UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Chemical Engineering

Third Year Syllabus with Effect from AY 2021-22

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

AC -
Item No. -

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year B.E. Chemical Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6242**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6242**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	**New** / ~~Revised~~ (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year: 2021-2022**

Date:

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
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Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of 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 University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to 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 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Third Year of Engineering from the academic year 2021-21. Subsequently this will be carried forward for Final Year Engineering in the academic years 2022-23.

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Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preamble to the Revision of Syllabus in Chemical Engineering

Development in all fields including Chemical Engineering along with use of soft wares for process plant and process engineering, there is demand on academician to upgrade the curriculum in Education. Choice based Credit and grading system enables a much required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. The Curriculum must integrate knowledge of the basic and advanced sciences with problem solving and creativity abilities.

The Curriculum must be broad enough to cover all areas from design to operation of Process plants. It should be deep enough to enable the learners to carry out research and develop products to meet rapidly changing needs and demands. The major challenge in the current scenario is to ensure quality to the stakeholders. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program.

With these objectives, online meeting was organized on 30th May 2020 which was attended by heads of the departments and subject faculty of affiliating Institutes. The program objectives and outcomes were thoroughly discussed in line with AICTE guidelines and the core structure of the syllabus was formulated keeping in mind choice based credit and grading system curriculum along with more emphasis on learning outcomes. Thus Skilled based laboratories and Mini projects are introduced in appropriate semesters. Views from experts and UG teachers were taken into consideration and final Academic and Exam scheme was prepared with the consent of all the members involved. Subject wise online meetings were held by various subjects convenors to finalize the detail syllabus in the month of June 2020.

The Program Educational Objectives finalized for the undergraduate program in Chemical Engineering are:

1. To prepare the student for mathematical, scientific and engineering fundamentals
2. To motivate the student to use modern tools for solving real life problems
3. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social and environmental responsibilities.
4. To prepare the student in achieving excellence which will benefit individually and society at large.

Board of Studies in Chemical Engineering

Dr. Parag R Gogte- Chairman
Dr. Kalpana S. Deshmukh - Member
Dr. Sunil J. Kulkarni - Member
Dr. Ramesh S. Bhande - Member
Dr. Shyamala P. Shingare - Member
Dr. Manisha V. Bagal - Member

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2019) wef 2021-2022
Semester V

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC501	Mass transfer Operations-I	3	-	-	3	-	-	3
CHC502	Heat transfer Operations	3	-	-	3	-	-	3
CHC503	Chemical Reaction Engineering-I	3	-	-	3	-	-	3
CHC504	Transport Phenomena	3	-	-	3	-	-	3
CHDO501X	Department Optional Course 1	3	-	-	3	-	-	3
CHL501	Mass transfer Operations-I Lab	-	3	-	-	1.5	-	1.5
CHL502	Heat transfer Operations Lab	-	3	-	-	1.5	-	1.5
CHL503	Chemical Reaction Engineering-I Lab	-	3	-	-	1.5	-	1.5
CHL504	Skilled Based Lab: Business Communication and Ethics Lab	-	2*2	-	-	2	-	2
CHM501	Mini Project-2A	-	3#	-	-	1.5	-	1.5
	Total	15	14	-	15	8	-	23

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC501	Mass transfer Operations-I	20	20	20	80	3	-	-	-	100
CHC502	Heat transfer Operations	20	20	20	80	3	-	-	-	100
CHC503	Chemical Reaction Engineering-I	20	20	20	80	3	-	-	-	100
CHC504	Transport Phenomena	20	20	20	80	3	-	-	-	100
CHDO501X	Department Optional Course 1	20	20	20	80	3	-	-	-	100
CHL501	Mass transfer Operations-I Lab	-	-	-	-	3	25	25	-	50
CHL502	Heat transfer Operations Lab	-	-	-	-	3	25	25	-	50
CHL503	Chemical Reaction Engineering-I Lab	-	-	-	-	3	25	25	-	50
CHL504	Skilled Based Lab: Business Communication and Ethics Lab	-	-	-	-	-	25	-	25	50
CHM501	Mini Project-2A	-	-	-	-	-	25	-	25	50
	Total			100	400	-	125	75	50	750

Department Optional Course 1 (Semester V)

Engineering Stream (Elective Code)	Technology Stream (Elective Code)	Management Stream
Food Engineering(CHDO5011)	Advanced Material Sciences (CHDO5012)	Total Quality Management (CHDO5013)

***Indicates Theory class to be conducted for full class;**
 # indicates work load of Learner (Not Faculty), for mini project.
For mini project faculty load: 1 hour per week per four groups

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2021-2022)
T.E Semester VI

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC601	Mass Transfer Operation II	3	-	-	3	-	-	3
CHC602	Chemical Reaction Engineering II	3	-	-	3	-	-	3
CHC603	Pollution Control Technology	3	-	-	3	-	-	3
CHC604	Process Engineering and Economics	3	-	1	3	-	1	4
CHDO602X	Departmental Optional Course 2	3	-	-	3	-	-	3
CHL601	Mass Transfer Operation II Lab	-	3	-	-	1.5	-	1.5
CHL602	Chemical Reaction Engineering II Lab	-	3	-	-	1.5	-	1.5
CHL603	Pollution Control Technology Lab	-	3	-	-	1.5	-	1.5
CHL604	Skilled Based Lab: Piping Design Engineering Lab	-	3	-	-	1.5	-	1.5
CHM601	Mini Project – 2B	-	2#	-	-	1	-	1
	Total	15	14	1	15	7	1	23

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs.)				
		Test 1	Test 2	Avg						
CHC601	Mass Transfer Operation II	20	20	20	80	3	-	-	-	100
CHC602	Chemical Reaction Engineering II	20	20	20	80	3	-	-	-	100
CHC603	Pollution Control Technology	20	20	20	80	3	-	-	-	100
CHC604	Process Engineering and Economics	20	20	20	80	3	25	-	-	125
CHDO602X	Departmental Optional Course 2	20	20	20	80	3	-	-	-	100
CHL601	Mass Transfer Operation II Lab	-	-	-	-	3	25	25	-	50
CHL602	Chemical Reaction Engineering II Lab	-	-	-	-	3	25	25	-	50
CHL603	Pollution Control TechnologyLab	-	-	-	-	3	25	25	-	50
CHL604	Skilled Based Lab: Piping Design Engineering Lab	-	-	-	-	-	25	-	25	50
CHM601	Mini Project – 2B	-	-	-	-	-	25	-	25	50
	Total			100	400	-	150	75	50	775

Department Optional Course 2 (Semester VI)

Engineering Stream (Elective Code)	Technology Stream (Elective Code)	Management Stream (Elective Code)
Piping Engineering (CHDO6021)	Polymer Technology (CHDO6022)	Industrial Organization and Management (CHDO6023)

 # indicates work load of Learner (Not Faculty), for Mini Project; For mini project faculty load: 1 hour per week per four groups

Semester V

Course Code	Course Name	Credits
CHC501	Mass Transfer Operation I	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Knowledge of chemistry, physics, physical chemistry, mathematics.
2. Knowledge process calculations (Material and energy balance).
3. Basics of unit operations.
4. Basic understanding of equilibrium.
5. Understanding of physical and chemical properties of compounds.
6. Students should have basic knowledge of properties such as heat capacity, enthalpy, sensible heat and SI system of units.

Objectives

1. To understand the basic principles of mass transfer by diffusion in gases, liquids and solids.
2. To understand types of mass transfer coefficients and then the basic of interphase mass transfer.
3. To understand the operations of various equipment's used for gas-liquid contact.
4. To understand the gas absorption, absorption with chemical reaction.
5. To study drying and draw drying curve and calculate time of drying. To study working principles of different types of dryers.
6. To study humidification-dehumidification and calculations for number of stages, HTU, NTU and HETP.

Detailed Syllabus

Module No	Course Contents	No. of Hours
1	**Molecular Diffusion in Gases and Liquid:** Basics of Molecular Diffusion, Fick's First Law of Molecular Diffusion, Various fluxes and relations between them, Molecular Diffusion in binary gas mixtures- Steady state diffusion of one component in non-diffusing second component, Equimolal counter diffusion of two components. Molecular Diffusion in binary liquid solutions- Steady state diffusion of one component in non-diffusing second component, Steady State Equimolal counter diffusion of two components. Diffusivity of gases. Theoretical and experimental determination of diffusivities, Diffusivities of liquids and their determination. Diffusion in	8

	Solids: Fick's law of diffusion in solids, Types of Solid Diffusion, Diffusion through Polymers, Diffusion through Crystalline Solids, Diffusion in Porous Solids.	
2	**Mass Transfer Coefficients:** Definition of Mass Transfer Coefficient, F-Type and K-Type Mass Transfer Coefficients and relations between them, Mass Transfer Coefficients in Laminar and Turbulent Flow. Heat, Mass and Momentum Transfer Analogies and dimensionless numbers, Interphase Mass Transfer- Individual and Overall Mass Transfer Coefficients and relation between them. Methods of contacting two insoluble phases- Continuous Contact, Stage-wise Contact.	**8**
3	**Equipments for Gas-Liquid Contacting:** Classification of equipments for gas-liquid contacting • Gas dispersed and liquid continuous phase-Sparged Vessels (Bubble Columns), Mechanically Agitated Vessels, Tray Towers. • Liquid dispersed phase and gas continuous phase - Venturi Scrubbers, Wetted Wall Towers, Spray Towers and Spray Chambers, Packed Towers. • Comparison of Packed Towers with Tray Towers.	**3**
4	**Gas Absorption:** Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, Single component gas absorption- Multistage Cross Current, Co-current, Counter current Operation. Absorption with Chemical Reactions.	**7**
5	**Drying:** Introduction to drying, Equilibrium, Different types of moisture contents, Rate of Drying and drying curve, Batch Drying and calculation of time of drying, Continuous drying. Equipments for drying.	**7**
6	**Humidification and Dehumidification:** Introduction, Vapour Pressure Curve, Properties of Vapour-Gas mixtures [Understanding various terms], Theory of wet bulb temperature, Adiabatic Saturation Curves, Humidity Charts, Adiabatic operation: (Air water systems) water coolers, cooling towers.	**6**

Note- Video, Digital, NPTL content should be used for understanding principles of working of Mass Transfer Equipment.

Course Outcomes

1. The students will be able to understand the molecular diffusion, classification of various mass transfer operations and their principles.
2. Students will be able to determine mass transfer coefficients.
3. Students will be able to determine interfacial concentrations, overall and individual mass transfer coefficients.
4. Students will be able to select contact pattern/equipment for absorption, drying, humidification and perform calculation for HTU, NTU, HETP.
5. Students will be able calculate number of stages, minimum solvent requirement for gas absorption.
6. Students will be able to determine time of drying and understand the concept efficiency of cooling tower, adiabatic saturation and perform calculations for cooling tower.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.

