DEPARTMENT OF CHEMICAL ENGINEERING
ANNA UNIVERISTY, CHENNAI

VISION:

To be recognized globally and to function as a catalyst in providing outstanding education, to develop engineers who will excel in academia, industry, and research, and to strive for sustainable technologies and societal needs.

MISSION:

1. To disseminate high-quality Chemical Engineering Education.
2. To develop quality engineers and technocrats with inter-disciplinary skills.
3. To collaborate with industries for innovative concepts/ideas.
4. To perform high-impact research for the benefit of society.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.TECH. PETROLEUM REFINING AND PETROCHEMICAL
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM

1. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1.	Technical expertise in the design, installation, operation, maintenance, planning, optimization, and assessment of petrochemical processes and plants.
2.	Integration, assimilation, and development for smooth co-existence.
3.	Operation as a team at different levels towards professional development.
4.	Develop the capacity for research, life-long learning, and independent thinking in petroleum and allied fields.
5.	Equip oneself for lateral thinking and leadership roles in the workplace.

2. PROGRAM OUTCOMES (POs)

S.No.	Programme Outcomes
1.	Ability to independently carry out research/investigation and development work to solve practical problems
2.	Ability to write and present a substantial technical report/document
3.	Able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery shall be at a level higher than the requirements in the appropriate bachelor programme.
4.	Able to control and analyze chemical, physical and biological processes including the hazards associated with petroleum related processes.
5.	Capability to create mathematical models for static and dynamic processes, as well as compute and simulate them.
6.	Ability to effectively practise as professional engineers, managers and leaders in the maritime, industrial and/or a wide range of other domains.

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME

Program Educational Objectives	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	3	3	3	2	3
PEO2	2	2	2	2	3	3
PEO3	3	3	3	2	2	3
PEO4	3	3	3	3	2	3
PEO5	2	2	2	3	3	2

4. PROGRAM ARTICULATION MATRIX

Year	Sem	Subjects	PO1	PO2	PO3	PO4	PO5	PO6
Year I	SEM 1	Advanced Numerical Methods	3	3	3	3	2	2
		Research Methodology and IPR						
		Petrochemical Technology	2.4	2.6	2.8	2.8	1	2.4
		Petroleum Refining Technology-I - Integrated	2.3	1.5	2.5	2.13	1	1.8
		Petroleum Refinery Equipment Design and drawing – Integrated	1.70	2.00	2.70	-	1.70	1.70
		Program Elective I						
Year I	SEM 2	Catalytic Reactor Theory	2	2.3	2.7	2	2.5	2
		Multicomponent Distillation	2.60	2.40	2.40	1.80	1.75	2.00
		Petroleum Refining Technology - II	1.6	1.7	2.2	2.9	1	2.5
		Petroleum Thermodynamics	2	1	3	2	1.8	2
		Program Elective II						
		Program Elective III						
		Practical						
		Petroleum Testing Lab	2.33	2.6	3	2.25	2	2.25
		Mini Project with Seminar	2.6	2.6	3	2.3	3	2
Year II	SEM 3	Process Modelling and Optimization	3.00	2.20	3.00	-	1.00	1.00
		Program Elective IV						
		Program Elective V						
		Program Elective VI						
		Practical						
		Internship						
		Project Work I	2.75	2.5	2.25	1.75	1.75	2
Year II	SEM 4	Practical						
		Project Work II	3	2.33	2	2	1.67	2
			2.75	2.5	2.25	1.75	1.75	2

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.TECH. PETROLEUM REFINING AND PETROCHEMICAL
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA & SYLLABI

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	PP3101	Petrochemical Technology	PCC	3	0	0	3	3
4.	PP3102	Petroleum Refining Technology-I	PCC	3	0	2	4	4
5.	PP3103	Petroleum Refinery Equipment Design and Drawing	PCC	3	0	2	4	4
6.		Professional Elective I	PEC	3	0	0	3	3
			TOTAL	**16**	**1**	**6**	**21**	**21**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PP3201	Catalytic Reactor Theory	PCC	3	0	0	3	3
2.	PP3251	Multicomponent Distillation	PCC	3	0	0	3	3
3.	PP3202	Petroleum Refining Technology - II	PCC	3	0	0	3	3
4.	PP3203	Petroleum Thermodynamics	PCC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
7.	PP3211	Petroleum Testing Lab	PCC	0	0	4	4	2
8.	PP3212	Mini Project with Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**0**	**6**	**24**	**21**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PP3301	Process Modelling and Optimization	PCC	3	1	0	4	4
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Professional Elective V	PEC	3	0	0	3	3
4.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
5.	PP3311	Internship	EEC	0	0	4	4	2
6.	PP3312	Project Work I	EEC	0	0	12	12	6
			TOTAL	**12**	**1**	**16**	**29**	**21**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PP3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 75

FOUNDATIONAL COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4

PROFESSIONAL ELECTIVE COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	PP3001	Petroleum Geology	PEC	3	0	0	3	3
2.	PP3002	Biofuels	PEC	3	0	0	3	3
3.	PP3003	Petroleum Exploration Technology	PEC	3	0	0	3	3
4.	PP3004	Oil and Gas Well Testing	PEC	3	0	0	3	3
5.	CL3053	Fluidization Engineering	PEC	3	0	0	3	3
6.	PP3005	Modern Separation Techniques	PEC	3	0	0	3	3
7.	PP3051	Multiphase Flow	PEC	3	0	0	3	3
8.	CL3051	Computational Fluid Dynamics	PEC	3	0	0	3	3
9.	PP3006	Offshore drilling and Production Practices	PEC	3	0	0	3	3
10.	CL3056	Polymer Processing Technology	PEC	3	0	0	3	3
11.	PP3007	Non-conventional Treatment of	PEC	3	0	0	3	3

		Natural gas						
12.	PP3052	Piping and Instrumentation	PEC	3	0	0	3	3
13.	CL3052	Design of Experiments	PEC	2	0	2	4	3
14.	CL3055	Sustainable Management	PEC	3	0	0	3	3
15.	PP3008	Modelling of Transport Processes	PEC	3	0	0	3	3
16.	PP3009	Advanced Process Dynamics and Control	PEC	3	0	0	3	3
17.	PP3010	Fuel Cell Technology	PEC	3	0	0	3	3
18.	PP3011	Enhanced Oil Recovery	PEC	3	0	0	3	3
19.	PP3012	Supply Chain Management in Oil and Gas	PEC	3	0	0	3	3
20.	PP3013	Petroleum Economics	PEC	3	0	0	3	3
21.	PP3014	Process Plant Safety in Petroleum Industries and Risk Analysis	PEC	3	0	0	3	3
22.	PP3015	Storage and Transportation of Petroleum products	PEC	3	0	0	3	3
23.	PP3016	Corrosion Engineering	PEC	3	0	0	3	3
24.	CL3054	Industrial Instrumentation	PEC	3	0	0	3	3

LIST OF PROFESSIONAL CORE COURSES (PCC)

S.NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	PP3101	Petrochemical Technology	3	0	0	3
2.	PP3102	Petroleum Refining Technology-I	3	0	2	4
3.	PP3103	Petroleum Refinery Equipment Design and Drawing	3	0	2	4
4.	PP3201	Catalytic Reactor Theory	3	0	0	3
5.	PP3251	Multicomponent Distillation	3	0	0	3
6.	PP3202	Petroleum Refining Technology- II	3	0	0	3
7.	PP3203	Petroleum Thermodynamics	3	0	0	3
8.	PP3211	Petroleum Testing Lab	0	0	4	2
9.	PP3301	Process Modelling and Optimization	3	1	0	4

LIST OF EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	PP3212	Mini Project with Seminar	0	0	2	1
2.	PP3311	Internship	0	0	4	2
3.	PP3312	Project Work I	0	0	12	6
4.	PP3411	Project Work II	0	0	24	12
					TOTAL CREDITS	**21**

SUMMARY

	Name of the Programme: M.E					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	4	0	0	0	4
2.	PCC	11	14	4	0	29
3.	PEC	3	6	9	0	18
4.	RMC	3	0	0	0	3
5.	EEC	0	1	8	12	21
6.	**TOTAL CREDIT**	**21**	**21**	**21**	**12**	**75**

SEMESTER I

MA3155 ADVANCED NUMERICAL METHODS L T P C
4 0 0 4

OBJECTIVES

- To make the students understand the methods/algorithms to numerically solve a system of simultaneous algebraic equations.
- To make the students understand the methods to numerically solve the system of simultaneous ordinary differential equations.
- To make the students understand the methods to numerically solve the partial differential equations.
- To make the students understand the methods to numerically solve the elliptic equations.
- To make the students understand the finite element methods for solving the PDEs.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax-Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 Solve numerically system of simultaneous algebraic equations.
CO2 Solve the simultaneous ordinary differential equations (IVP) numerically.
CO3 Solve numerically set of Partial differential equations.
CO4 Solve the set of Elliptic equations numerically.
CO5 Solve the set of PDEs by finite element method.

REFERENCES:

1. Burden. R. L. and Faires. J. D., "Numerical Analysis; Theory and Applications", India Edition, Cengage Learning, 2010.

2. Jain M.K., Iyengar S.R.K. and Jain R.K., Computational Methods for Partial Differential Equations, New Age International, 2nd Edition, New Delhi, 2016.
3. Morton K.W., and Mayers D.F., “Numerical Solution of Partial Differential Equations, Cambridge University Press, Second Edition, Cambridge, 2005.
4. Santosh K Gupta, “Numerical Methods for Engineers”, New Age International (P) Limited, Publishers, New Delhi, 2014.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

PP3101	**PETROCHEMICAL TECHNOLOGY**	**L**	**T**	**P**	**C**
			3	**0**	**0** **3**

OBJECTIVES

- To impart knowledge on feedstocks and their purification.
- To enable the students to learn about the production and development of petrochemicals.
- To enable the students acquire knowledge in manufacture of third- generation petrochemicals.
- To enable the students to learn about the production and application of polymeric products.
- To impart knowledge on the application of petrochemicals.

UNIT I OVERVIEW OF PETROCHEMICALS 9

Petrochemical Industries and their feedstock selection; History, Economics, Growth of petrochemical industry; Resources and generation of different feedstock and their purification, separation based on adsorption.

UNIT II FIRST AND SECOND-GENERATION PETROCHEMICALS 9

Production Methods - Reforming and cracking of feedstocks; Sources- Chemicals from synthesis gas, olefins and aromatics; Ethylene, Propylene, C4 olefins, higher olefins, Benzene, Toluene, Xylene.

UNIT III THIRD GENERATION PETROCHEMICALS 9

Acrylonitrile, Acrylic acid, dimethyl terephthalate, ethanol, ethylene glycol, linear alkyl benzene, methyl tertiary butyl ether, vinyl acetate, vinyl chloride.

UNIT IV POLYMERS 9

Polymers production - Fibers, Rubbers, and Plastics; Acrylonitrile butadiene styrene (ABS); polyethylene -LDPE, HDPE; Silicone- polysilicones; Polypropylene, PVC, PS, SAN, SBR, PAN, Nylon and Polycarbonates.

UNIT V PETROCHEMICALS APPLICATION 9

Petrochemicals-Lubricants, additives, adhesives, agrochemicals, cosmetics raw materials, electronic chemicals, detergents, paint, healthcare and pharmaceuticals.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Comprehend the history, economics, growth, and feedstocks selection of the petrochemical Industry.
CO2: Recognize and recall the manufacturing and development of first & second-generation petrochemicals.
CO3: Describe the manufacturing, development, and applications of third-generation petrochemicals.
CO4: Classify the production and applications of important polymeric products.
CO5: Recognize and recall the application of petrochemicals as lubricants, agrochemicals, cosmetics, and pharmaceuticals.

REFERENCE BOOKS

1. Brownstein A.M. 'Trends in Petrochemical Technology', Petroleum Publishing Company, 1976.
2. Robert Meyers, 'Handbook of Petrochemicals production processes', (McGraw Hill Handbooks), 2004.
3. G.Margaret Wells , 'Handbook of Petrochemicals and Processes' 2nd Revised Edition, Gower Publishing Company. 2018.
4. B.K.B.Rao, 'A Text on Petrochemicals', Khanna publishers, 2004.
5. I D Mall, 'Petrochemical process Technology', Macmillan India Limited, 2007.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	2	3	2	1	2
CO2	2	3	2	3	1	2
CO3	3	3	3	3	1	3
CO4	3	3	3	3	1	2
CO5	3	2	3	3	1	3
Average CO	2.4	2.6	2.8	2.8	1	2.4

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3102 PETROLEUM REFINING TECHNOLOGY - I

L	T	P	C
3	0	2	4

OBJECTIVES

1. To enable the students to learn about the types and composition of crude and its products.
2. To enable the student to learn the importance of distillation process in a refinery.
3. To impart knowledge in different cracking processes involved in the refinery.
4. To enable the student to learn about different refining processes involved using hydrogen.
5. To impart knowledge on the processes involving heavy hydrocarbons and the importance of safety, environmental, and quality control of petroleum products.

UNIT I ORIGIN AND EXPLORATION OF CRUDE OIL 9

Origin, Exploration and production of petroleum, types of composition and characteristics of crude oil; the crude oil assay; predicting product qualities Petroleum products; Crude Oil Receiving, Desalting of Crude Oil.

UNIT II ATMOSPHERIC AND VACUUM DISTILLATION 9

Refining process - The atmospheric crude distillation unit - Process Description and design characteristics of atmospheric crude distillation fractionating tower, The fractionator overhead system, The side streams and intermediate reflux sections, The crude feed preheat exchanger system design; The vacuum crude distillation unit - Process description, The vacuum crude distillation unit's flash zone, The tower overhead ejector system, Draw-off temperatures, Determination of pump around and internal flows for vacuum towers, Calculation of tower loading in the packed section of vacuum towers.

UNIT III REFORMING AND CRACKING 9

Catalytic reforming - Feedstocks, Catalysts, Process flow schemes; Hydrogen Generation Fluid catalytic cracking (FCC) - Fluidization, Process control, catalyst, Reaction chemistry and mechanisms; Distillate hydrocracking - Flow schemes, chemistry, Catalysts, Catalyst loading and activation, Catalyst deactivation and regeneration, Design and operation of hydrocracking reactors, Residcracking – implications and technology.

UNIT IV HYDROTREATING AND ALKYLATION 9

Hydrotreating- Flow schemes, Chemistry, Catalysts, Catalyst loading and activation, Catalyst deactivation and regeneration Design and operation of Hydrotreating reactors; Gasoline components - Motor fuel alkylation, HF alkylation process flow description, Sulfuric acid alkylation, Alkylate properties; Catalytic olefin condensation, Catalytic condensation process for gasoline production, Isomerization technologies for the upgrading of light naphtha and refinery light ends.

UNIT V THERMAL CRACKING, LUBE OIL AND ASPHALT PRODUCTION 9

Thermal cracking processes, Residum hydrocracking, Lube oil refinery, Lube oil properties; Asphalt production- Propane Deasphalting, Solvent Dewaxing, Hydrofinishing. Environmental aspects of refining, Quality control of products in petroleum refining.

THEORY: 45 PERIODS

LIST OF EXPERIMENTS:

PRACTICAL: 30 PERIODS

1. Moisture content and Water separability index determination of a given fuel sample
2. Obtain the Thermal stability and color of the given fuel sample.
3. Characterization of a given sample of gases/liquids using Gas chromatography, Refractive index and HPLC.
4. Estimation of Lead in gasoline sample
5. Determine the Ash content and ORSAT analysis of the given sample.

COURSE OUTCOMES:
CO1: Define the types and composition of crude and its products.
CO2: Illustrate the importance of distillation process in a refinery.
CO3: Describe the different cracking processes involved in the refinery.
CO4: Explain the different refining processes involved using hydrogen.
CO5: Explain the processes involving heavy hydrocarbons and the importance of safety, environmental, and quality control of petroleum products.
CO6: Demonstrate proficiency in performing quantitative analysis techniques for fuel analysis.
CO7: Demonstrate the ability to analyze and interpret data obtained from experiments.
CO8: Apply relevant techniques to determine and assess specific properties and parameters of fuel samples.

