MINOR IN CHEMICAL ENGINEERINMG

VNIT, Nagpur

APRIL 2, 2026

DEPARTMENT OF CHEMICAL ENGINEERING
Visvesvaraya National Institute of Technology, Nagpur

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING

Courses for B.Tech. Minor in Chemical Engineering
Title of Minor: Minor in Chemical Engineering

The details of the courses to be offered for Minor in Chemical Engineering as follows.

S. N.	Course Code	Course Name	Structure L-T-P-Cr	Semester (Even / Odd	Name of Course Coordinator
1	CML2xx	Introduction to Chemical Engineering	3-0-0-3	3rd Sem	Dr. P.B. Dhamole
2	CML2xx	Chemical Engineering Thermodynamics	3-0-0-3	4th Sem	Dr. R.P. Vijayakumar
3	CML3xx	Chemical Reaction Engineering	3-0-0-3	5th Sem	Dr. K.L. Wasewar
4	CML3xx	Heat, Mass and Momentum Transport	3-0-0-3	6th Sem	Dr. M.N. Varma
5	CMP3xx	Chemical Engineering Laboratory	0-0-2-1	6th Sem	Dr. A. Das
6	CMD4xx	Mini Project	0-0-4-2	6th Sem	HoD, Chemical Engg.

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE OUTLINE

Department	**: Chemical Engineering**
Course Code	**: CMLxxx**
Course Title	**: Introduction to Chemical Engineering**
Course Type	**: Theory**
Course Credits	**: 03**
L-T-P	**: 3-0-0**

I. Course description:

This course will cover the stoichiometry, material and energy balance and some of the important mechanical operations. Also, the fundamental knowledge of all unit operation and unit processes involved in the synthesis of various chemicals, acids, and fertilizers.

II. Pre-requisites: None

III. Objectives:

1. To be aware about the basic calculations in chemical processes mainly the stoichiometry, material and energy balance
2. To provide basic knowledge of the unit operation and processes
3. To impart knowledge on the process flow of various chemical products,
4. To provide knowledge on the overall synthesis of the various chemical products

IV. Outcomes:

1. Students will be able to do material and energy balance calculations for a chemical process
2. Students will understand the basic principles, working and construction of various unit operations
3. At the end of the course, the students will be able to develop the process flow diagrams involved in the large-scale synthesis of various chemical products.
4. Students shall acquire knowledge on the development of science and technology of various chemical process industries.

V. Expanded Course description:

Stoichiometry, molarity, molality, normality, Degrees of freedom, fundamental concepts of material balance. Material balance in various unit processes and unit operations. Material balance with chemical reactions, combustion

Energy balance related to various process equipment.

Size Reduction, Screening, Size Separation and Filtration

Basics of instrumentation diagrams and Process symbols, Petroleum refining process- crude desalting, atmospheric and vacuum distillation of crude, hydrotreating, hydrocracking, fluid catalytic cracking (FCC), catalytic reforming, alkylation, Fischer–Tropsch (FT) process, deasphaltation and dewaxing of crude, vis-breaking and delayed coking; manufacture of acids- nitric acid, sulfuric acid, phosphoric acid; manufacture of fertilizers- ammonia, urea, NPK, monoammonium phosphate (MAP), diammonium phosphate (DAP), super phosphate (NSP), triple super phosphate (TSP) and nitrophosphates.

Carbon footprint, water footprint for chemical process plant using suitable software like GaBi

VI. Textbooks:

1. David M. Himmelblau and James B. Riggs. Basic Principles and Calculations in Chemical Engineering. Prentice Hall of India Ltd, 8th Edition, 2014.
2. Walter L. Badger (Author), Julius T. Banchero (Author), Julius T. Bancheo. Introduction to Chemical Engineering. McGraw Hill, 1955.

3. C. L. Dryden, Outlines of Chemical Technology, Edited and Revised by M.Gopala Rao and S. Marshall, Affiliated East West, New Delhi, 3rd Edition, 1997.

