Department of Chemical Engineering

Vision:

Department of Chemical Engineering strives to be a premier institute in India, to create quality chemical engineers who will be highly successful in academic, industries and research. Our research motive is to develop sustainable technologies for the betterment of society.

Mission:

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

ANNA UNIVERSITY, CHENNAI:600 025

UNIVERSITY DEPARTMENTS

REGULATIONS – 2019

M.TECH. PETROLEUM REFINING AND PETROCHEMICALS

CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To master the advanced principles of Petroleum Engineering and Technology that underlies the concept of modern chemical process principles used in petroleum industries.
2. To prepare the students to apply knowledge in new areas within the field and to work towards the development of sustainable technologies in petroleum and allied industries.
3. To train the students to adapt different roles and demonstrate practical skills in global working environment with respect to diversity and ethical policies.
4. Graduates will have broad technical knowledge, communicative and interpersonal skills to occupy positions in professional leadership.
5. To function effectively in the complex modern work environment with the ability to excel in industry and academic roles.
6. To exhibit professional, ethical codes of conduct, team work and continuous learning for catering the ever changing needs of the society.

2. PROGRAMME OUTCOMES (POs)

On successful completion of this programme, the students will have

PO1: An ability to independently carry out research/ investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: To demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: Capability to identify the impact of engineering solutions in a global, economic, and societal context.

PO5: Effective skill to solve complex problems and design new processes in academic and engineering practices.

PO6: Expertise in the interpersonal skills and communicate effectively relating to petroleum engineering field.

PO7: Ability to use the state of art technology, skills and modern engineering tools necessary in petroleum and allied industries.

PO8: Competency in research and development in sustainable processes and in line with environmental regulations.

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PO9: Inclination towards acquiring knowledge and skills to new challenges on the latest advanced developments.

PO10: Understanding of professional, ethical, social, health, safety and environmental responsibilities in an organization.

PO11: Skill to work effectively in groups to accomplish assigned tasks, objectives and to excel in areas such as entrepreneurship, law, government and education in groups.

PO12: Competency in utilizing the available resources effectively and optimally.

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

Programme Educational Objectives	Programme Outcomes												Program Specific Objectives		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
2.	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
3.	✓	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	-	✓
4.	✓	✓	✓	✓	✓	-	-	✓	-	✓	✓	✓	-	✓	✓
5.	✓	✓	✓	✓	-	-	✓	✓	-	✓	✓	✓	-	✓	✓
6.	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	✓	-	-	✓

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4. MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

Year	SEM	Subjects	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
YEAR I	SEMESTER 1	Catalytic Reactor Theory And Design	2	2	3	1	1	2	1	3	2	1	1	1	3	3	2
		Petroleum Refining Technology-I	3	3	3	3	2	3	3	3	-	2	1	1	3	3	3
		Petroleum Thermodynamics	2	3	2	3	2	-	2	2	-	2	-	1	3	-	3
		Petroleum Equipment design	3	3	2	1	2	3	3	3	3	2	2	2	3	3	3
		Program Elective-I															
		Research Methodology and IPR															
		Audit Course -I															
		PRACTICALS															
		Laboratory –I Petroleum Testing Lab I	3	3	3	3	-	1	2	-	1	3	1	2	3	2	3
		Laboratory –II Instrumental Methods of Analysis Lab	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
YEAR II	SEMESTER 2	Petrochemical Technology	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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		Petroleum Refining Technology-II	3	3	2	2	1	2	3	2	-	2	1	-	3	3	3
		Process Modelling and optimization	3	3	1	2	2	2	2	2	3	-	3	1	3	3	2
		Program Elective-II															
		Program Elective III															
		Audit Course –II (one from list of Audit courses)															
		PRACTICALS															
		Laboratory III (Petroleum Testing Lab II)	3	3	3	3	-	1	2	-	1	3	1	2	3	2	3
		Laboratory IV (Fuel Analysis Lab)	3	3	3	3	-	1	2	-	1	3	1	2	3	2	3
		Mini Project with Seminar	3	3	3	3	3	2	3	3	3	2	2	2	2	2	2
YEAR III	SEMESTER 3	Program Elective IV															
		Program Elective V															
		Open Elective (one from list of 6 courses)															
		PRACTICALS															
		Project Phase I	3	3	3	3	3	2	3	3	3	2	3	2	3	3	3

YEAR IV																		
	SEMESTER 4	PRACTICALS																
		Project Phase II	3	3	3	3	3	2	3	3	3	2	3	2	3	3	3

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

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UNIVERSITY DEPARTMENTS
REGULATIONS – 2019
M.TECH. PETROLEUM REFINING AND PETROCHEMICALS
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER – I

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PP5101	Catalytic Reactor Theory and Design	PCC	3	1	0	4	4
2.	PP5102	Petroleum Refining Technology-I	PCC	3	0	0	3	3
3.	PP5103	Petroleum Thermodynamics	PCC	3	0	0	3	3
4.	PP5104	Petroleum Equipment Design	PCC	2	2	0	4	4
5.		Program Elective I	PEC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course – I*	AC	2	0	0	2	0
PRACTICALS								
8.	PP5111	Petroleum Testing Laboratory I	PCC	0	0	4	4	2
9.	PP5112	Instrumental Methods of Analysis Lab	PCC	0	0	4	4	2
			TOTAL	**18**	**3**	**8**	**29**	**23**

*Audit Course is Optional

SEMESTER – II

S. NO.	CODE NO.	COURSETITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PP5201	Petrochemical Technology	PCC	3	0	0	3	3
2.	PP5202	Petroleum Refining Technology-II	PCC	3	0	0	3	3
3.	PP5203	Process Modelling and Optimization	PCC	3	1	0	4	4
4.		Program Elective II	PEC	3	0	0	3	3
5.		Program Elective III	PEC	3	0	0	3	3
6.		Audit Course –II*	AC	2	0	0	2	0
PRACTICALS								
7.	PP5211	Petroleum Testing Lab-II	PCC	0	0	4	4	2
8.	PP5212	Fuel Analysis Lab	PCC	0	0	4	4	2
9.	PP5213	Mini Project with Seminar	EEC	0	0	2	2	1
			TOTAL	**17**	**1**	**10**	**28**	**21**

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SEMESTER III

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	PP5311	Project Phase I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	CODE NO.	COURSETITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PP5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 71

PROGRAM CORE COURSES (PCC)

S. No.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	PP5101	Catalytic Reactor Theory and Design	3	1	0	4	I
2.	PP5102	Petroleum Refining Technology-I	3	0	0	3	I
3.	PP5103	Petroleum Thermodynamics	3	0	0	3	I
4.	PP5104	Petroleum Equipment Design	2	2	0	4	I
5.	PP5111	Petroleum Testing Laboratory I	0	0	4	2	I
6.	PP5112	Instrumental Methods of Analysis Lab	0	0	4	2	I
7.	PP5201	Petrochemical Technology	3	0	0	3	II
8.	PP5202	Petroleum Refining Technology-II	3	0	0	3	II
9.	PP5203	Process Modelling and Optimization	3	1	0	4	II
10.	PP5211	Petroleum Testing Lab-II	0	0	4	2	II
11.	PP5212	Fuel Analysis Lab	0	0	4	2	II

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PROFESSIONAL ELECTIVE COURSES (PEC)

Program Elective – I

S. NO.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	PP5001	Petroleum Geology	3	0	0	3	I
2	PP5002	Separation Process Techniques	3	0	0	3	I
3	PP5003	Modelling of Transport Processes	3	0	0	3	I
	PP5004	Process Dynamics and Control	3	0	0	3	I
5	PP5005	Biofuels	3	0	0	3	I
6	CL5074	Multiphase Flow	3	0	0	3	II
7	PP5006	Corrosion Engineering	3	0	0	3	II
8	PP5007	Petroleum Exploration Technology	3	0	0	3	II
9	PP5008	Fuel Cell Technology	3	0	0	3	II
10	PP5009	Multicomponent Distillation	3	0	0	3	II
11	PP5010	Enhanced Oil Recovery	3	0	0	3	II
12	CL5071	Computational Fluid Dynamics	3	0	0	3	II
13	PP5011	Offshore drilling and production practices	3	0	0	3	II
14	PP5012	Supply chain management in oil & gas	3	0	0	3	II
15	PP5013	Petroleum Economics	3	0	0	3	III
16	PP5014	Polymer Process Technology	3	0	0	3	III
17	PP5015	Project Engineering of Process plants	3	0	0	3	III
18	PP5016	Oil and gas well testing	3	0	0	3	III
19	PP5017	Process plant safety in petroleum industries and risk analysis	3	0	0	3	III
20	PP5018	Additives, storage and transportation of petroleum products	3	0	0	3	III
21	CL5073	Fluidization Engineering	3	0	0	3	III
22	PP5019	Unconventional Treatment of Natural gas	3	0	0	3	III

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. No.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	RM5151	Research Methodology and IPR	2	0	0	2	I

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OPEN ELECTIVE COURSES [OEC*

*(Out of 6 Courses one Course must be selected)

S.NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO.	COURSE CODE	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			Lectur	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1	PP5213	Mini Project with Seminar	0	0	2	1	II
2	PP5311	Project Phase I	0	0	12	6	III
3	PP5411	Project Phase II	0	0	24	12	IV

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SUMMARY

S. No	Subject Area	Credits per Semester				Credits Total
		I	II	III	IV	
1	PCC	18	14	-	-	32
2	PEC	3	6	6	-	15
3	OEC	-	-	3	-	3
4	EEC	-	2	6	12	20
5	RMC	2	-	-	-	2
6	AC (Non Credit)	-	-	-	-	0
	Total	23	22	15	12	**72**
	Audit courses	*	*			

SEMESTER I

PP5101 CATALYTIC REACTOR THEORY AND DESIGN

L	T	P	C
3	1	0	4

OBJECTIVE

To understand the dynamics of heterogeneous reactors and be able to design, mode heterogeneous reactors.

UNIT I **12**

Catalytic reactor types and their industrial significance, Reactors with fixed bed, 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 **12**

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

UNIT III **12**

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

UNIT IV **12**

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, case studies.

UNIT V **12**

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: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basics of Reactor types and kinetic parameters involved in reactor design

CO2: Analyze the transport processes in heterogeneous reactions

CO3: Study the performance of two and three phase reactors

CO4: Identify the type of reactors based on performance.

CO5: Evaluate the kinetics of heterogeneous reactors and apply with computational studies

CO6: Apply the acquired modelling and design knowledge to Industrial heterogeneous catalytic reactors.

TEXT BOOKS

1. G.F. Froment, K.B, Bischoff, J. de Wilde, Chemical Reactor Analysis and Design, 3rded., Wiley & Sons, 2011.

2. Carberry – J.J. Chemical and Catalytic, Reaction Engineering, McGraw – Hill Book Co.,NY, 2001.

REFERENCES

1. Muchlyonor I, Dobkina E.,.DeryozhkinaV,.andSorco V., Catalyst Technology – CatalystTechnology MIR Publication, Moscow, 1982.

2. Z.I. Önsan, A.K. Avci, Multiphase catalytic reactor- Theory, Design, manufacturing and applications, John Wilaey and Sons, 2016.

3. Webterp K.R. Vanswaaij and Beenackers ACM, Chemical Reactor Design and Operations, Wiley, NY 1991

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Understand the basics of Reactor types and kinetic parameters involved in reactor design	2	2	2	-	1	3	1	3	-	-	-	2	2	3	2
CO2	Analyze the transport processes in heterogeneous reactions	2	2	1	-	-	2	1	3	2	-	-	2	2	3	2
CO3	Study the performance of two and three phase reactors	1	2	2	-	-	2	-	2	2	-	-	2	3	1	2
CO4	Identify the type of reactors based on performance.	2	2	3	1	-	1	-	1	1	1	1	1	3	2	2
CO5	Evaluate the kinetics of heterogeneous reactors and apply with computational studies	2	2	3	-	-	1	-	1	2	-	-	2	2	3	2
CO6	Apply the acquired modelling and design knowledge to Industrial heterogeneous catalytic	3	3	3	1	-	1	-	1	1	1	1	1	3	2	2
Over all CO		2	2	3	1	1	2	1	3	2	1	1	1	3	3	2

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

PP5012 PETROLEUM REFINING TECHNOLOGY - I

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

To impart detailed knowledge on petroleum refining processes and the quality up gradation process.