TOTAL: 75 PERIODS

REFERENCE BOOKS

1. Jones, David SJ, and Peter P. Pujadó, "Handbook of petroleum processing", Springer Science & Business Media, 2006.
2. Nelson, W.L "Petroleum Refinery Engineering" McGraw Hill Publishing Company Limited, 4th edition, 1985.
3. Hobson, G.D. – Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum. U.K. 1973.
4. Smalheer, C.V and R.Kennedy Smith Lubricant Additives. The Lezius – Hill Company, Cleveland, Ohio. USA, 1987.
5. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, Mc Graw – Hill Publishing.2nd edition, 1990
6. Watkins, R.N "Petroleum Refinery Distillation", 2nd Edition, Gulf Publishing Company, Texas, 1981

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	2	3	-	-	2
CO2	2	2	3	1	-	3
CO3	3	2	3	1	-	3
CO4	2	1	3	1	-	2
CO5	2	1	3	2	-	3
CO6	3	1	1	3	1	-
CO7	3	2	3	3	1	1
CO8	1	1	-	3	1	1
Average CO	2.3	1.5	2.5	2.13	1	1.8

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3103 PETROLEUM REFINERY EQUIPMENT DESIGN AND DRAWING

L	T	P	C
3	0	2	4

OBJECTIVES

- To enable the students to understand the fundamental concepts of equipment, utilities and its design in petroleum industry.
- To enable the students to learn the working and calculations of pumps and compressors.
- To enable the students to understand the reactor and vessel concepts, calculation and design the same.
- To enable the students to understand the heat transfer equipment concepts, calculation and design the same.
- To enable the students to learn and solve the given problems using ASPEN.

UNIT I REACTORS 9

Use of standards and codes in design activity; Reactors in Refineries - Batch, Continuous Stirred Tank Reactor, and Plug Flow Reactor Concepts; Naphtha Reformer Calculations, Calculations for a Fluidized Catalytic Cracking Reactor.

UNIT II PUMPS 9

Pumps, Pump selection, Selection characteristics, Capacity range, evaluating pump performance; specifying a centrifugal pump - mechanical specification, process specification, Compiling the pump calculation sheet, Centrifugal pump seals; Pump drivers and utilities, Reacceleration requirement, principle of the turbine driver, performance of the steam turbine.

UNIT III COMPRESSORS 9

Compressors, calculating horsepower of centrifugal compressors; Centrifugal compressor surge control; performance curves and seals, specifying a centrifugal compressor, calculating reciprocating compressor horsepower; Reciprocating compressor controls and inter-cooling, Specifying a reciprocating compressor, Compressor drivers, utilities, and ancillary equipment.

UNIT IV HEAT TRANSFER EQUIPMENTS 9

Heat exchangers - Theory of Heat Exchange; Fouling, General design considerations - Choice of tube side versus shell side, estimating shell and tube surface area and pressure drop; Air coolers, Condensers, separators, Reboilers, Pipe-Still Furnace, Pipe-Still Furnace Element; Operation of a Furnace, Draught in a Furnace, Furnace Design by the Wilson, Lobo and Hottel Method. Fired heaters, Codes and standards, Thermal rating, Heater efficiency, Burners, Refractories; stacks, and stack emissions, specifying a fired heater.

UNIT V VESSELS 9

Design consideration for mixing - Types of agitators; Design of agitation system components; Types of storage tank and their design considerations; Vessels, Fractionators, trays, and packing's, Gap and Overlap, Packie's Correlation, Drums and drum design, specifying pressure vessels. Horizontal and Vertical applications.

THEORY: 45 PERIODS

LIST OF DRAWINGS:

PRACTICAL: 30 PERIODS

1. Solve the given reactor problem using ASPEN and draw the equipment by free hand sketch/using AUTOCAD.
2. Solve the given pump problem using ASPEN and draw the equipment by free hand sketch/using AUTOCAD.
3. Solve the given compressor problem using ASPEN and draw the equipment by free hand sketch/using AUTOCAD.

4. Solve the given heat transfer equipment problem using ASPEN and draw the equipment by free hand sketch/using AUTOCAD.
5. Solve the given vessel problem using ASPEN and draw the equipment by free hand sketch/using AUTOCAD.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: Analyze reactor system, design and interpret data.

CO2: Apply the principles learned to select and calculate suitable pumps for industrial applications.

CO3: Apply the principles learned to select and calculate suitable compressors for industrial applications.

CO4: Evaluate heat transfer equipment and cooling systems for the petroleum industries.

CO5: Design and analyze various vessels, including storage tanks, fractionators, trays, and drums.

Laboratory:

CO6: Utilize Aspen software to solve reactor problems and generate equipment drawings using AUTOCAD.

CO7: Apply Aspen software to solve pump problems and create equipment drawings using AUTOCAD.

CO8: Employ Aspen software to solve compressor problems and generate equipment drawings using freehand drawing.

REFERENCE BOOKS

1. Joshi M. V.; V VMahajani, S B Umarji , "Process Equipment Design"; 5th edition, MacMillan India, 2016
2. Brownell, Young, "Process Equipment Design", Wiley, 2009
3. Lyons, William C., and Gary J. Plisga. Standard handbook of petroleum and natural gas engineering. Elsevier, 2011.
4. Kern, Donald Quentin, and Donald Q. Kern., "Process heat transfer", Vol. 871, New York McGraw-Hill, 1950.
5. Sarit K. Das, Process Heat Transfer, Narosa Publishing House, 2009.
6. S. B. Thakore, B I Bhatt, "Introduction to Process Engineering and Design", McGraw-Hill, 2007
7. Haydary, Juma. "Chemical process design and simulation: Aspen Plus and Aspen Hysys applications". John Wiley & Sons, 2019.
8. Al-Malah, Kamal IM. "Aspen plus: chemical engineering applications". John Wiley & Sons, 2022.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	2	3	-	2	2
CO2	2	2	3	-	2	2
CO3	2	2	3	-	2	2
CO4	2	2	3	-	2	2
CO5	2	2	3	-	2	2
CO6	1	2	2	-	1	1
CO7	1	2	2	-	1	1
CO8	1	2	2	-	1	1
Average CO	1.70	2.00	2.70	-	1.70	1.70

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

SEMESTER II

PP3201 CATALYTIC REACTOR THEORY L T P C

3 0 0 3

OBJECTIVES

1. To impart knowledge about the non-ideal flow, physical properties of solid catalysts, catalytic and non-catalytic heterogeneous systems.
2. To enable students to learn the chemical kinetics for homogeneous and heterogeneous reactions and their applications in design of batch and flow reactors.
3. To enable students to apply thermodynamic principles in petroleum and allied processes from a chemical engineering viewpoint.
4. To develop understanding of non-ideal reactor design.
5. To impart knowledge of hydrodynamics and transport effects in multiphase reactors.

UNIT I FUNDAMENTALS OF CATALYTIC REACTORS 9

Catalytic reactor types and their industrial significance, reactors with moving bed, Heterogeneous Catalysis, Intrinsic kinetics of heterogeneous reactions, External transport processes, Internal transport processes, Combination of external and internal transport effects.

UNIT II FIXED BED REACTORS 9

Fixed bed reactors: modelling, averaging over catalyst particles, Fluidized bed: Hydrodynamic features, reactor performance, reactor modelling, three phase FBR: Hydrodynamic features, Three phase slurry reactors: Design. Modelling and scale up of reactors.

UNIT III MONOLITH REACTORS 9

Monolith reactors: design of wall coated monolith channels, three phase processes, Micro reactors for catalyzing reactions: Single and multiphase reactors.

UNIT IV KINETICS AND DFT 9

Kinetic objectives, microkinetic approach to kinetic analysis, TAP approach to kinetic analysis, Reactor Types, Techniques for numerical solution of ordinary and partial differential equations, Computational fluid dynamics techniques. Introduction to Density Functional Theory (Born–Oppenheimer approximation, Hartree-Fock Theory, Self-Consistent Field, KohnSham Density Functional Theory, Bloch’s Theorem and Plane Wave Basis Set).

UNIT V REACTOR MODELING AND DESIGN 9

Hydro treating of oil fractions: Fundamentals of HDT, Reactor modelling, Catalytic reactors for fuel processing: Reactor design and fabrication, water gas-shift reactors, modelling of catalytic deoxygenation of fatty acids: model equations, adsorption parameter evaluation, particle diffusion and parameter estimation study.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Analyze the transport processes in heterogeneous reactions.
CO2: Assess the performance of two and three phase reactors.
CO3: Identify the type of reactors based on performance.
CO4: Evaluate the kinetics of heterogeneous reactors and apply with computational studies.
CO5: Apply the acquired modeling and design knowledge to Industrial heterogeneous catalytic reactors.

REFERENCE BOOKS

1. G.F. Froment, K.B, Bischoff, J. de Wilde, Chemical Reactor Analysis and Design, 3rd ed., Wiley & Sons, 2011.
2. Carberry – J.J. Chemical and Catalytic, Reaction Engineering, McGraw – Hill Book Co.,NY, 2001.
3. Muchlyonor I, Dobkina E.,.DeryozhkinaV,.andSorco V., Catalyst Technology – CatalystTechnology MIR Publication, Moscow, 1982.
4. Z.I. Önsan, A.K. Avci, Multiphase catalytic reactor- Theory, Design, manufacturing and applications, John Wilaey and Sons, 2016.
5. Westerp K.R. Vanswaaij and Beenackers ACM, Chemical Reactor Design and Operations, Wiley, NY 1991
6. M. Albert Vannice, Kinetics of Catalytic Reactions, Springer; 2005 edition (August 24, 2005)
7. Wolfram Koch, Max C. Holthausen, A Chemist's Guide to Density Functional Theory, WileyVCH; 2 edition (July 11, 2001), ISBN: 978-3527303724
8. Michel Boudart, Kinetics of Heterogeneous Catalytic Reactions, Princeton University Press 198 (1984), ISBN: 978-069108347

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	3	1	-	2	1
CO2	2	1	3	1	3	2
CO3	2	3	-	3	2	1
CO4	2	1	3	1	3	2
CO5	2	3	-	2	2	1
Average CO	2	2.3	2.7	2	2.5	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3251 MULTICOMPONENT DISTILLATION

L	T	P	C
3	0	0	3

OBJECTIVES

1. To enable the students to learn the thermodynamic principles involved in VLE and the nonideal behavior and characterize using activity and fugacity coefficients.
2. To enable the students to learn about bubble point and dew point temperatures for multicomponent mixtures.
3. To enable the students to learn the column sequencing for distillation trains and evaluate rigorous methods of distillation design.
4. To impart knowledge about Kb method and Lewis Matheson calculation.
5. To enable the students to study about staged columns for separation of multicomponent and petroleum mixtures.

UNIT I OVERVIEW OF MULTICOMPONENT DISTILLATION 9

Fundamental principles involved in the separation of multi-component mixtures; Determination of bubble-point and Dew Point Temperatures for multi-component mixtures; equilibrium flash distillation calculations for multi-component mixtures, Multiflash calculations.

UNIT II THERMODYNAMICS FOR MULTICOMPONENT DISTILLATION 9

Fundamental Thermodynamic principles involved in the calculation of vapor-liquid equilibria and enthalpies of multi-component mixtures; Use of multiple equations of state for the calculation of K values – DePriester Charts, Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid, phase activity coefficient; Residue curve bundles – Matrix Description of Residue curve structure.

UNIT III CONSIDERATION IN COLUMN DESIGN 9

General considerations in the design of columns, Column sequencing – Heuristics for column sequencing, Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rmin for multi-component distillation – Underwood method – Colburn method – Smoker's equation – Pinch technology.

UNIT IV METHODS FOR COLUMN DESIGN 9

Theta method of convergence – Kb method and the constant composition method, Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Thick and Geddes, Stage and reflux requirements – Short cut methods and Simplified graphical procedures – Hengstebeck Diagrams – Minimum reflux by Hengstebeck Diagrams – Key ratio Plots.

UNIT V TYPES OF MULTICOMPONENT DISTILLATION COLUMN 9

Hydro treating of oil fractions - Fundamentals of HDT, Reactor modelling and simulation, Catalytic reactors for fuel processing, Basic reactions for fuel processing, Reactor design and fabrication, water gas-shift reactors; modelling of catalytic deoxygenation of fatty acids: model equations, adsorption parameter evaluation, particle diffusion and parameter estimation study.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Explain the thermodynamic principles involved in VLE and the nonideal behavior and characterize using activity and fugacity coefficients.
CO2: Evaluate bubble point and dew point temperatures for multicomponent mixtures.
CO3: Apply column sequencing for distillation trains, evaluate rigorous methods of distillation design.
CO4: Practice Kb method and Lewis Matheson calculation.
CO5: Design staged columns for separation of multicomponent and petroleum mixtures.

REFERENCE BOOKS

1. Holland, C. D. Fundamentals of multicomponent distillation. McGraw-Hill. 1981.
2. Kister, H. Z., Haas, J. R., Hart, D. R., & Gill, D. R. Distillation design (Vol. 1). New York: McGraw-Hill. 1992.
3. Petlyuk, F. B. Distillation theory and its application to optimal design of separation units. Cambridge University Press. 2004.
4. Towler, G., &Sinnott, R. K. Chemical engineering design: principles, practice and economics of plant and process design. Elsevier. 2012.
5. Holland, C. D. Multicomponent distillation. Prentice-Hall. 1963.
6. Seader, Junior D., Ernest J. Henley, and D. Keith Roper., "Separation process principles: With applications using process simulators", John Wiley & Sons, 2016.
7. Mc Cabe, Warren L., Julian C. Smith, and Peter Harriott., "Unit operation of chemical engineering", McGraw-Hill, 2018.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	2	1	-	2
CO2	3	2	2	2	1	2
CO3	3	3	3	2	2	2
CO4	3	3	3	2	2	2

CO5	3	3	2	2	2	2
Average CO	2.60	2.40	2.40	1.80	1.75	2.00

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3202 PETROLEUM REFINING TECHNOLOGY – II **L T P C**
3 0 0 3

OBJECTIVES

1. To enable the students to learn about the importance of different pilot distillation process in refineries and analysis of petroleum fractions and crude oils.
2. To enable the students to study the low boiling products, distillates, residual fluids and blending components.
3. To impart knowledge about the different processing units involved for processing the removal of acid gas and mercaptans.
4. To enable the students to learn about the importance of hydrogen, asphalt and lubricants in refineries.
5. To enable the students to study the safety systems involved during crude processing and the importance of safety and environmental considerations.

UNIT I CHARACTERISATION OF REFINERY FEEDSTOCKS 9

Refinery feed stocks and products, physical property characterization data, true boiling point distillation, ASTM distillation, simulated distillation by gas chromatography; chemical analysis data, thermo physical properties of petroleum fractions and crude oils. Standards.

UNIT II GASOLINE AND PETROCHEMICAL BLENDING 8

Low boiling products- Gasoline, leaded gasoline, gasoline blending and impact; distillate and residual fuels, petrochemical blending components.

UNIT III GAS PROCESSING AND ACID GAS PROCESSING 10

Gas processing units- Acid gas processing, chemical solvents, physical solvents, mercaptans removal, Refinery gas plant.

UNIT IV HYDROGEN, ASPHALT AND LUBRICANTS IN PETROCHEMICAL INDUSTRIES 9

Hydrogen requirements in modern refineries- hydrogen source, hydro treating; sulphur facilities in refinery- claus process, tail gas clean up; asphalt- asphalt products, lubricants, synthetic lubes, ethylene plants, refinery interactions, solvent recovery of aromatics, fuel values- heating values, Clean fuels.

