Familiarize primary and secondary crushers.
5. Acquire knowledge of mixing operation.
6. Understand filtration and sedimentation operation.

Lab Outcomes:

1. Acquire analytical skills for determination of particle size of solid mixture and determining the effectiveness of screen
2. Understand the operation of various equipment and applying laws of crushing
3. Understand the operation of mixing and evaluating the mixing index

4. Understand the operation of fluidization and filtration parameters
5. Understanding the sedimentation process and design of thickener
6. Understanding the concept of gas solid separation.

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Prerequisite:

1. Fluid Flow Operations
2. Basic knowledge on mechanical operations
3. Introduction to Chemical Engineering
4. Differential Equations

List of Experiments

Sr No	List of Experiments	Hrs
01	Sieve Analysis	2
02	Effectiveness of screen	2
03	Size reduction by jaw crusher	2
04	Size reduction by hammer mill	2
05	Size reduction by ball mill	2
06	Size reduction by Roll crusher	2
07	Batch sedimentation	2
08	Flow through fluidized bed	2
09	Filtration	2
10	Mixing	2
11	Cyclone separator	2
12	Elutriation	2
13	Froth floatation	2
14	Experiments using virtual labs	2

Assessment:
Term Work: Term Work shall consist of at least 10 to 12 practical's based on the above list. Also, Term work Journal must include at least 2 assignments.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)
Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.
Text Books

1. W. McCabe, J.C. Smith and P. Harriot, Unit operations of chemical engineering, 7th edition, McGraw Hill, 2004.
2. J .M Coulson and J. F Richardson, Chemical Engineering, vol 2, Pergamon Press, 1974.

Online References:

Sr. No.	Website Name
6.	https://onlinecourses.nptel.ac.in/noc23_ch47/preview#
7.	https://archive.nptel.ac.in/courses/103/103/103103155/
3.	https://www.scribd.com/document/386040724/103107090-pdf

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Reference

1. Perry's Chemical Engineers' Handbook , Robert H. Perry & Don W. Green, 8th edition, McGraw Hill
2. A.S. Foust and L.A. Wenzel, Principles of unit operation, 2nd edition, Wiley, 1980.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2074115	Heat Transfer Operations 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)				
2074115	Heat Transfer Operations Lab	--	--	--	--	25	25	50

Prerequisites:

1. Knowledge of fluid, flow pattern and properties of fluids.
2. Knowledge of flow measurement and temperature measurement devices.
3. Knowledge of basic process calculations and process safety.

Lab Objectives: (Students should be able……)

1. To gain hands-on experience of lab-scale experiments on conductive heat transfer systems.
2. To define the fundamental concepts to students in the area of convective heat transfer systems.
3. To determine the heat transfer rate and heat transfer coefficient in phase change systems such as condensation and boiling.
4. To apply the knowledge of radiative heat transfer in an effective manner for different applications.
5. To observe and record the steady state temperatures and evaluate the heat transfer coefficient, effectiveness of heat exchangers, agitated vessel and evaporators in chemical industries.
6. To familiar themselves with software's like Excel, HTRI, ANSI etc. for design of heat transfer equipment's.

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

1. Determine the thermal conductivity and heat transfer rate by using Fourier's law.
2. Evaluate the heat transfer coefficient for natural and force convection.
3. Estimate the heat transfer coefficient in drop wise and film wise condensation.
4. Determine the rate of heat transfer in radiation.

5. Analyze heat exchanger performance by using the method of log mean temperature difference and Measure the heat transfer coefficient in agitated vessel and efficiency in evaporator.
6. Design and calculate the performance of heat Exchangers by using Excel, HTRI, ANSI software's.

List of Experiment

Experiment No.	Name of Experiment	Lab Hours
1	Heat Transfer by Conduction (Insulating Materials / Composite Wall)	2
2	Thermal Conductivity of Fluid	2
3	Unsteady State Conduction	2
4	Natural Convection	2
5	Forced Convection	2
6	Film wise and Drop wise Condensation	2
7	Emissivity Measurement Apparatus	2
8	Double Pipe Heat Exchanger	2
9	Shell and Tube Heat Exchanger	2
10	Plate Heat Exchanger	2
11	Finned tube heat exchanger	2
12	Agitated vessel	2
13	Spiral Heat Exchanger	2
14	Evaporator	2
15	Design of Shell and Tube Heat Exchanger by Kerns method (Virtual Lab / software)	2
16	Design of Shell and Tube Heat Exchanger by Bell Delaware method (Virtual Lab / software)	2

Assessment:

Term Work: Term Work shall consist of at least 10 practical's based on the above list. Also, Term work Journal must include at least 5 assignments.