UNIT I **6**

Origin, Exploration and production of petroleum, the composition and characteristics of crude oil, the crude oil assay, Predicting product qualities Petroleum products, a refinery process configuration development, Crude Oil Receiving , Desalting of Crude Oil.

UNIT II **10**

The atmospheric crude distillation unit, the 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, Determine pump around and internal flows for vacuum towers, Calculate tower loading in the packed section of vacuum towers

UNIT III **10**

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 **10**

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 **9**

The thermal cracking processes, Residuum hydrocracking, the lube oil refinery, Lube oil properties, Asphalt production, Propane Deasphalting, Solvent Dewaxing, Hydrofinishing. Environmental aspects of refining, Quality control of products in petroleum refining

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Know the types and composition of crude and its products

CO2: Understand the importance of distillation process in a refinery

CO3: Know the different cracking process involved in the refinery process

CO4: Explain the different process involved using hydrogen

CO5: Explain the process involving the heavy hydrocarbons

CO6: Understand the importance of safety, environmental and quality control of petroleum products.

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TEXT BOOKS

1. David.S.J."STAN"Jones and Peter R.Pujado "Handbook of Petroleum Processing,Springer,2006.
2. Nelson, W.L "Petroleum Refinery Engineering" McGraw Hill Publishing Company Limited, 1985.
3. Hobson, G.D. – Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum U.K. 1973.

REFERENCES

1. Smalheer, C.V and R.Kennedy Smith Lubricant Additives. The Lezius – Hill Company, Cleveland, Ohio. USA, 1987
2. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, Mc Graw – Hill Publishing
3. Watkins, R.N "Petroleum Refinery Distillation", 2nd Edition, Gulf Publishing Company,Texas, 1981.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Know the types and composition of crude and its products	3	3	3	-	-	2	1	-	-	2	-	-	3	2	2
CO2	Understand the importance of distillation process in a refinery	3	3	3	-	-	3	1	2	-	1	-	-	3	2	2
CO3	Know the different cracking process involved in the refinery process	3	3	3	-	-	3	2	2	-	2	-	-	3	3	2
CO4	Explain the different process involved using hydrogen	3	3	3	3	-	3	2	2	-	2	-	-	3	3	2
CO5	Explain the process involving the heavy hydrocarbons	3	3	3	3	2	3	3	3	-	2	1	-	3	3	3
CO6	Understand the importance of safety, environmental and quality control of petroleum products.	3	3	3	3	2	3	3	3	-	2	1	1	3	3	3
Over all CO		3	3	3	3	2	3	3	3	-	2	1	1	3	3	3

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

PP5103 **PETROLEUM THERMODYNAMICS**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

Students will learn PVT behaviour of fluids, laws of thermodynamics, thermodynamic property relations and their application to fluids.

UNIT I INTRODUCTION **9**

Behaviour of Gases and Liquids – Gas laws, Density, Mole percent, Weight percent, Volumepercent, Specific gravity, Heat, Work Closed and Open Systems, First and Second Laws ofthermodynamics, specific heats, Compressibility factor, PVT relationships, Vapour pressure,Claussius – Clayperson equation, heat of vaporization.

UNIT II CHEMICAL THERMODYNAMICS OF PETROLEUM HYDROCARBONS **9**

Free energy change, Heat of reaction, Entropy change, Heat capacity, Heat of formation,Fugacity, Pressure – Temperature diagram, Pressure – Volume diagram, Density – Pressure – Composition diagram, Temperature – Composition diagram, VLE in ideal solution.

UNIT III QUALITATIVE PHASE BEHAVIOUR OF HYDROCARBON SYSTEMS **9**

Calculation of liquid and vapour composition of Bubble point and Dew point pressure for Multi component system. Equilibrium constant

UNIT IV HYDROCARBON FLUID CHARACTERISTICS **9**

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

UNIT V PROPERTIES OF MIXTURES AND LABORATORY ANALYSISOF RESERVOID FLUID **9**

Dalton Law Volumetric analysis of a gas mixture – apparent weight and gas constant –vapour mixtures – steam condenser, composition of reservoir fluid, vaporization test.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understanding the fundamental concepts of thermodynamics

CO2: Understanding the composition of volume, temperature and pressure.

CO3: To learn to predict and correlate important thermodynamic properties.

CO4: To gain insight into phase equilibria and chemical equilibria.

CO5: To understand the thermodynamics properties on hydrocarbon fluids.

CO6: To understand the application of thermodynamics on laboratory analysis

TEXT BOOKS

1. Smith, J.M., Van Ness, H.C and Abbot M.M “Introduction to Chemical Engineering Thermodynamics “, McGraw Hill Publishers, VI edition, 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 Francaisbupetrolepublications,France 2003.

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REFERENCES

1. Stanley.I.sandler,' Chemical and Engineering Thermodynamics' Wiley, 1988. 3. John J.McKetta Jr. ""Advances in Petroleum Chemistry and Refining"" – Volume 9 (Inter- science Publications), NY, 1983.
2. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid-phase Equilibria, 3rd Edn, Prentice Hall Inc., New Jersey, 1999

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Understanding the fundamental concepts of thermodynamics	3	2	1	-	-	-	-	3	-	1	-	-	3	-	3
CO2	Understanding the composition of volume, temperature and pressure.	1	3	2	-	2	-	-	2	-	2	-	-	2	-	-
CO3	To learn to predict and correlate important thermodynamic properties.	1	3	3	3	3	-	-	2	-	-	-	-	3	-	3
CO4	To gain insight into phase equilibria and chemical equilibria.	2	2	-	-	2	-	-	2	-	-	- -	-	2	-	-
CO5	To understand the thermodynamics properties on hydrocarbon fluids.	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO6	To understand the application of thermodynamics on laboratory analysis	1	-	-	-	-	-	2	-	-	-	-	1	3	-	3
Over all CO		2	3	2	3	2	-	2	2	-	2	-	1	3	-	3

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

PP5104 **PETROLEUM EQUIPMENT DESIGN**

	L	T	P	C
OBJECTIVE	**2**	**2**	**0**	**4**

To understand the fundamental concepts of equipment, utilities and its design in petroleum industry.

UNIT I **12**

Use of standards and codes in design activity, Vessels, Fractionators, trays, and packing's, Gap and Overlap, Packie's Correlation, Drums and drum design, Specifying pressure vessels, Reactors in Refineries, Batch, Continuous Stirred Tank Reactor, and Plug Flow Reactor Concepts, Naphtha Reformer Calculations, Calculations for a Fluidised Catalytic Cracking Reactor.

UNIT II **12**

Pumps, Pump selection, Selection characteristics, Capacity range, Evaluating pump performance, Specifying a centrifugal pump, The mechanical specification, The process specification, Compiling the pump calculation sheet, Centrifugal pump seals, Pump drivers and utilities, Reacceleration requirement, The principle of the turbine driver, The performance of the steam turbine

UNIT III **12**

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 **12**

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 and condensers, Condensers, 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.

UNIT V **12**

Fired heaters, Codes and standards, Thermal rating, Heater efficiency, Burners, Refractories, stacks, and stack emissions, specifying a fired heater. Design consideration for mixing. Types of agitators. Design of agitation system components. Types of storage tank and their design considerations.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Design, analyze reactor system and interpret data.

CO2: Understand the importance of pumps in the industrial perspective.

CO3: Classify the types of compressors and its importance

CO4: Design heat transfer equipment and cooling systems.

CO5: Understand the importance of storage and mixing in petroleum industries

CO6: Understand the standards and codes for designing petroleum equipments

TEXT BOOKS

1. Joshi M. V.; V VMahajani, S B Umarji , "Process Equipment Design"; 5th edition, MacMillan,2016
2. Brownell, Young, "Process Equipment Design", Wiley, 2009

REFERENCES

1. Standard Hand Book of Petroleum & Natural Gas Engineering" –2ndEdition 2005-William C.Lyons& Gary J.Plisga-Gulf professional publishing comp (Elsevier).

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	Design, analyze reactor system and interpret data.	3	3	3	-	2	3	3	3	3	-	1	2	3	3	3
CO2	Understand the importance of pumps in the industrial perspective.	2	-	-	-	-	3	-	-	-	-	-	-	3	-	-
CO3	Classify the types of compressors and its importance	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO4	Design heat transfer equipment and cooling systems.	-	3	2	-	-	3	-	2	-	-	-	-	3	3	3
CO5	Understand the importance of storage and mixing in petroleum industries	1	-	2	-	-	-	3	2	-	-	-	-	3	-	-
CO6	Understand the standards and codes for designing petroleum equipments	3	3	1	2	2	3	3	2	-	3	3	2	3	3	3
Over all CO		3	3	2	1	2	3	3	3	3	2	2	2	3	3	3

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

RM5151 RESEARCH METHODOLOGY AND IPR

L T P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.
Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

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REFERENCES:

1. Asimov, “Introduction to Design”, Prentice Hall, 1962.
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners” 2010

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PP5111 **PETROLEUM TESTING LAB I**

L	T	P	C
0	0	4	2

OBJECTIVE

Students will gain the understanding about quality testing of petroleum products

LIST OF EXPERIMENTS

1. Determination of Flash point for a given sample
2. Estimation of Fire point for a given sample
3. Determination of Aniline point
4. Determination of API gravity for a given sample
5. Estimation of kinematic Viscosity determination
6. Determination Cloud point and pour point
7. Smoke point determination for a given sample
8. Melting point determination for a given sample
9. Estimation Softening point for a given sample
10. Doctors test
11. Distillation characteristics
12. Congealing point of wax.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1: Analyze the volatility level of given crude products

CO2: classify the type of crude using API gravity method

CO3: Understand the importance of viscosity during storage, transportation using different viscometers

CO4: Evaluate the strength of given bitumen and to identify the grades

CO5: Determine the cut points of crude products using distillation apparatus.

CO6: Understand the importance of safety aspects in storage, handling and transportation of petroleum products

Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Analyze the volatility level of given crude products	3	3	3	2	-	1	2	-	1	3	1	2	3	2	3
CO2	classify the type of crude using API gravity method	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO3	Understand the importance of viscosity during storage, transportation using different viscometers	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO4	Evaluate the strength of given bitumen and to identify the grades	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO5	Determine the cut points of crude products using distillation apparatus.	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO6	Understand the importance of safety aspects in storage, handling and transportation of petroleum products	3	3	3	3	-	1	2	-	1	3	1	2	3	2	3
Overall CO		3	3	3	3	-	1	2	-	1	3	1	2	3	2	3

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

PP5112 **INSTRUMENTAL METHODS OF ANALYSIS LAB**

L	T	P	C
0	0	4	2

OBJECTIVE

To impart practical knowledge on various sophisticated analytical instruments used in upstream and downstream petroleum processing.

LIST OF EXPERIMENTS
(Minimum 10 experiments to be performed)

1. Validation of Beer- lambert's law using UV-Visible spectrophotometer.
2. Estimation of concentration of a given liquid sample using UV – DRS.
3. Determination of Particle characteristics using Scanning Electron Microscopy.
4. Determination of Particle size using Laser particle size diffraction analyser.
5. Estimation of concentration using Gas chromatography.
6. Determination of retention time using High performance liquid chromatography.
7. Obtain absorption spectra and concentration of Atomic absorption spectrophotometer.
8. Determine the sample characteristics using Thermo gravimetric analyser.
9. Determine the porosity and pore characteristics of the given sample using automated capillary micro flow porometer.
10. Determine the charge –discharge hysteresis curve using Cyclic Voltammetry.
11. Determination of thermal characteristics and activation energy using Differential Scanning Calorimetry.
12. Purify the given sample by solvent evaporation using Rotary Evaporator.
13. Analyse Rheological behaviour of the given polymer suspension using Rheometry.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1: Understand and implement the principles of spectrophotometry in composition measurement
CO2: Perform evaluation of rate parameters using DSC.
CO3: Understand rheology of petroleum products
CO4: Estimate purity and composition of petroleum products using chromatographic techniques
CO5: Apply electrochemical analysis for petroleum products
CO6: Analyze and select appropriate composition estimation techniques.

Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3
CO1	Understand and implement the principles of spectrophotometry in composition measurement	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
CO2	Perform evaluation of rate parameters using DSC.	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
CO3	Understand rheology of petroleum products	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
CO4	Estimate purity and composition of petroleum products using chromatographic techniques	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
CO5	Apply electrochemical analysis for petroleum products	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
CO6	Analyze and select appropriate composition estimation techniques.	3	3	3	3	2	3	1	2	2	1	1	1	3	2	2
Overall CO		3	3	3	3	2	3	1	2	2	1	1	1	3	2	2

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

SEMESTER II

PP5201 **PETROCHEMICAL TECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVE

Students will learn the manufacture of petrochemicals and their applications.

UNIT I **9**

Petrochemical Industries and their feed stocks selection. History, Economics, Growth of petrochemical industry.

UNIT II **9**

Production Methods - Reforming and cracking of feed stocks; Sources: Chemicals from synthesis gas, olefins and aromatics - Ethylene, Propylene, C_4 hydrocarbons, higher olefins, Benzene, Toluene, Xylene.

UNIT III **9**

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

UNIT IV **9**

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

UNIT V **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1: Learn the history, economics, growth and the feed stocks selection of petrochemical Industry.

CO2: Study the manufacture and the developments of first generation petrochemicals.

CO3: Understand the manufacture and the challenges of second generation petrochemicals.

CO4: Study the manufacture, developments and applications of the third generation petrochemicals.

CO5: Learn the production and applications of important polymeric products.

CO6: Understand the application of petrochemicals as lubricants, agrochemicals, cosmetics and pharmaceuticals.

TEXT 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.

REFERENCES

1. B.K.B.Rao, 'A Text on Petrochemicals', Khanna publishers, 2004.
2. I D Mall, 'Petrochemical process Technology', Macmillan India Limited, 2007.

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Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO 2	PSO 3
CO1	Learn the history, economics, growth and the feed stocks selection of petrochemical Industry.	1	3	3	1	1	3	3	1	3	3	3	3	3	3	3
CO2	Study the manufacture and the developments of first generation petrochemicals.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	Understand the manufacture and the challenges of second generation petrochemicals.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	Study the manufacture, developments and applications of the third generation petrochemicals.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	Learn the production and applications of important polymeric products.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	Understand the application of petrochemicals as lubricants, agrochemicals, cosmetics and pharmaceuticals.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Overall CO		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

PP5202

PETROLEUM REFINING TECHNOLOGY - II

	L	T	P	C
OBJECTIVE	3	0	0	3

To understand the important process technology in petroleum industries.

UNIT I **9**

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

UNIT II **8**

Low boiling products, Gasoline, leaded gasoline, gasoline blending and impact, combating smog and ozone, distillate and residual fuels, petrochemical blending components.

UNIT III **9**

Gas processing units, Acid gas processing, chemical solvents, physical solvents, mercaptans removal

UNIT IV **10**

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 **9**

Safety in petroleum refineries, 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:

The students will be able to

CO1 To understand the importance of different distillation process in refineries

CO2 Know the different crude products and its importance

CO3 Explain the different processing units involved for processing the removal of acid gas and mercaptans.

CO4 Understand the importance of hydrogen in refineries.

CO5 Understand the safety systems involved during crude processing.

CO6 Explain in detail the crude process technology involved, the importance of safety and environmental considerations.

TEXT BOOKS

1. M.A.Fahim, T.A.AL-Sahhaf, A.S.Elkilani, “Fundamentals of Petroleum Refining, Elsevier, 2010
2. William.L.Leffler, Petroleum Refining in Non-technical Language, 4th edition, Pennwellcorporation, 2008.

REFERENCES

1. David.S.J.”STAN”Jones and Peter R.Pujado “Handbook of Petroleum Processing,Springer,2006.
2. Nelson, W.L “Petroleum Refinery Engineering” McGraw Hill Publishing Company Limited, 1985.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CO1	To understand the importance of different distillation process in refineries	3	3	3	-	1	3	-	3	1	-	-	1	3	3	2
CO2	Know the different crude products and its importance	-	1	1	1	1	2	2	2	-	1	-	-	3	1	3
CO3	Explain the different processing units involved for processing the removal of acid gas and mercaptans.	3	3	1	-	-	-	2	-	-	-	-	-	3	2	-
CO4	Understand the importance of hydrogen in refineries.	3	3	1	-	-	2	2	3	-	-	-	-	3	3	2
CO5	Understand the safety systems involved during crude processing.	1	1	-	2	1	2	3	-	1	3	1	-	2	1	3
CO6	Explain in detail the crude process technology involved, the importance of safety and environmental considerations.	2	2	2	1	1	2	2	2	1	2	1	1	3	3	3
Over all CO		3	3	2	2	1	2	3	2	-	2	1	-	3	3	3

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

PP5203 **PROCESS MODELING AND OPTIMIZATION**

	L	T	P	C
OBJECTIVE	**3**	**1**	**0**	**4**

To model mathematically the process and operations in Petroleum Industries and to optimize the units using Linear and Non Linear Programming and to model reservoirs using reservoir / well log data.

UNIT I **12**

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations, constitutive relations in thermodynamics, kinetics, transport equations, Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flow sheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, decomposition of networks.

UNIT II **12**

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, Monolith Reactor Modeling – Pseudohomogeneous and Heterogeneous models for catalytic reactors- plug flow reactor - heat exchanger - Solution of ODE initial value problems, – Solution of ODE using Eigen values – Jordan Canonical Form – Stiff equations – Solution of BVP – Shooting method - Solution of PDE

UNIT III **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 simulation - Reservoir modeling using software tools for statistical analysis of reservoir data

UNIT IV **12**

Continuity of function, NLP problem statement, convexity and its applications, interpretation of the objective function in terms of its quadratic approximation, necessary and sufficient conditions for an extremum of an unconstrained function - One-Dimensional search numerical methods for optimizing a function of one variable, scanning and bracketing procedures, 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 V **12**

Examples of optimization in chemical processes like: optimizing recovery of waste heat, optimal shell and tube heat exchanger design, optimal design and operation of binary distillation column, chemical reactor design and operation.

TOTAL: 60 PERIODS

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COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibria kinetics

CO2: Associate the model with constitutive relations such as phenomenological laws, rate equations, equations of state, property estimation methods

CO3: Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns

CO4: Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems

CO5: Apply mathematical modeling for reservoir and wells, Apply Linear and Non-linear programming for Petroleum Engineering

CO6: Apply Optimization for heat exchanger, reactors and separation columns in Petroleum and Process industries

TEXT 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

REFERENCES

1. Ogunnaike B. and W. Harmon Ray. *Process Dynamics, Modeling, and Control*, Oxford University Press, 1995
2. Chapra S.C. and Canale R.P. *Numerical Methods for Engineers*, McGraw Hill, 2001
3. Press W.H., Teukolsky S.A., Vetterling W.T. and Flannery B.P., *Numerical Recipes: The Art of Scientific Computing*, Cambridge University Press, 3rd Edition, 2007
4. Ramirez, W.; " Computational Methods in Process Simulation ", 2nd Edn., Butterworths Publishers, New York, 2000.
5. Luyben, W.L., " Process Modelling Simulation and Control ",2nd Edn, McGraw-Hill Book Co., 1990
6. Venkataraman, P. (2009). *Applied optimization with MATLAB programming*. John Wiley & Sons.
7. Ferris, M. C., Mangasarian, O. L., & Wright, S. J. (2007). *Linear programming with MATLAB* (Vol. 7). SIAM.
8. J Nocedal and S J Wright (2006). Numerical Optimization. Springer Verlag.
9. Joshi, M. C., &Moudgalya, K. M. (2004). *Optimization: theory and practice*. Alpha Science Int'l Ltd.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibria kinetics	3	3	1	1	2	2	2	2	3	-	3	1	3	3	2
CO2	Associate the model with constitutive relations such as phenomenological laws, rate equations, equations of state, property estimation methods	3	3	1	2	2	2	2	2	3	-	3	1	3	3	2
CO3	Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns	3	3	1	2	2	2	2	2	3	-	3	1	3	3	2
CO4	Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems	3	3	1	2	2	2	2	2	3	-	3	1	3	3	2
CO5	Apply mathematical modelling for reservoir and wells, Apply Linear and Non-linear programming for Petroleum Engineering	3	3	1	2	2	2	2	2	3	-	3	1	3	3	2
CO6	Apply Optimization for heat exchanger, reactors and separation columns in Petroleum and Process industries	3	3	1	2	2	2	2	2	3	-	3	1	3	3	2
Over all CO		3	3	1	2	2	2	2	2	3	-	3	1	3	3	2

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

PP5211 **PETROLEUM TESTING LAB II**

L	T	P	C
0	0	4	2

OBJECTIVE

Students will gain knowledge in the physical and chemical characteristics of petroleum products

LIST OF EXPERIMENTS

1. Determination of Reid vapor pressure
2. Estimation of Calorific value of the given sample.
3. Determination of Octane number
4. Obtain the Penetration index of the given sample.
5. Estimation of Ductility of Bitumen
6. Determination of Freezing point of the given sample.
7. Determination of Drop point of the given sample.
8. Obtain the thermal stability of the given sample.
9. Gum content determination
10. Copper strip corrosion test of the given sample.
11. Determination of Acidity & alkalinity of the given sample.
12. Estimation of Total sulphur determination of the given sample.
13. Carbon residue determination.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1: Determine the volatile & ignition characteristics of petroleum products

CO2: Understand the antiknocking property of Gasoline

CO3: Evaluate the consistency of given bitumen and to identify the grades

CO4: Understand the thermal stability of fuels

CO5: Assess the ASTM corrosion standards for given petroleum samples

CO6: Understand the importance of safety aspects in storage, handling and transportation of petroleum products

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Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Determine the volatile & ignition characteristics of petroleum products	3	3	3	2	-	1	2	-	1	3	1	2	3	2	3
CO2	Understand the antiknocking property of Gasoline	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO3	Evaluate the consistency of given bitumen and to identify the grades	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO4	Understand the thermal stability of fuels	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO5	Assess the ASTM corrosion standards for given petroleum samples	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO6	Understand the importance of safety aspects in storage, handling and transportation of petroleum products	3	3	3	3	-	1	2	-	1	3	1	2	3	2	3
Overall CO		3	3	3	3	-	1	2	-	1	3	1	2	3	2	3

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

PP5212 **FUEL ANALYSIS LAB**

L	T	P	C
0	0	4	2

OBJECTIVE

Students will understand the analytical techniques involved in determination of various components such as types of hydro carbons.

LIST OF EXPERIMENTS

1. Perform ORSAT analysis of the given sample.
2. Estimate the VOC's of the given sample using HC Analyzer
3. Estimation of concentration of Lead in gasoline sample.
4. Characterization of a given sample of gases/liquids using Gas chromatography Refractive index
5. Estimation of concentration of the given sample using HPLC
6. Estimation of colour of a given fuel sample using colorimeter.
7. Determine the nature of Impurities and their concentration in a given fuel sample.
8. Determine the Ash content of the given sample.
9. Determine Water separability index of a given fuel sample
10. Obtain the Thermal stability of the given sample.
11. Moisture content determination of a given fuel sample.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1 Analyse a gas sample (typically fossil fuel flue gas) for its oxygen, carbon monoxide and carbon dioxide content

CO2 Understand the lead levels in gasoline

CO3 Predict the proximate analysis of the given fuel

CO4 Obtain the various sulphur, nitrogen and oxygen impurities present in liquid fuels

CO5 Analyze the thermal stability of liquid and gaseous fuels

CO6 Understand the importance of fuel analysis

Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Analyse a gas sample (typically fossil fuel flue gas) for its oxygen, carbon monoxide and carbon dioxide content	3	3	3	2	-	1	2	-	1	3	1	2	3	2	3
CO2	Understand the lead levels in gasoline	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO3	Predict the proximate analysis of the given fuel	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO4	Obtain the various sulphur, nitrogen and oxygen impurities present in liquid fuels	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO5	Analyze the thermal stability of liquid and gaseous fuels	3	3	3	1	-	1	2	-	1	3	1	2	3	2	3
CO6	Understand the importance of fuel analysis	3	3	3	3	-	1	2	-	1	3	1	2	3	2	3
Overall CO		3	3	3	3	-	1	2	-	1	3	1	2	3	2	3

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

PP5213 **MINI PROJECT WITH SEMINAR**

L	T	P	C
0	0	2	1

OBJECTIVE:
To provide exposure to the recent developments, and to improve the students presentation skills.