VII. Reference Books:

1. Richard M. Felder, Ronald W. Rousseau. Elementary Principles of Chemical Processes. John Wiley & Sons, 3rd Edition, 2004.
2. Warren McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering. McGraw Hill, 7th Edition, 2017.
3. T. G. Austin and S. Shreve, Chemical Process Industries. McGraw Hill, 5th Edition, New Delhi, 2017.
4. P. H. Groggins, Unit Processes in Organic Synthesis, McGraw Hill, 5th Edition, 2001.

VIII. Class Schedule

Three lectures of 55 minutes each per week.

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE OUTLINE

Department	**: Chemical Engineering**
Course Code	**: CMLxxx**
Course Title	**: Chemical Engineering Thermodynamics**
Course Type	**: Core**
Course Credits	**: 03**
L-T-P	**: 3-0-0**

I. Course description:

The course present thermodynamics from a chemical engineering viewpoint. Thermodynamic properties, Concepts of phase and chemical equilibria and its application are stressed in this course.

II. Pre-requisites: None

III. Objectives:

Based on the concepts taught, Student shall be able to apply the concepts of thermodynamics to solve the given problem on thermodynamic process accurately.

IV. Outcomes:

1. Describe the Thermodynamic properties like free energy, activity, fugacity etc., for pure substances and solve the related problems.
2. Describe the thermodynamic properties of solutions and solve the related problems.
3. Use the concepts of phase equilibrium and solve the problems.
4. Apply the concepts of chemical equilibrium and solve the problems.

V. Expanded Course description:

Unit 1: Review of Classical Engineering Thermodynamics: Definition of terms and fundamental concepts , Laws of thermodynamics and their applications.

Unit 2: Equations of state, free energy, phase rule, properties of pure fluids, fugacity, fugacity coefficient, compressibility factor, activity.

Unit 3: Solution thermodynamics: Ideal and non-ideal gas mixtures and liquid solutions, partial molar properties, physical significance and determination methods, chemical potential. Gibbs-Duhem equation

Unit 4: Phase Equilibria: Criteria of phase equilibrium, Duhem theorem. Vapour liquid equilibrium, VLE equation, Activity coefficient - equations used for the determination, Thermodynamic consistency

Unit 5: Chemical reaction equilibrium: Criteria of equilibrium, equilibrium constant, Gibbs free energy change, feasibility of chemical reactions, effect of temperature on equilibrium constant, evaluation of van't Hoff constant, Effect of parameters like temperature, pressure, composition on the equilibrium conversion.

Unit 6: Computation equation of state, fugacity, ideal and non-ideal mixtures, chemical potential, vapour liquid equilibrium, activity coefficient, Gibbs free energy, etc. using Matlab or suitable open source software.

VI. Textbooks:

1. Smith J.M., Van Ness H.C., Abbott M.M., Swihart M.T., and Bhatt B.I. Introduction to Chemical Engineering Thermodynamics, McGraw Hill, 8th Edition, 2019.
2. Narayan K.V., A text book of Chemical Engineering Thermodynamics, PHI, 2nd Edition, 2013.

VII. Reference Books:

1. S. Sandler, Chemical, biochemical and engineering thermodynamics. Wiley, 5th Edition, 2020.
2. Rao Y.V.C., Chemical Engineering Thermodynamics. University Press India Ltd., 1997.
3. Hill, T.L., An Introduction to Statistical Thermodynamics. Dover Publications, 2003.

VIII. Class Schedule

Three lectures of 55 minutes each per week.

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE OUTLINE

Department	**: Chemical Engineering**
Course Code	**: CMLxxx**
Course Title	**: Chemical Reaction Engineering**
Course Type	**: Core**
Course Credits	**: 03**
L-T-P	**: 3-0-0**

I. Course description:

The course present the basics of reaction kinetics and its mechanism, type of reactors and their arrangements, multiple reactions, catalysis, residence time distribution and heat effects to be used.

