Syllabus Upload as per letter No. AA/ICD/290 dt. 15.11.21

University of Mumbai

No. AAMS (UG)/75 of 2021-22

CIRCULAR :-

Attention of the Principals of the Affiliated Colleges, Directors of the recognized Institutions in Faculty of Science & Technology is invited to this office circular No. UG/52 of 2021 dated 21st January, 2021 relating to the revised syllabus as per the (CBCGS) for the revised scheme (Rev 2019 'C' Scheme) for the B.E. in Chemical Engineering (Sem III to VIII).

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in Chemical Engineering at its meeting held on 5th April, 2021 and subsequently made by the Board of Deans at its meeting held on 11th June, 2021 vide item No. 6.3 (R) have been accepted by the Academic Council at its meeting held on 29th June, 2021 **vide** item No. 6.3 (R) and that in accordance therewith, the revised syllabus (Rev-2019 'C' Scheme) for the B.E. in Chemical Engineering (T.E. - Sem. V & VI) has been brought into force with effect from the academic year 2021-22. (The same is available on the University's website www.mu.ac.in).

(Dr. B.N.Gaikwad)
I/c REGISTRAR

MUMBAI – 400 032
30th September, 2021

To

The Principals of the Affiliated Colleges and Directors of the recognized Institutions in Faculty of Science & Technology.

A.C/6.3/29/06/2021

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No. UG/75 -A of 2021-22 MUMBAI-400 032 30th September, 2021

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Chemical Engineering,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-ordinator, University Computerization Centre.

(Dr. B.N.Gaikwad)
I/c REGISTRAR

Copy to :-

1. **The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
2. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
5. **The Deputy Registrar, Executive Authorities Section (EA),**
6. **The Deputy Registrar, PRO, Fort, (Publication Section),**
7. **The Deputy Registrar, (Special Cell),**
8. **The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
9. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

1. **P.A to Hon'ble Vice-Chancellor,**
2. **P.A Pro-Vice-Chancellor,**
3. **P.A to Registrar,**
4. **All Deans of all Faculties,**
5. **P.A to Finance & Account Officers, (F.& A.O),**
6. **P.A to Director, Board of Examinations and Evaluation,**
7. **P.A to Director, Innovation, Incubation and Linkages,**
8. **P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
9. **The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
10. **The Director of Board of Student Development,**
11. **The Director, Department of Students Walfare (DSD),**
12. **All Deputy Registrar, Examination House,**
13. **The Deputy Registrars, Finance & Accounts Section,**
14. **The Assistant Registrar, Administrative sub-Campus Thane,**
15. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
16. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
17. **The Assistant Registrar, Constituent Colleges Unit,**
18. **BUCTU,**
19. **The Receptionist,**
20. **The Telephone Operator,**
21. **The Secretary MUASA**

for information.

AC- 29/06/2021
Item No.: 6.3

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 – 2020

Under

FACULTY OF SCIENCE & TECHNOLOGY

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

AC – 29/06/2021
Item No. -6.3

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year Bachelor of Chemical Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	**Under Graduation**
7	Pattern	**Semester**
8	Status	**Revised**
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
Dean
Faculty of Science and Technology
University of Mumbai

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.

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

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

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 of semester V and VI in the month of December 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 Gogate - 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: Professional Communication and Ethics II	-	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: Professional Communication and Ethics II	-	-	-	-	-	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 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. 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
CHL504	Skilled Based Lab: Professional Communication and Ethics II	2

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	2* + 2 Hours (Batch wise)	-	-	2	-	2

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

***Theory class to be conducted for full class.**

Course Rationale

This curriculum is designed to build up a professional and ethical approach, effective oral and written communication with enhanced soft skills. Through practical sessions, it augments student's interactive competence and confidence to respond appropriately and creatively to the implied challenges of the global Industrial and Corporate requirements. It further inculcates the social responsibility of engineers as technical citizens.

Course Objectives

Learners should be able to:

1. discern and develop an effective style of writing important technical/business documents.
2. investigate possible resources and plan a successful job campaign.
3. understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4. develop creative and impactful presentation skills.
5. analyse personal traits, interests, values, aptitudes and skills.
6. understand the importance of integrity and develop a personal code of ethics.

Course Outcomes

Learners will be able to:

1. plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2. strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3. emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4. deliver persuasive and professional presentations.
5. develop creative thinking and interpersonal skills required for effective professional communication.
6. apply codes of ethical conduct, personal integrity and norms of organizational behaviour.

