

Course Structure and Syllabus for 2-year 4-semester M. Tech. Course in Petrochemicals & Petroleum Refinery Engineering

(With effect from Academic year 2024-2025)

1st Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
I	CHT101	Process Modelling and Simulation	3	1	-	4	30	70	100
II	PPR102	Analytical Method in Petroleum Industry	3	1	-	4	30	70	100
III	PPR103	Petrochemicals	3	1	-	4	30	70	100
Practical									
IV	CHT104	Computer Application in Chemical Industries	-	-	8	4	60	40	100
V	PPR105	Petrochemical Technology Laboratory I	-	-	8	4	60	40	100
		Total	9	3	16	20	310	290	500

2nd Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
VI	CHT201	Optimization	3	1	-	4	30	70	100
VII	PPR202	Reaction Engineering & Catalyst Technology	3	1	-	4	30	70	100
VIII	PPR203	Refinery Engineering	3	1	-	4	30	70	100
IX	PPR204	High Pressure Technology	3	1	-	4	30	70	100
Practical									
X	PPR205	Petroleum Technology Laboratory II	-	-	8	4	60	40	100
		Total	12	4	8	20	180	320	500

3rd Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
XI	CHT301	Research Methodology	-	2	-	2	15	35	50
XII	PPR302	a. Project Feasibility – Report	-	2	8	6	90	60	150
		b. Project Feasibility – Viva Voce	-	-	-	4	-	100	100
XIII	PPR303	Mini Project with seminar	-	4	-	4	-	100	100
XIV	PPR304	Thesis: Foundation	-	-	-	4	-	100	100
		Total	-	8	8	20	105	405	500

4th Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
XV	PPR401	a. Thesis: Final-Report	-	4	16	12	-	-	300
		b. Thesis: Final-Viva Voce	-	-	-	4	-	100	100
XVI	PPR402	General Viva Voce	-	-	-	4	-	100	100
		Total	-	4	16	20	-	500	500

Total Credit Point: 20 + 20 + 20 + 20 = 80; **Grand Total:** 2000

IA: Internal Assessment; UE: University Examination; TM: Total Marks

SYLLABI OF 2 YEARS (FOUR SEMESTER) M.TECH. COURSE IN PETROCHEMICALS & PETROLEUM REFINERY ENGINEERING

First Semester

Paper I

Course CHT 101

100Marks/4credits

Process Modeling & Simulation

Module 1: Mathematical Modeling Fundamentals: Art of modeling, laws, assumptions, degrees of freedom, consistent modeling, synthesis, analysis and optimization. General purpose modeling, specific purpose modeling, scientific modeling, engineering modeling.

Module 2: Models of equipment, unit operation/unit process; material & energy balance, property relations, Constraints, steady state and unsteady state models. Specific Equipment Design models: Batch reactor, continuous tank reactor, Continuous tubular, catalytic reactor, heat exchanger, Distillation column.

Module 3: Plant modeling, stream variable and stream properties, tear stream and tear variable, modular approaches: sequential, simultaneous and equation solving approaches. Sequencing and ordering of solving equations.

Plant modeling: A plant with/without a recycle stream, plant with controlling elements.

Module 4: Solution algorithm and flow chart development for various mathematical models. Computer simulation: Programming languages, sequences and algorithm development.

Specific simulators: Binary distillation column, Heat exchanger, reactor, flasher.

Plant flow sheeting: Three CSTR in series, Propylene dimerization plant, sulfuric acid plant, etc.

Paper II

Course PPR102

100marks/4credits

Analytical Methods in Petroleum Industry

Module 1: Crude oils, sampling, analysis and evaluation

Module 2: Chromatography–Principle, Classification, Techniques, Application, GLC, HPLC, HTSD, Emission and Atomic Absorption Spectroscopy, Infrared, Ultraviolet, Visible and Raman Spectroscopy, Nuclear magnetic resonance and Electron Spin Resonance Spectroscopy.

Module 3: Light Scattering and X-Ray methods

Module 4: Mass Spectrometry–principle, techniques, application; GC-MS, LC-MS

Recommended books:

1. Crude oils, Their sampling, analysis and evaluation – H.N. Giles & Clifford O. Mills, ASTM International, 2011
2. The Chemistry and Technology of Petroleum – J. G. Speight, CRC Press, 2014
3. Crude Oil Chemistry – V. Simanzhenkov & R. Idem, Marcel Dekker, USA, 2003
4. Crude Oil Petroleum Products Process Flowsheets – J-P Wauquier Institut Francais du Petrole Publications, Editions TECHNIP, 1995

Paper III
Course PPR103

100marks/4credits

Petrochemicals

Module 1: Definitions of Petrochemicals, feed stocks, intermediates and finished products. Major 1st generation petrochemicals production, thermodynamics & kinetics and their uses. Comparison of gas based and naphtha based petrochemicals manufacture.

Module 2: Naphtha cracking, operating conditions for cracking, the products streams, fractionating the products. Pyrolysis gasoline and other by products. Flow diagram of a typical naphtha cracking plant.