2. Question paper will comprise of total **six questions, each carrying 20 marks**

3. Question 1 will be compulsory and should cover **maximum contents of the curriculum.**

4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)

5. Only **Four questions need to be solved.**

Text Books

1.Treybal R.E., Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.

2.Datta B.K., Mass Transfer and separation processes, Eastern economy edition, PHI learning private ltd, New Delhi, 2009

Reference Books:

1.McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill, New York 1993.

2.Geankoplis C.J., Transport processed and unit operations, Prentice Hall , New Delhi 1997.

3.Coulson J.M. Richardson J.F., Backhurst J.R. and Harker J.H., Coulson and Richardson chemical engineering, vol 1 & 2, Butterworth Heinman, New Delhi, 2000.

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

Semester V

Course Code	Course Name	Credits
CHC502	Heat Transfer Operations	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	--	--	--	100

Prerequisites

Units and Dimensions, Fluid Flow Principles, Laws of Thermodynamics, Chemical Reaction Engineering, Process Safety.

Course Objectives

Students should be able:
1. To understand scope of the heat transfer unit operations in chemical industry and basic mode of heat transfer and conduction.
2. To demonstrate the knowledge of various analogies and empirical equation in convective heat transfer system.
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.

Detailed Syllabus

Module no.	Course Contents	No. of Hours
1	**Introduction:** Fundamentals of heat transfer, basic modes of heat transfer. Concept of driving force and heat transfer coefficients, rate expressions for three modes i. e. conduction, convection, radiation. **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.	7

2	**Heat Transfer without Phase Change:** **Individual and Overall Heat Transfer Coefficient:** Types of flow, energy balance, rate of heat transfer, individual and Overall Heat Transfer Coefficients, LMTD, Wilson plot and fouling factors. **Natural Convection:** Introduction, Natural convection currents. Heat transfer correlations for free convection. Coefficient of thermal expansion, Dimensional analysis for Natural convection. **Forced Convection:** Introduction, thermal and hydrodynamic boundary layer. Dimensional analysis, Heat transfer in laminar and turbulent flows inside and outside tubes. Significance of various dimensionless numbers. Empirical correlations. Reynolds's Analogy, Prandtl' Analogy, Coulburn's Analogy.	8

3	**Heat Transfer with Phase Change:** **Condensation:** Introduction, types of condensation, Nusselt's theory of condensation, correlations for vertical and horizontal tube, plate. **Boiling:** Heat transfer to boiling liquids, regimes of pool boiling of saturated liquid, correlations for estimating the boiling heat transfer coefficients. Numericals on condensation.	**4**
4	**Heat Transfer by Radiation:** Introduction, Transmissivity, Absorptivity & reflectivity, Grey body, Black body, opaque body etc. Laws of radiation. Radiative heat exchange between surfaces, Multiple reflection method, Radiation shield.	**4**
5	**Heat Exchangers: Introduction, Classification, Preliminary process design of** Double pipe heat exchangers. Design of Shell & tube heat exchangers by Kerns method. 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.	**10**
6	**Evaporators:** Types of Tubular Evaporators, Performance Capacity and Economy, Boiling Point Elevation, Mass and Enthalpy Balances For Single Effect Evaporators. Multiple effect Evaporators, Methods of Feeding. Numerical on single effect evaporator.	**6**

Course Outcomes

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

1. Evaluate rate of heat transfer for steady and unsteady state conduction systems.
2. Calculate LMTD and convective heat transfer coefficients.
3. Calculate heat duty in condensation and boiling process.
4. Analyze radiative heat transfer systems.
5. Identify, Design and select tubular type of heat exchangers.
6. Calculate heat load and efficiency in the evaporators.

Assesment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lecture.
2. Question paper will comprise of total **six questions, each carrying 20marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the Curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from Module 3 then part (b) will be from any module other than module3).
5. Only **Four Questions need to be solved.**

Recommended 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.

Reference Books

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

Semester V

Course Code	Course Name	Credits
CHC503	Chemical Reaction Engineering -I	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Students should know basic chemistry pertaining to chemical reactions, chemical formula etc.
2. Students are required to be aware of chemical process and unit operations used for the manufacturing of chemical products.
3. Students should have knowledge of simple to complex numerical methods of solving one and two dimensional Mathematical equations.

Objectives

1. To understand the different types of reactions
2. To formulate rate equation from reaction mechanism.
3. To analyse kinetic data for various type of reactions and develop Kinetic model for homogeneous reactions
4. To design reactors for different kind of reactions.
5. To analyse different reactor combinations for various type of reactions.
6. To evaluate the effect of temperature on reactor performance for adiabatic and non adiabatic operation.

Detailed Syllabus

Module No	Course Contents	No. of Hours
1	**Introduction to Reaction Engineering**: Classification of reactions, Definitions of reactions rate, Variables affecting reaction rate, Speed of chemical reactions. **Kinetics of homogenous reactions** : Formulation of rate equation. Molecularity and Order of reaction. Rate constant k, Temperature dependant term of rate equations from Arrhenius theory.	06
2	**Elementary and Nonelementary Reactions:** Representation of an elementary and non elementary reaction. Kinetic Models for non	06

	elementary reactions. Reaction mechanism and its influence on kinetics, search for plausible mechanism via reaction kinetics.	
3	**Methods of analysis of experimental data :** For constant volume and Variable Volume Batch Reactor a) Integral Method of analysis of experimental data. b) Differential Method of analysis of experimental data. c) Concept of Half Life/Fractional Life. Overall order of irreversible reaction. d) Analysis of total pressure data. First order Reversible reaction. Irreversible reaction in parallel and in series. Homogeneous catalyzed reactions, Auto catalytic reactions, Shifting Order reactions.	**08**
4	**Design of Reactors:** Ideal batch reactor and concept of batch time. Flow reactor and concept of space time / space velocity and holding time/residence time. Ideal Mixed Flow reactor(MFR) and Plug Flow Reactor (PFR). **Design for single reactions:** Single reactor performance of reversible and irreversible first order, pseudo first order, second order reactions for MFR, PFR. Graphical and analytical techniques.	**06**
5	**Combination of reactors:** PFR in series/ parallel, unequal size MFR in series, performance of the above for the first order reactions. Introduction to Semi batch and Recycle Reactor. Design for Irreversible reactions in series and parallel with same or different order in various combinations.	**06**
6	**Heat and pressure effects:** Calculations of heats of reaction and equilibrium constants from thermodynamics, General graphical design procedure. Optimum temperature progression, Energy balances equations in adiabatic and non-adiabatic case. Exothermic reaction in mixed flow.	**07**

Course Outcome

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

1. Identify and analyze different types of homogeneous reactions.
2. Apply the knowledge they have gained to develop kinetic models for different types of homogeneous reactions.
3. Derive Batch, CSTR, and PFR performance equations from general material balances.
4. Develop skills to choose right type of reactor among single, multiple and recycle reactor.
5. Perform design calculation for isothermal plug, mixed, and batch reactors for different reactions.
6. Understand the effect of temperature on reactor performance for adiabatic and non-adiabatic operation of batch and flow reactors.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of

respective lecture

2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books:

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

Reference Books:

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

Semester V

Course Code	Course Name	Credits
CHC504	Transport Phenomena	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Basic transport properties, laws and equations.
2. Engineering Mathematics: Differential equations and Vector tensors.
3. Engineering Physics and Engineering Chemistry.

Course Objectives

1. To apply differential equations, vector tensors in Chemical Engineering Transport Processes.
2. To explain the analogies between different transport processes.
3. To apply the equation of continuity, equation of motion and equation of energy in Chemical Engineering processes.
4. To perform momentum transfer analysis for solving various industry oriented problems
5. To analyze various industry oriented problems and solve based on energy transfer principles
6. To perform mass transfer analysis for solving various industry oriented problems

Detailed Syllabus

Module No	Course Contents	No. of Hours
1	1.1 Introduction to differential equations (1^{st} and 2^{nd} order) 1.2 vector tensors (Gradient, Divergence and Curl), 1.3 Importance of Transport Phenomena (Macroscopic and Microscopic approach)	04
2	2.1 Introduction to analogies between momentum, heat and mass transfer, Defining Dimensionless numbers 2.2 Temperature and Pressure dependency of viscosity, thermal conductivity and mass diffusivity in gases and liquids.	06
3	3.1 Eulerian and Lagrangian approach, Equation of continuity, Equation of motion and Equation of energy	05

4	4.1 Mechanism of momentum transport: Newton's law of viscosity, Newtonian & Non-Newtonian fluids 4.2 Velocity distribution in laminar flow: Shell momentum balances and boundary conditions a) Flow of falling film b) Flow through the circular tube c) Flow through an annulus d) Flow in a narrow slit e) Adjacent flow of two immiscible fluids.	**07**
5	5.1 Mechanism of energy transport: Fourier's law of heat conduction 5.2 Temperature distribution in solids and in laminar flow, shell energy balance and boundary conditions a) Heat conduction with electrical heat source b) Heat conduction with a nuclear heat source c) Heat conduction with a viscous heat source. e) Heat conduction with variable thermal conductivity f) Heat conduction in composite wall and cylinder g) Heat conduction in a cooling fin	**10**
6	6.1 Mechanism of mass transport: Definitions of concentrations, velocities and mass fluxes, Fick's law of diffusion 6.2 Concentration distribution in solids and in laminar flow, Shell mass balances and boundary conditions a) Diffusion through stagnant gas film b) Diffusion with heterogeneous chemical reaction c) Diffusion with homogeneous chemical reaction d) Diffusion into a falling liquid film (Gas absorption)	**07**

Course Outcomes

On completion of the course the students will:

1. Apply the differential equations, vector tensors in Chemical Engineering Transport Processes.
2. Compute transport properties for liquids and gases using various empirical correlations.
3. Analyze different flow processes based on equation of continuity, equation of motion and equation of energy.
4. Analyze and solve industry oriented problems based on momentum transfer analysis.
5. Apply energy transfer principles to determine temperature distribution for various geometries.
6. Determine the concentration gradients in laminar flow and solids based on mass transfer analysis.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Recommended Books

1. Bird, R.B., W.E. Stewart and E.N. Lightfoot, Transport Phenomena, Wiley, New York, 2nd ed., 2002
2. William J. Thomson, Introduction to Transport Phenomena, Prentice Hall,2000
3. Ismail Tosun, Modelling In Transport Phenomena A Conceptual Approach, Elsevier Science B.V. 2002 1st Edition

Reference Books

1. Christie J. Geankoplis, Transport Processes and Separation Process Principles, 4th Edition, 2004
2. Brodkey, R.S. and H.C. Hershey, Transport Phenomena: A Unified Approach, McGraw-Hill, New York. 1988
3. Bodh Raj, Introduction to Transport Phenomena (Momentum, Heat and Mas), PHI Learning Pvt. Ltd, Eastern Economy Edition.
4. Grewal B.S., Higher Engineering Mathematics, Khanna Publisher 44th Edition

Semester V

Course Code	Course Name	Credits
CHDO5011	Department Elective 1: Food Technology	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	-	--	100

Prerequisites

1. Knowledge of Chemical Engineering.
2. Food biotechnology
3. Food microbiology

Objectives

To impart knowledge to the students about

1. Various unit operations involved in Food processing.
2. The role of HEAT transfer in Food processing.
3. The laws to prevent adulteration.
4. Proper packaging & storage of materials.
5. The importance of microorganisms in food processing and
6. To encourage students for Entrepreneurship.