II. Pre-requisites: None

III. Objectives:

1. Provide students with a basic understanding of basic reaction engineering, type of reactions & kinetics, and reactors and third configurations.
2. Enhance their knowledge on multiple reactions, catalysis, residence time distribution, and heat effects.
3. Improve the student's ability in deciding type of reactor and their arrangement for achieving desired conversion keeping economy in point of view

IV. Outcomes:

At the end of the course, the student will understand the basics of reaction kinetics and its mechanism, type of reactors and their arrangements, multiple reactions, catalysis, residence time distribution and heat effects to be used.

V. Expanded Course description:

1. Introduction to Chemical Reaction Engineering
   Classification, rate expressions, batch reactor data and their interpretation. Constant volume and variable volume batch reactor, Integral, differential, and other methods of analysis of kinetic data.
2. Reactor Design
   Types of reactors, PFR, CSTR etc., Material & energy balances single ideal reactor, Space-time and space-velocity, Holding time, Introduction of non-ideal flow, Ideal Reactors for a Single Reaction, Ideal Batch, Mixed, Plugflow Reactor. Design for Single Reactions, Size comparison of single reactors, General graphical comparison, Multiple reactor system, Recycle reactor, Autocatalytic reactions.
3. Design for Series - Parallel Reactions:
   Introduction to design of series - parallel reactions, Qualitative and Quantitative discussion on product distribution, Contacting patterns, Reactor Size and arrangement, Selectivity, Yield, Successive reversible reactions of different orders, reversible reactions, Irreversible series-parallel reactions, Graphical representation, Denbigh reactions and their special cases.
4. Solid Catalysed Reactions:
   Introduction and Spectrum of kinetic regimes, Surface kinetics and rate equation, pore diffusion, porous catalyst, Heat effects, Performance Equation, Experimental methods and rate equation, Controlling Resistance, Product distribution in multiple reactions. Typical Catalysts, Catalyst Characterizations, Catalyst Deactivation and Regeneration, Packed bed reactor, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors etc.
5. Temperature and Pressure Effects

Single and multiple reactions, Heats of reaction from thermodynamics, Equilibrium constant, Temperature, Graphical design procedure, Optimum Temperature Progression, Heat Effects, Adiabatic and non-adiabatic operations, Catalytic reactions.

6. Flow Pattern, Contacting, and Non-Ideal Flow:
   Non ideal flow in reactors, RTD of fluid in reactors, Age distribution, F curve, C curve and E curve, Compartment model, Dispersion model, Tank in Series model.
7. Computation and simulation of plug flow reactor, batch reactor, continuous stirred tank reactor, nonlinear equations with fuel cell applications, chemical reactors with mass transfer limitations, chemical reaction in microfluidic device, optimal cooling of a tubular reactor, optimization of a catalytic microreactor, determination of arrhenius parameters etc. using Comsol Multiphysics or suitable open source software.

VI. Textbooks:

1. Levenspiel O., Chemical Reaction Engineering. Wiley India Pvt. Ltd., 3rd Edition, 2021.
2. Fogler H.S., Elements of Chemical Reaction Engineering. Prentice Hall India Pvt. Ltd., 4th edition, 2008.
3. Smith J. M., Chemical Engineering Kinetics. McGraw Hill, N Y, 3rd edition, 1981.

VII. Reference Books:

1. G. F. Froment and K. B. Bischoff, Chemical Reactor Analysis. Wiley, 3rd Edition, 2010.

VIII. Class Schedule

Three lectures of 55 minutes each per week.

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE OUTLINE

Department	**: Chemical Engineering**
Course No.	**: CML XXX**
Course Title	**: Heat, Mass and Momentum Transport**
Course Type	**: Core**
Course Credits	**: 03**
L-T-P	**: 3-0-0**

I. Course description:

This course mainly deals with understanding important basic principle and its application for fluid mechanics, heat transfer and mass transfer. This subject also covers the topic which shows the similarity between fluid mechanics, heat transfer and mass transfer

II. Pre-requisites: None

III. Objectives:

Students will be able to develop and solve some of the important design problem in fluid mechanics, heat transfer and mass transfer.