Module 3: Chemicals from Methane, Chemicals from Ethane, Ethylene, Acetylene, Chemicals from C₃, C₄ and higher carbon atoms, Synthesis gas and chemicals, Polymers of olefins, Petroleum aromatics, Synthetic Fibers, Synthetic Rubber, Plastics, Synthetic detergents, Petroleum coke and Carbon Black

Module 4: Pollution and toxicity, Waste management and Energy management in Petrochemical industries

Recommended books:

1. Petrochemical Processes – Technical & Economical Characteristics – A. Chauvel & G. Lefebvre, Institute Francis Du Petrole
2. Petrochemical Industries –Technology & Processes – C. R. Lahiri & Dipa Biswas, CBS Publishers
3. A Text on Petrochemicals, B. K. Bhaskara Rao, Khanna Publishers, 2022
4. Springer Handbook of Petroleum Technology, Chang Samuel Hsu, Paul R. Robinson, Springer, 2017
5. Petroleum Science and Technology, Chang Samuel Hsu, Paul R. Robinson, Springer, 2019

Paper IV Lab–I
Course CHT 104

100marks/4credits

Computer Application in Chemical Industries

Writing computer program to solve complex design and modeling problems like heat exchangers, flashers, reactors, distillation columns, plant simulation problems

Paper V Lab–II
Course PPR 105

100marks/4credits

Petroleum Technology Laboratory I

Analysis of Petroleum products–ultimate analysis, molecular analysis, structural analysis (n-d-M). Standard (ASTM/IP) analytical techniques: FIA and other chromatographic methods (Gas Chromatography and Column Chromatography), Sulphonation method

Application of UV, FTIR, Mass spectroscopy, AAS, XRD in petroleum analysis

Interpretation of data from laboratory experiments and design elements for some reactor types used in petrochemical industries.

Second Semester:

Paper VI

Course CHT 201

100marks/4credits

Optimization

Module 1: Introductory concepts : Objective function, single valued function, multi-valued function, non-linear function, linear function, stationary point, relative and absolute extreme, convex, concave and unimodal functions, gradient reduction method, Jacobian and Hessian matrix.

Module 2: Optimization of univariate system using analytical method. Search techniques, quadratic interpolation, cubic interpolation. Optimization of multivariate unconstrained system using.

Module 3: Search techniques. First order methods and second order methods. Optimization of multivariate constrained systems using Lagrange multipliers, penalty function, linear programming and non-linear programming.

Module 4: Computer programming of optimization of specific problems related with chemical industry.

Paper VII

Course PPR 202

100marks/4credits

Reaction Engineering & Catalyst Technology

Group A: Reaction Engineering

Module 1: Mechanism of catalytic and non-catalytic reaction, mathematical analysis of rate expressions used in flow and non-flow reactors. Introduction to chemical and physical rate processes, determinations of controlling steps in overall rate.

Residence time distributions: Residence time functions and relation amongst them. Modeling of real systems. Non-ideality parameters. Prediction of reactor performance.

Module 2: Thermal characteristics of reactors. Isothermal, adiabatic and non-adiabatic conditions. Principles of reactor stability and optimization.

Design of chemical reactors, comparison of performances, optimum operation analysis of reactors, detailed consideration of the design of reactors with emphasis on mass and momentum transport. Momentum, mass and heat transport in fixed and fluidized bed reactors.

Group B: Catalyst Technology

Module 3: Catalysts: Catalyst preparation techniques, catalyst characterization, catalyst activity and the factors which influence it. The effect of physical properties such as surface area and pore size etc. on catalyst activity, method of determination of their physical properties. Catalyst poisoning.

Module 4: The mechanism of heterogeneous catalytic reactions, adsorption isotherms, kinetics of solid catalyzed fluid reactions, interpretation of chemisorptions and surface catalysis based on modern solid state theories, reaction types and mechanism of selected reactions.

Methodology of catalyst selection and development. Promoters and supports.

Catalysts for various industrial processes executed in petroleum and petrochemical industries.

Paper VIII
Course PPR 203

100marks/4credits

Refinery Engineering

Module 1: Various major Refinery operations: desalting, atmospheric and vacuum distillation, solvent extraction, thermal cracking, catalytic cracking, reforming, hydrocoking, hydro-isomerization, Delayed coking, Hydrogen production, Blending, LOBS, Lube oil processing.

Module 2: Gas to liquid fuels, Renewable diesel and Jet fuels, Hydrocarbon processing by plasma

Module 3: Offsites and utilities, start-up and shut down operations, trouble shooting operations.

Module 4: Refinery-wide optimization. Crude oil and product quantity measurement and pricing methods. Automatic plant control instrumentation, logic and strategies. Maintenance and safety measures in a refinery. Management procedure of refining operations.