UNIT V SAFETY IN PETROCHEMICAL INDUSTRIES 9

Safety in petroleum refineries, Hazards in Refinery unit & Hazard Analysis, safety consideration in plant layout, pressure relief systems, flare relief systems, emergency alarms, noise in refineries, ecological consideration in petroleum refineries.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Explain the importance of different distillation process in refineries and chemical, physical analysis of petroleum fractions and crude oils.
CO2: Recognize and recall the low boiling products, distillates, residual fluids and blending components.
CO3: Illustrate the different processing units involved for removal of acid gas and mercaptans.
CO4: Differentiate the importance of hydrogen, asphalt and lubricants in refineries.
CO5: Formulate the safety systems involved during crude processing and the importance of safety and environmental considerations.

REFERENCE BOOKS

1. M.A.Fahim, T.A.AL-Sahhaf, A.S.Elkilani, “Fundamentals of Petroleum Refining, Elsevier, 2010
2. 2.William. L. Leffler, Petroleum Refining in Non-technical Language, 4th edition, Pennwell corporation, 2008.
3. Jones, David SJ, and Peter P. Pujadó, “Handbook of petroleum processing”, Springer Science & Business Media, 2006.
4. Nelson, W.L “Petroleum Refinery Engineering” McGraw Hill Publishing Company Limited, 1985.
5. Watkins, R.N “Petroleum Refinery Distillation”, 2nd Edition, Gulf Publishing Company, Texas, 1981

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	1	1	2	3	1	3
CO2	-	1	2	2	1	2
CO3	2	2	3	3	1	1
CO4	1	2	2	3	1	3
CO5	2	2	2	3	1	3
Average CO	1.6	1.7	2.2	2.9	1	2.5

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3203 PETROLEUM THERMODYNAMICS L T P C

3 0 0 3

OBJECTIVES

1. To impart knowledge on PVT behavior of fluids, laws of thermodynamics, thermodynamic property relations and their application to fluids.
2. To enable the students to learn about thermodynamic analysis of petroleum hydrocarbons.
3. To enable the students to learn about high pressure and low pressure VLE problems in hydrocarbon processing.
4. To enable the students to have in depth knowledge in hydrocarbon fluid characterization.
5. To enable the students to apply thermodynamic multicomponent principles for reservoir fluid characterization, transportation of petroleum products.

UNIT I INTRODUCTION TO PETROLEUM THERMODYNAMICS 9

Thermodynamic behavior and analysis; Volumetric analysis of a gas mixture , apparent weight and gas constant; isothermal compressibility; Heat capacities- specific heats; phase behavior, phase diagram for pure component and multicomponent system.

UNIT II CHEMICAL THERMODYNAMICS OF PETROLEUM HYDROCARBONS 9

Pressure-Temperature behavior; pure component system, Binary systems, Effect of composition on phase behaviour; Equation of state, Cubic Equation of state and their behavior, Comparative assessment of cubic EOS, Solution methods for cubic EoS; Z factor, Principle of corresponding states-Acentric factor.

UNIT III VAPOR-LIQUID PHASE EQUILIBRIA OF HYDROCARBON SYSTEMS 9

Equilibrium ratios for real solutions Wilson's correlation, Standing's correlation; convergence pressure method, Hadden's method, standing's method, Rzasa's method; Equilibrium ratios for the plus fraction, Campbell's method, Winn's method, Katz's method; Applications of the equilibrium ration in reservoir engineering, Separation- flash calculations with standing's method

UNIT IV HYDROCARBON FLUID CHARACTERISTICS 9

Gas formation volume factor; Gas solubility; Oil formation volume factor; Viscosity; fluid Compressibility.

UNIT V THERMODYNAMIC APPLICATION 9

Thermodynamics of functions of state; Property changes computation; Thermodynamics of systems of variable composition, Fugacity- cubic Eos Fugacity, Industrial application; Pipeline modeling Gas metering, Hydrate problems, Compositional modeling of reservoirs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Describe the concepts of phase behavior.
CO2: Apply to relate chemical analysis to hydrocarbon properties.
CO3: Analyze and calculate important thermodynamic properties.
CO4: Explain phase equilibria and chemical equilibria.
CO5: Construct the model using thermodynamic functions.

REFERENCE BOOKS

1. Smith, J.M., Van Ness, H.C and Abbot M.M., "Introduction to Chemical Engineering Thermodynamics ",VI edition, McGraw Hill Publishers, 2003.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2005
3. Jean vidal., "Thermodynamics Application in chemical Engineering and the petroleum industry", Institute Francais Du Petrole publications,France, 2003.
4. Stanley.I.sandler., "Chemical and Engineering Thermodynamics", Wiley, 1988.
5. Prausnitz. J.M., Lichtenthaler R.M. and Azevedo, E.G., "Molecular thermodynamics of fluidphase Equilibria", 3rd Edn, Prentice Hall Inc, New Jersey, 1999.
6. Tarek Ahmed.,"Reservoir Engineering",Gulf professional publishing, third edition, 2006.
7. K V Narayanan, "Chemical Engineering Thermodynamics", 2nd Edition, PHI Learning Pvt Ltd, 2013.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	3	2	1	2
CO2	1	1	3	2	1	2
CO3	3	1	3	2	2	2
CO4	2	1	3	2	2	2
CO5	3	1	3	2	3	2
Average CO	2	1	3	2	1.8	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3211 PETROLEUM TESTING LAB L T P C
0 0 4 2

OBJECTIVES

1. To impart practical knowledge in performing standardized tests and analyses
2. To enable the students to learn the fundamental principles underlying the testing and characterization.
3. To impart hands-on experience in operating specialized equipment and instruments.

4. To enable the students to learn and apply appropriate safety measures and procedures in handling petroleum samples.
5. To enable the students to learn and interpret and analyze test results to evaluate the quality, performance, and compliance of petroleum products.

LIST OF EXPERIMENTS

1. Determination of Flash Point.
2. Estimation of Fire Point.
3. Determination of Aniline Point.
4. Estimation of Kinematic Viscosity.
5. Determination of Cloud Point.
6. Estimation of Softening Point.
7. Distillation Characteristics.
8. Determination of Reid Vapor Pressure.
9. Estimation of Calorific Value.
10. Determination of Copper Strip Corrosion.
11. ASTM Distillation, boiling point classification.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Demonstrate competency in conducting a range of petroleum tests.
CO2: Assess, accurately record and analyze experimental data obtained from petroleum tests, employing appropriate statistical and graphical methods.
CO3: Apply theoretical knowledge to interpret test results and draw meaningful conclusions regarding the characteristics and behavior of different petroleum samples.
CO4: Practice standard laboratory procedures and safety protocols to ensure the proper handling, storage, and disposal of petroleum samples and hazardous substances.
CO5: Describe test findings effectively through comprehensive technical reports, including accurate documentation of experimental procedures, results, and analysis.

REFERENCE BOOKS

1. Swadesh, Joel K., "HPLC: practical and industrial applications", CRC press, 2000.
2. Skoog, D. A., Holler, F. J., & Crouch, S. R., "Principles of instrumental analysis", Cengage learning, 2017.
3. Jeffery, G. H. (2022). Vogel's Textbook of Quantitative Chemical Analysis 5th Ed.
4. Shaha, A. K.,"Combustion engineering and fuel technology", Oxford & IBH, 2018.
5. Nadkarni, R. A., & Nadkarni, R. A., "Guide to ASTM test methods for the analysis of petroleum products and lubricants", Vol. 44, West Conshohocken: ASTM International, 2007.
6. Butcher, Kenneth S. "Program Handbook for Engine Fuel, Petroleum and Lubricant Laboratories." NIST, 2012.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	2	-	3
CO2	-	3	-	2	-	2
CO3	2	2	3	2	-	2
CO4	2	3	-	3	-	2
CO5	-	3	-	-	2	-
Average CO	2.33	2.6	3	2.25	2	2.25

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3212 MINI PROJECT WITH SEMINAR **L T P C**
0 0 2 1

OBJECTIVES

1. To enable the students, get exposure to the recent developments in the petroleum field.
2. To enable the students to conduct the literature review and demonstrate the studies.
3. To enable the students achieve knowledge on writing and presentation skills.

COURSE CONTENT:

The students will select a topic related to the field of interest, select literature related to latest developments, analyse, prepare the report and present before the committee for assessment as per Regulations of University

COURSE OUTCOMES:

CO1 Report the latest improvements in their field of expertise
CO2 Review the significant works of literature for the selected and suitable topic
CO3 Practice the presentation and communication skills

Course Articulation Matrix:

Course Outcomes	**Statement**	**PROGRAM OUTCOMES**					
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	Report the latest improvements in their field of expertise	3	3	3	2	3	2
CO2	Review the significant works of literature for the selected and suitable topic	2	3	3	2	3	2
CO3	Practice the presentation and communication skills	3	2	3	3	3	2
	AVERAGE CO	**2.6**	**2.6**	**3**	**2.3**	**3**	**2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

SEMESTER III

PP3301 PROCESS MODELING AND OPTIMIZATION **L T P C**
3 1 0 4

OBJECTIVES

- To impart knowledge on the process and operations in Petroleum Industries
- To enable the students to model reservoirs using reservoir / well log data.
- To enable the students to optimize the units using Linear and Non-Linear Programming.
- To impart knowledge on various techniques used in optimization.
- To impart knowledge on apply optimization techniques in Petroleum and Process industries.

UNIT I INTRODUCTION TO PROCESS MODELING 12

Introduction, Role of models in process systems, Model classification, Model characteristics, conservation, Systematic approach to model building, Modeling goal, Systematic modeling. Conservation principles, Balance volume in process systems, Constitutive relations, Reaction kinetics, Thermodynamic relations, Balance volume relations, Equipment and control relations, auxiliary relations.

UNIT II UNCONSTRAINED SINGLE VARIABLE OPTIMIZATION 12

Newton and Quasi-Newton methods of uni-dimensional search, polynomial approximation methods - Methods using function values only, methods that use first derivatives, Newton's method, Quasi-Newton methods – Linear programming – Nonlinear programming – Penalty function – Lagrange's method.

UNIT II MODEL FORMULATION AND EQUATION-SOLVING APPROACH 12

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, Monolith Reactor Modeling – Pseudo-homogeneous and Heterogeneous models for catalytic reactors- plug flow reactor - heat exchanger, flow sheeting – sequential modular and equation-oriented approach, tearing, partitioning and precedence ordering, decomposition of networks.

UNIT IV RESERVOIR MODELING 12

Geophysical, geological, petrophysical and engineering data with geostatistical methods to create reservoir descriptions for dynamic reservoir modeling (simulation); geostatistical concepts such as variogrammodeling, kriging and sequential Gaussian simulation; combines several techniques to quantify uncertainty in a realistic dynamic reservoir.

UNIT V OPTIMIZATION IN CHEMICAL PROCESS 12

Optimizing recovery of waste heat, optimal shell and tube heat exchanger design, optimal design and operation of distillation column, chemical reactor design and operation.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Explain the fundamentals of modeling and phase equilibria kinetics.
CO2: Analyze the mathematical models for different unit operations equipment.
CO3: Demonstrate mathematical modeling for petroleum reservoirs.
CO4: Evaluate the design data with mathematical calculations.
CO5: Optimize heat recovery and reactor design.

REFERENCE BOOKS

1. Bequette, B.W., "Process Dynamics: Modelling, Analysis and Simulation," Prentice Hall (1998)
2. Himmelblau D.M. and Bischoff K.B., Process Analysis and Simulation, Wiley, 1988
3. Varma A. and Morbidelli M., Mathematical Methods in Chemical Engineering, Oxford University Press, 1997.
4. Edgar, T.F., Himmelblau, D.M., "Optimisation of Chemical Processes ", McGraw-Hill Book Co., New York, 2003.
5. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M. "Engineering Optimisation ", John Wiley, New York, 1980
6. Ogunnaike B. and W. Harmon Ray. Process Dynamics, Modeling, and Control, Oxford University Press, 1995

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3	-	1	1
CO2	3	2	3	-	1	1
CO3	3	3	3	-	1	1
CO4	3	2	3	-	1	1
CO5	3	2	3	-	1	1
Average CO	3.00	2.20	3.00	-	1.00	1.00

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3312 PROJECT WORK I

L	T	P	C
0	0	12	6

OBJECTIVES:

The course aims to enable the students to identify the research problem relevant to their field of interest, search databases to define the problem, design experiment, conduct preliminary study and report the findings.

COURSE CONTENT

Individual students will identify a research problem relevant to his/her field of study with the approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out preliminary study, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 180 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1: Identify the research problem

CO2: Collect, analyze the relevant literature and finalize the research problem

CO3: Design the experiment, conduct preliminary experiment, analyse the data and conclude

CO4: Prepare project report and present

TOTAL: 180 PERIODS

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
CO4	2	3	3	1	2	2
Average CO	2.75	2.5	2.25	1.75	1.75	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

SEMESTER IV

PP3411 PROJECT WORK II

L	T	P	C
0	0	24	12

I. Continuation of Project Work I (at Institution/Industry)

OBJECTIVES:

The course aims to enable the students to conduct experiment as per the plan submitted in Project work I to find solution for the research problem identified.

COURSE CONTENT

The student shall continue Project work I as per the formulated methodology and findings of preliminary study. The student shall conduct experiment, collect data, interpret the result and provide solution for the identified research problem. The student shall prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Conduct the experiment and collect data
CO2: Analyze the data, interpret the results and conclude
CO3: Prepare project report and present

Course articulation Matrix

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
Average CO	3	2.33	2	2	1.67	2

II. Not the continuation of Project Work I (at Industry)

OBJECTIVES:
The course aims to enable the students to identify the research problem at the company, search databases to define the problem, design experiment, and conduct experiment to find the solution.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study at the company and get approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out the experiment, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design and conduct the experiment, analyse the data and conclude
CO4: Prepare project report and present

TOTAL: 360 PERIODS

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
CO4	2	3	3	1	2	2
Average CO	2.75	2.5	2.25	1.75	1.75	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ELECTIVES

PP3001 **PETROLEUM GEOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

1. To impart knowledge on the origin of Earth, geological timescale, and properties of minerals and rocks.
2. To enable the students to learn about sedimentary basins and explore their relevance to petroleum exploration.
3. To enable the students to learn about the generation, migration, and properties of petroleum.
4. To impart knowledge on the importance of subsurface geology in petroleum operations.
5. To impart knowledge on the exploration methods and their application in studying subsurface geology.

UNIT I INTRODUCTION TO EARTH SCIENCE AND PLATE TECTONICS 9

Introduction to earth science – Origin of earth; Nature and properties of minerals and rocks; Sedimentation and sedimentary environment; Stratigraphy and geological time scale; Introduction of plate tectonics.

UNIT II SEDIMENTOLOGY AND PETROLEUM GENERATION 9

Sedimentology of Petroleum bearing sequences – Sedimentary basins; Generation and Migration of Petroleum; Physical and Chemical properties of Petroleum.

UNIT III SUBSURFACE ENVIRONMENT AND RESERVOIRS 9

Subsurface Environment – Formation fluids – Composition, temperature, pressure and dynamics; Traps and Seals; The Reservoir; Generation, Migration and Distribution.

UNIT IV EXPLORATION METHODS AND SUBSURFACE GEOLOGY 9

Exploration Methods – Well drilling; Formation Evaluation; Geophysical; Borehole Seismic and 4D Seismic; Subsurface geology.

UNIT V NON-CONVENTIONAL PETROLEUM RESOURCES AND RESERVE ESTIMATION 9

Non-conventional petroleum resources and reserve estimation - Plastic and solid hydrocarbons; Tar sands; Oil and gas shales; Coal bed methane; Assessment of reserves.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Describe the origin of Earth, geological timescale, and the nature and properties of minerals and rocks.
CO2: Explain the insights of sedimentary basins and their role in petroleum exploration.
CO3: Classify the mechanism of petroleum generation, migration, and its properties.
CO4: Appraise the importance of subsurface geology in the exploration and production of petroleum resources.
CO5: Assess the need for different exploration methods and their types, including the evaluation of non-conventional petroleum resources and reserve estimation.