COURSE OUTCOMES:

The students will be able to

CO1 Know the latest improvements in their field of expertise
CO2 Relate the significant literatures for the selected and suitable topic
CO3 Focus the salient features of the area of study
CO4 Understand he basic concepts and mechanism related to the problem
CO5 Improve the presentation on the topic
CO6 Practice their presentation in written and oral skills

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CO1	Know the latest improvements in their field of expertise	3	3	3	2	3	2	2	2	3	2	2	2	2	2	2
CO2	Relate the significant literatures for the selected and suitable topic	2	3	3	2	3	2	3	2	3	2	1	2	1	1	2
CO3	Focus the salient features of the area of study	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2
CO4	Understand he basic concepts and mechanism related to the problem	3	3	3	3	2	3	3	3	3	3	2	2	3	2	2
CO5	Improve the presentation on the topic	3	2	3	3	3	2	3	3	3	1	2	2	1	3	1
CO6	Practice their presentation in written and oral skills	3	2	1	2	3	2	3	3	2	3	2	3	2	1	2
Over all CO		3	3	3	3	3	2	3	3	3	2	2	2	2	2	2

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

PP5311 **PROJECT PHASE I**

	L	T	P	C
OBJECTIVE	**0**	**0**	**12**	**6**

Students have to do a research-based project in the department or in an industry and should submit a report at the end of Phase I

COURSE OUTCOMES:

The students will be able to

CO1: Know the latest improvements in their field of expertise

CO2: Relate the significant literatures for the selected and suitable topic

CO3: Focus the salient features of the area of study

CO4: Understand the basic concepts and mechanism related to the problem

CO5: Improve the presentation on the topic

CO6: Practice their presentation in written and oral skills

TOTAL: 180 PERIODS

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Know the latest improvements in their field of expertise	3	3	3	3	1	3	3	3	1	2	-	2	3	3	3
CO2	Relate the significant literatures for the selected and suitable topic	3	3	3	3	1	-	3	3	1	2	-	2	3	3	3
CO3	Focus the salient features of the area of study	3	3	3	3	1	3	3	3	1	2	-	2	3	3	3
CO4	Understand the basic concepts and mechanism related to the problem	3	3	3	3	3	3	3	3	1	-	3	2	3	3	3
CO5	Improve the presentation on the topic	3	3	-	-	3	-	-	3	3	-	3	1	1	-	1
CO6	Practice their presentation in written and oral skills	3	3	-	-	3	-	-	3	3	-	3	1	1	-	1
Over all CO		3	3	3	3	3	2	3	3	3	2	3	2	3	3	3

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

PP5411 **PROJECT PHASE II**

	L	T	P	C
OBJECTIVE	**0**	**0**	**24**	**12**

Students have to do a research-based project in the department or in an industry and should submit a report at the end of Phase II

COURSE OUTCOMES:

The students will be able to

CO1: Know the latest improvements in their field of expertise

CO2: Relate the significant literatures for the selected and suitable topic

CO3: Focus the salient features of the area of study

CO4: Understand he basic concepts and mechanism related to the problem

CO5: Improve the presentation on the topic

CO6: Practice their presentation in written and oral skills

TOTAL: 360 PERIODS

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Know the latest improvements in their field of expertise	3	3	3	3	1	3	3	3	1	2	-	2	3	3	3
CO2	Relate the significant literatures for the selected and suitable topic	3	3	3	3	1	-	3	3	1	2	-	2	3	3	3
CO3	Focus the salient features of the area of study	3	3	3	3	1	3	3	3	1	2	-	2	3	3	3
CO4	Understand he basic concepts and mechanism related to the problem	3	3	3	3	3	3	3	3	1	-	3	2	3	3	3
CO5	Improve the presentation on the topic	3	3	-	-	3	-	-	3	3	-	3	1	1	-	1
CO6	Practice their presentation in written and oral skills	3	3	-	-	3	-	-	3	3	-	3	1	1	-	1
Over all CO		3	3	3	3	3	2	3	3	3	2	3	2	3	3	3

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

PROFESSIONAL ELECTIVE COURSES (PEC)

PP5001 **PETROLEUM GEOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVE

Students will gain knowledge about petroleum refining process and production of petrochemical products

UNIT I **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 **9**

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

UNIT III **9**

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

UNIT IV **9**

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

UNIT V **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:

The students will be able to,

CO1: Learn the concepts of origin of earth, geological timescale, nature and properties of minerals and rocks.

CO2: Understand the insights of Sedimentary basins.

CO3: Study the mechanism of generation and migration of Petroleum & its properties.

CO4: Appreciate the importance of subsurface geology.

CO5: Understand the need of exploration methods and their types.

CO6: Learn the various types of Non-conventional petroleum resources and reserve estimation.

TEXT BOOKS

1. Cox, P.A., “The Elements on Earth”, Oxford University Press, Oxford 1995.
2. Wilson, M., "Igneous Petrogenesis”, Unwin Hyman, London 1989.

REFERENCES

1. Boggs, S., “Principles of Sedimentology and Stratigraphy”, second edition, Merrill Publishing Co., Toronto, 1995.

2. Krumblein, W.C. and Sloss, L.L., “Stratigraphy and Sedimentation”, second edition W.H. Freeman and Co., 1963.

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Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Learn the concepts of origin of earth, geological timescale, nature and properties of minerals and rocks.	3	3	3	3	3	3	3	3	3	1	3	3	3	3	3
CO2	Understand the insights of Sedimentary basins.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	Study the mechanism of generation and migration of Petroleum & its properties.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	Appreciate the importance of subsurface geology.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	Understand the need of exploration methods and their types.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	Learn the various types of Non-conventional petroleum resources and reserve estimation.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Overall CO		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

PP5002 **SEPARATION PROCESS TECHNIQUES**

OBJECTIVE

L	T	P	C
3	0	0	3

To know the recent advances in separation Techniques in industries from the chemical engineering point of view.

UNIT I **9**

Separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. Basic Separation Techniques: Separations by Phase Addition or Creation- Separations by Barriers- Separations by Solid Agents- Separations by External Field or Gradient, importance and variety of separation process, Thermodynamics of Separation Operations.

UNIT II **9**

Absorption and Stripping of Dilute Mixtures, Distillation of Binary Mixtures, Liquid–Liquid Extraction with TernarySystems Enhanced Distillation and Supercritical Extraction.

UNIT III **9**

Membrane Separations: Membrane Materials, Membrane Modules, Transport in Membranes, Adsorption, Ion Exchange, Chromatography and Electrophoresis.

UNIT IV **9**

Leaching: Equipment for Leaching, Crystallization: Precipitation, Melt Crystallization, Zone Melting, and desublimation, Evaporation, Drying of Solids: Drying Equipment.

UNIT V **9**

Mechanical Phase Separations: Separation-Device Selection, Industrial Particle-Separator Devices: Electrostatic Precipitators, Gravity Settlers, Filter-Cake Filtration Devices, Cyclones, Centrifuge Devices for Solid–Liquid Separations.

TOTAL: 45 PERIODS

COURSE OUTCOMES

The students will be able to,

CO1: Understand the fundamentals, theories and mechanisms of various separation techniques.

CO2: Understand the concept, design, mechanisms and economic importance of membrane separation

CO3: Understand the concept, design, mechanisms and economic importance of separation by adsorption

CO4: Understand the concept, design, mechanisms and economic importance of separation by ionic

CO5: Understand the concept, design, mechanisms and economic importance in recent advances of separation

CO6: To learn Liquid-solid, Gas-Solid, Liquid-Gas separation process, membrane modules, separation techniques and membrane materials.

REFERENCES

1. King, C. J., “Separation Processes”, Tata McGraw Hill Co., Ltd., 1982.
2. Nakagawal, O. V., “Membrane Science and Technology”, Marcel Dekker, 1992.
3. Rousseau, R. W., “Handbook of Separation Process Technology”, John Wiley, New York,2009.
4. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
5. Phillip C. Wankat, Separation Process Engineering (2nd Edition), Printice Hall,2007
6. J. D. Seader, Ernest J. Henley, D. Keith Roper, separation process principles: Chemical and Biochemical Operations, 4th edition, John Wiley & Sons, Inc.,2011

TEXT BOOKS

1. J. D. Seader, Ernest J. Henley, D. Keith Roper, separation process principles: Chemical and Biochemical Operations, 4th edition, John Wiley & Sons, Inc.,2011

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3
CO1	Understand the fundamentals, theories and mechanisms of various separation techniques.	3	3	2	2	3	1	2	2	2	-	2	1	3	3	2
CO2	Understand the concept, design, mechanisms and economic importance of membrane separation	3	3	2	2	3	-	3	3	3	-	-	-	3	3	1
CO3	Understand the concept, design, mechanisms and economic importance of separation by adsorption	3	3	2	1	2	-	3	3	3	-	-	-	3	3	1
CO4	Understand the concept, design, mechanisms and economic importance of separation by ionic	2	3	2	1	3	-	3	3	3	-	-	-	3	3	1
CO5	Understand the concept, design, mechanisms and economic importance in recent advances of separation	2	3	2	2	3	-	3	3	3	-	-	-	3	3	1
CO6	To learn Liquid-solid, Gas-Solid, Liquid-Gas separation process, membrane modules, separation techniques and membrane materials.	2	3	2	2	3	-	3	3	3	-	-	-	3	3	1
Overall CO		3	3	2	2	3	1	3	3	3	-	2	1	3	3	1

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

PP5003 MODELING OF TRANSPORT PROCESSES

L	T	P	C
3	0	0	3

OBJECTIVE

To give an overview of mass, momentum and energy transport, present the fundamental equations and illustrate how to use them to solve problems

UNIT I INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS 6

Definition of Friction Factors, Friction Factors for Flow in Tubes, 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 LIQUIDS 12

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. Polymeric liquid- Examples of the Behaviour of Polymeric Liquids, Rheometry and Material Functions, Non-Newtonian Viscosity and the Generalized Newtonian Models , Laminar Flow of an incompressible Power-Law Fluid in a Circular Tube , Flow of a Power-Law Fluid in a Narrow Slit , Tangential Annular Flow of a Power- Law Fluid , Elasticity and the Linear Viscoelastic Models, Molecular Theories for Polymeric Liquids

UNIT III INTERPHASE TRANSPORT IN NONISOTHERMAL 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-use of Sieder Tate equation , 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 NONISOTHERMAL 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.

UNIT V INTERPHASE TRANSPORT IN NONISOTHERMAL MIXTURES 9

Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Evaporation from a Freely Falling Drop, 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.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:

The Students will be

CO1: Able to understand about the interphase momentum transfer in isothermal system

CO2: Will have a detail study about macroscopic mass momentum and energy balance in a isothermal system and its applications

CO3: Able to understand about momentum transfer in polymeric liquids and its application

CO4: Will learn about the interphase energy transfer in non-isothermal system

CO5: Able to understand the concept of macroscopic energy balance in a non-isothermal process

CO6: Able to understand about interphase mass transfer in non-isothermal system

TEXT BOOKS

1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", Revised 2nd Edn., John Wiley and Sons, 2007

REFERENCES

1. Welty, J.R., Wicks, C. E. and Wilson, R. E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2010.
2. Brodkey, R. S. and Hershey, H. C., "Transport Phenomena – A Unified Approach", Brodkey Publishing, 2004.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Able to understand about the interphase momentum transfer in isothermal system	2	2	2	1	2	2	1	2	2	-	1	1	2	3	2
CO2	Will have a detail study about macroscopic mass momentum and energy balance in a isothermal system and its applications	3	3	3	2	2	2	1	1	2	-	1	1	3	2	2
CO3	Able to understand about momentum transfer in polymeric liquids and its application	2	2	2	2	2	2	1	2	2	-	1	1	2	2	2
CO4	Will learn about the interphase energy transfer in non-isothermal system	3	3	3	1	2	2	1	2	2	-	1	1	2	3	2
CO5	Able to understand the concept of macroscopic energy balance in a non- isothermal process	2	3	3	2	2	2	1	1	2	-	1	1	3	2	2
CO6	Able to understand about interphase mass transfer in non-isothermal system	3	3	3	1	2	2	1	2	2	-	1	1	2	3	2
Over all CO		3	3	3	2	2	2	1	2	2	-	1	1	2	3	2

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

PP5004 **PROCESS DYNAMICS AND CONTROL**

L	T	P	C
3	0	0	3

OBJECTIVE

To determine possible control objectives, use advanced control techniques, understand discrete control systems for multivariable process

UNIT I **9**

Feed forward, cascade, dead time compensation, split range, selective and override control; Inverse response; automatic tuning and gain scheduling

UNIT II **9**

Model based control – IMC structure – development and design; IMC based PID control, MPC - Models forms of model predictive control - Constrained and unconstrained approach - Analysis of dynamic matrix control - Extension to multivariable system - Other MPC methods.