IV. Outcomes:

1) Understand the basic principal and its application in fluid mechanics
2) Understand the basic principal and its application in Heat Transfer
3) Understand the basic principal and its application in Mass Transfer
4) Able to correlate similarities between fluid mechanics, heat transfer and mass transfer.

V. Expanded Course description:

Hydrostatic pressure, Hydrostatic force, pressure measurement, pressure vessel, pipeline thickness, manometer like real life cases, flow through pipe, Bernoulli's equation and its applications

Types of Pumps, working of pumps, trouble shooting, packed bed in Chemical Engineering application, agitating vessel for reaction

Basic modes of heat transfer, conduction, convection and radiation, heat conduction in plane, composite wall, cylinders, spheres, heat generation inside solids, critical thickness of insulation, extended surfaces, unsteady state heat conduction, free and forced convection, heat transfer in laminar flow and turbulent flow, radiation heat transfer, laws of radiation

Boiling and condensation, boiling curve and its characteristics, film condensation, drop wise condensing, heat exchangers, types of heat exchangers, analysis, LMTD, NTU, effectiveness, evaporators, classification

Diffusion: Fundamentals of diffusional mass transfer, steady state and unsteady state operations, concepts of mass transfer coefficient, application

Drying: Concepts of drying, constant rate and falling rate periods, equilibrium moisture contents, drying equipment's, applications

Crystallization: theory of Crystallization, saturation, supersaturation, nucleation and various equipments for crystallization, applications

Adsorption: Adsorption isotherms, adsorption agents, equipments for adsorption, applications.

Humidification and dehumidification: basics of humidification, introduction to humidifiers and dehumidifiers, applications.

Distillation: Raoult's law, Vapour – liquid equilibria, X-Y and H-X-Y diagrams, indtroction to various types of distillation viz. differential distillation, equilibrium distillation, distillation with rectification in binary distillation, concept of plate and packed columns, methods for

estimation of number of stages required in distillation column, minimum reflux ratio, optimum reflux ratio, overall plate efficiency. Concept of packings, HETP, HTU, NTU, applications.
Absorption: Equilibrium relationships, concept of driving force, selection of solvent for absorption and desorption, applications.
Leaching: Fundamentals of leaching, single stage, multistage concurrent and counter current operation, equilibrium relationship, Solvent selection, applications.
Liquid–Liquid Extraction: fundamentals of extraction, Single stage, multistage operations, equipments, applications.
Similarity between heat, momentum and mass transport and mass transport Molecular and Convective Transport, Definition of Transport Properties, Viscosity, Thermal Conductivity, Diffusivity, Newton's Law of Viscosity, Fourier's Law of Heat Conduction, Fick's First Law of Diffusion, Dimensionless Numbers in Molecular Transport, Convective transport and total flux.
Inter-phase Transport and Transport Coefficients, Physical Interpretation of Friction Factor, Heat Transfer Coefficient, Mass Transfer Coefficient, Dimensionless Numbers in inter-phase Transport. Various Transport Analogies, The Reynolds Analogy, The Chilton-Colburn Analogy
Evaluation of transport properties like Viscosity, Thermal Conductivity, Diffusivity and transfer coefficient: Engineering Correlations
Computation of exit streams in flash drum, bubble point and dew point temperature of hydrocarbon mixture, T-xy and P-xy diagrams of a binary mixture; Simulation of a Rstoic and RCSTR model, binary distillation - DSTWU model, multicomponent distillation - RadFrac model, etc. using DWSIM or suitable open source software.

VI. Textbooks:

1. N. de Nevers, Fluid Mechanics for Chemical Engineers, McGraw Hills, 4th Edition, 2021.
2. J.P. Hollman, Heat Transfer, McGraw Hill, 10th Edition, 2017.
3. R.E. Treybal, Mass Transfer Operations. McGraw Hills, 3rd Edition, 2017.
4. R.B. Bird, W. Stewart and E.N. Lightfoot, Transport Phenomena. John Wiley & Sons, 2nd Edition, 2006.