REFERENCE BOOKS

1. Cox, P.A., “The Elements on Earth”, Oxford University Press, Oxford 1995.
2. Wilson, M., "Igneous Petrogenesis”, Unwin Hyman, London 1989.
3. Boggs, S., “Principles of Sedimentology and Stratigraphy”, second edition, Merrill Publishing Co., Toronto, 1995.
4. Krumblein, W.C. and Sloss, L.L., “Stratigraphy and Sedimentation”, second edition W.H. Freeman and Co., 1963.

6. Selley, R. C., “Elements of petroleum geology”, Gulf Professional Publishing, 1998.
7. Mussett, A.E. and Khan, M.A., “Looking into the earth: an introduction to geological geophysics”, Cambridge University Press, 2000.
8. Gluyas, Jon G., and Richard E. Swarbrick., “Petroleum geoscience”, John Wiley & Sons, 2021.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	-	-	1
CO2	2	1	2	-	1	1
CO3	2	-	2	1	2	-
CO4	1	-	1	3	-	2
CO5	3	1	1	1	3	1
Average CO	2	1	1.6	1.67	2	1.25

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3002 BIOFUELS **L T P C**
3 0 0 3

OBJECTIVES

1. To enable the students to have a thorough understanding of various renewable feedstocks and their availability attributes for biofuel production.
2. To enable the students to apprehend the various pre-treatment techniques employed for bioethanol production.
3. To enable the students to understand the broad concept of biodiesel production from different sources.
4. To enable the student to learn the need for biohydrogen production and analyse the techno economic feasibility of the process.
5. To enable the student to learn about alternate green fuels and their applications in developing a sustainable process.

UNIT I THERMOCHEMICAL CONVERSION OF BIOMASS TO BIOFUELS 9

Principles of biorefining, biofuels - types based on feedstock, life-cycle assessment of biofuels, thermochemical conversion of biomass to biofuels, biomass derived syngas fermentation into biofuels.

UNIT II LIGNOCELLULOSIC BIOETHANOL: PRODUCTION AND CHALLENGES 9

Lignocellulosic bioethanol: current status and future perspectives; technoeconomic analysis of lignocellulosic ethanol; pre-treatment technologies for bioethanol conversion; hydrolysis: cellulolytic and hemicellulolytic enzyme production; fermentation: inhibitor formations; strategies to reduce their effects.

UNIT III BIODIESEL AND ALGAL BIOFUELS: SYNTHESIS AND CULTIVATION 9

Biodiesel: types and synthesis; biotechnological methods; supercritical fluids; biodiesel from palm oil; waste oil; biodiesel from algal biomass – current perspective and future; overview and assessment of algal biofuels production technology; algae cultivation in photobioreactors.

UNIT IV BIOHYDROGEN PRODUCTION AND HIGH-RATE BIOREACTORS 9

Biohydrogen production – current status and future prospects; feedstocks; sources- bio-oil and economic feasibility; industrial effluents – biological croutes; biocatalyst; strategies to improve process efficiency; thermophilic biohydrogen production: thermodynamic aspects; biochemical pathways and microbiology; challenges; high-rate bioreactors for process.

UNIT V BIOBUTANOL AND GREEN LIQUID HYDROCARBON FUELS 9

Biobutanol production; biomass sources; ABE fermentation; sporulation and solventogenesis; metabolic engineering approaches; fermentation technologies and downstream processing, green liquid hydrocarbon fuels- technologies: hydroprocessing of lipids; biomass gasification and fischer-Tropsch catalysis; sugars to hydrocarbon, pyrolysis; feedstock considerations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Review the basics of biorefining, biofuels and the various feedstocks for production of biofuels.
CO2: Comprehend the concepts of biomass pre-treatment methods and challenges.
CO3: Analyze the production of biodiesel output by different technologies.
CO4: Evaluate the production of biohydrogen from different biological routes.
CO5: Assess the need for green liquid fuels, their types and applications.

REFERENCE BOOKS

1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, “Biofuels Engineering Process Technology”, Mc Graw Hill Publishers, New York, 2008.
2. Jonathan R.M, “Biofuels – Methods and Protocols” (Methods in Molecular Biology Series), Humana Press, New York, 2009.
3. David M. Mousdale, Biofuel-Biotechnology, Chemistry, and sustainable Development, 1st Ed., CRC Press Taylor & Francis Group, 2008.
4. Lisbeth Olsson (Ed.), “Biofuels” (Advances in Biochemical Engineering/Biotechnology Series), Springer-Verlag Publishers, Berlin, 2007.
5. Ashok Pandey, Christian Larroche, Steven C Ricke, Claude-Gilles Dussap, Edgard Gnansounou (Ed(s).). Biofuels: Alternative feedstocks and conversion processes (1st ed.). Academic press, USA, 2011.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	-	1	-	-	-	-
CO2	-	1	-	-	-	1
CO3	1	3	-	-	-	1
CO4	-	2	-	-	-	2
CO5	1	3	-	-	-	-
Average CO	1	2	-	1	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3003 PETROLEUM EXPLORATION TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES

1. To enable the students to learn the concepts of origin, migration and accumulation of petroleum and insights of geophysical exploration techniques.
2. To impart knowledge on various seismic exploration techniques.
3. To impact the knowledge on the need of seismic survey techniques.
4. To enable the students to learn the interpretation of seismic and reflection data.
5. To enable the students to study about various types of hydrocarbon estimation and Safety in exploration.

UNIT I OVERVIEW OF PETROLEUM EXPLORATION AND EXPLORATION METHODS 9

Overview of petroleum exploration in India; Introduction to Geophysical/Geological methods used in petroleum exploration- mapping, source rock generation migration and accumulation of petroleum, petroleum traps, structural trap, stratigraphic traps, and combination traps.

UNIT II GEOPHYSICAL EXPLORATION TECHNIQUES 9

Types, Theory and working principles, Data acquisition: Data processing and Interpretation of Gravity and Magnetic Methods, Data acquisition: Data processing and Interpretation of Electrical, and Radioactivity methods, Geochemical Methods and Data Analysis.

UNIT III SEISMIC METHOD OF EXPLORATION 9

Seismic impedance, AVO, DHIS, Interpretation of seismic signatures using pattern recognition, Seismic facies, seismic stratigraphy, Basin classification, subsidence and thermal history: Understanding of petroleum system, continuous accumulation system, Development of integrated geological model.

UNIT IV SURVEY TECHNIQUES 9

Single horizontal reflector, seismic reflection survey over seismic refraction survey technique- Common depth point (CDP) profiling & stacking- 2D, 3D, & 4D seismic surveys- Field procedures & principles- Time corrections applied to seismic data- Data processing - Introduction to 2D & 3D data acquisition & interpretation of reflection data for identification of drillable structures.

UNIT V HYDROCARBON ESTIMATION AND SAFETY 9

SPE/SEG/AAPG terminology related to petroleum resources and reserves, introduction to enhanced oil recovery, Predicting petroleum resources, Volumes of Hydrocarbon in Place estimation, Risk analysis of exploration ventures. Safety in petroleum exploration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Illustrate the concepts of origin, migration and accumulation of petroleum and insights of geophysical exploration techniques.
CO2: Explain the various seismic exploration techniques.
CO3: Describe the need of seismic survey techniques.
CO4: Differentiate the interpretation of seismic and reflection data.
CO5: Compare the various types of hydrocarbon estimation and Safety in exploration.

REFERENCE BOOKS

1. Norman J. Hyne, Nontechnical Guide to Petroleum Geology, Exploration, Drilling, and Production, PennWell Books, 2012
2. G.B. Moody, “Petroleum Exploration Hand Book”, McGraw Hill Text, 1st Edition, June 1961.

3. Manoj Ghosh, Awadesh Rai, Bhagwan P Sahay, 'Wellsite Geological Techniques for Petroleum Exploration - Methods and systems of formation evaluation', CRC Press, Taylor & Francis Group 1988.
4. Palmer, Andrew Clennel., “Introduction to petroleum exploration and engineering”, World Scientific publishing co, 2016.
5. Parasnis, Dattetraya Shripad. “Principles of applied geophysics”, Springer Science & Business Media, 2012.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	2	2	1	3
CO2	1	1	1	1	1	3
CO3	1	1	1	1	1	3
CO4	1	1	1	1	1	3
CO5	1	1	2	2	1	3
Average CO	1	1	2.34	2.34	1	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3004 OIL AND GAS WELL TESTING **L T P C 3 0 0 3**

OBJECTIVES

1. To impart knowledge on oil and gas well testing process and drilling.
2. To enable the students to learn about the treatment and storage of explored products.
3. To impart knowledge about oil wells and gas wells.
4. To enable the students to learn the analysis and testing of oil well.
5. To enable the students to learn the analysis and testing of gas well.

UNIT I PETROLEUM EXPLORATION 9

Seismic Exploration; site preparation; government regulations; cable tool rigs; drilling a well; Drilling techniques; bottom hole completions; tubing; wellhead; finite reservoir; reservoir boundaries; horizontal well; fractured well; naturally fractured reservoir; formation volume factor.

UNIT II WELL ANALYSIS AND STIMULATION 9

Testing a well; typical flow regimes; Pressure curves analysis; type curve with wellbore storage & skin in homogeneous reservoir; wire well logs; completing a well, Chokes; multiple completions; intelligent wells; surface cased hole logs; bypassing and coning; cycling; Well stimulation; selection wells for optimum stimulation.

UNIT III TREATMENT AND STORAGE OF CRUDE OIL 9

Treatment and storage- separators, gas treatment, Pressure build-up test, Principle of superposition, well bore storage, drawdown, guidelines as per PESO.

UNIT IV OIL WELL ANALYSIS AND TESTING 9

Role of oil well test and information in petroleum industry; oil well test data acquisition; analysis and management; reservoir oil flow analysis; transient well and pressure buildup testing for horizontal oil well; drill stem testing methods; injection well transient analysis.

UNIT V GAS WELL ANALYSIS AND TESTING 9

Application of fluid flow equations to gas systems; Gas well testing; transient pressure analysis; transient rate analysis; multiphase flow; pressure derivative analysis; gas well testing field case studies; application of decline curve analysis methods; selection of gas well for production stimulation; overall skin effect and impact on gas well performance**.**

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Describe the techniques involved in site preparation, drilling methodology, government regulations, and the types of reservoir for both oil and gas well testing.

CO2: Explain the types of wells and to evaluate all the logs.

CO3: Classify different types of well bore storage and treatment techniques involved.

CO4: Identify the flow, transient pressure response in oil wells and also the limitation of oil well test interpretation.

CO5: Identify the flow, transient pressure response in gas wells and also the limitation of gas well test interpretation.

REFERENCE BOOKS

1. Norman.J.Hyne, "Nontechnical guide to petroleum geology, exploration, drilling, and production, Pennwell Books,2001.
2. Amanat Chaudry, "Oil well testing handbook, Elsevier, 2004
3. Earlougher, R. C. Jr.: Advances in Well Test Analysis. SPE of AIME, Dallas, Monograph, 1977
4. Bourdet, D.: Well Test Analysis: The Use of Advanced Interpretation Models. Elsevier, Amsterdam, 2002.

5. McAleese S, Operational Aspects of Oil and Gas Well Testing: Volume 1, Elsevier 2000.

2. Petroleum & Explosives Safety Organization (PESO) rules for handling and storage of petroleum compounds, 2023.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	-	3	-	-	3
CO2	-	-	3	2	-	3
CO3	1	-	3	-	-	3
CO4	1	-	3	3	-	3
CO5	1	-	3	3	-	3
Average CO	1	-	3	3	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3053 FLUIDIZATION ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

1. To enable the students to learn the fundamentals of fluidization and its applications.

2. To enable the students to understand the basic concept of hydrodynamics in fluidized bed.
3. To impart knowledge on bubble dynamics in dense beds.
4. To enable the students to encompass the new areas and introduce reactor models specifically for these Contacting regimes.
5. To enable the students to understand the fluidization behaviour, write model equations for fluidized beds and design gas-solid fluidized bed reactors.

UNIT I INTRODUCTION 9

Phenomenon of fluidization, behaviour of fluidized beds, Nature of hydrodynamic suspension, Characterization of particles, particle forces, Regimization of the fluidized state, operating models for fluidization systems, Industrial application of fluidized beds

UNIT II HYDRODYNAMICS OF FLUIDIZATION SYSTEMS 9

General bed behaviour, pressure drop, pressure regimes, Incipient Fluidization, Pressure fluctuations, Phase Holdups, Measurements Techniques minimum fluidization velocity, pressure drop, Geldart classification of particles, Fluidization with carryover of particles, mapping of fluidization regimes

UNIT III DENSE BEDS 9

Distributor types, gas entry region of a bed, gas jets in fluidized beds, pressure drop across distributors, design of a gas distributors, power consumption, Bubbles in dense beds: single rising bubbles, Davidson model for gas flow at bubbles, Evaluation of models for gas flow at bubbles, coalescence and splitting of bubbles, bubble formation. Slug flow

UNIT IV BUBBLING FLUIDIZED BEDS, ENTRAINMENT AND ELUTRIATION 9

Effect of temperature and pressure on bed properties, Estimation of bed properties, bubble size and bubble growth, physical model and flow model- K-L Model with its Davidson bubbles and wakes, freeboard behaviour, entrainment from tall and short vessels, high velocity fluidization: turbulent fluidized beds and fast fluidization

UNIT V SOLID MOVEMENT, MASS AND HEAT TRANSFER 9

Solid movement, mixing, segregation and staging, gas dispersion and gas interchange in bubbling beds, Particle to gas mass and heat transfer: Experimental interpolation of mass transfer coefficients, experimental heat transfer from bubbling bed model, applications of two phase and three phase fluidized beds

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: Recall the basics of fluidization and know the various industrial applications of fluidization
CO2: Demonstrate the concepts of hydrodynamics in fluidized bed
CO3: Describe the formation and growth of bubble dynamics in dense beds
CO4: Analyze the bed behavior for various geometries of fluidized beds
CO5: Evaluate the transport processes of fluidized beds

REFERENCE BOOKS

1. Kunii, D. and Levenspiel, O., “Fluidization Engineering”, 2nd Edn., Butterworth Heinemann, London, 1990.
2. Fan, L. S., “Gas- liquid Solid Fluidization Engineering”, Butterworths, 1989,
3. Kwauk, M., “Fluidization - Idealized and Bubbleless, with applications”, Science Press, 2009

Course Articulation Matrix:

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6

CO1	-	-	3	-	-	-
CO2	-	-	2	1	1	-
CO3	1	-	2	1	2	-
CO4	1	-	2	2	1	-
CO5	1	-	1	1	2	-
Average CO	**1**	**-**	**2**	**1.25**	**1.5**	**-**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

PP3005 MODERN SEPARATION TECHNIQUES **L T P C**
3 0 0 3

OBJECTIVES

1. To impart knowledge on fundamentals of separation processes.
2. To enable students to explore membrane separations and their applications in different processes.
3. To impart knowledge on adsorption and ion exchange principles and their commercial applications.
4. To enable the students to examine chromatography and electrophoresis techniques.
5. To enable students to get familiarize with other separation techniques and their industrial relevance.

UNIT I BASICS OF SEPARATION PROCESS 9

Review of Conventional Processes, Recent advances in Separation Techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and Equipment used in cross flow Filtration, cross flow Electro Filtration, Dual functional filters and Siro floc process, Surface based solid – liquid separations involving a second liquid.

UNIT II MEMBRANE SEPARATIONS 9

Types and choice of Membranes, Membrane modules, Membrane Reactors and their relative merits, commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Electrodialysis, EDR, Reverse Osmosis, Nano-filtration, Ultra filtration and Micro filtration, Pervaporation, Gas Permeation membranes,Bipolar Membranes, Membrane Distillation, Ceramic membranes, Membrane bioreactor, Liquid Membranes.