UNIT III **9**

Control loop interaction – general pairing problem, relative gain array and application, sensitivity. Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling

UNIT IV **9**

Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability - Design of digital feedback controllers, digital approximation of classical, effect of sampling

UNIT V **9**

Optimal Control with Complete Information on the Plant- Control of a Static Plant - Problems of Optimal Control for Dynamical Plants - Discrete Plant - Continuous Plant - Principle of Optimality and Dynamic Programming .Bellman Equation - Maximum Principle – Linear quadratic Problem – Observer Design – Kalman filters –Extended Kalman Filters

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

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

CO2: Develop, implement and optimize model based control

CO3: Understand the interaction and pairing in process systems

CO4: Apply and develop discrete control systems

CO5: Design digital feed controllers

CO6: Implement Optimal control for complete plant and design Kalman filters and extended Kalma filters

TEXT BOOKS

1. Smith, C. A., and Corripio, A. B., Principles and Practice of Automatic Process Control, John Wiley and Sons, New York, 1989

2. Ogata, K., Modern Control Engineering, Prentice Hall, 2009.

3. Ogata, K., Discrete Time Control Systems, Prentice Hall, 1995.

REFERENCES

1. Bequette, B. W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2003

2. Marlin, T. E., Process Control: Designing Processes and Control Systems for Dynamic Performance, 2nd Edition, Mc Graw Hill, 2000

3. Luyben, W. L., Process Modeling Simulation and Control for Chemical Engineers, 2nd Edition, Mc Graw Hill, 1990

4. D.E.Seborg, T. F.Edgar, D.A. Mellichamp, Process Dynamics and Control, Wiley, 2003.

5. Control System Design, by Graham C. Goodwin,Stefan F. Graebe, Mario E. Salgado,Prentice Hall, 2000.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Describe, identify and implement advanced control strategies such as cascade, split range, override control.	3	3	1	2	1	1	2	2	2	1	2	2	2	3	3
CO2	Develop, implement and optimize model based control	3	3	1	2	1	1	2	2	2	1	2	2	2	3	3
CO3	Understand the interaction and pairing in process systems	3	3	1	2	1	1	2	2	2	1	2	2	2	3	3
CO4	Apply and develop discrete control systems	3	3	1	2	1	1	2	2	2	1	2	2	2	3	3
CO5	Design digital feed controllers	3	3	1	2	1	1	2	2	2	1	2	2	2	3	3
CO6	Implement Optimal control for complete plant and design Kalman filters and extended Kalman filters	3	3	1	2	1	1	2	2	2	1	2	2	2	3	3
Over all CO		3	3	1	2	1	1	2	2	2	1	2	2	2	3	3

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

PP5005 **BIOFUELS**

L	T	P	C
3	0	0	3

OBJECTIVE

Students will have a thorough understanding of various renewable feedstocks of their availability and attributes for biofuels production and understand the broad concept of second and third generation biofuel production from biomass and other low-cost agri-residues and biowastes.

UNIT I **9**

Description of biofuels energy use & efficiency; biofuel production – I and II generation biofuels; alternative energies; biochemical pathways review for organoheterotrophic, lithotrophic& phototrophic metabolism; importance of COD; biofuel feedstocks: biomass, starch, sugar, lignocellulosic, agro & industrial by-products. Development of Biofuels, Biodiesel from Microalgae and Microbes

UNIT II **9**

Biomass as an Energy Source: Traditional and Modern Views, Structural and Industrial Chemistry of Lignocellulosic Biomass, Lignocellulose as a chemical resource, Physical and chemical pre-treatment of lignocellulosic biomass, Biological pre-treatments, Acid hydrolysis to saccharify pre-treated lignocellulosic biomass. Biomass production for fuel – algal cultures, yeasts (lipid and carbohydrate). Fuel production through biomass incineration.

UNIT III **9**

Bioethanol Production from sugar, starch and lignocellulosicFeedstocks, byproducts of biodiesel industry as feedstock; selection of micro-organisms and feedstock – ethanol tolerance; Traditional Ethanologenic Microbes, Yeasts, Bacteria, Metabolic Engineering of Novel Ethanologens, Comparison of industrial and laboratory yeast strains for ethanol production, Process technology for bioethanol production, determination of bioethanol yield; recovery of bioethanol; process integration. Advances in bioethanol production.

UNIT IV **9**

Chemical, thermodynamic & reaction kinetic aspects of biodiesel production: Esterification and transesterification. Free fatty acids; saponification; single step and two step biodiesel production. Catalysts for biodiesel production – homogeneous (alkali/acidic) and heterogeneous. Sources of oils – edible and non-edible; General procedure of biodiesel production and purification. Production technologies: Conventional method, microwave, ultrasonic, supercritical fluid, Lipase mediated process.

UNIT V **9**

Vegetable oils and chemically processed biofuels, Biodiesel composition and production processes, Biodiesel economics, Energetics of biodiesel production and effects on greenhouse gas emissions, Issues of ecotoxicity and sustainability with expanding biodiesel production, Fischer-Tropsch Diesel: Chemical Biomass–to–Liquid Fuel Transformations

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basics of biofuels and the various feedstocks for production of biofuels
CO2: Comprehend the concepts of biomass pre-treatment methods
CO3: Understand the production of biodiesel production output by different technologies.
CO4: Apply the concepts of biodiesel production and purification
CO5: Understand the energetics involved in the production of biodiesel
CO6: Outline the various biofuel technologies and their importance to society

Attested

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TEXT 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.

REFERENCES

1. David M. Mousdale, Biofuel-Biotechnology, Chemistry, and sustainable Development, 1st Ed., CRC Press Taylor & Francis Group, 2008.
2. Lisbeth Olsson (Ed.), "Biofuels" (Advances in Biochemical Engineering/Biotechnology Series), Springer-Verlag Publishers, Berlin, 2007.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand the basics of biofuels and the various feedstocks for production of biofuels	-	1	-	-	-	-	1	1	-	-	-	3	3	-	1
CO2	Comprehend the concepts of biomass pre-treatment methods	-	1	-	-	-	1	2	1	-	-	-	-	3	2	-
CO3	Understand the production of biodiesel production output by different technologies.	1	3	-	-	-	3	3	1	-	-	-	1	3	2	1
CO4	Apply the concepts of biodiesel production and purification	-	2	-	-	-	2	3	1	-	-	-	-	3	2	1
CO5	Understand the energetics involved in the production of biodiesel	1	3	-	-	-	-	1	1	-	-	-	-	2	3	2
CO6	Outline the various biofuel technologies and their importance to society	1	2	-	1	1	-	3	2	-	2	1	2	3	1	2
Over all		1	2	-	1	1	2	2	2	-	1	1	2	3	2	2

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

CL5074 **MULTIPHASE FLOW**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

- To analyze, characterize the multiphase systems and appreciate the role of structure in multiphase flows.
- To understand the limitations of modelling in multiphase flows and to comprehend engineering problems involving multiphase flows

UNIT I **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 **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 **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 **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 **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:

The students will be able to

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

CO2: Understand the determination of hydrodynamic parameters in the multiphase flow system

CO3: Understanding the concept of different flow models

CO4: Understand the one dimensional two dimensional flow equation in turbulent condition

CO5: Understanding the Hydrodynamic characteristics in different contactors

CO6: Measurement techniques in multiphase flow: Conventional and novel measurement techniques

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REFERENCES

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
6. Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York. 2008.
7. Wallis, G.B., “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes													
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	Understand the significance of multiphase flows and different flow pattern in multiphase flow.	1	1	2	2	-	-	2	-	-	-	-	3	3	3	-
CO2	Understand the determination of hydrodynamic parameters in the multiphase flow system	1	2	2	2	2	-	-	-	-	-	-	3	3	3	-
CO3	Understanding the concept of different flow models	1	2	3	2	-	1	1	-	-	-	-	3	3	3	-
CO4	Understand the one dimensional two dimensional flow equation in turbulent condition	2	2	3	2	2	1	1	-	-	-	-	3	3	3	-
CO5	Understanding the Hydrodynamic characteristics in different contactors	2	2	3	2	-	1	1	-	-	-	-	3	3	3	-
CO6	Measurement techniques in multiphase flow: Conventional and novel measurement techniques	2	3	3	2	2	1	2	-	-	-	-	3	3	3	-
Over all CO		2	2	3	3	2	1	2	-	-	-	-	3	3	3	-

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

PP5006

CORROSION ENGINEERING

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

To impart knowledge on corrosion in petroleum refining.

UNIT I **9**

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

UNIT II **9**

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

UNIT III **9**

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

UNIT IV **9**

Corrosion in structure – corrosion of stainless steels – corrosion in power equipments, corrosion in electrical and electronic industry – corrosion and selection of materials of pulp and paper plants – corrosion aspects in nuclear power plants – corrosion of surgical implants and prosthetic devices.

UNIT V **9**

Corrosion protection management–process maintenance procedures under corrosion Environments

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamental concepts of corrosion and its principles

CO2: Apply the concepts in various corrosion testing techniques

CO3: Understand the corrosion in specific environments and evaluate the corrosion prevention methods in pipelines.

CO4: Analyse corrosion monitoring and control methods in specific cases

CO5: Relate the corrosion aspects and testing using different industrial devices

CO6: Understand the risk assessment, protection management and evaluate the cost of corrosion

TEXT BOOKS

1. Fontana, M.G., “Corrosion Engineering”, Edn 3, McGraw Hill, 1989
2. Corrosion Control in the Oil and Gas Industry 1 st Edition, SankaraPapavinasam, 2013

REFERENCES

1. Roberge, P.R., Handbook of Corrosion Engineering, McGraw-Hill, 2000.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Understand the fundamental concepts of corrosion and its principles	3	2	2	2	2	2	2	2	1	2	2	2	3	3	3
CO2	Apply the concepts in various corrosion testing techniques	3	3	3	2	2	2	3	2	2	3	3	3	3	2	1
CO3	Understand the corrosion in specific environments and evaluate the corrosion prevention methods in pipelines.	3	3	3	3	2	2	2	1	2	3	3	3	3	2	2
CO4	Analyse corrosion monitoring and control methods in specific cases	3	3	3	3	3	3	3	2	2	2	3	3	3	3	2
CO5	Relate the corrosion aspects and testing using different industrial devices	2	3	3	3	3	2	2	3	2	2	3	3	3	3	2
CO6	Understand the risk assessment, protection management and evaluate the cost of corrosion	2	3	2	3	2	3	3	2	2	2	2	3	3	2	2
Over all CO		3	3	3	3	2	2	3	2	2	2	3	3	3	3	2

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

PP5007 **PETROLEUM EXPLORATION TECHNOLOGY**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

Students will gain exploit the various exploration practices.

UNIT I **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 **9**

Geophysical Exploration Techniques – 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 **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 **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 **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to,

CO1: Learn the concepts of origin, migration and accumulation of petroleum.

CO2: Understand the insights of geophysical exploration techniques.

CO3: Study the seismic exploration techniques.

CO4: Appreciate the need of seismic survey techniques.

CO5: Understand the interpretation of seismic and reflection data.

CO6: Learn the various types of hydrocarbon estimation.

TEXT 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.

REFERENCES

1. 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.

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Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Learn the concepts of origin, migration and accumulation of petroleum.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO2	Understand the insights of geophysical exploration techniques.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	Study the seismic exploration techniques.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	Appreciate the need of seismic survey techniques.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	Understand the interpretation of seismic and reflection data.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	Learn the various types of hydrocarbon estimation.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Overall CO		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

PP5008 **FUEL CELL TECHNOLOGY**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

Students will understand about fuel cells, their working principle, Types, Design and performance Analysis.

UNIT I **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 **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 **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 **9**

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

UNIT V **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:

The students will be able to

CO1 Understand basics and working principles of the Fuel cell technology.

CO2 Select 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 Analyse the cost and life cycle of fuel cells

CO6 Make use of various fields related to petroleum industries

TEXT 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.

REFERENCES

1. Bard,A. J. , L. R., Faulkner,Electrochemical Methods, Wiley, N.Y.(2004) Ref Book.
2. Basu,S.(Ed) Fuel Cell Science and Technology,Springer, N.Y.(2007).

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Understand basics and working principles of the Fuel cell technology.	3	3	1	2	3	2	2	1	2	2	2	2	2	2	2
CO2	Select the suitable materials for electrode, catalyst, membrane for the fuel cells.	3	3	3	3	2	2	2	2	1	1	2	1	3	1	2
CO3	Apply mass transfer processes such as pressure drop and velocity distribution in single cell as well as stack.	3	3	3	3	3	2	1	1	1	2	3	3	2	2	1
CO4	Design and stack making process for real field applications	3	2	2	3	2	3	1	2	1	2	3	3	3	3	3
CO5	Analyse the cost and life cycle of fuel cells	1	2	2	3	2	2	2	2	1	2	1	1	3	2	2
CO6	Make use of various fields related to petroleum industries	2	2	2	2	2	2	2	1	1	2	1	2	3	3	3
Over all		3	3	2	3	2	2	2	2	1	2	2	2	3	2	2

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

PP5009 **MULTICOMPONENT DISTILLATION**

	L	T	P	C
OBJECTIVES	**3**	**0**	**0**	**3**

- To understand multicomponent distillation for separation of multicomponent mixtures.
- To design columns using rigorous methods and to design staged columns and to apply multicomponent distillation for the separation of petroleum mixtures.

UNIT I **9**

Fundamental Thermodynamic principles involved in the calculation of vapor – liquid equilibria and enthalpies of multi component mixtures – Use of multiple equation 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 II **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 – separation of multi component mixtures at total reflux.

UNIT III **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 Rm for multi component distillation – Underwood method – Colburn method – Smoker's equation – Pinch

UNIT IV **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 – Stage and reflux requirements – Short cut methods and Simplified graphical procedures – Hengstebeck Diagrams – Minimum reflux by Hengstebeck Diagrams – Key ratio Plots

UNIT V **9**

Design of sieve, bubble cap, and structured packing columns for multi component distillation – computation of plate efficiencies – Reactive Distillation - Distillation of Petroleum Mixtures - Peculiarities of Petroleum as Raw Material for Separation - Methods of Petroleum Separability Increase - Modernization of Units for Petroleum Refining – solar distillation

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand and identify thermodynamic principles involved in VLE

CO2: Identify the nonideal behaviour and characterize using activity and fugacity coefficients

CO3: Evaluate bubble point and dew point temperatures for multicomponent mixtures

CO4: Apply column sequencing for distillation trains, evaluate rigorous methods of distillation design

CO5: Perform Kb method and Lewis Matheson calculation

CO6: Design staged columns for separation of multicomponent and petroleum mixtures.

Attested

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TEXT BOOKS

1. Holland, C. D. (1981). *Fundamentals of multicomponent distillation*. McGraw-Hill,
2. Kister, H. Z., Haas, J. R., Hart, D. R., & Gill, D. R. (1992). *Distillation design* (Vol. 1). New York: McGraw-Hill.
3. Winkle, M. V. (1967). Distillation. *Chem. Eng. Series, McGraw-Hill*.

REFERENCES

1. Petlyuk, F. B. (2004). *Distillation theory and its application to optimal design of separation units*. Cambridge University Press.
2. Towler, G., &Sinnott, R. K. (2012). *Chemical engineering design: principles, practice and economics of plant and process design*. Elsevier.
3. Holland, C. D. (1963). *Multicomponent distillation*. Prentice-Hall.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Understand and identify thermodynamic principles involved in VLE	3	3	2	3	2	2	2	3	1	-	2	2	3	3	3
CO2	Identify the non-ideal behaviour and characterize using activity and fugacity coefficients	3	3	2	3	2	2	2	3	1	-	2	2	3	3	3
CO3	Evaluate bubble point and dew point temperatures for multicomponent mixtures	3	3	2	3	2	2	2	3	1	-	2	2	3	3	3
CO4	Apply column sequencing for distillation trains, evaluate rigorous methods of distillation design	3	3	2	3	2	2	2	3	1	-	2	2	3	3	3
CO5	Perform Kb method and Lewis Matheson calculation	3	3	2	3	2	2	2	3	1	-	2	2	3	3	3
CO6	Design staged columns for separation of multicomponent and petroleum mixtures.	3	3	2	3	2	2	2	3	1	-	2	2	3	3	3
Over all CO		3	3	2	3	2	2	2	3	1	-	2	2	3	3	3

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

PP5010 **ENHANCED OIL RECOVERY**

	L	T	P	C
OBJECTIVE	3	0	0	3

To impart knowledge on how residual oil is recovered after primary recovery process using secondary and enhanced techniques and the problems associated during each recovery process.

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY 9

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, CO_2, 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, in-situ combustion technology, microbial method.

UNIT V PROBLEMS IN ENHANCED OIL RECOVERY 7

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:

The students will be able to

CO1: Understand the displacement process and fluid flow in reservoir

CO2: Understand the principles and effects of water flooding process

CO3: Know the types of chemical flooding and gas injection process to recover residual oil.

CO4: Explain the importance of steam flooding process during the recovery of highly viscous fluids and also the R &D activities of microbial method.

CO5: Understand the environmental issues related to each recovery process.

CO6: Understand the importance of upstream process, its R&D activities and also the energy & environmental issues associated.

TEXT 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.

REFERENCES

1. Lake, L.W., “Enhanced oil recovery”, Prentice Hall, 1989.
2. Schumacher, M.M., “Enhanced oil recovery: Secondary and tertiary methods”, Noyes Data Corp., 1978.
3. Van Poollen, H.K. “Fundamentals of enhanced oil recovery”, PennWell Books, 1980.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Understand the displacement process and fluid flow in reservoir	3	-	1	-	-	-	-	1	-	-	-	-	3	3	1
CO2	Understand the principles and effects of water flooding process	-	-	1	-	-	-	-	1	-	-	-	-	3	1	2
CO3	Know the types of chemical flooding and gas injection process to recover residual oil.	-	-	1	-	-	2	-	1	-	-	-	-	3	1	2
CO4	Explain the importance of steam flooding process during the recovery of highly viscous fluids and also the R &D activities of microbial method.	3	2	3	3	-	2	3	3	-	3	1	1	3	-	3
CO5	Understand the environmental issues related to each recovery process.	3	3	3	3	2	2	3	3	1	3	1	1	3	-	3
CO6	Understand the importance of upstream process, its R&D activities and also the energy & environmental issues associated.	3	3	3	3	2	2	3	3	1	3	1	1	3	-	3
Over all CO		3	3	3	3	2	2	3	3	2	3	1	1	3	2	3

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

CL5071 **COMPUTATIONAL FLUID DYNAMICS**

L	T	P	C
3	0	0	3

OBJECTIVE

To educate engineering graduates in the principles of computational fluid dynamics modelling and in interpretation of fluid dynamics principles.

UNIT I INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS AND PRINCIPLES OF CONSERVATION **9**

Basics Of Computational Fluid Dynamics, Fundamental principles of conservation, Governing equations of fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form.

UNIT II FINITE DIFFERNCE APPROXIMATION **9**

Classification of Partial Differential Equations, Mathematical behaviour of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods. Error and stability analysis

UNIT III FINITE VOLUME METHOD **12**

Diffusion problems – explicit and implicit time integration; Convection-diffusion problems – properties of discretisation schemes, central, upwind, hybrid, QUICK schemes; Solution of discretised equations.

UNIT IV FLOW FIELD COMPUTATION **6**

Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

UNIT V TURBULENCE MODELING AND GRID GENERATION **9**

Characteristics of turbulent flows, time averaged Navier Strokes equations, turbulence Models - one and two equation, Reynolds stress, LES and DNS, Physical aspects of Grid generation, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

TOTAL: 45 PERIODS

COURSE OBJECTIVES

The Student will be able to

CO1: Understand the basics of CFD and governing equations for conservation of mass momentum and energy.

CO2: Understand mathematical characteristics of partial differential equations.

CO3: learn computational solution techniques for time integration of ordinary differential equations

CO4: Understand various discretization techniques used in CFD

CO5: Understand flow field computation techniques for steady and unsteady flows

CO6: Understand various turbulence models and grid generation techniques.

TEXT 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.

REFERENCES

1. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, NarosaPublishing House, New Delhi, 2001.
2. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw – Hill Publishing Company Ltd. 1998.
3. Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stock Equation”, Pineridge Press Limited, U.K., 1981.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the basics of CFD and governing equations for conservation of mass momentum and energy.	3	3	2	2	2	3	1	3	1	-	-	1	2	1	1
CO2	Understand mathematical characteristics of partial differential equations.	2	3	3	2	2	3	1	3	1	-	-	1	1	1	1
CO3	Learn computational solution techniques for time integration of ordinary differential equations	3	3	3	2	2	3	1	3	1	-	-	1	1	-	-
CO4	Understand various discretization techniques used in CFD	3	3	3	2	2	3	1	3	1	-	-	1	1	-	-
CO5	Understand flow field computation techniques for steady and unsteady flows	2	3	3	2	2	3	-	3	1	-	-	1	1	1	1
CO6	Understand various turbulence models and grid generation techniques	3	3	2	2	2	3	-	3	1	-	-	1	1	1	1
Over all CO		3	3	3	2	2	3	1	3	1	-	-	1	1	1	1

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

PP5011 OFFSHORE DRILLING AND PRODUCTION PRACTICES

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

Students will gain the understanding about offshore drilling and production practices.

UNIT I **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 **9**

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

UNIT III **9**

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

UNIT IV **9**

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

UNIT V **9**

Offshore Production - Surface Production System, Fixed Production System, Floating Production System, Subsea Production System. 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:

The students will be able to,

CO1: Learn the concepts of origin, migration and accumulation of oil and gas.

CO2: Understand the insights of Offshore Oil and Gas Operations.

CO3: Study the Offshore Drilling and Production Platforms/Units and its components.

CO4: Appreciate the need of Drilling Methods and their types.

CO5: Understand the Procedure of Offshore Drilling and Offshore Well Completion operations.

CO6: Learn the various types of Offshore Production systems, Offshore Storage, Offshore transportation.

TEXT BOOKS

1. SukumarLaik, ' 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 2005- Gulf-Gulf Professional Publishing Comp (Elsevier).

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REFERENCES

1. 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.
2. G.B. Moody,'Petroleum Exploration Hand Book', McGraw Hill Text, 1st Edition, June 1961.

Course Articulation Matrix:

Course outcomes	Statement	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Learn the concepts of origin, migration and accumulation of oil and gas.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO2	Understand the insights of Offshore Oil and Gas Operations.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	Study the Offshore Drilling and Production Platforms/Units and its components.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	Appreciate the need of Drilling Methods and their types.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	Understand the Procedure of Offshore Drilling and Offshore Well Completion operations.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	Learn the various types of Offshore Production systems, Offshore Storage, Offshore transportation.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Overall CO		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

PP5012 **SUPPLY CHAIN MANAGEMENT IN OIL & GAS**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

To investigate the role of supply chain management in oil& gas industry

UNIT I **9**

Types of choices involving risk, approaches in managing supply chain risk, optimal term of commitment, materials unavailability strategies, oil climate.

UNIT II **9**

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

UNIT III **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 **9**

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

UNIT V **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.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Learn the risk involved in oil and gas industry

CO2: Understand the processes in bid and tendering

CO3: Analyse the risk and mitigate

CO4: Understanding the swapping process in oil and gas

CO5: Understand the importance of supply chain in upstream, midstream, downstream

CO6: Know the approaches involved in supply chain for oil and gas industries.

TEXT BOOKS

1. Optimal Supply Chain Management in Oil, Gas and Power Generation, David Jacoby, Pennwell Corporation, 2012

REFERENCES

1. A Practical Application of Supply Chain Management Principles, Thomas I. Schoenfeldt, American Society for Quality, Quality Press,2008

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO7	PO 8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Learn the risk involved in oil and gas industry	1	1	-	3	2	-	3	3	1	2	2	3	1	1	3
CO2	Understand the processes in bid and tendering	2	2	-	3	2	-	3	3	2	2	2	3	1	-	3
CO3	Analyse the risk and mitigate	2	2	-	3	2	-	3	3	1	2	2	3	2	-	3
CO4	Understanding the swapping process in oil and gas	1	2	-	3	2	-	3	3	2	2	2	3	2	2	3
CO5	Understand the importance of supply chain in upstream, midstream, downstream	2	2	-	3	2	1	3	3	2	2	2	3	2	-	3
CO6	Know the approaches involved in supply chain for oil and gas industries.	2	2	-	3	2	1	3	3	2	2	2	3	2	3	3
Over all CO		2	2	-	3	2	-	3	3	2	2	2	3	2	2	3

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

PP5013 **PETROLEUM ECONOMICS**

	L	T	P	C
OBJECTIVE	3	0	0	3

To get an overview of the economic dimension of the petroleum sector.

UNIT I **9**

Introduction to upstream economics analysis, energy overview of India – Time value of money, cash flow analysis, profit analysis techniques, capital budgeting techniques, elements of oil and gas project cash flows, decision trees.

UNIT II **9**

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

UNIT III **9**

Inflation and cost escalation, oil market and OPEC, share of non OPEC countries in oil production – International oil and gas pricing mechanism, price forecasting.

UNIT IV **9**

Petroleum Fiscal system, classification and analysis – Reserves Auditing – Accounting Systems for oil and gas.

UNIT V **9**

Project Economic Evaluation and petroleum economic models – Decision analysis – Valuation of petroleum properties, Cost and valuation control for petroleum agreements and taxation, commercial economic evaluation software

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Describe key cash flow components involved in net cash flow and discounted cash flow.

CO2: Explain the broader petroleum industry context within which economic evaluations take place, that impact organizational (public, private and national) business goals

CO3: Understand the marketing and pricing mechanism involved.

CO4: Have a thorough knowledge on auditing in the petroleum industry.

CO5: Develop an initial proficiency in use of economic project modelling through real-world problems with outcomes.

CO6: Have a fundamental understanding of the concepts behind economic evaluation and of techniques for performing them within a petroleum context

TEXT BOOKS

1. Abdel-Aal, H. K. Bakr, A. B. Al-Sahlawi. A : Petroleum Economics and Engineering, Dekrer Publication, 1992
2. Cronquist, C., Estimation and classification of Reserves of Crude oil, Natural Gas, and Condensate, SPE (2001)

REFERENCES

1. Johnston, D, “International Exploration Economics, Risk, and Contract Analysis”, Pennwell Books, 2003.
2. Seba R. D., “Economics of Worldwide Petroleum Production”, OGCL Publications, USA, 1998.
3. Thompson R. S. and Wright J. D., “Oil Property Evaluation”, 2nd Edition, Thompson Wright Associates, 1985.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CO1	Describe key cash flow components involved in net cash flow and discounted cash flow.	3	-	1	-	-	3	-	-	-	-	-	-	-	-	-
CO2	Explain the broader petroleum industry context within which economic evaluations take place, that impact organizational (public, private and national) business goals	3	3	1	3	-	-	3	2	-	2	-	-	3	-	2
CO3	Understand the marketing and pricing mechanism involved.	3	3	3	3	3	-	-	-	-	-	-	-	3	-	2
CO4	Have a thorough knowledge on auditing in the petroleum industry.	3	-	-	-	1	-	-	2	1	-	-	-	3	-	-
CO5	Develop an initial proficiency in use of economic project modelling through real-world problems with outcomes.	3	3	3	3	-	3	2	2	-	-	-	1	3	3	2
CO6	Have a fundamental understanding of the concepts behind economic evaluation and of techniques for performing them within a petroleum context	3	3	3	3	-	2	2	-	-	-	2	-	3	-	2
Over all CO		3	3	2	3	2	2	2	2	-	-	1	-	3	1	2

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

PP5014	POLYMER PROCESS TECHNOLOGY	L T P C
		3 0 0 3

OBJECTIVE

To get an overview of the polymer processes

UNIT I GENERAL ASPECTS OF POLYMERS 9

Classification, mechanisms and methods of polymerization, properties-molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II APPLICATION ORIENTED POLYMERS 9

Resins-PVC-Silicon oil and resin, fibrous polymers-nylon 66, polyacrylonitrile, adhesives epoxides, phenol formaldehyde, urea formaldehyde.

UNIT III ELASTOMERS 9

Natural rubber, styrene-butadiene, poly isopropane-neoprene, silicon rubber, thermoplastic elastomer.

UNIT IV PROCESSING OF POLYMERS 9

Processing additives, plasticizer, antiaging additives, surface and optical properties, modifiers, fire retardants, additives for rubber and elastomer, various molding techniques.

UNIT V PHYSICAL AND CHEMICAL TESTING OF PLASTICS 9

Mechanical properties, tensile strength and hardness, electrical properties, volume resistivity, dielectric strength, optical properties glass, light transmission and refractive index, chemical analysis-elemental and functional analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The Students will be

CO1: Able to understand about types, mechanism and methods of polymerisation and properties of polymer

CO2: Able to understand about thermal, electrical and mechanical properties

CO3: Able to study in detail about manufacturing of application oriented polymers

CO4: Able to study in detail about manufacturing of elastomers

CO5: Able to understand about the processing of polymers and molding techniques

CO6: Able to know about various physical and chemical testing of plastics

REFERENCES

1. Miles, D.C &Briston, J.H. Polymer Technology, Chemical publishing Co: Inc: NY:1979
2. Maturine Morton, “Rubber Technology”, 3rd Edition, Van Nostrand Re Inhold, NY:1987
3. Masic, L. “Thermoplastics Materials Engineering”, Applied science publishers Ltd, NY:1986

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Able to understand about types, mechanism and methods of polymerisation and properties of polymer	1	1	1	1	-	1	-	-	1	-	-	-	1	1	-
CO2	Able to understand about thermal, electrical and mechanical properties	2	1	1	1	-	1	-	-	1	-	-	-	1	1	-
CO3	Able to study in detail about manufacturing of application oriented polymers	1	1	1	1	-	1	-	-	1	-	-	-	2	1	1
CO4	Able to study in detail about manufacturing of elastomers	1	1	1	1	-	1	-	-	1	-	-	-	2	1	1
CO5	Able to understand about the processing of polymers and molding techniques	2	2	2	1	-	1	-	-	1	-	-	-	1	1	-
CO6	Able to know about various physical and chemical testing of plastics	2	2	2	1	-	1	-	-	1	-	-	-	1	1	1
	Over all CO	2	1	1	1	-	1	-	-	1	-	-	-	1	1	1

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

PP5015 **PROJECT ENGINEERING OF PROCESS PLANTS**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

To educate students about various Management roles and responsibilities in a Process Plants

UNIT I **9**

Basic considerations in chemical engineering plant design: Preliminary data collection, Plant Location and Site Selection, Construction of Plant , Layout diagrams, Flow diagrams, Plot plans

UNIT II **9**

Cost and costing, Cost Control systems, Economic Balancing, Network Planning, Methods (PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Cost – Benefit Ratio Analysis, Project Budgeting, Capital Requirements, capital Market, Cash Flow Analysis, Break even strategies.

UNIT III **9**

Plant Engineering Management, Objectives, Programme, Control, use of scale models, Scheduling, Engineering design and Drafting, Selection and procurement of equipment and machineries, Installation, pre commission, Commissioning and performance appraisal, Product planning and development, Provision and maintenance of service facilities.

UNIT IV **9**

Process safety, Materials safety and Handling regulations, Hazard studies, Safety in equipment and machinery operations, Design considerations of safety organization and control, Pollution, Pollution control and Abatement, Regulations of Pollution Control Board, Industrial Safety Standard Analysis.

UNIT V **9**

Government regulations on procurement of raw materials and its allocation. Export – Import regulations, Pricing policy, Industrial licensing procedure, Excise and other commercial taxes, Factory act, Value Engineering

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Obtain basic knowledge on subject and various graphical representations of a process plant

CO2: Carry out the primary techno-economic feasibility of project.

CO3: Understand the sequential process in starting a Chemical Plant

CO4: Gain knowledge on Safety, Environmental and Legal aspects of Process Plants

CO5: Obtain knowledge on various procedures involved in Taxes, Export/ Import, Licensing etc.,

CO6: Select appropriate process for a project.

REFERENCES

1. Cheremisinoff, N. P., Practical Guide to Industrial Safety: Methods for Process Safety Professionals, CRC Press, 2001
2. Couper, J. R., Process Engineering Economics, CRC Press, 2003.
3. Perry, J. H. “Chemical Engineer’s Hand Book”, 8th Ed., McGraw Hill, New York, 2007.
4. Peters, M. S., Timmerhaus, C. D. and West, R. E., “Plant Design and Economics for Chemical Engineers”, 5th Edn., McGraw Hill, 2003.
5. Silla, H., Chemical Process Engineering: Design and Economics, CRC Press, 2003
6. Vinoski, W., Plant Management Handbook, Pearson Education, Limited, 1998
7. Watermeyer, P., Handbook for Process Plant Project Engineers, John Wiley and Sons, 2002.
8. Gillian lawson Stephen wearne and Peter iles-smith., “Project management for the process industries”, Institution of Chemical Engineers, IChemE, 1999

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	Obtain basic knowledge on subject and various graphical representations of a process plant	2	3	1	1	2	1	1	1	3	1	1	2	1	1	-
CO2	Carry out the primary techno-economic feasibility of project.	3	2	3	3	3	1	2	2	2	2	3	3	1	1	-
CO3	Understand the sequential process in starting a Chemical Plant	1	2	3	3	3	1	1	1	1	2	3	1	2	1	1
CO4	Gain knowledge on Safety, Environmental and Legal aspects of Process Plants	3	1	2	3	3	3	3	3	2	3	3	3	2	1	1
CO5	Obtain knowledge on various procedures involved in Taxes, Export/ Import, Licensing etc.,	2	1	3	3	3	1	1	2	3	2	3	3	1	1	-
CO6	Select appropriate process for a project.	3	2	3	3	3	3	3	1	1	2	3	3	1	1	1
Over all CO		3	2	3	3	3	2	2	2	3	3	3	3	1	1	1

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

PP5016 **OIL AND GAS WELL TESTING**

	L	T	P	C
OBJECTIVE	3	0	0	3

To impart knowledge on oil and gas well testing process.

UNIT I **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 **9**

Testing a well, wirewell logs, completing a well, Chokes, multiple completions, intelligent wells, surface casedhole logs, bypassing and coning, cycling, Well stimulation, selection wells for optimum stimulation.

UNIT III **9**

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

UNIT IV **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 **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:

The students will be able to

CO1 Understand 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 Tell different types of well bore storage and treatment techniques involved.

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

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

CO6 Describe the fundamental concepts involved behind all types of well test and also the long term production forecast from a short test.

TEXT BOOKS

1. AmanatChaudry, “Oil well testing handbook, Elsevier,2004
2. AmanatChaudry, “gas well testing handbook, Elsevier,2003

REFERENCES

1. Norman.J.Hyne, “Nontechnical guide to petroleum geology, exploration, drilling, and production,Pennwell Books,2001.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CO1	Understand the techniques involved in site preparation, drilling methodology, government regulations, and the types of reservoir for both oil and gas well testing.	3	-	3	2	-	3	2	2	-	3	2	-	3	3	1
CO2	Explain the types of wells and to evaluate all the logs.	3	3	-	-	-	2	-	1	-	-	-	-	3	-	-
CO3	Tell different types of well bore storage and treatment techniques involved.	-	3	-	-	-	2	-	-	-	-	-	-	3 3	-	-
CO4	Understand the flow, transient pressure response in oil wells and also the limitation of oil well test interpretation.	3	3	3	-	-	3	-	-	-	-	-	-	3 3	3	-
CO5	Understand the flow, transient pressure response in gas wells and also the limitation of gas well test interpretation.	3	3	3	-	-	3	-	-	-	-	-	-	3	3	-
CO6	Describe the fundamental concepts involved behind all types of well test and also the long term production forecast from a short test.	3	2	3	2	3	3	3	2	1	2	2	2	3	-	2
Over all		3	3	3	2	3	3	2	2	1	2	2	1	3	3	1

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

PP5017 PROCESS PLANT SAFETY IN PETROLEUM INDUSTRIES AND RISK ANALYSIS

	L	T	P	C
OBJECTIVE	3	0	0	3

To impart knowledge on oil and gas well safety and hazard analysis

UNIT I **9**

Importance and need for safety, hazard and risk, types of hazard, hazard assessment, hazard identification during processing of crude and operation, risk assessment, case studies. PIPER ALPHA PLATFORM – 6 July 1988, Mumbai High North Disaster, 2005.

UNIT II **9**

Handling of hazardous materials, Anhydrous hydrofluoric acid, The amines used in gas treating, Caustic soda, Furfural, Hydrogen sulfide, H2S, Methyl ethyl ketone, MEK, Aqueous wastes,Importance of MSDS sheet

UNIT III **9**

Pollutants in aqueous waste streams, Emission to the atmosphere, 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, Environment concepts, and impact on eco-system, air, water and soil.

UNIT IV **9**

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

UNIT V **9**

HAZOP study and its importance, Fire prevention and firefighting, the design specification, Fire prevention with respect to equipment design and operation, the fire main, Fire foam and foam systems, Fire and explosion modelling.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the various risks in the process industries

CO2: Analyze, reduce and minimize the risks identified through risk analysis.

CO3: Understand different types hazards and risk assessment

CO4: Understand the various aspects of process plant safety

CO5: Understand the laws and risk assurance

CO6: Describe the fundamental concepts safety and risk managements

TEXT BOOKS

1. David.S.J. “STAN” Jones and Peter R.Pujado “Handbook of Petroleum Processing,Springer,2006
2. Srinivasan Chandrasekaran, “Health, Safety and Environmental Management in offshore and petroleum management”, Wiley,
3. Srivastav, S., “Industrial Maintenance Management”, Sultan Chand & Co., 1998.
4. Rao, P. C. K., “Project Management and Control”, Sultan Chand & Co., Ltd., 1996
5. Pandya, C. G., “Risks in Chemical Units”, Oxford and IBH Publishers, 1992.

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REFERENCES

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

2. Kind, R. W., “Industrial Hazard and Safety Handbook” Butterworth, 1982.

3. Steiner, H. M., “Engineering Economic Principles”, McGraw Hill Book Co., New York, 1996.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	Understand the various risks in the process industries	3	3	3	3	2	1	1	2	2	3	3	3	3	3	1
CO2	Analyze, reduce and minimize the risks identified through risk analysis.	2	3	3	3	3	2	2	3	2	3	3	3	3	-	-
CO3	Understand different types hazards and risk assessment	2	2	3	2	3	3	3	2	3	3	3	2	3	-	-
CO4	Understand the various aspects of process plant safety	3	3	3	3	2	3	3	3	2	3	2	2	3	3	-
CO5	Understand the laws and risk assurance	3	3	3	2	1	1	2	1	1	2	3	1	3	3	-
CO6	Describe the fundamental concepts safety and risk managements	3	3	3	2	3	3	3	3	3	3	2	3	3	-	2
Over all CO		3	3	3	3	3	3	3	3	2	3	3	3	3	3	1

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

PP5018 ADDITIVES, STORAGE AND TRANSPORATION OF PETROLEUM PRODUCTS

	L	T	P	C
OBJECTIVE	3	0	0	3

To impart detailed knowledge on the additive industry, storage of petroleum products and transportation of petroleum and gas respectively.

UNIT I **9**

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 lubricants.

UNIT II **9**

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

UNIT III **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 **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 **9**

Various means to protect pipelines against freezing, abrasion and corrosion, such as 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:

The students will be able to

CO1: Learn various types of additives and its importance of application with fuel in Engines

CO2: Learn various types of storage vessels and heat loss and gain in storage tank system

CO3: Learn special features of pipeline and fluid flow operations

CO4: Learn piping and instrumentation techniques in transporting petroleum products

CO5: Learn corrosion in pipes and inhibition of corrosion ,offshore transportation of petroleum products

TEXT BOOKS

1. David.S.J. “STAN” Jones and Peter R.Pujado “Handbook of Petroleum Processing,Springer,2006
2. Virgil B.Guthrie, “Petroleum Products Handbook”“ McGraw Hill, 1960.

REFERENCES

1. 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.
2. 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	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	Learn various types of additives and its importance of application with fuel in Engines	3	3	3	3	3	2	3	3	3	2	2	1	3	3	2
CO2	Learn various types of storage vessels and heat loss and gain in storage tank system	3	3	3	3	3	2	3	3	3	2	1	1	3	3	2
CO3	Learn special features of pipeline and fluid flow operations	3	3	3	3	3	2	3	3	3	2	1	1	3	3	2
CO4	Learn piping and instrumentation techniques in transporting petroleum products	3	3	3	3	3	2	3	3	3	2	2	2	3	3	2
CO5	Learn corrosion in pipes and inhibition of corrosion ,offshore transportation of petroleum products	3	3	3	3	3	2	3	3	3	2	1	1	3	3	2
Over all CO		3	3	3	3	3	2	3	3	3	2	1	1	3	3	2

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

CL5073 **FLUIDIZATION ENGINEERING**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

To encompass the new areas and introduce reactor models specifically for these Contacting regimes.

UNIT I INTRODUCTION **9**

Phenomenon of fluidization, behaviour of fluidized beds, Characterization of particles, particle forces, operating models for fluidization systems, Industrial application of fluidized beds

UNIT II HYDRODYNAMICS OF FLUIDIZATION SYSTEMS **9**

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

UNIT III DENSE BEDS **9**

Distributor types, gas entry region of a bed, gas jets, pressure drop across distributors, design of a gas distributors, power consumption, single rising bubbles, coalescence and splitting of bubbles, bubble formation. Slug flow

UNIT IV BUBBLING FLUIDIZED BEDS, ENTRAINMENT AND ELUTRIATION **9**

Estimation of bed properties, physical model and flow model, freeboard behaviour, entrainment from tall and short vessels, high velocity 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, applications of two phase and three phase fluidized beds

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students would be able to

CO1: Understand the basics of fluidization and know the various industrial applications of fluidization

CO2: Learn the concepts of hydrodynamics in fluidized bed

CO3: Comprehend the formation and growth of bubble dynamics

CO4: Understand the bed behavior for various geometries of fluidized beds

CO5: Identify with the transport processes of fluidized beds

CO6: Gain knowledge on the fundamentals, transport processes and applications of fluidized beds.

REFERENCES

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

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO2	PO 3	PO4	PO 5	PO6	PO7	PO8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	Understand the basics of fluidization and know the various industrial applications of fluidization	1	2	-	-	-	-	1	-	1	-	-	-	3	-	1
CO2	Learn the concepts of hydrodynamics in fluidized bed	2	1	-	-	-	-	-	1	-	-	-	-	2	2	1
CO3	Comprehend the formation and growth of bubble dynamics	1	1	-	-	-	-	-	1	-	-	-	-	2	2	1
CO4	Understand the bed behavior for various geometries of fluidized beds	2	1	-	-	-	-	-	-	-	-	-	-	2	3	1
CO5	Identify with the transport processes of fluidized beds	1	-	-	-	-	-	-	-	-	-	-	-	2	2	2
CO6	Gain knowledge on the fundamentals, transport processes and applications of fluidized beds.	-	2	-	2	-	-	2	1	-	1	-	-	3	1	3
Over all CO		2	2	-	1	1	-	1	1	1	1	-	-	3	3	2

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

PP5019 **UNCONVENTIONAL TREATMENT OF NATURAL GAS**

	L	T	P	C
OBJECTIVE	**3**	**0**	**0**	**3**

To learn the production and processing of natural gas, coal bed methane, gas hydrates and shale gas.

UNIT I **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 **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 **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 **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: estimated reserves and economics, Environmental issues in shale gas exploration.

UNIT V **9**

Markets and Globus impact on energy scenario, Gas compression and metering, transmission and distribution, storage and transportation of natural gas.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Learn various sources of natural gas sources and behavior of natural gas resources.

CO2: Learn about various aspects of coal bed methane and its behavior.

CO3: Learn about various aspects of gas hydrates and application of gas hydrates as energy source.

CO4: Learn about shale gas reserve estimation, exploration techniques, production techniques, environmental issues in exploration.

CO5: Learn storage and transportation aspects of unconventional natural gas processing.

CO6: Learn and importance of most recent date unconventional natural gas reserve estimation, production and exploration techniques and its application as potential energy resource.

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TEXT BOOKS

1. BoyunGuo, Natural Gas Engineering Handbook, Gulf Pub. Company, 2012
2. Donald La Verne Katz, Handbook of natural gas engineering, McGraw-Hill, 1959

REFERENCES

1. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, Mc Graw – Hill PublishingCompany, NY, 1990.
2. Dermott, M.C. Liquified Natural Gas Technology, Neysos Park Ridge, N.J. 1973.

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Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3
CO1	Learn various sources of natural gas sources and behavior of natural gas resources.	3	3	3	2	2	1	3	2	3	-	-	1	3	3	1
CO2	Learn about various aspects of coal bed methane and its behavior.	3	3	3	2	2	1	3	2	3	-	-	1	3	3	1
CO3	Learn about various aspects of gas hydrates and application of gas hydrates as energy source.	3	3	3	2	2	1	3	3	3	-	-	1	3	3	1
CO4	Learn about shale gas reserve estimation, exploration techniques, production techniques, environmental issues in exploration.	3	3	3	2	2	1	3	3	3	-	1	1	3	3	1
CO5	Learn storage and transportation aspects of unconventional natural gas processing.	3	3	3	2	2	1	3	3	3	-	-	1	3	3	1
CO6	Learn and importance of most recent date unconventional natural gas reserve estimation, production and exploration techniques and its application as potential energy resource.	3	3	3	3	3	3	3	3	3	2	2	3	3	3	2
Over all CO		3	3	3	2	2	1	3	3	3	-	-	1	3	3	1

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

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

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OE5092	INDUSTRIAL SAFETY	LT P C
		3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra' s algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

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OUTCOMES

CO1 – Understand the costing concepts and their role in decision making CO2– Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

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UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method –Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITIIBIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

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AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

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AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT **6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL :30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

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REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.
3. Sahni, Pardeep Et.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

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AX5094	VALUE EDUCATION	L T P C 2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Workethics, Indianvision of humanism. Moralandnon-moralvaluation. Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love fornature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the over all personality.

Suggested reading

1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

AX5095	CONSTITUTION OF INDIA	L T P C 2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHYOFTHE INDIANCONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- DiscussthegrowthofthedemandforcivilrightsinIndiaforthebulkofIndiansbeforethe arrival of Gandhi in Indian politics.
- Discusstheintellectualoriginsoftheframeworkofargumentthatinformedtheconceptualization
- of social reform sliding to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- DiscussthepassageoftheHinduCodeBillof1956.

Suggested reading

1. The Constitution of India, 1950(BareAct), Government Publication.
2. Dr. S. N. Busi, Dr. B. R.AmbedkarframingofIndianConstitution,1st Edition, 2015.
3. M.P. Jain, Indian ConstitutionLaw,7th Edn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

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AX5096	PEDAGOGY STUDIES	L T P C 2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OFPEDAGOGICALPRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

- Whatpedagogicalpracticesarebeingusedbyteachersinformalandinformalclassrooms in developing countries?
- What is the evidence on the effectiveness soft he sepedagogical practices, in what conditions, and with what population of learners?
- How can teacher education(curriculum and practicum)and the school curriculum and guidance materials best support effective pedagogy?

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Suggested reading

1. Ackers, HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare,31(2): 245-261.
2. AgrawalM (2004)Curricular reform in schools: The importance of evaluation, JournalofCurriculumStudies,36(3):361-379.
3. AkyeampongK(2003)TeachertraininginGhana-doesitcount?Multi-siteteachereducationresearchproject(MUSTER) country report 1.London:DFID.
4. Akyeampong K,LussierK, PryorJ, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. ChavanM (2003) Read India: Amass scale, rapid, 'learningtoread 'campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do`s and Don't'sin life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTEDREADING

1. 'YogicAsanasforGroupTarining-Part-I":JanardanSwamiYogabhyasiMandal, Nagpur
2. "Rajayogaorconquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department),Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To a waken wisdom in students

UNIT I

Neetishatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 - Verses 13, 14, 15, 16,17, 18 -Personality of role model - shrimadbhagwadgeeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad- Bhagwad- Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.

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