Term Work (25 marks)

Distribution of marks will be as follows:

Laboratory work: 15 marks

Assignments: 05

Attendance: 05

End Semester Practical Examination/Orals (25 marks):

Practical Examination will be based on experiments performed in the laboratory.

Reference Books:

1. Holman J. P., Heat Transfer, 9th Edition, McGraw Hill, 2008.
2. B. K. Datta, Heat Transfer: Principles and applications, PHI learning.
3. R. K. Sinnot, Coulson & Richardsons Chemical Engineering Design, Vol 1 & 6, Elsevier Science & Technology Books
4. Software's like Excel, HTRI, ANSI etc.

Vertical – 4

VSC

Detailed syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2074411	Mini Project-II	–	2*+2	–	–	2	–	2

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pral/ Oral	Total
		Internal Assessment (IAT)			End Sem Exam			
		IAT-1	IAT-II	Total (IAT-I + IAT-II)				
2074411	Mini Project-II	–	–	–	–	50	25	75

Course Objectives :

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To provide knowledge of unit operation and unit process.
3. To familiarize the process of solving the problem in a group.
4. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
5. To inculcate the process of self-learning and research.
6. Design and development of Small project based on various process and software

Course Outcome: Learner will…

1. Identify problems based on societal /research needs.
2. Reproduce, improve and refine technical aspects for engineering projects.
3. Draw the proper inferences from available results through theoretical/ experimental / simulation
4. Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
5. Students will be able to practice acquired knowledge within the chosen area of technology for project development.
6. Work as an individual or in a team in development of technical projects, which leads to lifelong learning.

2. **Guidelines for Mini Project**

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- Mini Projects should focus on self-learning, innovation, solving societal problems, and developing entrepreneurial skills, and it is preferred that a single, meaningful project be continued over the semester for deeper learning and better outcomes.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book: 20
  - Marks awarded by review committee: 20
  - Quality of Project report: 10

Assessment Criteria for Term Work (Internal Assessment):

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Vertical – 5

Detailed syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2994511	Business Model Development		2*+2	-	2*	2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2994511	Business Model Development	--	--	--	--	--	50	--	50

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

Lab Objectives:

1. To introduce a learner to entrepreneurship and its role in economic development.
2. To familiarize a learner with the start-up ecosystem and government initiatives in India.
3. To explain the process of starting a business.
4. To familiarize a learner with the building blocks of a business.
5. To teach a learner to plan their own business with the help of Business Model Canvas.
6. To teach a learner to have financial plan for a business model.

Lab Outcomes:

The learner will be able to:

1. Discuss the role of entrepreneurship in the economic development of a nation and describe the process of starting a business.
2. Describe start-up ecosystems in Indian and global context.
3. Identify different types of business models.
4. Identify customer segments, channels and customer relationship components for a particular business.
5. Identify key activities, key partners and key resources for a particular business.
6. Develop a financial plan for a business with the help of cost structure and revenue model.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Basic Design Thinking principles	**01**	**L2**
I	**Introduction to Entrepreneurship**	**Introduction to Entrepreneurship**: Definition, the role of entrepreneurship in the economic development, the entrepreneurial process, Women entrepreneurs, Corporate entrepreneurship, Entrepreneurial mindset **Self-learning Topics:** Case	**04**	**L2, L3**

		studies: Henry Ford https://www.thehenryford.org/docs/default-source/default-document-library/default-document-library/henryfordandinnovation.pdf?sfvrsn=0 The Tatas: How a Family Built a Business and a Nation by Girish Kuber, April 2019, Harper Business		
II	**Entrepreneurship Development**	**Entrepreneurship Development**: Types of business ownerships: Proprietorship, Public and Private Companies, Co-operative businesses, Micro, Small and Medium Enterprises (MSME): Definition and role of MSMEs in economic development	**05**	**L2, L3**
III	**Start-up financing**	**Start-up financing:** Cost and revenue models, Sources of start-up fundings: Angel investors, Venture capitalists, Crowd funding, Government schemes for start-up funding **Self-learning Topics:** Successful business pitching	**04**	**L2, L3**
IV	**Intellectual Property Rights (IPR)**	**Intellectual Property Rights (IPR):** Types of IPR: Patents, trademarks and copyrights, Patent search and analysis, Strategies for IPR protection, Ethics in technology and innovation	**04**	**L2,L3**
V	**Business Model Development**	**Business Model Development:** Types of business models, Value proposition, Customer segments, Customer relationships, Channels, Key partners, Key activities, Key resources, Prototyping and MVP **Self-learning Topics:** The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything by Guy Kawasaki	**04**	**L5, L6**
VI	**Digital Business Management**	**Digital Business Management:** Digital Business models (Subscription, Freemium *etc*), Digital marketing: Search Engine Optimization (SEO), Search Engine Marketing	**04**	**L2, L3**