UNIT III SEPARATION BY ADSORPTION AND ION EXCHANGE 9

Adsorption: Types and choice of Adsorbents, Equilibrium Consideration, Kinetic and Transport Consideration, Adsorption Techniques, Thermal swing Adsorption, Pressure Swing adsorption, Commercial application of TSA and PSA. Ion Exchange: Ion Exchangers, Ion Exchange Equilibria, Ion Exchange Chromatography, Equipment for Ion Exchange operation, Ion Exchange cycle, Commercial application of IE.

UNIT IV CHROMATOGRAPHY AND ELECTROPHORESIS 9

Chromatography: Terminologies, Sorbents, Types of Chromatography, Equilibrium, kinetic and transport considerations, Bio chromatography Adsorbents, Multicomponent Differential Chromatography, Electrophoresis: General Principles of Electrophoresis, Controlling factors, Types of Electrophoresis, Equipment employed for Electrophoresis and its Application, Special Types of Gel and Capillary Electrophoresis.

UNIT V OTHER TECHNIQUES 9

Separation involving Lyophilisation, Reactive and catalytic distillation, Advantage & disadvantages, zone melting, Adductive Crystallization, melt Crystallization, Supercritical fluid Extraction, Oil spill Management, Hybrid Systems, Industrial Effluent Treatment by Modern Techniques, CDI (Capacitive deionization technique).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Discuss the interphase momentum transfer in an isothermal system.

CO2: Analyze the macroscopic mass momentum and energy balance in an isothermal system and its applications.

CO3 Illustrate the interphase energy transfer in a non-isothermal system.

CO4: Recall the concept of macroscopic energy balance in a non-isothermal process.

CO5: Illustrate the interphase mass transfer in a non-isothermal system.

REFERENCE BOOKS

1. Ronald W.Roussel - " Handbook of Separation Process Technology ", John Wiley,New York, 1987
2. Seader J.D. and Henley E.J., “Separation Process Principles”, 2nd Ed., John Wiley, 2006.
3. Schoew, H.M. - " New Chemical Engineering Separation Techniques ", Interscience Publishers, 1972.
4. Lacey, R.E. and S.Loeb - "Industrial Processing with Membranes", Wiley – InterScience, New York, 1972.
6. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd.,1982.
7. Osadar, Varid Nakagawa I - " Membrane Science and Technology ", MarcelDekkar, 1992.
8. Wankat, P., “Equilibrium Stage Separations”, Prentice Hall, 1993. 5. Wankat, P., “Rate Controlled Separations”, Prentice Hall, 1993.
1. 8.Philip C. Wankat, “Separation Process Engineering”, Prentice-Hall, 5th Edition, 2022.
9. Christie J Geankoplis, “Transport Processes and Separation Process principles”, Prentice-Hall of India Private Ltd, New Delhi, 4th Edition 2006.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	1	2	1	1
CO2	3	1	1	2	1	1
CO3	3	1	1	2	1	1
CO4	3	1	1	2	1	1
CO5	3	1	1	2	1	1
Average CO	3	1	1	2	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3051	**MULTIPHASE FLOW**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

1. To enable the students to understand the significance of multiphase flows and different flow pattern in multiphase flow
2. To enable the students to determine the hydrodynamic parameters in the multiphase flow system

3. To enable the students to understand the concept of different flow models in different phases.
4. To enable the students to understand the one-dimensional two-dimensional flow equation in turbulent condition
5. To enable the students to understand the Hydrodynamic characteristics in different contactors

UNIT I INTRODUCTION 9

Introduction to Multiphase Flow, Scope and significance of multiphase flows, Dimensionless numbers in multiphase flows; Flow Pattern and Flow Regimes: Fluid-Solid System, Fluid-Fluid Systems, Solid- Fluid-Fluid systems. Flow patterns in pipes, analysis of two phase flow situations. Two-phase Co- current flow of Gas-Liquid, Gas-Solid and Liquid-Liquid, Upward and Downward Flow in Vertical pipes. Suspensions of Solid and their transport in Horizontal Pipes. Drag Reduction Phenomena, Laminar, Turbulent and Creeping Flow Regimes.

UNIT II PREDICTION 9

Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lock chart- Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction.

UNIT III MODELS 9

Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two-phase flow - drift flux model - correlations for bubble, slug and annular flows

UNIT IV AVERAGING PROCEDURES 9

Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling

UNIT V APPLICATIONS 9

Flow regime Hydrodynamic characteristics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Applications of these contactors. Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Carpt ,Laser Doppler anemometry, Particle Image Velocimetry)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Explain the significance of multiphase flows and different flow pattern in multiphase flow

CO2: Review the hydrodynamic parameters in the multiphase flow system

CO3: Develop different flow models in multiphase system.

CO4: Formulate the one-dimensional and two-dimensional flow equation in turbulent condition

CO5: Demonstrate the Hydrodynamic characteristics in different contactors

REFERENCE BOOKS

1. Govier, G. W. and Aziz. K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold, New York, 1972.
2. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 2005.

3. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 2011
4. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 2005
5. Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	1	1	2	1
CO2	2	3	1	1	-	1
CO3	2	-	1	1	2	-
CO4	2	3	1	-	2	1
CO5	2	3	1	1	-	-
Average CO	2	3	1	1	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3051 COMPUTATIONAL FLUID DYNAMICS **L T P C**
3 0 0 3

OBJECTIVES

1. To impart knowledge on Computational Fluid Dynamics (CFD) and reminisce conservation principles.
2. To enable the student to understand discretization techniques.
3. To enable the student to learn the numerical analysis of solving diffusion in 1D, 2D and 3D.
4. To impart knowledge on numerical analysis of solving of convection-diffusion problems.
5. To impart the knowledge of turbulence modelling and grid generation.

UNIT I INTRODUCTION AND PRINCIPLES OF CONSERVATION 9

Basics of Computational Fluid Dynamics, Illustration of the CFD approach, CFD as an engineering analysis tool, CFD application in Chemical Engineering, Fundamental principles of conservation, governing equations of fluid flow, heat and mass transfer. Equations of continuity, motion and energy in differential and integral forms, conservation and non-conservation form.

UNIT II DISCRETISATION TECHNIQUES: FINITE DIFFERNCE APPROXIMATION 9

Classification of Partial Differential Equations, Mathematical behaviour of PDE, Basic aspects of discretization, Discretization techniques using finite difference methods – Taylor's Series, explicit and implicit methods. Error and stability analysis.

UNIT III DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

Steady one-dimensional diffusion, two- and three-dimensional steady state diffusion problems, Solution of discretized equations.

UNIT IV CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme, Hybrid and power law discretization techniques, QUICK scheme, Assessment of discretization scheme properties, Solution of discretized equations.

UNIT V TURBULENCE MODELING AND GRID GENERATION 9

Characteristics of turbulent flows, time averaged Navier Stokes equations, turbulence Models – one and two equation, Reynolds stress, LES and DNS. Physical aspects of Grid generation, staggered grid, SIMPLE algorithm, PISO algorithm.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Describe the basics of CFD and governing equations for conservation of mass momentum and energy.
CO2: Analyze mathematical characteristics of partial differential equations.
CO3: Solve computational solution techniques for time integration of ordinary differential equations.
CO4: Formulate various discretization techniques used in CFD.
CO5: Assess various turbulence models and grid generation techniques.

REFERENCE BOOKS

1. Anderson, J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill, 1995.
2. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education Ltd., 2007.
3. Chung T.J Computational Fluid Dynamics Cambridge University Press 2003.
4. Fletcher, C. A. J., “Computational Techniques for Fluid Dynamics”, Springer Verlag, 1997.
5. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”,Narosa Publishing House, New Delhi, 2001.
6. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw – Hill Publishing Company Ltd. 1998.
7. Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
8. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stoke Equation”,Pineridge Press Limited, U.K., 1981.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	-	-	-	2	-	-
CO2	1	-	2	1	2	2
CO3	1	-	2	3	3	2
CO4	1	-	2	3	2	2
CO5	-	-	2	1	1	1
Average CO	1	-	2	2	2	1.75

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3006 OFFSHORE DRILLING AND PRODUCTION PRACTICES

L T P C
3 0 0 3

OBJECTIVES

1. To impart knowledge on the offshore gas industry.
2. To impart knowledge on the ocean environment.
3. To enable students to learn the different types of offshore drilling and production platforms.

4. To enable students to learn about the configurations of offshore wells, drilling methods, and the drilling procedure.
5. To impart knowledge on surface production systems, storage options, and offshore pipeline systems.

UNIT I OFFSHORE GAS INDUSTRY AND RESERVOIR CHARACTERISTICS 9

Offshore gas Industry; Background of Geology and Reservoir of Oil and Gas; Migration of Oil and Gas; Structure for Accumulation of Oil and Gas; Reservoir Types and Drives; Oil and Gas Reserve Estimation.

UNIT II OCEAN ENVIRONMENT AND OFFSHORE OIL AND GAS OPERATIONS 9

Offshore Oil and Gas Operations; Ocean Environment/Sea States, Meteorology, Oceanography, Sea bed Soil.

UNIT III OFFSHORE DRILLING AND PRODUCTION PLATFORMS 9

Offshore Drilling and Production Platforms/Units - Fixed Platforms, Compliant Platforms, Mobile Units; Offshore Drilling- Rotary Drilling Rig Operation and Its Components.

UNIT IV CONFIGURATION OF WELLS AND OFFSHORE DRILLING PROCEDURES 9

Types of Configurations of Wells and Drilling Methods; Procedure of Offshore Drilling; Offshore Well Completion - Well Completion Equipment, Completion Specific Operations.

UNIT V OFFSHORE PRODUCTION, STORAGE, AND PIPELINE SYSTEMS 9

Offshore Production - Surface Production System, Fixed Production System; Floating Production System; Subsea Production System; FPSO. Offshore Storage - Above Water Storage, Over and Under Water Storage Tank, Submerged Storage Tank; Offshore Pipeline - Laying, Flow assurance, Pigging, Corrosion and Maintenance.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Demonstrate comprehensive knowledge of the offshore gas industry.

CO2: Recognize and recall the significant impact of the ocean environment on offshore operations.

CO3: Identify different types of offshore drilling and production platforms/units, their operations, and the components of rotary drilling rigs.

CO4: Analyze and differentiate the well configurations, drilling methods, the offshore drilling procedure, and the equipment and operations involved in well completion.

CO5: Apply and evaluate expertise in offshore production systems, storage options, and pipeline laying, encompassing flow assurance, pigging, corrosion prevention, and maintenance techniques.

REFERENCE BOOKS

1. Sukumar Laik, 'Offshore Petroleum Drilling and Production', CRC Press Taylor & Francis Group, 2018.
2. William C. Lyons & Gary, ' Standard Hand Book Of Petroleum & Natural Gas Engineering' - 2nd Edition, Gulf-Gulf Professional Publishing Comp (Elsevier). 2005
3. Manoj Ghosh, Awadesh Rai, Bhagwan P Sahay, 'Wellsite Geological Techniques For Petroleum Exploration - Methods and systems of formation evaluation', CRC Press, Taylor & Francis Group, 1988.
4. G.B. Moody,'Petroleum Exploration Hand Book', McGraw Hill Text, 1st Edition, June 1961.Programming of the Navier Stoke Equation",Pineridge Press Limited, U.K., 1981.
5. Speight, James G., "Handbook of offshore oil and gas operations", Elsevier, 2014.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	3	2	1	1	2
CO2	-	-	-	-	-	-
CO3	2	1	3	1	-	3
CO4	2	1	2	1	2	2
CO5	2	-	3	2	3	2
Average CO	1.75	1.67	2.50	1.25	2.00	2.25

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3056 POLYMER PROCESSING TECHNOLOGY

L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge on the types of polymers, polymerization reactions, polymerization techniques.
- To impart knowledge on processing of elastomers and application-oriented polymers.
- To enable the students to learn the analytical characteristics of polymers
- To enable the students to learn the testing procedures of polymer composites
- To impart knowledge on polymer composites

UNIT I GENERAL ASPECTS OF POLYMERS 9

Classification of polymers - natural and synthetic, thermoplastic and thermosetting; types and mechanism of polymerization reactions; polymerization techniques; Polymer properties - degree of polymerization, molecular weight determination, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II POLYMER PROCESSING 9

Process additives and significance; types of additives; mixing processes; Types of moulds; mould cooling and ejection techniques; moulding - extrusion moulding, injection moulding, blow mouldind and other moulding techniques.

UNIT III ELASTOMERS AND APPLICATION ORIENTED POLYMERS 9

Natural Rubber and synthetic rubber; unit operations; styrene – butadiene, polyisopropane – neoprene, silicone rubber, thermoplastic elastomers; Resins – epoxy, phenol formaldehyde, urea formaldehyde; fibrous Polymers - Nylon 66, PAN; PVC, Silicon Oil.

UNIT IV POLYMER TESTING AND CHARACTERIZATION 9

Analytical tests - determination of specific gravity, water absorption; Non-destructive testing - ultrasonic testing, Acoustic emission (AE) testing, thermal stability, X-ray fluorescence, FT-IR, XRD, SEM, AFM, etc.

UNIT V POLYMER COMPOSITES 9

Polymer composites and general concepts; structure and components of polymer composites; classification of polymer composites; hybrid composites; usage areas of composites in daily life.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall the fundamentals of polymers and mechanism of polymerization techniques and polymer properties.

CO2: Apply the mechanism and effectiveness of polymerization in making finished materials.

CO3: Demonstrate the knowledge of elastomers and its processing.

CO4: Construct the knowledge of analytical characteristics of polymer.

CO5: Assess the general aspects of polymer composite materials.

REFERENCE BOOKS:

1. Birley, Haworth, Batchelor, “Physics of Plastics – Processing Properties and Materials Engineering”, Hamer Publication, 1992.
2. Billmayer F.W., “Text Book of Polymer Science” 3rd Ed., John Wiley and sons, New York, 2002.
3. Richard G. Griskey, “Polymer Process Engineering”, Chapman and Hall, 1995.
4. Vishu Shah, “Hand book of Plastics Testing and Failure Analysis”, 3rd Ed., John-Willey &Sons, New York, 2007.
5. Sabu Thomas, Kuruvilla Josep, “Polymer Composites: Volume 1” 1st Ed., Wiley, 2012.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	-	1	-	2	3	3
CO2	3	3	1	3	3	3
CO3	3	3	1	3	3	3
CO4	-	3	1	-	3	3
CO5	3	3	1	3	3	3
Average CO	2	2.6	1	2.75	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

PP3007 NON-CONVENTIONAL TREATMENT OF NATURAL GAS **L T P C**
3 0 0 3

OBJECTIVES:

1. To enable the students to learn the production and processing of natural gas.
2. To impart knowledge on importance of coal bed methane and its impact on Environment.
3. To enable the students to learn the concept of gas hydrates and its application.
4. To enable the student to learn the economics for various natural gases.
5. To impart knowledge on the various storage techniques available for storing Natural Gas its application.

UNIT I OVERVIEW OF NATURAL GASES 9

Energy resources of earth; phase behaviour of natural gas systems - properties of natural gases, equation of state, critical pressure and temperature determination; Gas compressibility, viscosity and thermal conductivity, formation volume factor, the dehydration and sweetening process of natural gas

UNIT II COAL BED METHANE 9

Introduction & present status of coal bed methane- Global and Indian Scenario; Formation and properties of coal bed methane - Generation of coal bed methane gas & its properties, properties of coal as reservoir rock & Reserve Estimation; Thermodynamics of coal bed methane - isotherm studies, Hydro-fracturing of coal seams, testing of coal bed methane wells, coal bed methane Water and Greenhouse Emissions.

UNIT III GAS HYDRATES AND ITS APPLICATION 9

Introduction & present status of gas hydrates - Formation, accumulation and properties of gas hydrates; Thermodynamics, kinetics and phase behaviour of gas hydrates; Prevention & control of gas hydrates, Gas extraction from gas hydrates, Uses and application of gas hydrates.

UNIT IV IMPORTANCE OF SHALE GAS 9

Global Scenario of shale gas/ Oil production; Nature, origin and distribution of Shale Gas/ Oil - Characterization of Shale for Production of Shale Gas/ Oil; Extraction methods of Shale gas/ Oil - development of current practices, Location and size of production areas, Environmental issues in shale gas exploration.