Recommended books:

1. Fundamentals of Petroleum and Petrochemical Engineering, U. Ray Chaudhuri, CRC Press, Taylor & Francis group, 2013
2. Crude Oil Chemistry, V. Simanzhenkov, R. Idem, Marcel Dekker, Inc., 2016
3. Modern Petroleum Technology, Vol. II, A. G. Lucas, John Wiley & Sons Ltd., 2000
4. Fundamentals of Petroleum Refining, M. A. Fahim, T.A. Alsahhaf, A. Elkilani, Elsevier, 2010
5. Petroleum Refining, 3 Conversion Processes, P. Leprince, Editions Technip, 2001
6. Springer Handbook of Petroleum Technology, Chang Samuel Hsu, Paul R. Robinson, Springer, 2017
7. Petroleum Science and Technology, Chang Samuel Hsu, Paul R. Robinson, Springer, 2019
8. Thermal and Catalytic Processes in Petroleum Refining, Serge Raseev, CRC Press, 2003
9. Handbook of Petroleum Processing, David Jones, Peter Pujado, 2006

Paper IX
Course PPR 204

100marks/4credits

High Pressure Technology

Module 1: Behaviour of metal under high pressure and temperature, stress and strain distribution in thick-walled cylinder pressure reactors.

Module 2: High pressure equipment used in measurement of high pressure, closures, connections, valves, compressors, liquid pumps.

Module 3: P-V-T relationships, phase equilibria, specific heat, viscosity under high pressure. **Module 4:** Design aspects of high pressure reactors used in petroleum and petrochemical industries.

Recommended books:

1. High Pressure Technology, Edward W. Comings, McGraw-Hill, 1956
2. High Pressure Process Technology: Fundamentals and Applications, A Bertucco, G. Vetter, Elsevier, 2001
3. Introduction to High Pressure science and technology, Jose Manuel Recio, Jose Manuel Menendez, Alberto Otero de la Roza, CRC Press, 2015

Paper X Lab–III
Course PPR 205

100marks/4credits

Petroleum Technology Laboratory II

Catalytic Cracking Catalyst - preparation, characterization and application

Preparation and characterization of some petrochemicals:

Polystyrene, Polyvinyl alcohol from polyvinyl acetate, Epoxy resins

Third Semester:

Paper XI

Course CHT 301

50 Marks/2 credits

Research Methodology

Module 1: Introduction:

Definition of Research Methodology. Different types of methods for research. Approaches of investigation of solutions for research problem, Effective literature studies approaches, (Discuss in class Web Search: Introduction to Internet. Use of Internet and www. Using of search engines and advanced search tools.)

Data Collection and Simulation

Module 2: Data Analysis

Analysis tools: Review of Basic Statistical Measures (mean, median, mode, quartile, percentile, variance, covariance, correlation, regression), Probability Distributions (Binomial, Poisson, Uniform, Exponential, Normal), Central Limit Theorem, ANOVA, Latin Square Design, Sampling (Chi-square Distribution, F- Distribution), Test of Hypothesis.

Module 3: Reporting

Technical report writing, Technical paper writing, Plagiarism and citation. Major contribution, outcome of the research, patent possibilities. Patent writing, Patent filing, IPR

Introduction to presentation tool, features and functions, creating presentations, customising presentation using Microsoft PowerPoint, Open Office etc.

Introduction to spread-sheet applications, features and functions, using formulae and functions, data storing, features for statistical data analysis, generating charts/graphs and other features.

Paper XII

Course PPR 302

(150+100) Marks/(6+4) credits

a) Project Feasibility

Each student shall be required to submit two bound type written copies of a project report on a proposed chemical plant manufacturing product/products related to one's course/subject to be worked out under the supervision of a faculty member. The report shall include mass and energy balances, type and capacity of equipment selected and recommended, plant layout, feasibility analysis highlighting market survey, pattern of assistance available from the central and state

government agencies, bank and financial institutions. Assistance for technology, raw materials, finance.

Legal obligation.

- b) The student is to appear in a **Viva-Voce** examination.

Paper XIII

Course PPR 303

100 Marks/4 credits

Mini Project with seminar

Each student will be required to prepare and submit an essay or review paper on selected technological topic related to subject under the supervision of a faculty member. He/She shall give a talk based on his/her paper before the Seminar. The attendance in the seminar is compulsory for all the students.

Paper XIV

Course PPR 304

100 Marks/4 credits

Thesis: Foundation

Each student shall be required to carry out under the supervision of Faculty member (s) and/or External member as the case may be, an original investigation on an industrial problem related to one's course/subject. She/he shall submit two typewritten bound copies of a report on Research Work at least 15 days before the commencement of final semester examination and shall defend her/his report in a Viva-voce Examination.

Fourth Semester

Paper XV

Course PPR 401

(300+100) Marks/ (12+4) credits

Thesis: Final

- (a) Each student shall be required to carry out under the supervision of a faculty member original investigation on an industrial problem related to subject. He/She shall submit three type-written bound copies of thesis embodying the results of his/her investigations
- (b) The student shall defend his/her thesis in a **viva-voce** examination.

Paper XVI

Course PPR 402

(100) Marks/ (4) credits

General Viva Voce

Each student shall be required to appear General Viva Voce Examination.