		(SEM), Social media and influencer marketing, Disruption and innovation in digital business **Self-learning Topics:** Case study: Airbnb https://www.prismetric.com/airbnb-business-m		

Textbooks:

1. Entrepreneurship: David A. Kirby, McGraw Hill, 2002
2. Harvard Business Review: Entrepreneurs Handbook, HBR Press, 2018
3. Business Model Generation; Alexander Ostlewalder and Yves Pigneur, Strategyzer, 2010
4. E- Business & E– Commerce Management: Strategy, Implementation, Practice – Dave Chaffey, Pearson Education

Reference books:

1. Entrepreneurship: New venture creation by David Holt, Prentice Hall of India Pvt. Ltd.
2. E- Business & E– Commerce Management: Strategy, Implementation, Practice – Dave Chaffey, Pearson Education

Online Resources:

Sr. No.	Website Name
6.	Entrepreneurship by Prof. C Bhaktavatsala Rao https://onlinecourses.nptel.ac.in/noc20_mg35/preview
7.	Innovation, Business Models and Entrepreneurship by Prof. Rajat Agrawal, Prof. Vinay Sharma https://onlinecourses.nptel.ac.in/noc21_mg63/preview
3.	Sarasvathy's principles for effectuation https://innovationenglish.sites.ku.dk/model/sarasvathy-effectuation/

List of Experiments.

The lab activities are to be conducted in a group. One group can be formed with 4-5 students. A group has to develop a Business Model Canvas and a digital prototype (Web App/ mobile app). Weekly activities are to be conducted as follows:

Sr No	Lab activities	Hrs
01	Problem identification (Pain points, Market survey)	2
02	Design a digital solution for the problem (Ideation techniques)	2
03	Preparing a business model canvas: Value proposition, Key partners, Key resources, Key activities	2
04	Preparing a business model canvas: Customer segment, Customer relationships and channels	2
05	Preparing a business model canvas: Cost and Revenue structure	2
06	Prototype development: Low fidelity	2
07	Prototype development: Customer feedback	2
08	Prototype development: High fidelity	2
09	Presentation of high-fidelity prototype	2

Sr No	List of Assignments / Tutorials	Hrs
01	Presentation on case study of a failed business model	2
02	Presentation on case study of a woman entrepreneur	2

Assessment:

Term Work: Term Work shall consist of 10 lab activities based on the above list. Also, Term work journal must include any 2 assignments from the above list.

Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 10 Marks (Assignments) + 5 Marks (Attendance)+10 Marks (Report).

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2994512	Design Thinking		2*+2	-	2*	2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2994512	Design Thinking	--	--	--	--	--	50	--	50

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

Lab Objectives:

1. To introduce a learner to the principles of Design Thinking.
2. To familiarize a learner with the process (stages) of Design Thinking.
3. To introduce various design thinking tools.
4. Study of the techniques for generation of solutions for a problem.
5. To expose a learner to various case studies of Design Thinking.
6. Create and test a prototype.

Lab Outcomes:

Students will be able to …

1. Compare traditional approach to problem solving with the Design Thinking approach and discuss the principles of Design Thinking
2. Define a user persona using empathy techniques
3. Frame a problem statement using various Design Thinking tools
4. Use ideation techniques to generate a pool of solutions for a problem
5. Create prototypes using different techniques
6. Test the prototypes and gather feedback for refining the prototype

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	No perquisites	-	-
I	**Introduction to Design Thinking**	**Introduction to Design Thinking:** Definition, Comparison of Design Thinking and traditional problem-solving approach, Need for Design Thinking approach, Key tenets of Design Thinking, 5 stages of Design Thinking (Empathize, Define, Ideate, Prototype, Test) **Self-learning Topics:** Design thinking case studies from various domains https://www.design-thinking-association.org/explore-design-thinking-	**05**	**L1, L2**