Detailed Syllabus

Module no	Course Contents	No. of Hours
1	Food Biochemistry and Food Microbiology: Food Constituents: Carbohydrates, Proteins, Enzymes, Vitamins, Lipids and Minerals, Flavors, Nutritional & sensory characteristics, Food fortification. Water activity , role of microorganisms , D & Z values, TDT curve, Indian laws regulating Foods and Food processing	5
2	Ambient Temperature Process: Raw material preparation, Size reduction of solid, fibrous foods; Emulsification and Homogenization in liquids , Mixing and Forming, Extraction and expression ,Membrane concentration ,Fermentation : Theory , Types, Equipment's and Effect on foods. Numericals	7
3	Thermal Processing: Theory, Equipment, Effect on foods, blanching, extrusion, pasteurization, Heat Sterilization, Incontainer Ultra high temperature(UHT)/aseptic processes, Numericals	7

4	Freezing and Refrigeration: Types, Equipments, refrigerants, effects of low temperature on quality, chilling, freezing , freeze drying and freeze concentration. Numericals	**6**
5	Food Storage & Packaging: Modified Atmosphere Storage (MAS), Hurdle Technology, Modified atmosphere packaging(MAP) Food Adulteration & Quality Management: food safety., HACCP, GMP, GHP, GLP.	**6**
6	Food Processing: Manufacturing and processing of food products: Fruit juice processing, Alcoholic beverages, Milk and Milk Products; Milk powder, cheese, Ice cream, Tea coffee, cocoa, Bread , Biscuits , confectionary(hard boiled sweets & chocolates)	**8**

Course Outcome

On completion of the course the students will be able to:
1. Know about essential nutrients in food and fortifying, if needed.
2. Give importance to hygiene in Food Units.
3. Apply HACCP in processing units.
4. Start own unit, with the guidance from CFTRI, Mumbai/Mysore.
5. Do higher studies in India/ abroad.
6. Apply value addition/modification in processing units.

Assessment
Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):
1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. Question 1 will be compulsory and should cover **maximum contents of the curriculum.**
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books:
1. Fellows. P. Food Processing Technology: principles and practice. Woodhead publishing Ltd, England
2. B. Sivasankar. Food processing and Preservation, Prentice Hall of India pvt ltd

Reference Books:
1.Toledo.R. Fundamentals of Food process Engineering, CBS publishers, New Delhi
2.D.G.Rao.Fundamentals of Food engineering, PHI Learning pvt ltd
3.Sukumar Dey. Outlines of Dairy Technology (free download available)
4. Minnife, Bernard. Cocoa, chocolates & confectionaries, Springer

Semester V

Course Code	Course Name	Credits
CHDO5012	Department Elective 1: Advanced Material Sciences	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

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

Course Objectives

1. To identify various advanced materials such as conducting polymers, high temperature polymers, stainless steels, composites and ceramics.
2. To evaluate the properties of the advanced materials used in chemical engineering.
3. To outline the engineering applications of the advanced materials.
4. To describe the fabrication methods of the advanced materials used in chemical engineering.
5. To explain the properties and applications of nanomaterials.
6. To evaluate the different types of thin film coating methods and outline their applications.

Detailed Syllabus

Module no	Course Contents	No. of Hours
1	**Advanced Metallic Materials :** Stainless Steels: Types, properties of stainless steels, failure of stainless steels. High Temperature Alloys: Properties and types. Titanium Alloys and Cobalt-Chromium Alloys: Composition, properties and applications. Nitinol as Shape Memory Alloy and its applications.	06
2	**Advanced Polymeric Materials :** Structure, preparation, and application of various conducting polymers, high temperature polymers and liquid crystal polymers. Biomedical applications of polymers such as hydrogels, polyethylene, polyurethanes, polyamides and silicone rubber.	06
3	**Ceramic Materials :**	06

	Properties of ceramic materials, classification of ceramic materials, ceramic crystal structures. Preparation and application of ceramic materials: Alumina, Partially Stabilized Zirconia, Sialon, Silicon Nitride, Silicon Carbide. Processing of Ceramics.	
4	**Composite Materials :** Necessity of composite materials, classification of composite materials, types of matrix materials and reinforcements, reinforcement mechanism. **Fiber Reinforced Plastic Processing :** Open Moulding Processes : Filament Winding Process Closed Moulding Processes : Pultrusion and Pulforming, Sheet Moulding Compound Process **Carbon-Carbon Composites :** Fabrication and Properties	**07**
5	**Metal Composites :** Advantage of metal composite over metal, types of reinforcement and matrix fabrication types, properties, various fabrication processes: diffusion bonding process, in-situ process. **Ceramic Composites :** Matrices and reinforcements, properties, fabrication methods: slurry infiltration process, chemical vapour infiltration process.	**07**
6	**Carbon Nanotubes:** Synthesis, properties and applications. **Nanoshells :** Types, properties and applications. **Nanosensors :** Assembly methods, nanosensors based on optical, quantum size, electrochemical and physical properties. **Thin Film Coatings :** Physical and chemical vapour deposition coatings, hardfacing, thermal spraying, diffusion process.	**07**

Course Outcomes

On completion of the course the students will be able to:
1. Identify various types of advanced materials such as metals and alloys, polymers, ceramics and composites.
2. Evaluate and utilize the properties of various advanced polymeric, ceramic and metallic materials and discuss their applications in various fields.
3. Select and analyze different types of composite materials, their properties and applications.
4. Explain the fabrication of various composite materials.
5. Outline the types of nanotubes and nanosensors and their applications.

6. Evaluate the different thin film coating methods and discuss their applications in various fields.

Assessment
Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests .** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):
1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

5. Only **Four questions need to be solved.**

Recommended Books:

1. B.K. Agrawal, Introduction to Engineering Materials, Tata McGraw Hill Education Pvt. Ltd., 1988.
2. A.K. Bhargava, Engineering Material: Polymers, Ceramics and Composites, PHI Learning Pvt. Ltd., 2nd Edition 2012.
3. Sujata V. Bhat, Biomaterials, Narosa Publication Pvt. Ltd., 2nd Edition, 2005.
4. Dr. H.K. Shivanand and B.V. Babu Kiran, Composite Material, Asian Books Private Limited, 2010.
5. T. Pradeep, Nano : The Essentials, Tata McGraw-Hill Education Pvt. Ltd., 2010.

Reference Books:

1. William Smith, Javed Hashemi, Ravi Prakash, Material Science and Engineering, 5th Edition, Tata McGraw Hill Education Company Ltd., 2013.
2. Kenneth G. Budinski, Engineering Materials : Properties and Selection, 4th Edition, Prentice Hall,1992.
3. James A. Jacob and Thomas F. Kilduff, Engineering Materials Technology : Structures, Processing, Properties, and Selection, 5th Edition, Pearson/Prentice Hall, 2005.
4. D.A. Hansen and R.B. Puyear, Material Selection for Hydrocarbon and Chemical Plants, Marcel Dekker, Inc., 1996.
5. C.P. Dillon, Materials Selection for the Chemical Process Industries, Materials Technology Institute, Incorporated, 2004.
6. W.D. Callister, Jr. and D.G. Rethwisch, Callister's Materials Science and Engineering, 10th Edition, John Wiley and Sons, 2020.

Semester V

Course Code	Course Name	Credits
CHDO5013	Department Elective I : Total Quality Management	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Basic knowledge regarding Quality Improvement Processes and their applications in chemical industries.
2. Commitment and steps required to provide an environment for changing attitudes must be provided.

Course Objectives

Learners should be able to:

1. Become acquainted with the significance and features of TQM philosophy.
2. Be familiarized with various quality tools and their uses in problem solving.
3. to appraise on the modern productivity improvement approaches and their interface with TQM.
4. Know various quality standards, quality auditing and certification methodology.
5. obtain an insight into the ongoing global trends in quality approach and practices with special forms to the customer relationship.
6. Make the learners aware of the quality, system and standards in TQM.

Detailed Syllabus

Module no	Course Contents	No. Of Hours
1	**Introduction to TQM**: ● Definition of Quality, Concept, Principles, Features, Dimensions and Quality in manufacturing and service segments of TQM ● Approach & barriers in implementation of TQM ● Cost of quality prevention, appraisal and failure costs, hidden costs, trade-o between quality and cost	6
2	**Planning for Quality and Quality improvement:** ● **Planning for quality:** Need for quality policies and objective. Significance of top management commitment, strategic planning for quality	6

	● **Quality improvement**: Management of controllable defects, operator controllable defects, sporadic and chronic problems of operator controllable defects, sporadic and chronic problems of quality, Pareto's principle and Bench marking (Definition and significance, data collection for benchmarking and its use)	
3	**Customer relations:** ● Customers, user and consumers, , types of customers, customer perception and expectations and product awareness ● Quality feedback and redressal ● Basic principles of reliability (quality and reliability), Product life cycle, trade-o between maintainability	6
4	**Vendor relations**: ● Vendor as a partner, vendor selection, vendor evaluation ● Push-Pull view of supply chain and cycle view of chain management	5
5	**SQC Tool**: ● Histograms, Pie charts, Scatter diagrams, Cause and Effect diagram etc. ● **Statistical Process Control:** **Process variability**: Variables and process variation, measures of accuracy and centering, precision or spread, normal distribution **Process Control**: Control charts for variables (X-chart, R- chart, Pie -chart) and attributes (np-charts, p-chart, c-charts, U-chart) **Process capability**: OC curve, acceptance sampling, single and double sampling producers and consumer's risk	8
6.	**Quality System:** ● **Quality standards**: · ISO 9001:2000 Quality management system. · ISO 14001:2004 Environmental management system. · ISO 27001:2005 Information security management system ● **Quality assurance:** Nature of assurance, reports on quality, measuring performance, internal audit, surveillance audit, quality certification methodology and implications. ● **Productivity improvement Tools/ Approaches/ Techniques:** Principles of Six-Sigma, approaches like JIT, Lean manufacturing zero defect concept, KANBAN, QFD, FMEA, Basics of DOE and Shining concepts of quality. Productivity improvement techniques like 5S, POKAYOKE, SMED, KAIZEN and Concurrent Engineering	8

Course Outcomes

After completing the course, the learners should be able to:

1. Appreciate the importance of quality and its dimensions in striving for excellence.
2. Understand the conscious compromise between cost and quality for problem solving.
3. Develop skill in the selection of various manufacturing processes and service functions.
4. Improve capability in the use of appropriate quality tools in various manufacturing and service functions.
5. Integrate quality approaches for productivity improvement.
6. Acquire knowledge base and develop skills for conducting quality audits.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents of syllabus and second test based on remaining contents of syllabus (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example, if Q.2 has part (a) from module 3, then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Reference Books:

1. Juran, J. M., Gryana, F. M., Quality planning and analysis, TMH.
2. Bester Fidd, D. H., et. al., Total quality management, Prentice Hall.
3. Erossbly, Pillip b., Quality is free, Mentor/New American Library.
4. Fergenbaum, Armand V., Total Quality Control, McGraw-Hill Inc.
5. Logothetis, N., Managing For Total Quality, Prentice Hall

Recommended Text Books:

1. Aurora, K. C., Total Quality Management, S. K. Kataria and Sons.
2. Ishikawa, K., What is total quality control? The Japanese way, Prentice Hall

Semester V

Course Code	Course Name	Credits
CHL501	Mass Transfer Operation I Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	--	50

Prerequisities

1. Knowledge of chemistry, physics, physical chemistry, mathematics.
2. Knowledge process calculations (Material and energy balance).
3. Basics of unit operations.
4. Basic understanding of equilibrium.
5. Understanding of physical and chemical properties of compounds.
6. Students should know precautions to be taken in laboratories.

Objectives

1.To understand the basic principles of mass transfer by molecular diffusion in gases, liquids and solids To study diffusion through solids
2. To understand and determine mass transfer coefficients for various systems.
3. To understand the working of various equipment used for contacting gas- liquid systems and to calculate NTU, HTU, Number of stages etc.
4. To understand the unit operation of gas absorption and carry material and energy balance. Also students will carry out the calculations for tray and packed column.
5. To study and draw drying curve and calculate time of drying.
6. To study humidification and calculations for number of stages, HTU, NTU and HETP.

List of Suggested Experiments (any 8 can be performed)

- To determine the diffusivity of given liquid sample.
- To study diffusion through porous solids and determine effective diffusivity.
- To estimate the mass transfer coefficient in flow process system (eg.benzoic acid + water).
- To determine mass transfer co-efficient in gas liquid system by evaporation.
- To study absorption in packed tower.
- To determine the efficiency of cooling tower and study of Humidification and water-cooling operations.

- To study the operation of a fluidized bed drier and analyze drying curve.
- To determine rate of absorption and study absorption in spray tower.
- To study batch drying and plot drying curve.
- To study hydrodynamics of packed bed and study variation in pressure drop with velocity.
- To determine Mass Transfer Coefficient in a packed extraction column.
- Experiments demonstrating determination of mass transfer coefficient/diffusivity/ number of transfer units, HTU, HETP are envisaged
- Note: Virtual platforms can be used for better understanding of concepts (Virtual platform should be used for at least one Experiment).

Course Outcomes

1. Students will be able to determine diffusivity of given samples.
2. Students will be able to understand diffusion through solids.
3. Students will be able to determine mass transfer coefficient for various systems.
4. Students will understand various contact patterns and equipment for mass transfer.
5. Students will be able to carry out mass and energy balance for gas absorption, Humidification-dehumidification and calculate number of stages, NTU and HTU.
6. Students will be able to calculate time of drying, number of stages. Also, they will be able to calculate efficiency and effectiveness of cooling tower.

Term work

Term work should evaluated based on performance in practical.

Practical journal:	20 marks
Attendance:	05 marks
Total:	25 marks

Practical Examination

- Duration for practical examination will be same as assigned to respective lab.
- A student will become eligible for practical examination after completing 8 experiments

Semester V

Course Code	Course Name	Credits
CHL502	Heat Transfer Operations Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	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 to:

1. To give the in-hand experience of lab-scale experiments on conductive heat transfer systems.
2. 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. Apply the knowledge of radiative heat transfer in an effective manner for different applications.
5. To observe and note down the steady state temperatures and evaluate the heat transfer coefficient, effectiveness of heat exchangers.
6. To determine the heat transfer rate, understand the working and application of agitated vessel and evaporators in chemical industries.

Lab Outcome

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 dropwise and filmwise condensation.
4. Determine the rate of heat transfer in radiation.
5. Analyze heat exchanger performance by using the method of log mean temperature difference.
6. Measure the heat transfer coefficient in agitated vessel and efficiency in evaporator.

List of Experiments (Minimum Eight)

Experiment No.	Name of Experiment	Lab Hours
1	Heat Transfer through various Insulating materials	3
2	Composite Wall	3
2	Unsteady State Conduction	3
3	Natural Convection	3
4	Forced Convection	3
5	Film wise and Dropwise Condensation	3
6	Emissivity Measurement Apparatus	3
7	Double Pipe Heat Exchanger	3
8	Shell and Tube Heat Exchanger	3
9	Plate Heat Exchanger	3
10	Finned tube heat exchanger	3
11	Agitated vessel	3
12	Evaporator	3
13	Design of Shell and Tube Heat Exchanger by Kerns method (Virtual Lab.)	3

Assessment:

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.

Semester V

Course Code	Course Name	Credits
CHL503	Chemical Reaction Engineering -I Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	-	50

Prerequisites

1. Basic knowledge of chemistry & kinetics.
2. Knowledge of data fitting
3. Concept of Molarity, Normality
4. Knowledge of lab safety rules.

Course Objectives

1. Understand the importance of reaction kinetics
2. Analyse effect of temperature on rate of homogeneous reaction
3. Selection of appropriate analysis technique depending on type of homogeneous reaction
4. Visualise operation of various reactor types
5. Evaluating performance of single and multiple reactors
6. Choose appropriate reactor set-up for various type of homogeneous reactions.

Course Outcome

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

1. Employ various methods to determine the kinetics of homogeneous reaction.
2. Acquire analytical skills for the analysis of varying concentration and temperature data
3. Analyze experimental data collected to determine the kinetics of reaction and interpret the result.
4. Understand operation and design of Batch and flow reactors.
5. Compare performance of different reactor types.
6. Select appropriate Reactor Set up for different homogeneous reactions,

List of Experiments (minimum eight)

Experiment no.	Details of Experiment	Lab Hours
1	Differential and Integral Analysis (Order of Reaction at Room Temperature)	3

2	Arrhenius Constants (Verification of Laws)	3
3	Order and Rate constant using Half Life Method	3
4	Study of Pseudo Order Reaction	3
5	Acidic Hydrolysis	3
6	Batch Reactor	3
7	Plug Flow Reactor (PFR)	3
8	Continuous Stirred Tank Reactor (CSTR)	3
9	Continuous Stirred Tank Reactors Series (Three CSTRs In Series)	3
10	PFR – CSTR In Series Combination	3
11	Experiments from Virtual Lab	3

Assessment:

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. Levenspiel O., Chemical Reaction Engineering, John Wiley & Sons, 3ed.,1999.
2. Smith J.M., Chemical Reaction Engineering, 3ed.,Tata McGrawHill,1980.
3. Fogler, H.S. Elements of Chemical Reaction Engineering, 4ed.,PHI, 2008
4. www.vlab.co.in
5. http://www.olabs.edu.in/
6. http://amrita.olabs.edu.in/

Semester V

Course Code	Course Name	Credits
CHM501	Mini Project-2A	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

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:

At the end of this course, students will be able to:

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.

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.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 2 in semester V and VI.
- 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 review/ progress monitoring committee shall be constituted by head of departments of each institute. 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 : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
- First shall be for finalization of problem
- Second shall be on finalization of proposed solution of problem.
- In second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
- First review is based on readiness of building working prototype to be conducted.
- Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
- Identification of need/problem

- Proposed final solution
- Procurement of components/systems
- Building prototype and testing
- Two reviews will be conducted for continuous assessment,
- First shall be for finalization of problem and proposed solution
- Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

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

- In one year, project, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of half year project all criteria's in generic may be considered for evaluation of performance of students in mini project.

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 organizations 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.

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2021-2022)
T.E Semester VI

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC601	Mass Transfer Operation II	3	-	-	3	-	-	3
CHC602	Chemical Reaction Engineering II	3	-	-	3	-	-	3
CHC603	Pollution Control Technology	3	-	-	3	-	-	3
CHC604	Process Engineering and Economics	3	-	1	3	-	1	4
CHDO602X	Departmental Optional Course 2	3	-	-	3	-	-	3
CHL601	Mass Transfer Operation II Lab	-	3	-	-	1.5	-	1.5
CHL602	Chemical Reaction Engineering II Lab	-	3	-	-	1.5	-	1.5
CHL603	Pollution Control Technology Lab	-	3	-	-	1.5	-	1.5
CHL604	Skilled Based Lab: Piping Design Engineering Lab	-	3	-	-	1.5	-	1.5
CHM601	Mini Project – 2B	-	2#	-	-	1	-	1
	Total	15	14	1	15	7	1	23

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs.)				
		Test 1	Test 2	Avg						
CHC601	Mass Transfer Operation II	20	20	20	80	3	-	-	-	100
CHC602	Chemical Reaction Engineering II	20	20	20	80	3	-	-	-	100
CHC603	Pollution Control Technology	20	20	20	80	3	-	-	-	100
CHC604	Process Engineering and Economics	20	20	20	80	3	25	-	-	125
CHDO602X	Departmental Optional Course 2	20	20	20	80	3	-	-	-	100
CHL601	Mass Transfer Operation II Lab	-	-	-	-	3	25	25	-	50
CHL602	Chemical Reaction Engineering II Lab	-	-	-	-	3	25	25	-	50
CHL603	Pollution Control TechnologyLab	-	-	-	-	3	25	25	-	50
CHL604	Skilled Based Lab: Piping Design Engineering Lab	-	-	-	-	-	25	-	25	50
CHM601	Mini Project – 2B	-	-	-	-	-	25	-	25	50
	Total			100	400	-	150	75	50	775

Department Optional Course 2 (Semester VI)

Engineering Stream (Elective Code)	Technology Stream (Elective Code)	Management Stream (Elective Code)
Piping Engineering (CHDO6021)	Polymer Technology (CHDO6022)	Industrial Organization and Management (CHDO6023)

 # indicates work load of Learner (Not Faculty), for Mini Project; For mini project faculty load: 1 hour per week per four groups

Semester VI

Course Code	Course Name	Credits
CHC601	Mass Transfer Operation II	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Knowledge of chemistry, physics, physical chemistry and mathematics.
2. Knowledge of process calculations.
3. Knowledge of diffusion, mass transfer coefficients, modes of contact of two immiscible phases.
4. Basic understanding of equilibrium.
5. Understanding of physical and chemical properties of compounds.
6. Students should know precautions to be taken in laboratories.

Objectives

1. To understand Vapor liquid equilibrium and study different types of distillation and equipment's for distillation.
2. To study various contact patterns and equipment of extraction and leaching.
3. To study batch, semi batch and continuous adsorption.
4. To study crystallization principles and equipment.
5. To calculate no of stages, HTU, NTU, Height of bed, Efficiency for above operations wherever applicable.
6. To study principles of various membrane separation methods.

Detailed Syllabus

Module	Course Contents	Hours
1	**Distillation:** Introduction to Distillation, Concept of relative volatility, Minimum and maximum boiling Azeotropes. Methods of distillation [binary mixtures] - Flash Distillation, Differential distillation, Rectification. Calculations of number of ideal stages in multistage countercurrent rectification. McCabe Thiele Method. Ponchon-Savarit Method, Lewis-Sorel Method, Concepts of [Brief Discussion]-Steam Distillation, Azeotropic Distillation, Extractive Distillation, Reactive Distillation, Molecular Distillation, Membrane distillation, Introduction to Multicomponent Distillation,	12
2	**Liquid-Liquid Extraction:** Introduction to Liquid-Liquid Extraction, Choice of Solvent for Liquid-Liquid Extraction, Triangular coordinate system, Ternary Equilibria	08

	[Binodal Solubility Curve with effect of temperature and pressure on it], Single Stage Operation, Multistage Cross Current Operation, Multistage Counter Current Operation [with and without reflux], Equipments for liquid-liquid extraction.	
3	**Leaching:** Representation of Equilibria, Single stage leaching, Multistage Cross Current Leaching, Multistage Counter Current Leaching, Equipments for Leaching.	06
4	**Adsorption and Ion Exchange:** Introduction to Adsorption, Types of Adsorption, Adsorption Isotherms, Single Stage Adsorption, Multistage Cross Current Adsorption, Multistage Counter Current adsorption, Equipment's for Adsorption, Break through curve, Ion Exchange Equilibria, Ion Exchange Equipment's.	08
5	**Crystallization:** Solubility curve, Super saturation, Method of obtaining super saturation, Effect of heat of size and growth of crystal, Rate of Crystal growth and ΔL law of crystal growth, Material and energy balance for crystallizers, Crystallization equipment-description.	03
6	**Membrane separation Technique:** Need of membrane separation, and its advantages, classification of membrane separation process, Principles of Ultrafiltration, Nanofiltration. Reverse osmosis.	02

Note: Video, Digital, NPTL content can be used for equipment section of each chapter /unit operation.

Course Outcomes

At the end of the course student will be able to:

1. Understand equilibrium in all separation processes.
2. Design the mass transfer equipments for various operations.
3. Understand principles of different distillation operations.
4. Choose the separation operation which will be economical for the given separation.
5. Design adsorption column and find optimum process parameters.
6. Understand membrane separation processes, their principles and working.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):
1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. Question 1 will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Text Books
1. Treybal R.E., Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.

2. Datta B.K., Mass Transfer and separation processes, Eastern economy edition, PHI learning private ltd, New Delhi, 2009

Reference Books:

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

Semester VI

Course Code	Course Name	Credits
CHC602	Chemical Reaction Engineering -II	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	--	--	--	100

Prerequisites

1. Students should know basic chemistry pertaining to chemical reactions , chemical formula and basic kinetics
2. Students are required to be aware of chemical process and unit operations used for the manufacturing of chemical products.
3. Students should have knowledge of simple to complex numerical methods of solving one and two dimensional Mathematical equations.

Objectives

1. To understand the concept of Residence Time Distribution (RTD) in case of non ideal flow
2. To predict the performance of real reactor based on RTD studies
3. To understand the difference between performance of homogeneous and heterogeneous reaction.
4. To find the model equation and use this model to design the reactors used for heterogeneous non catalytic reactions.
5. To develop kinetic model and Design strategy for heterogeneous catalytic reactions.
6. To apply the knowledge they have gained to develop kinetic model and use this model to design the reactors used for Fluid-Fluid reactions.

Detailed Syllabus

Module	Course Contents	Hours
1	**Non Ideal flow reactors:** Concept of residence time distribution (RTD), Measurement and characteristics of RTD, RTD in Ideal batch reactors, Plug Flow Reactor and CSTR. Zero Parameter Model –Segregation and Maximum mixedness model. One parameter model–Tanks in series model and Dispersion Model. Introduction to two parameter model	10
2	**Hetrogeneous Reaction System: Introduction** Rate Steps involved in hetrogeneous reactions. Overall Rate Expression for Linear and Nonlinear Process. Types of hetrogeneous reaction system with industrial examples	04
3	**Non Catalytic Heterogeneous Reactions:**	08

	Kinetics: General mechanism of reaction. Various models. Specific cases with respect: (a) Film diffusion controlling. (b) Ash diffusion controlling. (c) Chemical reaction controlling. **Design of reactors for non-catalytic reactions**: Experimental reactors for heterogeneous Reactions, Non-Catalytic Fluid Solid Reactions in Flow Reactor. Application to design of continuous solid flow reactors; various design considerations, Application of fluid bed reactors and their design consideration.	
4	**Catalytic Heterogeneous Reactions**: Properties of solid catalysts, Physical adsorption and Chemisorption, Surface area and pore size distribution, Langmuir- Hinshelwood model, and General mechanism of solid catalyzed fluid phase reactions. Derivations for LHHW model mechanism-various cases, Concept of effectiveness factor of catalyst and its dependence on catalyst properties and kinetic parameters.	**07**
5	**Introduction to Catalytic Reactors**: Packed Bed Reactor, Fluidized Bed, Trickle Bed and Slurry Reactor. Experimental Methods for finding reaction rates. Numericals based on Design of Packed Bed Reactor (Calculation of weight/volume of catalyst).	**04**
6	**Kinetics of fluid-fluid reactions**: Reaction with mass transfer, the rate equation pertaining to fast to very slow reactions. **Applications to design:** Design of gas-liquid, heterogeneous reactors for straight mass transfer case.	**06**

Course Outcome

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

1. understand the concept of Residence Time Distribution (RTD) in various reactors
2. Obtain the actual design parameters to design Real Reactor based on various models.
3. find out kinetic model equation and use this model to design the reactors used for heterogeneous non catalytic reactions.
4. Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution.
5. develop kinetic model for catalytic reaction based on reaction mechanism
6. Analyse reactor design for catalytic reaction.
7. identify kinetic regime and design the reactors as per specification for Fluid-Fluid reactions

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):
1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books:

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

Reference Books:

1. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.

Semester VI

Course Code	Course Name	Credits
CHC603	Pollution Control Technology	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	--	--	--	100

Prerequisites

Basic concepts of Fluid Flow Operations, Solid Fluid Mechanical Operations, Mass Transfer Operations and Chemical Reaction Engineering.

Course Objectives

1. The aim of the course is to provide basic understanding of air and water pollution control, regulations, and standards.
2. Course will provide basics of water pollution sources, properties, measurement and control techniques.
3. Course will provide air pollutions sources, properties, measurements, control methods, design of pollution control devices and efficiency analysis, as well as their applications.
4. Course will provide understanding of solid waste and noise pollution management.
5. Course will provide understanding of waste management in chemical industries.
6. Course will provide understanding of zero discharge management in chemical industries.

Detailed Syllabus		
Module	Course Contents	Hours
1	Introduction to Pollution Control: Importance of environmental pollution control, Environmental Legislation & Regulations, Industrial pollution emissions & Indian standards for ambient air, noise and water emission and effluents, Water (prevention & control of pollution) act, Air (prevention & control of pollution) act. Environmental audit: Definition and concepts, Introduction to ISO and ISO 14000.	4
2	**Water Pollution and wastewater treatment technologies:** Classification of sources and effect of water pollutant on human being and ecology, Sampling, measurement and standards of water quality, Determination of organic matters: DO, BOD, COD, and TOC. Mathematical model for BOD, Re-oxygenation and de-oxygenation in natural purification process. **Determination of inorganic substances**: nitrogen, phosphorus, trace elements, alkalinity. **Physical characteristics**: suspended solids, dissolved solids, colour and odour, Bacteriological measurements.	10

	Primary treatment: pre-treatment, settling tanks and their sizing. **Secondary treatment**: micro-organisms growth kinetics, aerobic biological treatment, activated sludge process, evaluation of biokinetic parameters, trickling filters, rotating biological contractors, anaerobic treatment, sludge treatment and disposal. **Tertiary treatment**: Advanced methods for removal of nutrients, suspended and dissolved solids, Advanced biological systems, Oxidation methods (**Chemical Oxidatio**n – Chlorine/Hypochlorite/Chlorine Dioxide, Hydrogen Peroxide, Hydroxyl Radical, Oxygen (Atomic and Molecular) and Ozone, **Catalytic Oxidation** - Fenton's Reagent (H_2O_2 + Ferrous Ion), Photo Catalysis (UV + TiO_2), Supercritical Water Oxidation) , Recovery of materials from process effluents.	
3	**Air pollution management:** Air pollutants sources, classification and characterization of air pollutants, effect on health, vegetation & materials, types of inversion, behaviour and fate of air pollutants, **Meteorological aspects of air pollutants:** Temperature lapse rate & stability, wind velocity & turbulence, plume behavior, measurement of meteorological variables, wind rose diagrams, Plume Rise, estimation of effective stack height and mixing depths. Development of air quality models-Gaussian dispersion model **Sampling:** Sampling of particulate and gaseous pollutants (Stack, Ambient & indoor air pollution), Monitoring and analysis of air pollutants (like PM2.5, PM10, SOX, NOX, CO, NH_3) **Air pollution control:** Source correction methods for air pollution control, Cleaning of gaseous effluents, Particulate emission control, Equipment, system and processes for particulate pollutants and gaseous pollutants.	12
4	**Solid Waste Management and noise pollution:** Waste sources and generation rates, Traditional methods of waste collection and disposal, Factors influencing waste generation and health hazards, **Waste processing:** Size and volume reduction, recycling of solid wastes, hazardous waste characterization, treatment and disposal, e-waste management rules, plastic waste, biomedical waste, solid waste management in rural areas and recent advances in solid waste management. Noise pollution: generation, control and management.	8
5	Industrial waste management: Case studies of i) petroleum refineries and petrochemical units, ii) fertilizer industry	2
6.	Zero discharge technology adapted in selected industries: Case studies of i) Sugar industry ii) Pulp and paper	3

Course Outcomes

After successfully completing the course, the students will be able to:

1 Identify sources, types of pollutants and determine their impact on the environment, related laws and standards.
2 To understand sampling, measurement of various water pollutants, natural purification process, design various waste water treatments methods.
3 Analyze sampling, measurements, meteorological aspects air pollutant dispersion, its control and equipment's used for air pollution control.
4 To manage solid waste and noise pollution control.

5 Analyze and select appropriate treatment process for specific effluents emerging from chemical industries.
6 To minimize use of resources in chemical industries.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents of syllabus and second test based on remaining contents of syllabus (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):
1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. Question 1 will be compulsory and should cover **maximum contents of the curriculum.**
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Text Books:
1. Rao, C.S., Environmental Pollution Control Engineering, New Age International (P) Ltd.
2. Peavy, H. S., Rowe, D.R., Tchobanoglous, G., Environmental Engineering, McGraw-Hill Book Company Limited
3. Metcalf et al., Waste Water Treatment, Disposal & Reuse, Tata McGraw Hill Publishing Company Limited.
4. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw Hill Publishing Company Limited.
5. Davis, M. L. And Cornwell, D. A. , Introduction to Environmental Engineering, aGraw-Hill Series in Water Resources and Environmental Engineering

Reference Books:
1. Hilary Theisen and Samuel A, Vigil, George Tchobanoglous, “Integrated Solid Waste Management”, McGraw- Hill, New York, 1993
2. Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001.

Semester VI

Course Code	Course Name	Credits
CHC604	Process Engineering and Economics	04

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	01	03	-	01	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs.	25	--	--	125

Prerequisites

1. Knowledge of Physics, Chemistry and Mathematics.
2. Knowledge of different types of chemical processes.
3. Knowledge of fluid flow operations.
4. Knowledge of mass transfer operations.
5. Knowledge of equipments used for gas-liquid contact.
6. Preliminary knowledge of economics.

Objectives

1. Students should know the fundamental concepts in process engineering.
2. Students should know different methods of interest and depreciation calculations.
3. Students should know various flow diagrams and methodology for process design of piping and fluid moving devices.
4. Students should know the methodology for process design of distillation and absorption columns.
5. Students should know various short cut methods of sizing and cost estimation of process equipments and understand different types of costs and cost estimates.
6. Students should understand cash flow in an industrial operation and know break-even and profitability analysis.

Detailed Syllabus

Module	Course Contents	Hours
1	**Process Engineering for Chemical Engineers:** Basic functions of Process Engineering; Role and responsibilities of Process Engineer; Chemical Products; Formulation of the Design Problem; The Hierarchy of Chemical Process; Continuous and Batch Processes; New Design and Retrofit; Approaches to Chemical Process Design and Integration; Process Control; Importance of safety and environmental aspects.	05
2	**Economics for Chemical Engineers:** Different types of Interest: Simple interest, compound interest, nominal & effective interest rates; Present worth & Discount; Annuities; Perpetuity &	06

	Capitalized cost; Depreciation: Concept causes and types, methods of depreciation accounting without interest consideration and with interest consideration	
3	**Process design of piping and fluid moving devices:** Block diagrams; Process flow diagram; Piping and Instrumentation Diagram; Process design of piping; Process design of fluid moving devices: Process design of pumps, revision of formulae for power requirement for fans, blowers and adiabatic compressor; Process Design for orifice meter.	**09**
4	**Process design of separation systems:** ***Process design of Distillation Column*** Packed tower DC vs Tray tower DC; Design steps in DC design (12 steps); Underwood's method for R_{Min} calculation; FUG method for design of multicomponent distillation; Selection of tray: Types and factors to be considered during tray selection; Short path distillation unit (SPDU): Concept, working and applications. ***Process Design of Absorber*** Equipment used for absorption and selection criteria; Shortcut method for design of Absorption column (based on Kremser's Equation)	**09**
5	**Equipment sizing and cost estimation:** ***Equipment sizing*** Shortcut methods for sizing of major process equipment: Process vessels, distillation columns, pumps, compressors, heat exchangers, ***Cost Estimation*** Shortcut methods of costing (Bare module cost) of above equipment (based on Guthrie's method); Six Tenth rule and its application for cost estimation of equipment; Types of costs and capital cost estimates; Concept of total product cost.	**05**
6	**Profitability analysis:** Cash flow in an industrial operation (Concept of tree diagram.); Break even analysis; Different methods of profitability analysis: Rate of return-on-investment method, discounted cash flow method, net present worth method, capitalized cost method, pay-out period method; Comparison of alternative investments based on incremental rate of return; replacement analysis.	**05**

Course Outcome

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

1. Understand the functions of process engineering and various approaches of chemical process design.
2. To calculate different types of interests and annual depreciation costs using different methods.
3. To draw various flow diagrams and carry out process design of piping and various flow moving devices.
4. To carry out process design of multicomponent distillation and absorption columns using various approaches.
5. Evaluate basic design aspects of major process equipments, carry out their quick cost estimation and demonstrate their knowledge of different types of costs and capital cost estimates.
6. Demonstrate their knowledge of cash flow in an industrial operation and perform break-even and profitability analysis using different methods.

Tutorials

- Minimum 8 tutorials should be conducted.

- At least one tutorial on each module is expected and tutorial on modules 2 to 6 must include numerical problems.
- One tutorial will be based on solving detailed process design along with cost estimation by using appropriate software/platform.
- One tutorial will be based on contents beyond syllabus.

Term work

- Term work should consist of minimum 8 tutorials from entire syllabus which are to be given at regular intervals batch wise.
- Tutorial: 20 marks Attendance: 05 marks Total: 25 marks

Assessment

- Internal Assessment consists of two tests which should be conducted at proper intervals.
- End Semester theory examination Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Process Engineering and Design: Shuchen B. Thakore, Bharat I Bhatt, Second Ed., McGraw Hill Education(I) Private Limited,2011
2. Robin Smith, Chemical Process Design and Integration, John Wiley and Sons
3. Systematic Methods Of Chemical Process Design, Loren T Biegler, Grossman E.I., West-berg, A.W. Prentice Hall Intl ed., 1997.
4. Richard M. Felder, Ronald W. Rousseau, Elementary Principles of Chemical Processes, John Wiley &Sons
5. Atul Sathe, Shubhada Kanchan, "Chemical Engineering Economics", Vipul Prakashan, Mumbai.
6. Indrajit N. Yadav, "Chemical Engineering Economics" Sai- publication, Pune 211d edition, 2017

Reference Books

1. Chemical Engineering Design, R. K. Sinnott, Coulson and Richardson Chemical Engineering Series, Volume 6, fourth edition, Elsevier Butterworth-Heinemann, 2005.
2. Conceptual Design of Chemical Processes, J.M. Douglas, McGraw Hill International Editions, 1988.
3. Chemical Process Equipment: selection & design, Walas, S.M., Butterworth, London,1980.
4. Strategy of Process Engineering, John D.F. Rudd& C.C. Watson, Wiley & Sons International, 1968.
5. Process Design Principles: synthesis analysis & evaluation, Sieder, W.D., Seader J.D. & Lewin D.R., John Wiley & Sons, 1998.
6. Analysis, Synthesis, and Design of Chemical Processes, Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, PHI Learning Private Limited, New Delhi, 2011.
7. Peters, M. S. and Timmerhaus, K. D. , "Plant design and economics for chemical engineers", latest edition, Mcgraw Hill, New York.
8. Pravin Kumar "Fundamentals of Engineering Economics" Wiley India.

9. Kharbanda, 0. P. and Stallworthy, E. A. "Capital cost estimating for process industries", Butterworths, Londen
10. K. K Dewett and Adarsh chand, " Modern Economic Theory", latest edition. S Chand and Company.

Semester VI

Course Code	Course Name	Credits
CHDO6021	Piping Engineering	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Basics of Chemical Engineering Process
2. Fluid flow fundamentals

Objectives

1. To introduce students to the crucial role of piping engineer in turn key projects
2. Student will able to select suitable material of construction of pipe
3. Students will understand selection of right piping elements
4. Students will be able to design piping system for a chemical process industry
5. To make students understand the approval drawings and execute the work adhering to procedures and standards
6. To understand the layout and manage the work with adequate safety and reliability

Detailed Syllabus

Module	Course Content	Hours
1.	**Introduction to Piping** • Introduction to piping • Pipe and tube • Pipe classification • Manufacturing processes of pipe • General definitions • Length, area, surface & volume acronyms and abbreviation. • Concept of high point vent and low point drain. • Duties & responsibilities of piping field engineer	6
2.	**Materials of Piping** • Selection of material for piping, • Desirable properties of piping materials • Iron Carbide Diagram • Materials for various temperature and pressure conditions, • Materials for corrosion resistance.	4

	• Pipe coating and insulation • Color coding of piping as per types fluid passing through piping (IS 2379:1990)	
3.	**Codes and Standard** • Codes and standards such as, ANSI codes for pressure piping 31.1 and 31.3. International standards, DIN and API.	**2**
4.	**Piping Components** • Pipe sizes and schedule number • Pipe fittings • Pipes joints & bending (Cold & Hot Bending) • Welding defect (NDT) • Valves: Types of valves and selection • Strainers & traps, sight glass, • Flame arresters, • Inline mixers and static mixtures. • Jacketed piping • Expansion joints • Threaded joints • Types of piping support and Pipe rack	**8**
5.	**Piping System Design** • Flows through Pipes. • Loss of energy / head in pipes, Loss of head due to friction. • Minor energy losses, • Water hammer in pipes • Design Principles and Line Sizing • Miter Joint Calculation. • Stress intensification factor • Flexibility analysis • Various stresses in piping and stress analysis • Pipeline designation	**12**
6.	**Piping Drawing** • Piping drawing symbols and abbreviations • Classification/Types of drawing • Introduction to simple piping drawings • Plot Plan • G.A.Drawing • Process flow diagram (P.F.D) • Piping and instrumentation diagram (P&ID) / Engineering flow diagram.	**7**

Course Outcome

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

1. Recognize role of piping engineer
2. Understand Pipe Material selection
3. Choose the piping fundamentals, codes and standards
4. Select piping system components
5. Examine piping system
6. Choose and Design different piping drawing

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books:

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

Reference Books:

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

Semester VI

Course Code	Course Name	Credits
CHDO6022	Department Elective VI: Polymer Technology	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Chemistry, Physics, Chemical reaction Engineering.

Objectives

1. Understand thermodynamics of polymer structure
2. Understand different kind of Polymerization Process with their properties & applications.
3. Understand techniques of Polymerization, uses and applications.
4. Understand different molding methods of Polymer processing.
5. Understand different kind of polymers and their properties & applications
6. Understand polymer Rheology and Morphology

Detailed Syllabus

Module	Course Contents	Hours
1	**Introduction:** Introduction, basic concepts and definition, Classification of Polymers, Factors influencing the polymer properties, Polymer Structure (Linear, Branch and Cross Linked), Glass Transition Temperature, Significance and different methods of measurement of Glass transition temperature, Molecular Weights, Polydispersity Index, Different Methods of determination of Molecular weight, Effect of Molecular weight on Engineering Properties of Polymers	04
2	**Free Radical addition (Chain- growth) Polymerisation** Introduction, Mechanism, Kinetics of homogeneous polymerization **Step-growth (Condensation) Polymerisation** Features; Definition, mechanism and kinetics, Derivation of Carother's equation.	06
3	**Polymerisation Techniques**: Bulk polymerization, Solution polymerisation, Emulsion polymerisation, Suspension polymerisation and Interfacial Polymerisation with their	09

	merits Comparison of the various processes advantages and disadvantages. **Co-Polymerisation:** Introduction, Copolymer equation, Monomer reactivity ratios, Significance and method of determination, Types of copolymerisation (Ideal, alternating and block copolymerisation)	
4	**Polymer Processing:** Different moulding methods of polymers. Injection moulding, blow moulding, thermo forming (Vacuum, Pressure and mechanical thermoforming), film blowing, Filament winding, Pultrusion	**04**
5	**Manufacturing Processes:** Manufacturing of typical polymers with flow-sheet diagrams properties & application: PE, PP Nylons, ABS Manufacturing of thermoset polymers such as Phenolic resins **Polymer Degradation:** Introduction, random and chain end degradation, Types of degradation (Thermal, Mechanical, Degradation by ultrasonic waves, degradation by high energy radiation)	**10**
6	**Polymer Rheology and Morphology** Concept of rheology; Newtonian and Non –Newtonian fluids- flow curves; apparent viscosity, Power law, Viscoelasticity, free volume or molecular hole concept, Concept of morphology, Requirements for crystallinity, Effects on mechanical and optical properties	**06**

Course Outcomes

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

1. Students will understand the basic concepts, Polymer structure and applications of various techniques used for molecular weights of polymers.
2. Students will demonstrate an ability to distinguish different Polymerisation reactions and their mechanisms and kinetics.
3. Students will have deep understanding of the various analytical Polymerisation techniques used for identification and characterization of polymeric materials.
4. Student will have the knowledge of moulding processes along with their parameter and process control.
5. Students will have the knowledge of manufacturing process, properties and applications of variety of polymer.
6. Student should be able to understand various Rheological and Morphological parameters of polymers.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module

3 then part (b) will be from any module other than module 3).

5. Only **Four questions need to be solved.**

Recommended Books:

1. Gowarikar V.R. et.al., Polymer Science Wiley Eastern 1984.
2. Premamoy Ghosh, Polymer Science and Technology, 3rd Edition, Tata Mc. Graw-Hill Publishing Company, New Delhi, 2010.

Reference Books:

1. Fried J R, Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Edition, 2000.
2. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
3. Bhatnagar, M.S., a Textbook of Polymers, Vol .1, S.Chand & Co.Ltd., New Delhi 2004.
4. Bhatnagar, M.S., a Textbook of Polymers, Vol .II, S.Chand & Co.Ltd., New Delhi 2004

Semester VI

Course Code	Course Name	Credits
CHDO6023	INDUSTRIAL ORGANIZATION AND MANAGEMENT	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	00	03	-	-	03

Theory					Term-Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem. Exam	TW	PR	OR	
Test -I	Test-II	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Prerequisites

- Communication skills
- Basic Mathematical skills
- Analytical, logical and reasoning skills

Course Objectives

- Understand basic concepts of business, administration and management.
- Recognize functions of management such as planning, organizing and decision making.
- Interpret corporate/company governance structures and laws governing industries.
- Know production and quality management.
- Explain basics of marketing and sales management.
- Illustrate financial management of companies.

Detailed Syllabus

Module no	Course Contents	No. Of Hours
1	**INTRODUCTION TO BUSINESS AND MANAGEMENT AND FUNCTIONS OF MANAGEMENT** **Business and Management** • Definition, Objectives, Characteristics, Divisions and Principles of Business/Management, Types of Business • Difference between Policies-Goals-Objectives and Role of a Manager • Difference of relationship between business, administration and management • Types of Management, Typical Management Structure, Management Structure Chart for Medium Scale Industry Development of Management Thought (Taylor, Fayol, Follet, Gilbreth, Gantt) **Functions of Management** • **Planning:** Types of Plans, Steps in Planning, Management by Objectives **(MBO)** • **Organization:** Definition ,Importance, Process, Characteristics,	05

	Principles and Structure of Organization • **Types of Organizations:** Military, Functional, Line and Staff, Committee,Matrix; Departmentalization, Span of Management • **Decision Making:** Theories, Types, Techniques and Process of Decision Making **Quantitative methods** in Decision Making and Markov Analysis (Numericals based on Decision Making)	
2	**PERSONNEL MANAGEMENT** **Functions and Elements** • Personnel Policies and Procedures • Role of a Personnel Manager • Functions of Personnel Management (Manpower Planning, Recruitment, Selection, Training and Development) • Elements of Personnel Management (Organization, Job, People) Difference between Personnel Management and Human Resource Management, Socio-psychological aspects of personnel management	**08**
3	**CORPORATE MANAGEMENT STRUCTURES AND LAWS GOVERNING INDUSTRIES** **Industrial Ownership** ● **Types of Company Ownership:** Single Ownership, Partnership, Joint Stock Company, Co-operative, Government Companies • **Organs of Company Management and their Functions:** Shareholders, Board of Directors, CEO, Managing Director, Manager, Secretary, State Regulation of Management, Company Law Board **Corporate, Social and Environment Responsibility** • CSR through Triple Bottom Line and Sustainable Business • Relation between CSR and Corporate Governance • Chronological Evolution of CSR in India; Models of CSR in India, Carroll's Model; Drivers Of CSR; Major Codes in CSR; Initiatives in India • Environmental Policy and Law • Environmental Audit (ISO-19011, Qualities of Environmental Auditor, Contents Of EA Reports) Case Studies (Eg., Nestle's bottled water enterprise, Adani's coal mines in Australia, China's development of cattle ranches in Brazillian Amazon	06
4	**PRODUCTION AND QUALITY MANAGEMENT** **Production System** ● Input-Output Model ● Application of Microeconomics in Industries ● Productivity and Measures to Increase Productivity **Production, Planning and Production Control** ● Routing, Scheduling, Dispatching, Follow-up and Expediting ● Types of Production Systems ● Supervision and Functions of Supervisor **Quality Management** ● Definition of Quality, Dimensions of Quality ● **Quality Control:** Meaning, Objectives and Benefits ● Demings 14 Points for Management ● Juran's Quality Trilogy ● TQM, ISO 9000,ISO 14000	06

	● Inspection, Cost of Quality, Quality Control Tools for Improvement, Quality Circles, Statistical Quality Control	
5	**MARKETING AND SALES MANAGEMENT** **Sales Management** Sales Organization, Functions of Sales Department, Duties of Sales Manager, 'The Selling' and Functions of Sales Department,The Selling and Marketing Concepts **Marketing** ● Definition,Principles and Functions of Marketing ● Marketing Research, Pricing Policies, Sales Forecasting, Marketing Mix, Advertising, Sales Promotion ● Channels of Distribution, Pricing, Product mix and International Marketing	06
6.	**International Trade** Concepts of International Trade, Government Aids for Export Promotion (Export Houses, Export Promotion Counsel,Patent and Patent Rights) **Management Laws** Concepts of Contract Act, Offer and acceptance, Types of Contacts, Void Contract, Concept of Guarantee and Warranty **Finance and Accounts** • Definition and Difference between Finance and Accounts • Functions, Objectives, Role and Scope of Financial Management • Sources of Finance, Cash Management and Capitalization • Definitions of Assets, Liabilities, Book Keeping, Capital and Types of Capital, Discounts, Commission, Debtor, Creditor and Turnover **Mechanics Of Accounting:** • Cash Books, Sales Book, Purchase Book, Debit/Credit Note, Journal, Ledger • Financial Accounting, Accounting Equation, Balance Sheet, Income Statements, Preparation and Analysis of Financial Statements, Analysis and Interpretation of Financial Statements, Cash Flow Statements and Ratio Analysis **Management Information System:** **MIS** Definition, Objectives, Functions, Difference between Data and Information, Information as Organizational Resource, Qualities of Good Information, Management Information Categories, Designing Information Systems, Integrated Information Systems	08

Course Outcomes

Learners should be able to:

- Apply concepts and knowledge of management to excel in their careers.
- Prepare detailed plans, organization structures and use modern tools for decision making.
- Utilize the knowledge of corporate government structures and government laws to upgrade their skills.
- Identify concepts of production and quality management to improve productivity and quality in manufacturing plants.
- Relate concepts of marketing and sales to improve profitability of business.
- Analyses the tools of finance and accounting to keep control and improve profitability in the industry.

Internal Assessment (20 Marks):
Two Class Tests (Compulsory):

- First test will be based on approximately 40% of content of the syllabus.
- Second test will be based on the remaining content of the syllabus (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportionate to number of respective lectures.
- Question paper will comprise of total **six questions, each carrying 20 marks.**
- **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only **Four questions need to be solved.**

Reference Books:

1. Industrial Engineering and Management-O.P. Khanna, Dhanpat Rai publications
2. Fundamentals of Business Organization and Management, Y.K. Bhushan, S. Chand
3. Industrial Organization and Management: Dani, Sabhalok, Parikh, Shahani-Manan Prakashan
4. Engineering Management, A.K. Gupta, S. Chand
5. Basic Financial Accounting for Management, Paresh Shah, Oxford Press
6. Industrial Organization and Management, Basu S.K ,Prentice Hall India Learning Private Limited
7. Work Organization and Human Resource Management, Editors: Carolina Machado · J. Paulo Davim, Springer
8. Personnel Management – C.B. Mammoria, Himalaya
9. Case Studies in Personnel Management Industrial Relations and Trade Unions, Dr. Anandram, Everest Publishing House
10. Cases in Personnel Management, Shyamkant Gokhale, Everest Publication
11. Environmental Audit: ISO-19011, Qualities of Environmental Auditor, Contents of EA reports
12. R. K. Trivedy – Handbook of Environmental Laws, Guidelines, Compliance & Standards, Vol. 1 & 2 Environ – Media karad, India
13. Sharma, J.P., Corporate Governance and Social Responsibility of Business, Ane Books Pvt. Ltd, New Delhi

Recommended Text Books:

1. Management for Business and Industry-C.S. George Jr.
2. Principles of Management – Knoots and O. Donnell
3. Business Organization and Management – M.C. Shulka

Semester VI

Course Code	Course Name	Credits
CHL601	Mass Transfer Operation II Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	3	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	--	50

Prerequisites

1. Knowledge of chemistry, physics, physical chemistry, mathematics.
2. Knowledge process calculations (Material and energy balance).
3. Basics of unit operations.
4. Basic understanding of equilibrium.
5. Understanding of physical and chemical properties of compounds.
6. Students should know precautions to be taken in laboratories.

Lab Objectives

1. To understand different types of distillations and to obtain VLE data for binary systems. Also, to check experimental and theoretical results for flash, differential and fractional distillation. Students will also find no of stages at total reflux for fractional distillation.
2. To study extraction and find distribution coefficient in binary system. Also, to perform cross current multistage extraction and compare it with single stage extraction.
3. To determine recovery in single and multistage leaching.
4. To verify isotherms for adsorption. Also, to draw break through curve for fixed bed adsorption and determine breakthrough time.
5. To determine yield in crystallization.
6. To study distillation, adsorption, extraction leaching equipments and their working.

List of Experiments

- Verification of Rayleigh's Equation
- To determine the percentage recovery of solute by solid liquid leaching operation (multistage cross-current).
- To determine the vapour-liquid equilibrium curve.
- To find out distribution coefficient. [Eg. acetic acid between water and toluene]
- To verify Freundlich adsorption isotherm
- To find the yield of crystals in batch crystallizer.
- To prepare the ternary phase diagram of Binodal curve and tie line relationship for ternary system

- To study distillation of total reflux in a packed column.
- To determine the efficiency of steam distillation
- To study the performance of Swenson Walker crystallizer and also to determine the yield.
- To carry out multistage cross current operation in liquid liquid extraction and compare with single stage operation
- To carry out multistage cross current adsorption and compare with single stage operation.
- Note: Virtual platforms can be used for better understanding of concepts (Virtual platform should be used for at least one Experiment).

Lab Outcomes

1. Students will be able to determine no of stages at total reflux for fractional distillation. They will be able determine experimental and theoretical recovery of separation.
2. Students will be able to calculate recovery for single and multistage extraction.
3. Students will be able to verify isotherms and determine nature of adsorption. Also, they will be able to determine break through and exhaustion time and parameters affecting breakthrough curve.
4. Students will be able to find recovery in single and multistage leaching operations.
5. Students will be able to determine recovery in batch crystallization.
6. Students will be able to find number of stages, minimum reflux ratio, no of stages at total reflux for tray columns and NTU, HTU, height of bed for packed columns. They will be able to decide suitable equipment for given separation.

Term work

Term work should evaluated based on performance in practical.

Practical journal:	20 marks
Attendance:	05 marks
Total:	25 marks

Practical Examination

- Duration for practical examination will be same as assigned to respective lab per week

A student will become eligible for practical examination after completing 8 out of 10 experiments

Semester VI

Course Code	Course Name	Credits
CHL602	Chemical Reaction Engineering -II Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	-	50

Prerequisites

1. Basic knowledge of chemistry
2. Knowledge of data fitting , differential equation
3. Concept of Molarity, Normality
4. Knowledge of lab safety rules.

Course Objectives

1. Understand techniques to determine residence time distribution studies in different types of reactor.
2. Apply RTD studies for analysis of Non ideal reactor.
3. Identify mode of operation in case of Semi batch reactor
4. Understand adiabatic mode of reactor operation and predict batch operation time
5. Determination of catalyst properties and significance in reactor design
6. Develop kinetics of Solid Fluid non catalytic reaction .

Course Outcome

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

1. employ various methods to determine residence time distribution in different types of reactor.
2. interpret RTD data and predict the behavior of real reactor.
3. acquire analytical skills for the analysis of Adiabatic batch reactor.
4. understand operation of Semi batch reactor.
5. analyze experimental data collected to determine catalyst properties
6. able to determine controlling resistance in case of non catalytic reaction.

List of Experiments (minimum eight)

Experiment no.	Details of Experiment	Lab Hours
1	Residence Time Distribution (RTD) In Continuous Stirred Tank Reactor (CSTR)- Pulse Input	3
2	Residence Time Distribution (RTD) In Plug Flow Reactor (PFR) – Pulse Input	3

3	Residence Time Distribution (RTD) In Packed Bed Reactor (PBR) – Pulse Input	3
4	Residence Time Distribution (RTD) In Continuous Stirred Tank Reactor (CSTR) – Step Input	3
5	Residence Time Distribution (RTD) In Plug Flow Reactor (PFR) – Step Input	3
6	Void volume, Porosity and solid density of catalyst	3
7	Semi batch reactor	3
8	Solid fluid heterogeneous non – catalytic reaction	3
9	Study of adsorption isotherm and calculation of specific surface area of catalyst	3
10	Adiabatic batch reactor	3
11	Experiments from Virtual Lab	3

Assessment:

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 on experiments performed in the laboratory

Reference Books

1. Levenspiel O., Chemical Reaction Engineering, John Wiley&Sons,3ed.,1999.
2. Smith J.M., Chemical Reaction Engineering, 3ed.,Tata McGrawHill,1980.
3. Fogler, H.S. Elements of Chemical Reaction Engineering, 4ed.,PHI, 2008
4. www.vlab.co.in
5. http://www.olabs.edu.in/
6. http://amrita.olabs.edu.in/

Semester VI

Course Code	Course Name	Credits
CHL603	Pollution Control Technology Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	-	50

Prerequisites

Basic concepts of Fluid Flow Operations, Solid Fluid Mechanical Operations, Mass Transfer Operations and Chemical Reaction Engineering.

Course Objectives

1. The aim of the course is to provide basic understanding of air and water pollution control, regulations, standards.
2. Course will provide basics of water pollution sources, properties, measurement and control techniques.
3. Course will provide air pollutions sources, properties, measurements, control methods, design of pollution control devices and efficiency analysis, as well as their applications.
4. Course will provide understanding of solid waste and noise pollution management.
5. Course will provide understanding of waste management in chemical industries.
6. Course will provide understanding of zero discharge management in chemical industries.

Course Outcomes

After successfully completing the course, the students will be able to

1 Acquire the knowledge and understanding of the methods and technologies to reduce the effects of pollution.
2 Understand the basic concepts of water and waste water quality standards.
3 Acquire a working knowledge of parameters to be examined in water and waste waters for various purposes.
4 Get a working knowledge of preparation of standard solutions and reagents.
5 Do experimental projects on water and air quality measurements.
6 Test and assess water and air samples.

Experiment no.	List of Experiments (minimum 8 practical to be performed)	Hours
1	To determine the concentration of CO_2 present in waste water sample.	3
2	To determine the alkalinity of a water sample.	3
3	Determination of dissolved oxygen (DO) present in various water samples.	3

4	Determination of chemical oxygen demand (COD) present in waste water sample.	3
5	Determination biological oxygen demand (BOD) present in waste water sample	3
6	To determine pH, TDS, SS of wastewater.	3
7	Measurement of gaseous pollutant present (any one) in air.	3
8.	Measurement of particulate matter pollutant present in air.	3
9.	Measurement of sound level at various locations.	3
10.	Determination of Sludge Volume Index and design of clarifier for settling sludge.	3

Term work
Term work shall be evaluated based on performance in practical.
Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination
 Duration for practical examination would be the same as assigned to the respective lab per week.
 A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments

Semester VI

Course Code	Course Name	Credits
CHL604	Skilled based lab: Piping Design Engineering Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites

1. Basic computer skills including MS EXCEL is essential.
2. Basic Knowledge of Fluid Flow Operation
3. Process Equipment design material Selection

Course Objectives

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

Course Outcome

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

1. To apply piping standards in design of complex piping networks.
2. To solve complex engineering problem of selection of appropriate material for pipes and fittings for chemical plants
3. To identify, analyze and solve pipe sizing, pump sizing, valve sizing and pipe-valve-pump selection problems
4. To design and draw piping networks, piping layout ,P & ID ,isometric drawings and plot plan by considering legal, environmental, societal and ethical aspects
5. To use modern IT tools such as MS Excel/Libre office Calc/WPS spreadsheets, DWSIM, AutoCAD 2D and 3D,CAE demo and Edraw Fluid flow for design and analysis of piping networks
6. To carry out stress analysis, network analysis, flexibility analysis and surge analysis for chemical plants which will benefit society and environment by following strict ethical standards.

List of Experiments (Minimum eight)

For all the experiments select any suitable chemical industry or section of chemical industry and do the calculations or drawings. The piping experiments must be carried out on piping network and not on isolated piece of pipe.

Experiment no.	Details of Experiment	Lab Hours
1	Introduction to Code and Standards: IS, AWWA, IWWA, ASME, ANSI, BS, HIS, CPHEEO Manual, ISO, DIN and Material selection of pipes and fittings.	3
2	Equivalent diameter calculations of pipelines	3
3	Control valve sizing and selection of valves	3
4	Pipe sizing, thickness calculation and Pump head calculations	3
5	Line hydraulics and network analysis: Flow rate and Pressure drop calculations	3
6	Pipe stress analysis for piping and piping support by using CAE	3
7	Piping layouts for a given chemical process on AutoCAD	3
8	Preparation of Piping and Instrument Diagram for a given chemical process on AutoCAD/DWSIM	3
9	Developing plot plan from given data on Autocad	3
10	Pipe rack design	3
11	Piping engineering of standard piping modules like distillation column piping, heat exchanger piping, tank piping, vessel / drum piping, reformers piping. **Any one of this module should be given to students**.	3
12	Flexibility analysis calculations for piping	3
13	Water hammer /surge analysis for piping	3

Note: All the Experiments (Minimum eight) should perform using any open source software (such as MS Excel/Libre office Calc/WPS spreadsheets, DWSIM, Autocad 2D and 3D, CAE demo and Edraw etc.,) **or** any paid software (PDMS,CAESAR, Smart Plant 3D, Smart Plat Review, Revit, Plant 3D, SP3D, Navisworks, Smart Plant Review, Smart P&ID etc.) if available in institute.

Assessment:

Term Work (25 marks)

Distribution of marks will be as follows:

Laboratory work: 20 marks

Attendance : 05 marks

End Semester Orals (25 marks)

Orals on experiments carried out in the laboratory.

Recommended Books

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

Reference Books

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

Semester VI

Course Code	Course Name	Credits
CHM601	Mini Project-2B	1

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	1	-	1

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

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:

At the end of this course, students will be able to:

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.

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.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 2 in semester V and VI.
- 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 review/ progress monitoring committee shall be constituted by head of departments of each institute. 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 : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
- First shall be for finalization of problem
- Second shall be on finalization of proposed solution of problem.
- In second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
- First review is based on readiness of building working prototype to be conducted.
- Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
- Identification of need/problem
- Proposed final solution
- Procurement of components/systems
- Building prototype and testing

- Two reviews will be conducted for continuous assessment,
- First shall be for finalization of problem and proposed solution
- Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.
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

- In one year, project, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of half year project all criteria's in generic may be considered for evaluation of performance of students in mini project.

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 organizations 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.