Detailed Syllabus

Module	Contents	Hours
1	**ADVANCED TECHNICAL WRITING :PROJECT/PROBLEM BASED LEARNING (PBL)** **1.1 Purpose and Classification of Reports:** **Classification on the basis of:** • Subject Matter (Technology, Accounting, Finance, Marketing, etc.) • Time Interval (Periodic, One-time, Special) • Function (Informational, Analytical, etc.) • Physical Factors (Memorandum, Letter, Short & Long) **1.2. Parts of a Long Formal Report:** ● Prefatory Parts (Front Matter) ● Report Proper (Main Body) ● Appended Parts (Back Matter) **1.3. Language and Style of Reports** ● Tense, Person & Voice of Reports ● Numbering Style of Chapters, Sections, Figures, Tables and Equations ● Referencing Styles in APA & MLA Format ● Proofreading through Plagiarism Checkers **1.4. Definition, Purpose & Types of Proposals** • Solicited (in conformance with RFP) & Unsolicited Proposals • Types (Short and Long proposals) **1.5. Parts of a Proposal** ● Elements ● Scope and Limitations ● Conclusion **1.6. Technical Paper Writing** • Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) • Language and Formatting • Referencing in IEEE Format	**06**
2	**EMPLOYMENT SKILLS** **2.1. Cover Letter & Resume** • Parts and Content of a Cover Letter • Difference between Bio-data, Resume & CV • Essential Parts of a Resume • Types of Resume (Chronological, Functional & Combination) **2.2 Statement of Purpose** ● Importance of SOP ● Tips for Writing an Effective SOP **2.3 Verbal Aptitude Test** • Modelled on CAT, GRE, GMAT exams **2.4. Group Discussions** • Purpose of a GD • Parameters of Evaluating a GD	**06**

	• Types of GDs (Normal, Case-based & Role Plays) • GD Etiquettes **2.5. Personal Interviews** • Planning and Preparation • Types of Questions • Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) • Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
3	**BUSINESS MEETINGS** **1.1. Conducting Business Meetings** • Types of Meetings • Roles and Responsibilities of Chairperson, Secretary and Members • Meeting Etiquette **3.2. Documentation** • Notice • Agenda • Minutes	**02**
4	**TECHNICAL/ BUSINESS PRESENTATIONS** **1.1 Effective Presentation Strategies** • Defining Purpose • Analyzing Audience, Location and Event • Gathering, Selecting &Arranging Material • Structuring a Presentation • Making Effective Slides • Types of Presentations Aids • Closing a Presentation • Platform skills **1.2 Group Presentations** • Sharing Responsibility in a Team • Building the contents and visuals together • Transition Phases	**02**
5	**INTERPERSONAL SKILLS** **1.1. Interpersonal Skills** • Emotional Intelligence • Leadership & Motivation • Conflict Management & Negotiation • Time Management • Assertiveness • Decision Making **5.2 Start-up Skills** • Financial Literacy • Risk Assessment • Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	**08**
6	**CORPORATE ETHICS** **6.1Intellectual Property Rights** • Copyrights • Trademarks • Patents	**02**

	• Industrial Designs • Geographical Indications • Integrated Circuits • Trade Secrets (Undisclosed Information) **6.2 Case Studies** • Cases related to Business/ Corporate Ethics	

List of assignments:
(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal
3. Meeting Documentation
4. Writing a Technical Paper/ Analyzing a Published Technical Paper
5. Writing a SOP
6. IPR
7. Interpersonal Skills
8. Aptitude test (Verbal Ability)

Note:

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3. There will be an end–semester presentation based on the book report.

Assessment:

Term Work:
Term work shall consist of minimum 8 experiments.
The distribution of marks for term work shall be as follows:
Assignment : 10 Marks
Attendance : 5 Marks
Presentation slides : 5 Marks
Book Report (hard copy) : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal oral:

Oral Examination will be based on a GD & the Project/Book Report presentation.

Group Discussion : 10 marks
Project Presentation : 10 Marks
Group Dynamics : 5 Marks

Books Recommended:
Textbooks and Reference books:

1. Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition*. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021). *Business communication today*. Upper Saddle River, NJ: Pearson.

3. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).*Personal development for life and work*. Mason: South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour*. Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
8. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

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.