		topics/external-links/design-thinking-case-study-index		
II	**Empathy**	**Empathy:** Foundation of empathy, Purpose of empathy, Observation for empathy, User observation technique, Creation of empathy map **Self-learning Topics:** Creation of empathy maps https://www.interaction-design.org/literature/topics/empathy-mapping	**05**	**L2, L3**
III	**Define**	**Define:** Significance of defining a problem, Rules of prioritizing problem solving, Conditions for robust problem framing, Problem statement and POV **Self-learning Topics:** Creating a Persona – A step-by-step guide with tips and examples https://uxpressia.com/blog/how-to-create-persona-guide-examples	**05**	**L2, L3**
IV	**Ideate**	**Ideate:** What is ideation? Need for ideation, Ideation techniques, Guidelines for ideation: Multi-disciplinary approach, Imitating with grace, Breaking patterns, Challenging assumptions, Looking across value chain, Looking beyond recommendation, Techniques for ideation: Brainstorming, Mind mapping **Self-learning Topics:** How To Run an Effective Ideation Workshop: A Step-By-Step Guide https://uxplanet.org/how-to-run-an-effective-ideation-workshop-a-step-by-step-guide-d520e41b1b96	**05**	**L3, L7**
V	**Prototype**	**Prototype:** Low and high-fidelity prototypes, Paper prototype, Story board prototype, Scenario prototype	**03**	**L6**
VI	**Test**	**Test:** 5 guidelines of conducting test, The end goals of test: Desirability, Feasibility and Viability, Usability testing	**03**	**L4, L5**

Textbooks:

1. Design Your Thinking: The Mindsets, Toolsets, and Skill Sets for Creative Problem-solving, Pavan Soni, Penguin Random House India Private Limited
2. Design Thinking: Methodology Book, Emrah Yayichi, 2016
3. Handbook of Design Thinking: Christian Mueller-Roterberg, 2018

Reference books:

1. Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, Idris Mootee, Wiley, 2013
2. Change by Design, Tim Brown, Harper Business, 2009

Online Resources:

Sr. No.	Website Name
8.	Design Thinking and Innovation by Ravi Poovaiah https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
9.	Introduction to Design Thinking by Dr. Rajeshwari Patil, Dr. Manisha Shukla, Dr. Deepali Raheja, Dr. Mansi Kapoor https://onlinecourses.swayam2.ac.in/imb24_mg37/preview
3.	Usability Testing https://www.interaction-design.org/literature/topics/usability-testing

List of Experiments.

The experiments are to be performed in groups. A practical batch may be divided into groups of 4-5 students.

Sr No	List of Experiments	Hrs
01	Customer Journey Mapping: Visualize the steps users take to interact with a product or service. Map out the customer journey from discovering a product to making a purchase and using the product. Identify pain points and opportunities for improvement.	2
02	Stakeholder mapping: Identify all relevant stakeholders in a project. Create a stakeholder map, categorizing stakeholders based on their influence and interest. Include management of relationships with key stakeholders.	2
03	"How Might We" Problem Framing: Transform user insights into actionable problem statements. After empathizing with users, turn challenges into "How Might We" statements that define the problem without prescribing a solution.	2
04	Brainstorming Session: Generate a pool of ideas in a creative, non-judgmental environment. Using ideation techniques like mind mapping and brainwriting, students brainstorm as many solutions as possible to their "How Might We" problem statements.	2
05	Affinity Diagramming: Organize group ideas to find patterns and insights. After brainstorming, students will categorize their ideas into themes by placing sticky notes on a wall and moving them into groups based on similarities.	2
06	Rapid Prototyping: Create quick, low-fidelity versions of solutions. Use materials like paper, cardboard, and markers to build a prototype of their solution within 30 minutes. The focus is on speed and functionality, not aesthetics.	2
07	Wireframing: Create a visual guide for digital interfaces for mobile app / web app for the problems identified in earlier lab sessions. Students will sketch wireframes of the user interface for their product or service. Use tools like Balsamiq or paper and pen for low-fidelity wireframes.	2
08	Role-Playing: Walk through a prototype from the user's perspective. Students act as both users and designers, role-playing scenarios where they interact with their prototype (Developed in earlier lab sessions). Gather feedback from participants on how to improve the experience.	2
09	Usability Testing: Evaluation of the effectiveness and user-friendliness of a prototype (developed in earlier lab sessions). Students will have peers or target users test their prototypes, observe how they interact with it, and collect feedback on any issues or improvements needed.	2
10	Feedback Loop and Iteration: Refine solutions based on user feedback. After usability testing, students will refine their prototypes. Document changes made based on feedback and discuss how continuous iteration improves the design.	2

Sr No	List of Assignments (Any two)	Hrs
01	Create an empathy map for a target user group. Break them into four sections: *Says, Thinks, Feels, and Does*. Interview users or research their experiences to fill in the map.	3
02	Based on research, students will create user personas including demographic details, motivations, pain points, and goals. Each group will present their persona to the class.	3
03	Consider 3 examples of real-life products which have good design and bad design. Write down reasons why do you think they are good or bad designs. May take user survey to support your work.	3
04	Study any open-source design thinking tool and write a brief report about it.	3

Assessment:

Term Work: Term Work shall consist of 10 to 12 lab activities based on the above list. Also, Term work journal must include any 2 to 4 assignments from the above list.

Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 10 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report).

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 – 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sd/-

Dr. Parag R. 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