UNIT V STORAGE AND ECONOMICS 9

Markets and Global impact on energy scenario; Circular economy, energy recovery, estimated reserves and storage for shale gas, natural gas and coal bed; Gas compression and metering, transmission and distribution, storage and transportation of natural gas.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Recall various sources of natural gas sources and behavior of natural gas resources.
CO2: Explain about various aspects of coal bed methane and its behavior.
CO3: Assess various aspects of gas hydrates and application of gas hydrates as energy source.
CO4: Evaluate about shale gas reserve estimation, exploration techniques, production techniques, environmental issues in exploration.
CO5: Analyze storage and transportation aspects of unconventional natural gas processing and its application as potential energy resource.

REFERENCE BOOKS

1.Donald L.Katz and Robert L.Lee, “Natural Gas Engineering”, Mc Graw – Hill Publishing Company, NY, 1990.
2. Dermott M.C. “Liquified Natural Gas Technology”, Neysos Park Ridge, N.J. 1973.
3. BoyunGuo, “Natural Gas Engineering Handbook”, Gulf Pub. Company, 2012.
4. Donald La Verne Katz, “Handbook of Natural Gas Engineering”, McGraw-Hill, 1959.
5. Ma, Y. Zee, and Stephen Holditch., “Unconventional oil and gas resources handbook: Evaluation and development”, Gulf professional publishing, 2015.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	3	2	2
CO2	2	2	2	2	2	2
CO3	2	2	2	2	2	2
CO4	2	2	2	3	2	2
CO5	2	2	2	2	3	2
Average CO	2.2	2	2	2.4	2.2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3052 PIPING AND INSTRUMENTATION

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable students to learn the key concepts in piping and instrumentation of process plants.
- To enable the students to integrate the piping drawing with the different components and process equipment.
- To enable the students to carry out the sizing calculations and develop the drawings.
- To impart knowledge on the importance of safety and implement the control systems.
- To enable the students to develop the P&ID drawing with all basic requirements.

UNIT I BASICS OF P&ID 9

Block flow diagram, process flow diagram, symbols, P&ID, P&ID symbols, line and valve numbering concept, equipment identification, detailed engineering of the process. Introduction to piping, Evolution of piping, Manufacturing methods, Piping materials and selection, Pipe dimensioning, Schedule numbers, Common piping abbreviations, Major organizations for standards, Commonly American code in piping ASME/ANSI, Common abbreviations.

UNIT II COMPONENTS AND EQUIPMENTS 9

Design principles, insulation concept, manual valves and automatic valves, ease of maintenance, pumps and compressors, pressure relief devices, heat transfer units, utilities, plant interlocks and alarms, stress analysis.

UNIT III SELECTION AND DIAGRAMS 9

Types of fluid flow, Friction factor, line sizing, pressure drop and velocity calculation, selection of material under various condition, codes and standards, selection of pipe fittings, flanges, fasteners, and gaskets. Piping isometrics, general arrangement drawings-sections/elevations/ detail drawings, plot plan procedures, vendor data drawings, Case studies.

UNIT IV CONTROLS 9

P&ID controls, Distributed Control Systems, signal lines, Selection of instruments - pressure, temperature, flow. P&ID for the given problem statement.

UNIT V SAFETY AND COST ANALYSIS 9

Final Control Elements; safety systems-application of P&ID in HAZOP, what – if, Fault tree analysis, Event tree analysis, & Risk analysis, Management of Change, cost approach. Practice & produce P&I diagrams using software packages during the period of the course. Occupational Safety and Health Administration (OSHA) - OSHA 29 CFR 1910.119

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Classify the materials, codes & standards used for piping the process plants.
CO2: Apply the piping design principle & importance of utilities in industrial process plants.
CO3: Analyze the isometric drawing and general arrangement drawings.
CO4: Appraise the importance of safety control systems during piping instrumentation.

CO5: Construct a complete Process & Instrumentation Diagram with effective plant wide control strategies using appropriate heuristics and its application.

REFERENCES:

1. Piping Handbook, 6 th edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook edited by Johan J McKetta, CRC Press, 1992.
3. Luyben, W. L.," Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
4. Moe Toghraei, “Piping and Instrumentation Diagram Development”, Wiley, First Edition, 2019.
5. Jagadeesh Pandiyan, “Introduction to Smart Plant(R) P&ID: The Piping and Instrumentation Diagrams (P&ID) Handbook”, APJ Books, 2010.
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7. American National Standards Institute (ANSI) - ANSI/FCI 70-2-2003 - Control Valve Seat Leakage - American Society of Mechanical Engineers (ASME) - ASME Boiler and Pressure Vessel Code. Section VIII - Pressure Vessels - The Instrumentation, Systems and Automation Society (ISA) – ISA 5.1, ISA 5.2, ISA 5.3, ISA 84.01

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	1	2
CO2	3	3	3	2	1	2
CO3	3	3	3	2	1	2
CO4	3	3	3	2	1	2
CO5	3	3	3	2	1	2
Average CO	3	3	3	2	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3052 DESIGN OF EXPERIMENTS

L	T	P	C
2	0	2	3

OBJECTIVE:

- To impart knowledge on sampling and sampling distribution and to apply hypothesis testing with different confidence intervals.
- To enable the students, develop skills in linear regression, both univariate and multivariate, and utilize least squares methods to estimate and interpret regression models.
- To enable the students to interpret experimental results using ANOVA, report data, and construct confidence intervals.
- To enable the students to perform ANOVA and regression analysis.
- To enable the students to explore variable selection, fractional factorial design, and robustness in experimental design.

UNIT I FOUNDATIONS OF PROBABILITY AND STATISTICS FOR ENGINEERS 6

Introduction to probability and statistics - including concepts and principles; Statistical inference fundamentals - such as estimation and hypothesis testing; Confidence intervals - providing a range of plausible values for population parameters; Hypothesis tests to make decisions based on experimental data.

UNIT II PRINCIPLES OF EXPERIMENTAL DESIGN 6

Statistical principles in experimental design - including the control of sources of variation; Blocking and complete randomization techniques; Factorial design to study the effects of multiple factors on the response variable; Analysis of individual factor effects and interaction effects; Introduction to response surface methodologies for optimizing response variables within a design space.

UNIT III REGRESSION MODELING AND ANALYSIS 6

Linear regression techniques - both univariate and multivariate - to model relationships between variables; Least Squares estimation - including its basic principles and variants; Nonlinear regression methods to model non-linear relationships; Techniques for model assessment, interpretation, and evaluation of regression models.

UNIT IV ANALYSIS OF VARIANCE AND EXPERIMENTAL INFERENCE 6

Introduction to ANOVA - a statistical technique for comparing means among multiple groups or treatments; Interpretation of results from experiments using ANOVA; Effective reporting of experimental data; Construction of confidence intervals to estimate population means and differences.

UNIT V ADVANCED TOPICS IN STATISTICS AND EXPERIMENTAL DESIGN. 6

Exploration of additional topics in statistics and experimental design; Variable selection techniques to identify significant factors in regression models; Fractional factorial design for efficient exploration of factor combinations; Robustness in experimental design and analysis - focusing on the stability and reliability of statistical methods in the presence of deviations from assumptions.

THEORY: 30 PERIODS

List of tasks to be performed by students: Software Minitab/equivalent alternative

PRACTICAL: 30 PERIODS

1) Exploratory Data Analysis: Import a dataset into Minitab and perform exploratory data analysis; Calculate descriptive statistics - such as mean, median, and standard deviation; Create graphical representations of the data, including histograms, box plots, and scatter plots.

2) Probability Distribution Analysis: Generate random numbers from different probability distributions in Minitab - such as normal, exponential, or binomial; Fit probability distributions to data and assess goodness-of-fit using Minitab's distribution fitting tools.

3) Hypothesis Testing and Confidence Intervals: Formulate hypotheses and perform hypothesis tests using Minitab for various scenarios; Conduct t-tests, chi-square tests, or ANOVA tests to compare population means or proportions.

4) Experimental Design and Analysis: Design and execute experiments using Minitab's design of experiments (DOE) tools; Analyze the results of designed experiments - including factorial designs, using Minitab's DOE analysis features; Assess the significance of factor effects and interaction effects.

5) Regression Modeling and Analysis: Perform linear regression analysis in Minitab to model relationships between variables; Interpret the coefficients and significance of predictors in regression models; Assess the goodness-of-fit and validity of regression models using diagnostic plots and statistical tests in Minitab.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Theory

CO1: Recognize and recall foundational probability and statistics concepts and apply them to solve engineering problems.

CO2: Apply statistical inference techniques to draw conclusions from experimental data.

CO3: Analyze variance (ANOVA) technique and apply it to experimental design and interpretation of results.

CO4: Illustrate skills in linear regression modeling and interpret regression models for engineering applications.
CO5: Apply statistical principles to experimental design and assess model adequacy for regression models.
CO6: Recall and apply foundational statistical concepts in practical data analysis using software tools like Minitab.
CO7: Demonstrate proficiency in conducting hypothesis tests, constructing confidence intervals, and analyzing experimental data using software.
CO8: Analyze regression models, interpret their coefficients, and evaluate model adequacy through diagnostic plots and statistical tests using software.

REFERENCES:

1. R.L. Mason, R.F. Gunst and J.L. Hess (2005). Statistical Design and Analysis of Experiments – with applications to engineering and science, 2 nd edition, John Wiley & Sons
2. Design of Experiments in Chemical Engineering: A Practical Guide by Z. R. Lazic, John Wiley
3. R.A. Johnson, I. Miller and J. Freund (2007). Probability and Statistics for Engineers, 7 th edition, Prentice Hall Inc.
4. D.C. Montgomery and G.C. Runger (2007). Applied Statistics and Probability for Engineers, 4th edition, John Wiley & Sons Inc.
5. Box, George EP, J. Stuart Hunter, and William G. Hunter. "Statistics for experimenters." In Wiley series in probability and statistics. Hoboken, NJ: Wiley, 2005.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	1
CO2	1	3	1	1	3	1
CO3	1	1	3	1	1	1
CO4	2	1	3	1	1	1
CO5	1	1	1	1	3	1
CO6	1	1	2	2	3	2
CO7	3	2	2	2	3	2
CO8	2	1	1	2	3	2
Average CO	1.80	1.40	2.00	1.40	2.30	1.40

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3055 SUSTAINABLE MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES

- To enable the students to learn the fundamentals of sustainability in the context of engineering.
- To enable the students to analyze the environmental impact of chemical processes and identify opportunities for improvement.
- To impart knowledge on sustainable process design and optimization techniques.
- To enable the students to evaluate energy efficiency and resource conservation strategies in industries/ plants.

- To enable the students to develop skills for implementing sustainable practices in engineering projects and operations.

UNIT I INTRODUCTION TO SUSTAINABLE MANAGEMENT 9

Overview of sustainability principles and their relevance to chemical/petroleum/environmental engineering; Environmental challenges in the chemical industry; Introduction to sustainable development goals and their application in chemical engineering; Role of engineers in promoting sustainability; Introduction to life cycle assessment (LCA) and environmental impact analysis.

UNIT II SUSTAINABLE PROCESS DESIGN AND OPTIMIZATION 9

Principles and strategies for sustainable process design, Analysis and optimization of chemical processes for sustainability; Integration of green chemistry principles in process design; Case studies on sustainable process design in chemical engineering; Tools and software for sustainable process design and optimization.

UNIT III ENERGY EFFICIENCY AND CONSERVATION 9

Energy consumption and environmental impact of chemical processes; Strategies for improving energy efficiency in chemical plants; Energy conservation techniques in heat transfer, separation processes, and reactions; Integration of renewable energy sources in chemical processes; Case studies on energy-efficient operations in chemical engineering.

UNIT IV WASTE MINIMIZATION AND RESOURCE RECOVERY 9

Waste generation in chemical processes and its impact on the environment; Techniques for waste minimization and treatment; Resource recovery from waste streams, Recycling and circular economy principles in chemical engineering; Case studies on waste reduction and resource recovery in chemical processes.

UNIT V SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN INDUSTRY 9

Sustainability considerations in the chemical supply chain; Responsible sourcing of raw materials, Green packaging and logistics practices; Supplier assessment and management for sustainability; Certification systems and standards for sustainable supply chains.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Identify and discuss the key principles and concepts of sustainability in the context of engineering.

CO2: Analyze and evaluate the environmental impact of chemical processes and propose sustainable solutions.

CO3: Design and optimize chemical processes considering sustainability factors and green chemistry principles.

CO4: Assess and implement energy-efficient strategies and resource conservation techniques in chemical plants.

CO5: Apply sustainable supply chain management principles to ensure responsible sourcing and minimize environmental impact.

REFERENCE BOOKS

1. Beder, Sharon., “Environmental principles and policies: an interdisciplinary introduction”, Routledge, 2013.
2. Elkington, John, and Ian H. Rowlands. "Cannibals with forks: The triple bottom line of 21st century business." Alternatives Journal 25, no. 4,42, 1999.
3. Fiksel, Joseph. Design for environment: a guide to sustainable product development. McGraw-Hill Education, 2009.
4. Johansson, Allan. Clean technology. CRC Press, 1992.

5. Kane, Gareth. The green executive: corporate leadership in a low carbon economy. Routledge, 2012.
6. Kirkwood, Ralph, and Anite Longley, eds. Clean technology and the environment. Springer Science & Business Media, 1994.
7. Mulder, Karel, ed. Sustainable development for engineers: A handbook and resource guide. Routledge, 2017.
8. Marinova, Dora, David Annandale, and John Phillimore, eds. The international handbook on environmental technology management. Edward Elgar Publishing, 2008.
9. Von Weizsäcker, Ernst Ulrich, Amory B. Lovins, and L. Hunter Lovins. Factor four: doubling wealth—halving resource use: a new report to the club of Rome. Springer International Publishing, 2014.
10. Willums, Jan-Olaf. The sustainable business challenge: a briefing for tomorrow's business leaders. Routledge, 1998.
11. Harmsen, Jan, and Joseph B. Powell. Sustainable development in the process industries. Hoboken, NJ: John Wiley & Sons, 2010.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	1	1
CO2	1	2	2	3	3	2
CO3	2	3	3	3	3	2
CO4	2	2	1	3	1	1
CO5	1	2	2	2	3	2
Average CO	1.80	2.40	2.20	2.40	2.20	1.60

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3008 MODELLING OF TRANSPORT PROCESSES **L T P C**
3 0 0 3

OBJECTIVES

1. To impart knowledge on Interphase Transport in Isothermal systems.
2. To enable students to solve unsteady state problems for isothermal systems.
3. To impart knowledge on Inter-phase Transport in Non-Isothermal Systems.
4. To enable students to solve unsteady state problems for non-isothermal systems.
5. To impart knowledge on Inter-phase Transport in Non-Isothermal Mixtures.

UNIT I INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS 9

Definition of Friction Factors, Friction Factors for Flow in Tubes, Pressure drop required for a given flow, Friction Factors for Flow around Spheres, Determination of the Diameter of a Falling Sphere, Friction Factors for Packed Columns

UNIT II MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS AND POLYMERIC LIQUID 9

The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous Loss, Use of the Macroscopic Balances for Steady-State problems - Pressure Rise and Friction Loss in a Sudden Enlargement - Isothermal Flow of a Liquid through an Orifice. Use of macroscopic balance to solve unsteady state problems

UNIT III INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS 9

Definitions of Heat Transfer Coefficients, Analytical Calculations of Heat Transfer Coefficients for Forced Convection through Tubes and Slits, Heat Transfer Coefficients for Forced Convection in Tubes, Heat Transfer Coefficients for Forced Convection around Submerged Objects, Heat Transfer Coefficients for Forced Convection through Packed Beds, Heat Transfer Coefficients for Free and Mixed Convection, Heat Transfer Coefficients for Condensation of Pure Vapours on Solid Surfaces.