VII. Reference Books:

1. F.P. Incropera, Fundamentals of Heat and Mass Transfer, John Wiley & Sons, 7th Edition, 2011.
2. Y.A. Cengel , Heat Transfer: A Practical Approach McGraw-Hill; 2nd Edition, 2002.
3. D.Q. Kern, Process Heat Transfer, Tata McGraw Hill Book Co., New Delhi, 1990.
4. B.K. Dutta, Heat Transfer: Principles and Applications. PHI Pvt.Ltd New Delhi, 2006.
5. W.L. McCabe, and J.C.Smith & Harriot, Unit Operations of Chemical Engineering, McGraw Hills, 7th Edition, 2017.
6. C.O. Bennet and J.E. Myres, Momentum, Heat & Mass Transfer, McGraw Hills, 3rd Edition, 1994.

VIII. Class Schedule

Three lectures of 55 minutes each per week.

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE OUTLINE

Department	**: Chemical Engineering**
Course No.	**: CMP XXX**
Course Title	**: Chemical Engineering Laboratory**
Course Type	**: Core**
Course Credits	**: 01**
L-T-P	**: 0-0-2**

I. Course description:

This course mainly deals with the understanding the basic fundamental principles of Chemical Engineering by performing different experiments

II. Pre-requisites:

Preliminary knowledge about fluid mechanics, mechanical operations, heat transfer, mass transfer and chemical reaction engineering

III. Objectives:

1) To understand the basic principle of Chemical Engineering subjects like fluid mechanics, mechanical operations, heat transfer, mass transfer and chemical reaction engineering

IV. Outcomes:

1) Students will understand the basic of Chemical Engineering and its practical application.

V. Expanded Course description:

List of experiments

1) Friction in Pipeline (To determine the friction coefficient factor for different size as well as different material of pipes.)
2) Pressure Measurement (Pressure measurement in pipeline)
3) Sedimentation (To carry out the batch sedimentation test and use the results to design a Thickener)
4) Jaw crusher (To perform the sieve analysis of the product obtained from Jaw crusher and verify the power law).
5) Heat transfer trough lagged pipe
6) Emissivity of a surface
7) Vapour-Liquid Equilibria Set up
8) Liquid-air Diffusion (To determine the diffusion co-efficient of an organic vapor in air).
9) Study the kinetics of reaction for all the combination for given three CSTR in series
10) Study the kinetics of reaction for all the combination for given PFR and CSTR in series

Total Experiments to be conducted: Any eight out of above list

VI. Textbooks and reference books

1. N. de Nevers, Fluid Mechanics for Chemical Engineers, McGraw Hills, 4th Edition, 2021.
2. J.P. Hollman, Heat Transfer, McGraw Hill, 10th Edition, 2017.
3. R.E. Treybal, Mass Transfer Operations. McGraw Hills, 3rd Edition, 2017.
4. R.B. Bird, W. Stewart and E.N. Lightfoot, Transport Phenomena. John Wiley & Sons, 2nd Edition, 2006.
5. Levenspiel O., Chemical Reaction Engineering. Wiley India Pvt. Ltd., 3rd Edition, 2021.

VII. Lab Schedule

Two hours per week.

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR
DEPARTMENT OF CHEMICAL ENGINEERING

COURSE OUTLINE

Department	**: Chemical Engineering**
Course No.	**: CMD XXX**
Course Title	**: Mini Project**
Course Type	**: Core**
Course Credits	**: 02**
L-T-P	**: 0-0-4**

I. Course description:
This course mainly deals with the understanding and implementing the basic fundamental principles of Chemical Engineering.

II. Pre-requisites: None

III. Objectives:
To expose students to apply their knowledge to solve a given problem
Increase the student's ability to function effectively on a project team

IV. Outcomes:
Develop skills and attitudes such as experimentation, design thinking, teamwork, communication, and societal context.

V. Expanded Course description:
Student will select the project topic according to his/her choice in consultation with the project advisor.

VI. Schedule
Four hours per week.