UNIT IV MACROSCOPIC BALANCES FOR NON-ISOTHERMAL SYSTEMS 9

The Macroscopic Energy Balance, The Macroscopic Mechanical Energy Balance, Use of the Macroscopic Balances to Solve Steady-State Problems with Flat Velocity Profiles, D-forms of Macroscopic Balance, Parallel- or Counter-Flow Heat Exchangers, Flow of Compressible Fluids through Head Meters, Use of Macroscopic Balance to Solve Unsteady State Problems.

UNIT V INTERPHASE TRANSPORT IN NON-ISOTHERMAL MIXTURES 9

Definition of Transfer Coefficients in One-Phase Evaporation from a Freely Falling Drop, Wet and Dry Bulb, Mass Transfer in Creeping Flow through Packed Beds, Mass Transfer to Drops and Bubbles, Definition of Transfer Coefficients in Two Phases, Determination of the Controlling Resistance, Estimation of the Interfacial Area in a Packed Column, Estimation of Volumetric Mass Transfer Coefficients, Combined Mass and Heat Transfer by Free Convection

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Demonstrate the interphase momentum transfer in an isothermal system.
CO2: Analyze macroscopic mass momentum and energy balance in an isothermal system and its applications.
CO3: Illustrate the interphase energy transfer in a non-isothermal system.
CO4: Analyze the concept of macroscopic energy balance in a non-isothermal process.
CO5: illustrate the interphase mass transfer in a non-isothermal system.

REFERENCE BOOKS

1. Bird R.B., Stewart, W.E. and Lightfoot, E.N., "Transport Phenomena", Revised 2nd Edn., John Wiley and Sons, 2007
2. Welty, J.R., Wicks, C.E. and Wilson, R.E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2010.
3. Brodkey, R.S. and Hershey, H.C., "Transport Phenomena – A Unified Approach", Brodkey Publishing, 2004
4. C.J. Geankopolis, "Transport Processes in Chemical Operations", 3rd Edn., Prentice Hall of India, New Delhi, 1996
5. Shyy, Wei, “Computational modeling for fluid flow and interfacial transport”, Elsevier, 2013.
6. Leal, L. Gary., “Advanced transport phenomena: fluid mechanics and convective transport processes”, Vol. 7, Cambridge University Press, 2007.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	1	2	1	1
CO2	3	1	1	2	1	1
CO3	3	1	1	2	1	1
CO4	3	1	1	2	1	1
CO5	3	1	1	2	1	1

Average CO	3	1	1	2	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3009 ADVANCED PROCESS DYNAMICS AND CONTROL L T P C
3 0 0 3

OBJECTIVES

1. To impart knowledge on the concepts of control objectives and advanced control techniques.
2. To enable the students to learn and apply internal model control and model predictive control systems.
3. To impart knowledge on discrete control systems for multiple input and output systems.
4. To enable the students to understand the operational aspects and challenges associated with steam injection processes.
5. To enable the students to learn, identify and analyze common problems encountered in enhanced oil recovery.

UNIT I CONTROL STRATEGY 9

Feed forward, cascade, dead time compensation, split range, selective and override control; Inverse response; automatic tuning and gain scheduling; First-Order Plus Time Delay (FOPTD).

UNIT II INTERNAL MODEL CONTROL 9

Development and design- IMC structure, open loop IMC for first order and second order, inverse response and dead time; Factorization – simple factorization, all pass factorization; closed loop IMC; model uncertainty and disturbance; improved disturbance rejection design; integration process; IMC based PID control for first and second order system; first order with dead time.

UNIT III MULTIPLE INPUT AND OUTPUT SYSTEMS 9

Control loop interaction – general pairing problem, relative gain array and application, sensitivity; Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling, steady state effective gain properties and applications, scaling consideration.

UNIT IV DISCRETE SYSTEMS 9

Sampling of continuous signal; pulse transformation; construction of discrete signal from control signal, reconstruction of discrete signal to control signal, conversion of continuous to discrete model; Z – Transform and inverse Z – transform properties; Discrete – Time Response of dynamic system, discrete time analysis of continuous system; pure integrated first order system; Pulse Transfer Function; Closed Loop System Stability - Design of digital feedback controllers, physically realizable controller, deadbeat controller and dahlin's controller, digital approximation of classical, effect of sampling.

UNIT V MPC, OPTIONAL CONTROL AND DYNAMIC PROGRAMING 9

MPC - Models forms of model predictive control; Constrained and unconstrained approach; Analysis of dynamic matrix control; Extension to multivariable system; Other MPC methods. Optimal Control with Complete Information on the Plant, Control of a Static Plant, Problems of Optimal Control for Dynamical Plants; Principle of Optimality and Dynamic Programming.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Describe, identify and implement advanced control strategies such as cascade, split range override control.

CO2: Develop, implement and optimize internal model control.
CO3: Demonstrate the interaction and pairing in process systems.
CO4: Apply and develop discrete control systems.
CO5: Develop, implement and optimize model predictive control, Optimal control and digital feed controllers.

REFERENCE BOOKS

1. Smith C. A., Corripio, A. B., “Principles and Practice of Automatic Process Control”, 2nd Ed., John Wiley and Sons, New York, 1989.
2. Bequette, B. W., “Process Control: Modeling, Design and Simulation”, Prentice Hall, 2003.
3. Luyben W. L., “Process Modeling Simulation and Control for Chemical Engineers”, 2nd Ed., Mc Graw Hill publisher, 1990.
4. Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, “Control System Design” Prentice Hall, 2000.
5. George Stephanopoulos, “Chemical Process Control: An Introduction to Theory and Practice”, Pearson, 2015.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	2	2	1	3
CO2	3	3	2	2	1	3
CO3	3	3	2	2	2	3
CO4	3	3	2	2	2	3
CO5	3	3	2	2	2	3
Average CO	3	3	2	2	1.6	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3010 FUEL CELL TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES

1. To enable the student to learn the concept of Fuel cell.
2. To enable the student to learn the Fuel Cell Kinetics.
3. To impart knowledge on the basics of Fuel cell characterization.
4. To impart knowledge on the preparation of Stack Cell.
5. To enable the student to learn about the Hydrogen production from renewable energy.

UNIT I OVERVIEW OF FUEL CELLS AND TYPES 9

Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency. Types of fuel cells-AFC, PAFC, SOFC, MCFC, DMFC, PEMFC relative merits and demerits selection and use of materials**.**

UNIT II FUEL CELL REACTION KINETICS 9

Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and ass transport - flow field, transport in electrode and electrolyte.

UNIT III FUEL CELL CHARACTERIZATION AND MODELING 9

Fuel cell characterization - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modelling and system integration: - 1D model – analytical solution and CFD models.

UNIT IV BALANCE OF PLANT AND HYDROGEN PRODUCTION 9

Balance of plant; Hydrogen production from renewable energy sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

UNIT V FUEL CELL POWER PLANTS AND APPLICATIONS 9

Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Describe the basics and working principles of the Fuel cell technology.
CO2: Choose the suitable materials for electrode, catalyst, membrane for the fuel cells.
CO3: Apply mass transfer processes such as pressure drop and velocity distribution in single cell as well as stack.
CO4: Design and stack making process for real field applications.
CO5: Analyze the cost and life cycle of fuel cells.

REFERENCE BOOKS

1. O'Hayre, R.P.,S.Cha,W. Colella, F.B.Prinz, Fuel Cell Fundamentals,Wiley, NY (2006).
2. Liu, H.,Principles of fuel cells, Taylor & Francis, N.Y. (2006).
3. Fuel cell technology handbook, edited by GregorHoogers, CRC Press 2003.
4. Bard,A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y.(2004) Ref Book.
5. Basu,S.(Ed) Fuel Cell Science and Technology,Springer, N.Y.(2007).

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	1	2	1	1
CO2	3	3	3	2	1	1
CO3	3	3	3	2	2	1
CO4	3	2	2	2	2	1
CO5	1	2	2	2	2	1
Average CO	2.60	2.60	2.20	2.00	1.60	1.00

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3011 ENHANCED OIL RECOVERY L T P C
3 0 0 3

OBJECTIVES

- To enable the students to understand the fundamental principles of enhanced oil recovery.
- To impart knowledge on water flooding techniques.
- To enable the students to learn various enhanced oil recovery operations.
- To impart knowledge on the operational aspects and challenges associated with steam injection processes.
- To enable students to analyze common problems encountered in enhanced oil recovery.

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY 8

Pore Geometry; Microscopic aspects of displacement; Residual oil; Buoyancy forces and prevention of trapping, Wettability; Residual oil and Oil recovery; Macroscopic aspect of displacement, relative permeability, Drainage, Imbibition; Basic equation for flow in permeable media.

UNIT II WATER FLOODING 9

Properties, sampling and analysis of oil field water; Injection waters water quality test; Water flooding – Sweep efficiency; Rules of thumb; Improved water flood processes using chemicals; Performance of some important water floods.

UNIT III ENHANCED OIL RECOVERY OPERATIONS-1 10

Flooding – miscible, CO2, polymer, alkaline, surfactants; Gas injection; Gas injection in carbonate reservoir; inert Gas injection.

UNIT IV ENHANCED OIL RECOVERY OPERATIONS-2 10

Steam; operational aspects of steam injection process; water treatment for steam generation; insitu combustion technology; microbial method.

UNIT V PROBLEMS IN ENHANCED OIL RECOVERY 8

Precipitation and deposition of Asphaltenes and Paraffins; Scaling problems; Formation of damage due to migration of fines; Environmental factors associated with EOR processes.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Recognize and recall the displacement process and fluid flow in reservoir.
CO2: Explain and describe the principles and effects of water flooding process by evaluating its impact and predicting the outcomes.
CO3: Explain the importance of steam flooding process during the recovery of highly viscous fluids and evaluate the R &D activities of microbial method.
CO4: Analyze the environmental issues related to each recovery process and assess their implications on sustainability.
CO5: Recognize the importance of upstream process, assess the ongoing R&D activities, and evaluate the energy and environmental issues associated with it.

REFERENCE BOOKS

1. Donaldson, E.C. and G. V. Chilingarian, T. F. Yen, “Enhanced oil Recovery – I & II”, Fundamentals and Analysis, Elsevier Science Publishers, New York, 1985.
2. Lake, L.W., “Enhanced oil recovery”, Prentice Hall, 1989.
3. Schumacher, M.M., “Enhanced oil recovery: Secondary and tertiary methods”, Noyes Data Corp., 1978.
4. Van Poollen, H.K. “Fundamentals of enhanced oil recovery”, PennWell Books, 198
5. Kremieniewski, Marcin, “Fundamentals of Enhanced Oil Recovery”, MDPI, Basel, 2022.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	-	1	-	1	-
CO2	-	-	1	1	1	-
CO3	3	2	3	3	2	3
CO4	1	-	1	1	-	2
CO5	3	2	3	3	2	3
Average CO	2.50	2.00	1.80	2.00	1.50	2.67

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3012 SUPPLY CHAIN MANAGEMENT IN OIL AND GAS

L	T	P	C
3	0	0	3

OBJECTIVES

1. To impart knowledge on the role of planning in oil and gas
2. To impart knowledge on oil and gas network integration and coordination
3. To enable the students to understand supply chain development in oil and gas industry
4. To impart knowledge on modules of supply chain
5. To learn and apply on optimization of system of supply of petroleum products.

UNIT I RISKS IN SUPPLY CHAIN 9

Types of choices involving risk, approaches in managing supply chain risk; optimal term of commitment, materials unavailability strategies; Oil climate-Oil and gas network planning, Integration and coordination.

UNIT II SUPPLY CHAIN DEVELOPMENT 9

project structure choices, partner relationship, bid slate development, tendering process, international risk management standards, mitigation frameworks.

UNIT III SUPPLY CHAIN VALUE 9

Supply chain cost drivers, project risk mitigation, supply availability and price risk; engineering and procurement-construction and installations-operations and maintenance reduction.

UNIT IV SUPPLY CHAIN OPERATIONAL CHALLENGES 9

Challenges in supply chain-logistical challenges- swap practices- asset swapping- swapping business- swapping shipments.

UNIT V SUPPLY CHAIN OPTIMIZATION 9

KPI indicators, Upstream – exploration and production, downstream – retail and marketing, environment, supply chain overall, cost cutting, vertical integration, revenue models, consolidation, design to value; Optimization and business improvement studies in oil and gas industry.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Identify the risks involved in the oil and gas industry and assess their potential impact.
CO2: Comprehend the processes involved in bid and tendering and analyze their significance in supply chain management.
CO3: Analyze the risks associated with supply chain management in the oil and gas industry and develop strategies to mitigate them.

CO4: Describe the swapping process in the oil and gas industry and evaluate its implications on supply chain operations.
CO5: Recognize the importance of supply chain in upstream, midstream, and downstream sectors of the oil and gas industry and evaluate the approaches involved in effective supply chain management.

REFERENCE BOOKS

1. David Jacoby.,"Optimal Supply Chain Management in Oil, Gas and Power Generation", Pennwell Corporation, 2012.
2. Thomas I. Schoenfeld.,"A Practical Application of Supply Chain Management Principles", , American Society for Quality, Quality Press,2008.
3. Sanchay Roy., Stewart DunbarI.,"mproving Supply Chains in the Oil and Gas Industry",2022.
4. Ali Elkamel, Khalid Y., Al-Qahtani .,"Planning and Integration of Refinery and Petrochemical Operations",,2011.
5. Lazaros Papageorgiou.,Michael C. Georgiadis.,"Supply-Chain Optimization", Part II,wiley,2008.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	3	3	3	3	1
CO2	2	2	2	3	3	1
CO3	2	2	2	3	3	2
CO4	2	2	2	3	3	2
CO5	2	2	2	3	3	2
Average CO	2	2	2	2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3013 PETROLEUM ECONOMICS L T P C
3 0 0 3

OBJECTIVES

1. To impart knowledge on the basics of project economics and obtain an overview of the economic dimension of the petroleum sector.
2. To make students learn about reserve assessments and forecasting methodologies and the world petroleum market.
3. To enable the students learn about the global petroleum market.
4. To enable the students to understand auditing, pricing and taxation.
5. To enable the students to understand modelling and economic evaluation in petroleum industries.

UNIT I CAPITAL BUDGETING TECHNIQUES 9

Introduction to economics analysis; energy overview of India; Time value of money; cash flow analysis; profit analysis techniques; project cash flows; decision trees.

UNIT II ASSESSMENT, FORECAST AND CLASSIFICATION OF RESERVES 9

Reserves classification methods; quantification, assessment of geoscience and reservoir engineering uncertainties; Assessment of reserves; reserve forecasting; production and demand in the international market.

UNIT III GLOBAL OIL MARKET 9

Oil market and OPEC; share of non OPEC countries in oil production; Role of OCED countries in oil trade; International oil and gas pricing mechanism; price forecasting; oil purchase pattern of India.

UNIT IV AUDITING AND TAXATION 9

Petroleum Fiscal system: classification and analysis; Reserves Auditing; Accounting Systems for oil and gas; Inflation and cost escalation; depreciation; depletion and amortization; government taxation.

UNIT V ECONOMIC EVALUATION AND MODELING 9

Project Economic Evaluation and petroleum economic models; Decision analysis; Valuation of petroleum.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Explain the different kinds of budgeting techniques used in the petroleum industry.

CO2: Comprehend the classification, assessment, and forecast of reserves in the petroleum sector.

CO3: Analyze the production and consumption patterns of petroleum and understand the pricing mechanism associated with it.

CO4: Demonstrate a comprehensive understanding of auditing practices in the petroleum industry.

CO5: Apply economic project modeling techniques to real-world problems in order to generate outcomes.

REFERENCE BOOKS

1. Johnston, D, “International Exploration Economics, Risk, and Contract Analysis”, Pennwell Books, 2003.
2. Abdel-Aal, H. K. Bakr, A. B. Al-Sahlawi. A : Petroleum Economics and Engineering, Dekrer Publication, 1992
3. Seba R. D., “Economics of Worldwide Petroleum Production”, OGCL Publications, USA, 1998.
4. Thompson R. S. and Wright J. D., “Oil Property Evaluation”, 2nd Edition, Thompson Wright Associates, 1985.
5. Mark Cook., “Petroleum Economics and Risk Analysis”, 1st edition, Elsevier, 2021.
6. Cronquist, C., Estimation and classification of Reserves of Crude oil, Natural Gas, and Condensate, SPE, 2001.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	-	3	-	-	3
CO2	1	-	3	2	1	3
CO3	1	-	3	-	-	3
CO4	1	1	3	-	-	3
CO5	2	-	3	1	2	3
Average CO	1.40	1.00	3.00	1.50	1.50	3.00

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3014 PROCESS PLANT SAFETY IN PETROLEUM INDUSTRIES AND RISK ANALYSIS

L	T	P	C
3	0	0	3

OBJECTIVES

1. To enable the student to learn about hazard identification and assessment.
2. To enable the students to understand the importance of safe hazardous materials handling.
3. To enable the students to understand the effects of petroleum pollutants on different environments.
4. To enable the students to understand the health impacts of petroleum pollutants.
5. To impart knowledge on design and enable students to perform modelling for safety in petroleum industries.

UNIT I HAZARD TYPES, IDENTIFICATION AND ASSESSMENT 9

Importance and need for safety; hazard and risk; types of hazards; hazard assessment; hazard identification during processing of crude and operation; risk assessment; Risk analysis methods- Quantitative Risk Assessment (QRA), Preliminary Hazard Analysis (PHA), Fault Tree Analysis (FTA); case studies- PIPER ALPHA PLATFORM 1988, Mumbai High North Disaster, 2005.

UNIT II HAZARDOUS MATERIALS HANDLING 9

Handling of hazardous materials; Anhydrous hydrofluoric acid; the amines used in gas treating; Caustic soda; Furfural; Hydrogen sulfide; Methyl ethyl ketone; Aqueous wastes; Importance of Material Safety Data Sheet (MSDS) sheet.

UNIT III ENVIRONMENTAL IMPACTS OF PETROLEUM POLLUTANTS 9

Pollutants in aqueous waste streams and impacts; Emission to the atmosphere and impacts; Reducing and controlling the atmospheric pollution in refinery products; Features of the Clean Air Act; Noise problems and typical in-plant community noise standards; Fundamentals of acoustics and noise control; Coping with noise in the design phase.

UNIT IV HEALTH IMPACTS OF PETROLEUM COMPONENTS 9

Health hazards in Petroleum Industry: Toxicity, Physiological, Asphyxiation, Respiratory and skin effect of petroleum hydrocarbons, sour gases; Safety System- Manual and automatic shutdown system, blow down systems, Gas detection systems.

UNIT V SAFETY DESIGN AND MODELLING 9

HAZOP study and its importance; Fire prevention and firefighting; the design specification for safety; Fire prevention with respect to equipment design and operation; Fire and explosion modelling.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Define the fundamental concepts of safety and risk management in the petroleum industry.

CO2: Comprehend the dangers associated with hazardous materials used in petroleum operations.

CO3: Identify the environmental effects of pollutants emitted by the petroleum industry.

CO4: Understand the health impacts of petroleum hazards and explain the safety systems implemented to mitigate risks.

CO5: Recognize fire hazards in petroleum plants and demonstrate knowledge of preventive measures and firefighting techniques.

REFERENCE BOOKS

1. Fawcett, H. H., “Safety and Accident Prevention in Chemical Operations by John Wiley & Sons, 1982.

2. Srinivasan Chandrasekaran, “Health, Safety and Environmental Management in offshore and petroleum management”, Wiley, 2016
3. Kind, R. W., “Industrial Hazard and Safety Handbook” Butterworth, 1982.
4. Rao, P. C. K., “Project Management and Control”, Sultan Chand & Co., Ltd., 1996
5. David.S.J. “STAN” Jones and Peter R.Pujado, “Handbook of Petroleum Processing,Springer, 2006.
6. Pandya, C. G., “Risks in Chemical Units”, Oxford and IBH Publishers, 1992.
7. Crowl, D. A. and Louvar, J. F., “Chemical process safety; Fundamentals with applications”, Prentice Hall Publications Inc., 2002.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	-	1	2	3	-	3
CO2	-	2	2	3	-	3
CO3	-	-	2	3	-	3
CO4	1	-	2	3	-	3
CO5	-	-	2	3	3	3
Average CO	1	1.50	2.00	3.00	3.00	3.00

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3015 STORAGE AND TRANSPORTATION OF PETROLEUM PRODUCTS **L T P C 3 0 0 3**

OBJECTIVES

1. To impart knowledge on Learn different types of additives and its significance with fuel in Engines.
2. To enable the students to learn about various types of storage tank energy loss and gain in storage tank system.
3. To enable the students to learn about special features of fluid transport in pipelines.
4. To enable the students to learn about piping and instrumentation techniques in transporting petroleum products.
5. To impart knowledge about corrosion in pipes and inhibition of corrosion, offshore transportation of petroleum products.

UNIT I ADDITIVES PETROLEUM PRODUCTS AND AUTOMOTIVE LUBRICANTS9

Additives for petroleum products, scope for additive industry, general properties of additives, selection and control of additives- liquid fuel additives- liquefied petroleum gas-gasoline additives- jet fuel additives- distillate fuel oils- residual fuel oil additives- additives for automotive lubricant .

UNIT II STORAGE SYSTEMS 9

Storage facilities- Atmospheric storage- Fixed Roof Tank- Floating Roof Tank- Pressure storage- Horton Sphere- Bullet type storage- Heated storage tanks; Accessories, Calculating heat loss and heater size for a tank, case study – Bhopal Tragedy

UNIT III FLOW MECHANICS 9

Advantages and the special features of pipelines; The fluid mechanics of various types of pipe flow including incompressible and compressible flows of Newtonian fluids, non-Newtonian fluids, flow of solid/liquid mixture (slurry), flow of solid/air mixture (pneumatic transport), and flow of capsules (capsule pipelines).

UNIT IV PETROLEUM TRANSPORTATION SYSTEM 9

Various types of pipes (steel, concrete, PE, PVC, etc.), valves (gate, globe, ball, butterfly, etc.) and pressure regulators in pipelines, Blowers and compressors (for gases), Various kinds of flowmeters, sensors, pigs (scrapers) and automatic control systems used in pipelines.

UNIT V PIPELINE TRANSPORTATION OF OIL AND GAS 9

Various means to protect pipelines against freezing- abrasion and corrosion- cathodic protection; Planning, construction and operation of pipelines, including modern use of advanced technologies such as global positioning systems (GPS), Product blending facilities, Road and rail loading facilities, Jetty and dock facilities, Filling, Loading, and despatch Operations, Jetty size, access and location.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Understand the importance of applying various types of additives with fuel in engines.

CO2: Analyze the heat loss and gain in storage tank systems and evaluate different types of storage vessels.

CO3: Assess the special features of pipelines and demonstrate knowledge of fluid flow operations.

CO4: Apply piping and instrumentation techniques in the transportation of petroleum products.

CO5: Evaluate corrosion in pipes, implement corrosion inhibition strategies, and assess the offshore transportation of petroleum products.

REFERENCE BOOKS

1. Jones, David SJ, and Peter P. Pujadó., “Handbook of petroleum processing”, Springer Science & Business Media, 2006.
2. Virgil B.Guthrie., “Petroleum Products Handbook”, McGraw Hill, 1960.
3. Pál A. Szilas., “Production and Transport of Oil and Gas”, Elsevier,1986.
4. Harold Sill Bell., “Petroleum Transportation Handbook”, McGraw-Hill,1963.
5. Liu., H., R. L. Gandhi., M. R. Carstens and G. Klinzing., "Freight pipelines: current status and anticipated use",(Report of American Society of Civil Engineers (ASCE) Task Committee on freight Pipelines), ASCE J. of Transportation Engr., vol. 124, no.4, pp.300- 310, Jul/Aug 1998.
6. Liu, H and T. Marrero., "Pipeline engineering research and education at universities in the United States," C.D. Proc. of Intl. Conf. on Engr. Education (ICEE-98), Rio de Janeiro Brazil, 15 pages, August 17-20, 1998.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3	3	3	1
CO2	3	3	3	3	3	1
CO3	3	3	3	3	3	2
CO4	2	3	3	3	3	2
CO5	3	3	3	3	3	2

Average CO	2.80	3.00	3.00	3.00	3.00	1.60

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3016 CORROSION ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To enable the students to understand the basic principles of corrosion.
- To enable the students to learn and explore corrosion testing techniques, both in the field and through electrochemical methods.
- To impart knowledge to study the use of corrosion inhibitors and various coating techniques.
- To enable the students to examine the corrosion damage to concrete in industrial and marine environments.
- to impart knowledge to Investigate corrosion in specific contexts.

UNIT I BASIC PRINCIPLES OF CORROSION AND TESTING TECHNIQUES 9

Basic principles of corrosion and its control – Forms of corrosion, uniform, Galvanic, Crevice, pitting, selective leaching, erosion, stress-corrosion, cracking – Cavitation phenomena and their effects – Corrosion testing – Field testing – Electrochemical techniques for measurement of corrosion rates, corrosion detection and components examination – Accelerated salt-spray testing.

UNIT II CORROSION INHIBITORS AND COATING TECHNIQUES 9

Corrosion inhibitors, electroplated coatings, conversion coatings, anodizing, hot dipping, spray metal coatings, zinc coating by alloying, electrophoretic coatings and electro painting, powder coating, electrical methods of corrosion protection, composite materials in corrosion minimization – Cathodic and Anodic protections.

UNIT III CORROSION DAMAGE AND PROTECTION IN CONCRETE ENVIRONMENTS 9

Corrosion damage to concrete in industrial and marine environments and its protection; Prediction of corrosion failures, biological corrosion, halogen corrosion of metals, environmental degradation of materials, corrosion and inspection management in chemical processing and petrochemical industries.

UNIT IV CORROSION IN SPECIFIC INDUSTRIES AND APPLICATIONS 9

Corrosion in structure – corrosion of stainless steels – corrosion in power equipments, corrosion in electrical and electronic industry – Oil field corrosion– Location description and equipment design -oil field corrosion control phenomena – Drill mud, Wet H2S cracking, corrosion control in fossil fuel boilers and steam raising- corrosion aspects in nuclear power plants – corrosion of surgical implants and prosthetic devices.

UNIT V CORROSION PROTECTION MANAGEMENT AND MAINTENANCE PROCEDURE 9

Corrosion protection management–process maintenance procedures under corrosion Environments.

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Understand the fundamental concepts of corrosion and its principles.
CO2: Apply the concepts in various corrosion testing techniques.

CO3: Evaluate the corrosion in specific environments and evaluate the corrosion prevention methods in pipelines.
CO4: Analyze corrosion monitoring and control methods in specific cases.
CO5: Relate the corrosion aspects and testing using different industrial devices and understand the risk assessment, protection management and evaluate the cost of corrosion.

REFERENCE BOOKS

1. Fontana, M.G., “Corrosion Engineering”, Edn 3, McGraw Hill, 2017
2. Corrosion Science and Technology, third edition, David E.J . Talbot and James D.R. Talbot,CRC press, 2018
3. Corrosion Control in the Oil and Gas Industry 1 st Edition, SankaraPapavinasam, 2013
4. Roberge, P.R., Handbook of Corrosion Engineering, McGraw-Hill, 2000.
5. Buchheit, R. G., and A. E. Hughes., "ASM Handbook, Volume 13A: Corrosion: Fundamentals, Testing, and Protection", 2003.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3	3	3	1
CO2	3	3	3	3	3	1
CO3	3	3	3	3	3	2
CO4	2	3	3	3	3	2
CO5	3	3	3	3	3	2
Average CO	2.80	3.00	3.00	3.00	3.00	1.60

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3054 INDUSTRIAL INSTRUMENTATION

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students to understand importance and measuring methods of various measurement parameters.
- To enable the students to understand and apply suitable instruments for measuring temperature, humidity and others.
- To enable the students to apply suitable analytical instruments for analyzing different samples.
- To enable the students to understand the necessity of controllers and sensors in measuring devices.
- To enable the students to analyze the industrial application and positioning of the measuring instruments.

UNIT I INTRODUCTION 9

Introduction – Variables, Units & standards of measurement, Measurement terms – characteristic. Data Analysis - why are the measurements of these parameters important in industry? Different methods for measurement of motion parameters: Displacement, velocity, acceleration, vibration, torque, force etc. Measurement of straightness, flatness, roundness and roughness. Typical case study/design example: Instrumentation system for motion measurement in industry.

UNIT II MEASURING INSTRUMENTS 9

Process Variables Measurement–Temperature systems– Thermocouples, Thermo resistive system, Filled-system thermometers, Radiation thermometry, Location of temperature measuring devices in equipments, Pressure system – Mechanical pressure elements Pressure Transducers and Transmitters, Vacuum measurement, Resonant wire pressure Transducer, Flow system – Differential producers, Variable area flow meters, Velocity, vortex, mass, ultrasonic & other flow meters, positive displacement flow meters, Open – channel flow measurements, Force systems, Strain gauges Humidity Moisture system, Humidity Measurement, Moisture measurement system, Rheological system, Viscosity measurement, Radiation system, Nuclear radiation instrumentation.

UNIT III ANALYTICAL INSTRUMENTS 9

Analytical instrumentation – Analysis instruments, Sample conditioning for process analyzers, X-ray Analytical methods, Quadrupole mass spectrometry, Ultra violet Absorption Analysis, Infra-red process analyzers, Photometric reaction product analyzers, Oxygen analyzers, Oxidation – reduction potential measurements, pH measuring systems, Electrical conductivity and Resistivity measurements, Thermal conductivity, gas analysis, Combustible, Total hydro carbon, and CO analyzer, Chromatography

UNIT IV CONTROLLERS AND SENSORS 9

Fundamentals of Automatic process control – Control algorithms-Automatic controllers – Electronic controllers -Electric controllers (Traditional) - Hydraulic controllers – Fluidics - Programmable controllers. Sensors, Transmitters and control valves - Pressure, Flow, Level, Temperature and Composition sensors, Transmitters, Pneumatic and electronic control valves, Types, Actuator, accessories, Instrumentation symbols and Labels.

UNIT V INDUSTRIAL SAFETY AND SPECIFICATIONS 9

Safety: Introduction, electrical hazards, hazardous areas and classification, Non-hazardous areas. Enclosures – NEMA types, fuses and circuit breakers, protection methods: purging, explosion proofing and intrinsic safety. Specification of instruments, preparation of project documentation, process flow sheet, Instrument index sheet, Instrument specification sheet, panel drawing and specifications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 List different process variables and their measurement units.

CO2 Recognize and recall the principle and working of various process variable measuring instruments.

CO3 Describe the principle, working and range of various analytical instruments.

CO4 Explain the role of controllers and sensors in industrial instrumentation.

CO5 Rate the need of safety and specifications in Industries.

TEXT BOOKS:

1. R.K.Jain, "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi.
2. C. D. Johnson, "Process Control Instrumentation Technology", PHI.
3. S.K. Singh, "Industrial Instrumentation and Control", Tata McGraw Hill Publishing Ltd., New Delhi.
4. Measurement Systems, Ernest O Doebelin & Dhanesh N Manik, McGraw Hill Education; 6 edition (July 2017).
5. Principles of Industrial Instrumentation, D Patranabis, McGraw Hill Education; 3 edition (July 2017).
6. A Course in Electronic Measurements and Instrumentation, A.K. Sawhney, Dhanpat Rai & Co. (P) Limited (2015).

7. Instrumentation, Measurement and Analysis, B. C. Nakra and K. K. Chaudhary, McGraw Hill Education India Private Limited; Fourth edition (1 August 2016).

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	2	2
CO2	3	3	3	1	2	2
CO3	3	3	3	1	2	2
CO4	3	3	3	1	2	2
CO5	3	3	3	1	2	2
Overall CO	3	3	3	1	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively