Department of Chemical Engineering

Vision:

Department of Chemical Engineering strives to become well known in India by creating quality chemical engineers who will be highly successful in academia, industries and research. The 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

M. TECH. CHEMICAL ENGINEERING

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. To impart knowledge to students in the latest technological aspects of Chemical Engineering and to provide them with opportunities in taking up advanced topics of the field of study.
2. To provide a solid foundation in mathematical, scientific and engineering fundamentals required to develop problem solving ability for higher level learning.
3. To prepare Post graduate students for a successful career with effective communication skills, teamwork skills and work with values that meet the diversified needs of industry, academia and research.
4. To train Post graduate's in comprehending, analyzing, designing and creating new technologies that provide solution frameworks to real world problems.
5. To broaden and deepen their capabilities in experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation.
6. To create a congenial environment that upholds learning, growth and impart ability to work with inter-disciplinary groups in professional, industry and research organizations

2.PROGRAMME OUTCOMES (POs)

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

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

PO3: Ability to demonstrate mastery over the specialized area of study higher than the appropriate bachelor program

PO4: Ability to undertake problem identification, formulation and providing optimum solution.

PO 5: Ability to identify, formulate, and solve multidisciplinary engineering problems.

PO6: Ability to use the techniques, skills, and modern engineering tools necessary for Academic and engineering practice

PO7: Understanding of the social, cultural, global and environmental responsibilities as a professional engineer.

PO8: Understanding the principles of inter-disciplinary domains for sustainable development.

PO9: Understanding professional & ethical responsibilities and commitment to them.

PO10: Ability to function effectively as an individual and in a group with the capacity to be a team leader.

PO11: Ability to communicate effectively, Understanding of engineering and management principles, work culture and apply to multidisciplinary environments.

PO12: Recognizing the need to undertake life-long learning, and possess/acquire the capacity to do so.

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

Programme Educational Objectives	Programme Outcomes												Programme Specific Objectives			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PS O4
1.	✓	✓	✓	✓	✓	✓	-	✓	-	-	✓	✓	✓	✓	✓	✓
2.	✓	✓	✓	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓
3.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4.	✓	✓	✓	✓	✓	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓
5.	✓	✓	✓	✓	✓	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓
6.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4. MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

		Course	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	PS O4
YEAR I	SEMESTER I	Advanced Transport Phenomena	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3
		Advanced Reaction Engineering	3	3	3	3	2	2	1	2	2	2	3	3	2	2	3	2
		Advanced Process Control	3	2	3	3	3	-	2	-	1	1	1	1	3	3	2	2
		Chemical Process Design	2	2	3	2	3	1	-	2	-	1	2	3	3	3	3	3
		Program Elective I																
		Research Methodology and IPR																
		Audit Course – I																
		Laboratory I Reaction Engineering Lab	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
		Laboratory II Process Control Lab	2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2
	SEMESTER II	Separation Processes	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
		Advanced Thermodynamics for Chemical Engineers	3	3	3	3	2	1	2	1	2	2	2	2	2	2	2	2
		Modeling of Chemical Processes	2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2
		Program Elective II																
		Program Elective III																
		Audit Course –II																
		Laboratory III Separation Laboratory	2	3	3	3	3	-	1	-	3	3	3	3	3	3	3	2
		Laboratory IV Computational Lab	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
		Mini Project with Seminar	3	3	3	3	2	1	2	2	2	2	3	3	3	3	3	3
YEAR II	SEMESTER III	Program Elective IV																
		Program Elective V																
		Open Elective																
		Project Phase I	3	3	3	3	2	1	2	2	2	2	3	3	3	3	3	3

	SEMESTER IV	Project Phase II	3	3	3	3	2	1	2	2	2	2	3	3	3	3	3	3

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

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M. TECH. CHEMICAL ENGINEERING

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

CURRICULAM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER – I

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CL5101	Advanced Transport Phenomena	PCC	3	1	0	4	4
2.	CL5102	Advanced Reaction Engineering	PCC	3	0	0	3	3
3.	CL5103	Advanced Process Control	PCC	3	0	0	3	3
4.	CL5104	Chemical Process Design	PCC	3	0	0	3	3
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.	CL5111	Laboratory I Reaction Engineering Lab	PCC	0	0	4	4	2
9.	CL5112	Laboratory II Process Control Lab	PCC	0	0	4	4	2
			TOTAL	**19**	**1**	**8**	**28**	**22**

*Audit Course is Optional

SEMESTER – II

S. NO.	CODE	COURSE NAME	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CL5201	Separation Processes	PCC	3	0	0	3	3
2.	CL5202	Advanced Thermodynamics for Chemical Engineers	PCC	3	0	0	3	3
3.	CL5203	Modelling of Chemical Processes	PCC	4	0	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.	CL5211	Laboratory III Separation Lab	PCC	0	0	4	4	2
8.	CL5212	Laboratory IV Computational Lab	PCC	0	0	4	4	2
9.	CL5213	Mini Project with Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**0**	**10**	**28**	**21**

*Audit Course is Optional

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.	CL5311	Project Phase I	EEC	0	0	12	12	6
TOTAL				**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	CL5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 70

PROGRAM CORE COURSES (PCC)

S. No.	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1.	CL5101	Advanced Transport Phenomena	3	1	0	4	1
2.	CL5102	Advanced Reaction Engineering	3	0	0	3	1
3.	CL5103	Advanced Process Control	3	0	0	3	1
4.	CL5104	Chemical Process Design	3	0	0	3	1
5.	CL5111	Laboratory I Reaction Engineering Lab	0	0	4	2	1
6.	CL5112	Laboratory II Process Control Lab	0	0	4	2	1
7.	CL5201	Separation Processes	3	0	0	3	2
8.	CL5202	Advanced Thermodynamics for Chemical Engineers	3	0	0	3	2
9.	CL5203	Modeling of Chemical Processes	4	0	0	4	2
10.	CL5211	Laboratory III Separation Lab	0	0	4	2	2
11.	CL5212	Laboratory IV Computational Lab	0	0	4	2	2

PROFESSIONAL ELECTIVE COURSES (PEC)

S. No.	Code No.	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1.	CL5071	Computational Fluid Dynamics	3	0	0	3	1
2.	CL5001	Distillation Components and its Processes	3	0	0	3	1
3.	CL5002	Business analytics	3	0	0	3	1
4.	CL5003	Biochemical Engineering	3	0	0	3	1
5.	CL5072	Design of Experiments	3	0	0	3	1
6.	CL5004	Multiphase flow	3	0	0	3	2
7.	CL5005	Nanocomposites	3	0	0	3	2
8.	CL5006	Piping and Instrumentation	3	0	0	3	2
9.	CL5007	Chemical Processes and Pollution Control	3	0	0	3	2
10.	CL5008	Polymer Processing Technology	3	0	0	3	2
11.	CL5009	Risk analysis and management	3	0	0	3	2
12.	CL5010	Project engineering of process plants	3	0	0	3	2
13.	CL5011	Resource Management Techniques	3	0	0	3	2
14.	CL5012	Process Optimization	3	0	0	3	3
15.	CL5013	Software applications in Chemical Industries	3	0	0	3	3
16.	CL5014	Thermal processing in food Products	3	0	0	3	3
17.	CL5015	Energy from Waste	3	0	0	3	3
18.	CL5073	Fluidization Engineering	3	0	0	3	3
19.	CL5016	Safety and Environment in Chemical Industries	3	0	0	3	3
20.	CL5017	Membrane Technology for water and waste water treatment	3	0	0	3	3
21.	CL5018	Bioprocess Technology	3	0	0	3	3

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	1

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	CL5213	Mini Project with Seminar	0	0	2	1	2
2	CL5311	Project Phase I	0	0	12	6	3
3	CL5411	Project Phase II	0	0	24	12	4

SUMMARY:

S. No.	Subject Area	Credits per Semester				Credits Total
		I	II	III	IV	
1	PCC	17	14	-	-	31
2	PEC	3	6	6	-	15
3	OEC	-	-	3	-	3
4	EEC	-	1	6	12	19
5	RMC	2	-	-	-	2
	Total	22	21	15	12	**70**
	Audit courses (Non Credit)	*	*			

SYLLABI

SEMESTER I

CL5101 ADVANCED TRANSPORT PHENOMENA

L	T	P	C
3	1	0	4

OBJECTIVE

To understand and appreciate the transport processes in chemical engineering and to seek solution of the macroscopic balances for isothermal and non-isothermal system and to identify c**o**nvenient coordinate systems for the solution.

UNIT I **12**

Phenomenological Equations and Transport properties, Rheological behaviour of fluids, Models for Rheological Behaviour- Balance Equations – Differential and Integral equations – Conversion from Cartesian, Cylindrical and Polar coordinates

UNIT II **12**

Applications in laminar and turbulent transport in compressible and incompressible fluids. Boundary layer theory – Momentum , Thermal and Concentration Boundary layer – Similarity Transformation – Blasius Solution

UNIT III **12**

Reynolds Transport Theorem – application of RTT to solutions for Macroscopic balance for isothermal and non isothermal systems and their applications in Momentum, Heat and Mass transport problems.

UNIT IV **12**

Friction factor, Fluid –Fluid systems, Flow patterns in vertical and horizontal pipes, Formulation of bubbles and drops and their size distribution, Solid – fluid systems, Forces acting on stagnant and moving solids, Flow through porous medium, capillary tube model and its applications- Concept of Representative Elementary volume - Darcy's Equation – Forscheimer Equation – Energy Equation in porous media – Evaluation of Thermal conductivity and Diffusivity in porous media

UNIT V **12**

Heat Transfer coefficient, Forced convection in tubes, around submerged objects, Heat Transfer by free convection, film type and dropwise condensation and equations for heat transfer, Heat transfer in boiling liquids- Graetz Heat transfer, Heat transfer in tubes in laminar and turbulent regime with constant wall temperature and constant heat flux- Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates, Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand and identify transport properties for the three transport phenomena and analyze the mechanisms of molecular and turbulent momentum, energy and mass transport.

CO2: Identify the convenient coordinate systems viz., rectangular, cylindrical and spherical , for transport phenomena problems

CO3: Formulate the differential forms and integral form of the equations of change for momentum, heat and mass transport in compressible and incompressible fluids for steady-state and unsteady flows

CO4: Apply RTT for macroscopic balances for isothermal and non isothermal systems.

CO5: Evaluate the flow behavior for external and internal flows

CO6: Evaluate thermal conductivity and mass diffusivity for flow through porous media.

CO7: Formulate methods for estimation of heat and mass transfer coefficients

TEXT BOOKS

1. Bird, R. B., Lightfoot, E. N., & Stewart, E. W. (2007). Transport phenomenon. Wiley.
2. Deen, W. M. (1998). Analysis of Transport Phenomena, Topics in Chemical Engineering (Vol. 3). Oxford University Press, New York.
3. Leal, L. G. (2007). *Advanced transport phenomena: fluid mechanics and convective transport processes* (Vol. 7). Cambridge University Press.

REFERENCES

1. Brodkey, R. S., & Hershey, H. C. (2003). Transport phenomena: a unified approach. Brodkey publishing.
2. Hauke, G. (2008). *An introduction to fluid mechanics and transport phenomena* (Vol. 86). the Netherlands: Springer.
3. Nield, D. A., & Bejan, A. (2006). *Convection in porous media*(Vol. 3). New York: springer.
4. Ingham, D. B., & Pop, I. (1998). *Transport phenomena in porous media*. Elsevier.
5. Middleman, S. (1998). *An introduction to fluid dynamics: principles of analysis and design*. New York:: Wiley.

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	PSO 4
CO1	Understand and identify transport properties for the three transport phenomena and analyze the mechanisms of molecular and turbulent momentum, energy and mass transport.	3	3	-	3	2	-	1	-	1	2	3	2	2	3	3	3
CO2	Identify the convenient coordinate systems viz., rectangular, cylindrical and spherical , for transport phenomena problems	3	3	-	3	2	-	1	-	1	2	3	2	2	3	3	3
CO3	Formulate the differential forms and integral form of the equations of change for momentum, heat and mass transport in compressible and incompressible fluids for steady-state and unsteady flows	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3
CO4	Apply RTT for macroscopic balances for isothermal and non isothermal systems.	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3
CO5	Evaluate the flow behavior for external and internal flows	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3
CO6	Evaluate thermal conductivity and mass diffusivity for flow through porous media.	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3
CO7	Formulate methods for estimation of heat and mass transfer coefficients	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3
	Over all	3	3	-	3	3	-	1	-	1	3	3	2	2	3	3	3

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

CL5102 ADVANCED REACTION ENGINEERING

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

To educate students with advanced knowledge on Reaction Engineering.

UNIT I KINETICS OF HETEROGENEOUS REACTIONS 9

Catalytic reactions, rate controlling steps, Langmuir-Hinshelwood model, Eley Rideal mechanism, steady state approximation, non-catalytic fluid-solid reactions, shrinking and unreacted core model.

UNIT II CATALYSIS 9

Nature of catalyses, mechanism and kinetics of catalyst, Adsorption Isotherms, properties and characterization of catalysts, surface area measurement, pore size distribution, evaluation of catalysis, choice of catalysts, promoters, inhibitors, poison, supports, Catalyst deactivation.

UNIT III EXTERNAL DIFFUSION EFFECTS IN HETEROGENEOUS REACTIONS 9

Mass and heat transfer coefficients in packed beds, quantitative treatment of external transport effects, effect of external transport on selectivity, modeling diffusion with and without reaction.

UNIT IV INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS 9

Intra pellet mass and heat transfer, evaluation of effectiveness factor, mass and heat transfer with reaction.

UNIT V ANALYSIS AND DESIGN OF HETEROGENEOUS REACTORS 9

Isothermal and non-isothermal fixed bed reactors, Fluidized bed model, slurry reactor model, trickle bed reactor model.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the kinetics of Heterogeneous reactions using various Theories

CO2: Understand properties and function of Catalyst

CO3: Obtain knowledge on External Diffusion effects in a Heterogeneous Reactions

CO4: Gain knowledge on Internal Transports in the Porous Catalysts

CO5: Design Heterogeneous Reactors

CO6: Obtain detailed knowledge on Chemical Reactions

REFERENCES

1. Carberry, J. J., “Chemical and Catalytic Reaction Engineering”, Dover Publications, 2001.
2. Froment, G. F. and Bischoff, K. B., “Chemical Reactor Design and Analysis”, 2nd Edition, John Wiley & Sons, New York, 1997.

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	PSO 4
CO1	Understand the kinetics of Heterogeneous reactions using various Theories	3	3	2	3	2	1	1	1	2	2	2	3	1	3	3	3
CO2	Understand properties and function of Catalyst	2	2	2	3	1	2	2	2	3	2	3	3	3	3	3	3
CO3	Obtain knowledge on External Diffusion effects in a Heterogeneous Reactions	3	3	2	3	1	1	1	1	1	1	2	2	1	1	2	1
CO4	Gain knowledge on Internal Transports in the Porous Catalysts	3	3	2	3	1	1	1	1	1	1	2	2	1	1	2	1
CO5	Design Heterogeneous Reactors	3	3	3	3	3	2	2	3	3	1	2	3	2	3	3	2
CO6	Obtain detailed knowledge on Chemical Reactions	3	3	3	3	3	2	1	3	3	3	2	3	3	3	3	3
Over all		3	3	3	3	2	2	1	2	2	2	3	3	2	2	3	2

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

CL5103 **ADVANCED PROCESS CONTROL**

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

To instruct students to build and analyze models for time-varying systems and non-linear systems.

UNIT I ADVANCED CONTROL STRATEGIES 9

Linear, nonlinear regression fitting for first order, second order models without and with time delay, development of discrete time model and parameter identification. Feed forward, cascade, dead time compensation, split range, inferential, selective and override control; smith predictor, automatic tuning and gain scheduling.

UNIT II INTERNAL MODEL CONTROL 9

Model based control – IMC structure – development and design; Direct synthesis method, IMC based PID control, Overview of MPC, prediction for SISO and MIMO models, MPC calculation, set point calculation, selecting the tuning parameters in MPC–Design examples for typical case studies.

UNIT III MULTIVARIABLE CONTROL 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 DISCRETE SYSTEMS & NON-LINEAR SYSTEMS 9

Z – Transform and inverse Z – transform properties,Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability. Models for Time-varying and Nonlinear systems, Hammerstein and Wiener Systems. Fuzzy logic controls. Neural network control

UNIT V DIGITAL FEEDBACK& ADAPTIVE CONTROLLERS 9

Design of digital feedback controllers, digital approximation of classical, effect of sampling, Velocity & Position form of PID controller, Dead beat and Dahlin's algorithms, Types of Adaptive Control - Gain scheduling -Adaptive Control - Deterministic Self-tuning Controller and Model Reference Adaptive Controller, Case study of Industrial Instrumentation and Control system, DCS, PLC, shutdown system. Simulation

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the dynamic response of open and closed loop systems, control loop components and stability of control systems along with instrumentation

CO2: Understand and analyze models for time-varying systems and non-linear systems.

CO3: Obtain skills needed to design adaptive controllers such as gain-scheduled adaptive controller

CO4: Gain knowledge on Model-reference adaptive controller and Self-tuning controller

CO5: Design MPC, Multivariable controls

CO6: Obtain familiarity on time-varying systems and non-linear systems for various applications

TEXT BOOKS:

1. Bequette, B. W., Process Control: Modeling, Design, and Simulation, Prentice Hall, 2003
2. Stephanopolous, G., “Chemical Process Control”, Prentice Hall of India, New Delhi,1985

3. Ramesh C. Panda & T. Thyagarajan, An Introduction to Process Modeling, Identification and Control for Engineers, Narosa Publishing House, New Delhi, 2017

REFERENCES

1. Kannan M. Moudgalya, Digital Process Control, John Wiley & Sons Ltd,2007
2. Donald R CoughanowrLeBlanc, Process System Analysis & Control, McGraw Hill Education; Third edition (1 July 2017)
3. W L Luyben, Process Modeling Simulation & Control for Chemical Engineers,McGraw Hill Education; 2 edition (17 December 2013)

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	PSO 4
CO1	Understand the dynamic response of open and closed loop systems, control loop components and stability of control systems along with instrumentation	2	2	1	2	2	-	2	-	1	1	1	1	2	3	2	2
CO2	Understand and analyze models for time-varying systems and non-linear systems.	1	2	3	1	2	-	2	-	1	1	1	1	3	3	2	2
CO3	Obtain skills needed to design adaptive controllers such as gain-scheduled adaptive controller	2	2	3	3	3	-	2	-	1	1	1	1	3	3	2	2
CO4	Gain knowledge on Model-reference adaptive controller and Self-tuning controller	3	2	3	3	3	-	2	-	1	1	1	1	3	2	2	2
CO5	Design MPC, Multivariable controls	3	3	3	3	3	-	2	-	1	1	1	1	2	1	2	2
CO6	Obtain familiarity on time-varying systems and non-linear systems for various applications	3	3	3	3	3	-	2	-	1	1	1	1	3	3	2	2
	Over all	3	2	3	3	3	-	2	-	1	1	1	1	3	3	2	2

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

CL5104 **CHEMICAL PROCESS DESIGN**

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

Students will learn individual aspects of chemical engineering for chemical plant design, optimization and the hierarchy of analysis and decisions in synthesis for chemical process and its alternatives.

UNIT I THE NATURE OF CHEMICAL PROCESS DESIGN AND INTEGRATION 9

Formulation of Design Problem-The Hierarchy and Approaches of Chemical Process Design and Integration.

UNIT II DESIGN OF REACTORS 9

Choice of Reactor-Reactor Performance-Reactor Conditions-Reactor Configuration

UNIT III DESIGN OF SEPARATION SYSTEM 9

Separation systems Introduction -Choice of Separator for Homogeneous Fluid Mixtures-Choice of separator for heterogeneous fluid mixtures- Distillation Sequencing.

UNIT IV ENERGY INTEGRATION AND HEAT EXCHANGER NETWORK SYNTHESIS 9

Heat Exchager Networks Design-Network Energy Targets-Capital and Total Cost Targets, Energy Integration-Basic Principles-Composite Curves, Problem Table Algorithm-Pinch Design Method

UNIT V RECYCLE SYSTEMS FOR CONTINUOUS AND BATCH PROCESS 9

Functions of process Recycles in continuous and batch processes- Process Yield-optimization of recycle loop in continuous and batch process.

TOTAL: 45 PERIODS

COURSE OUTCOMES: The students will be able to

CO1: Learn various aspects of process design project objectives, approaches of process design.

CO2: Learn various Choice of reactors and its performance assessment, reactor configuration

CO3: Learn design of different types of separations process for homogeneous and heterogeneous mixtures.

CO4: Learn types of Heat exchanger networks for the target of energy and costs.

CO5: Learn and Analyze Recycle systems in order to optimize the process

CO6: Learn design principles to attain cost, energy efficient and environment compliant process.

TEXT BOOKS

1. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, West Sussex, UK (2005)
2. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003)

REFERENCES

1. Silla.H.,Chemical Process Engineering(Design and Economics),Taylor and Francis Group LLC,USA (2003)
2. Douglas, James M., Conceptual Design of Chemical Processes, McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (1988)

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	PSO 4
CO1	Learn various aspects of process design project objectives, approaches of process design.	1	2	2	2	3	1	-	2	-	1	2	3	3	3	3	3
CO2	Learn various Choice of reactors and its performance assessment, reactor configuration	1	2	2	2	3	1	-	2	-	1	2	3	3	3	3	3
CO3	Learn design of different types of separations process for homogeneous and heterogeneous mixtures.	2	1	3	2	3	1	-	2	-	1	2	3	3	3	3	3
CO4	Learn types of Heat exchanger networks for the target of energy and costs.	2	2	3	2	3	1	-	2	-	1	2	3	3	3	3	3
CO5	Learn and Analyze Recycle systems in order to optimize the process	1	2	3	2	3	1	-	2	-	1	2	3	3	3	3	3
CO6	Learn design principles to attain cost, energy efficient and environment compliant process.	2	2	3	3	3	2	3	3	-	2	3	3	3	3	3	3
Over all		2	2	3	2	3	1	-	2	-	1	2	3	3	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 LT 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	✓					✓						✓

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

CL5111 REACTION ENGINEERING LABORATORY

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

To understand the principles of chemical reaction engineering

List of Experiments:

1. To find the reaction rate constant in a stirred batch reactor.
2. To find the effect of reactant concentration on the reaction rate by using batch rector.
3. To find the reaction rate constant in a continuous stirred tank reactor.
4. To determine the effect of inadequate mixing on the reaction rate using stirred tank reactor
   Dynamic behavior of continuous stirred tank reaction.
   Dynamics of stirred tank reactor in series
   Effect of step input change.
   Response of tank concentration to an impulse change.
5. Determination of the influence of flow rate on three tank system following a step change in input concentration.
6. Determination of the response to a step change in the input concentration of a system comprising one stirred vessel and a “dead time” module.
7. To determine the rate constant using tubular reactor.
8. To investigate the effect of throughput on the conversion using tubular reactor.
9. To demonstrate the temperature dependence of the reaction and the rate constant using tubular reactor.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the kinetics of Heterogeneous reactions using Laboratory experiments
CO2: Understand properties and function of Catalyst from Packed bed data
CO3: Obtain knowledge on External Diffusion effects in a Heterogeneous Reactions
CO4: Gain knowledge on Internal Transports in the Porous Catalysts
CO5: Analyze data on homogenous and heterogenous reactions
CO6: Obtain practical knowledge on Chemical Reactions

REFERENCES:

1) Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, Singapore, 1998 3 rd Edition

2) Elements of Chemical Reaction Engineering, Fogler H.S., Prentice-Hall, NJ, 2006, 4th Edition

3) Chemical Engineering Kinetics, Smith J. M., McGraw Hill, N Y, 1981, 3 rd Edition

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	PSO 4
CO1	Understand the kinetics of Heterogeneous reactions using Laboratory experiments	1	1	2	2	2	-	1	-	1	1	-	1	-	2	1	1
CO2	Understand properties and function of Catalyst from Packed bed data	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO3	Obtain knowledge on External Diffusion effects in a Heterogeneous Reactions	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO4	Gain knowledge on Internal Transports in the Porous Catalysts	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO5	Analyze data on homogenous and heterogenous reactions	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO6	Obtain practical knowledge on Chemical Reactions	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
Over all		2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1

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

CL5112 **PROCESS CONTROL LABORATORY**

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

To develop lumped and distributed models for processes and to model them using SIMULINK, to model and control thermal process, level using P, PI, PID control and to study the dynamics of inherent and installed characteristics of different process valves.

LIST OF EXPERIMENTS:

1. Realtime position control of a servo problem
2. Level control using P,PI and PID controllers
3. Tank Level control using LabView for single tank, two tanks and four tanks
4. Determination of control characteristics of a pneumatically actuated valve – with and without positioner
5. Installed and inherent Valve characteristics of valves – Linear, quick opening, equal percentage and hyperbolic valve
6. Dynamics and control of Rotary Inverted pendulum
7. Cascade Control of a Jacketed CSTR
8. Inferential Control of composition in a distillation column using thermocouples
9. Closed loop control for a servo problem for thermal process
10. Closed loop control for a servo problem for thermal process
11. Simulation and control of a lumped parameter process using SIMULINK
12. Simulation and control of a distributed parameter process using SIMULINK
13. Simulation of relay auto tuning of PID controllers using SIMULINK
14. Implementation of Model Predictive Control using SIMULINK for an industrial process
15. Simulation of closed loop response for a inverse response process using SIMULINK

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Implement closed loop control for servo and regulatory problems of thermal processes and level.

CO2: Determine the rangeability and flow parameters for various process valves

CO3: Design and implement control structure for cascade control

CO4: Design and implement Model Predictive control

CO5: Design and implement inferential control in a distillation column

CO6: Simulate process control techniques using SIMULINK

REFERENCES

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

2. Bubnicki, Z., Modern Control Theory, Springer Verlag, 2005.

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

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

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

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

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

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

9. 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	PSO 4
CO1	Implement closed loop control for servo and regulatory problems of thermal processes and level.	1	2	3	2	-	-	1	-	3	3	3	3	3	3	3	2
CO2	Determine the rangeability and flow parameters for various process valves	2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2
CO3	Design and implement control structure for cascade control	2	3	3	3	3	-	1	-	3	3	3	3	3	3	3	2
CO4	Design and implement Model Predictive control	2	2	3	3	3	-	1	-	3	3	1	3	3	3	3	2
CO5	Design and implement inferential control in a distillation column	2	2	3	3	3	-	1	-	3	3	2	3	3	3	3	2
CO6	Simulate process control techniques using SIMULINK	2	3	3	3	3	-	1	-	3	3	1	3	3	3	3	2
Over all		2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2

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

SEMESTER II

CL5201 SEPARATION PROCESSES

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

To gain knowledge about advanced separation process. Also to learn conceptual design of separation processes and design of equipment involved.

UNIT I GENERAL 9

Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. process concept, theory and equipment used in cross flow filtration, cross flow electro-filtration, dual functional filter, surface based solid-liquid separations involving a second liquid, sirofloc filter.

UNIT II MEMBRANE SEPARATIONS 9

Types and choice of membranes, plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, commercial, pilot plant and laboratory membrane pemeators involving dialysis, reverse osmosis, nanofiltration, ultrafiltration, microfiltration and Donnan dialysis, economics of membrane operations, ceramic membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES 9

Mechanism, types and choice of adsorbents, normal adsorption techniques, affinity chromatography and immuno chromatography, types of equipment and commercial processes, recent advances and process economics

UNIT IV IONIC SEPARATIONS 9

Controlling factors, Applications, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes

UNIT V OTHER TECHNIQUES 9

Separations involving lyophilization, pervaporation and permeation techniques for solids, liquids and gases, industrial viability and examples, zone melting, adductive crystallization, other separation processes, supercritical fluid extraction, oil spill management, industrial effluent treatment by modern techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On successful completion of the course, the students will be able to

CO1: Understand the key concepts of conventional and advanced aspects of separation processes and the selection of separation processes.

CO2: Understand the concepts and develop design equations for membrane separation processes.

CO3: Understand the principles and processes of adsorption and chromatographic techniques and to design an absorber to achieve specific separation.

CO4: Analyze the separation system for multi-component mixtures, design separation process based on electrical properties.

CO5: Apply the latest concepts like super critical fluid extraction, pervaporation, lyophilisation etc. also to understand Innovative techniques for controlling and managing oil spills in Chemical process industries.

CO6: Understand and select appropriate separation technique for intended problem.

TEXT BOOKS

1. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd.,1982.

2. Seader J.D. and Henley E.J., “Separation Process Principles”, 2nd Ed., John Wiley, 2006.

3. Schoew, H.M. - " New Chemical Engineering Separation Techniques ",Interscience Publishers, 1972.

REFERENCES

1. Nakagawal, O. V., “Membrane Science and Technology”, Marcel Dekker, 1992.

2. Rousseau, R. W., “Handbook of Separation Process Technology”, John Wiley, New York, 1987.

3. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997

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	PSO 4
CO1	Understand the key concepts of conventional and advanced aspects of separation processes, and the selection of separation processes.	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
CO2	Understand the concepts and develop design equations for membrane separation processes.	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
CO3	Understand the principles and processes of adsorption and chromatographic techniques and to design an absorber to achieve specific separation.	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
CO4	Analyze the separation system for multi-component mixtures, design separation process based on electrical properties.	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
CO5	Apply the latest concepts like super critical fluid extraction, pervaporation, lyophilisation etc., also to understand Innovative techniques for controlling and managing oil spills in Chemical process industries.	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
CO6	Understand and select appropriate separation technique for intended problem.	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3
	Overall	3	3	3	3	1	1	2	1	1	-	1	2	3	3	3	3

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

CL5202 **ADVANCED THERMODYNAMICS FOR CHEMICAL ENGINEERS**

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

This course helps the students to be expert in applying thermodynamic principles to various chemical engineering processes involving energy flow, phase and reaction equilibrium.

UNIT I **9**

Basic thermodynamic concepts, Energy and first Law; Reversibility and second Law; Review of Basic Postulates, equation of state and its applications, corresponding states, equilibrium criteria, Legendre Transformation and Maxwell's relations

UNIT II **9**

Phase rule, Stability of thermodynamic systems, first order phase transitions and critical phenomenon, single component phase diagrams, thermodynamic properties from volumetric and thermal data

UNIT III **9**

Partial molar properties, Gibbs-Duhem equation, fugacities in gas and liquid mixtures, activity coefficients, Ideal and Non-ideal solutions, azeotropes, Wilson, NRTL, and UNIQUAC equations, UNIFAC method.

UNIT IV **9**

Vapour Liquid Equilibrium involving low pressure, high pressures and multi component systems,VLE in ideal and non- ideal solutions, Henry's Law, Other phase equilibriums-SLE/LLE/VLLE.

UNIT V **9**

Criteria of chemical reaction equilibrium in thermodynamic systems, Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium

TOTAL: 45 PERIODS

COURSE OUTCOMES: The students will be able to

CO1: Associate the concepts of energy, laws of thermodynamics to applications that require quantitative knowledge of thermodynamic properties at macroscopic level.

CO2: Understand the thermodynamics of phase equilibria typically encountered in design of chemical processes such as separation operations.

CO3: Relate the theoretical results used to physical systems that convert matter and energy in terms of the laws of thermodynamics.

CO4: Analyze many of the thermodynamic properties of dilute solutions can be derived analytically from statistical formulations.

CO5: Apply the various phase equilibrium models in practical situations

CO6: Apply in the area of thermodynamics principles to various chemical engineering processes

TEXT BOOKS

1. M. Smith, H. C. Van Ness and M. M. Abbott; Introduction *to Chemical Engineering Thermodynamics*, Tata-McGraw Hill (2003).
2. I. Sandler; *Chemical, Biochemical, and Engineering Thermodynamics,* John Wiley &Sons, New Delhi (2007).
3. Koretsky, M. D.; *Engineering and Chemical Thermodynamics,* John Wiley and Sons, New Delhi (2004).
4. Callen, H. B. *Thermodynamics and an Introduction to* Thermostatistics; John Wiley and Sons: New York (1985).
5. Tester, J. W., Modell, M., Thermodynamics and its Applications*,* Prentice-Hall, New Jersey (1996).

REFERENCES

1. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad,2005
2. Narayanan K.V"A Text Book of Chemical Engineering Thermodynamics "Prentice Hall of India Pvt.Ltd.2001.

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	PS O 4
CO1	Associate the concepts of energy, laws of thermodynamics to applications that require quantitative knowledge of thermodynamic properties at macroscopic level.	2	2	2	1	-	2	2	1	1	1	2	1	2	1	1	1
CO2	Understand the thermodynamics of phase equilibria typically encountered in design of chemical processes such as separation operations.	3	3	3	3	2	1	2	-	1	2	1	1	2	2	2	1
CO3	Relate the theoretical results used to physical systems that convert matter and energy in terms of the laws of thermodynamics.	3	2	3	3	3	1	2	1	2	2	2	2	1	1	1	2
CO4	Analyze many of the thermodynamic properties of dilute solutions can be derived analytically from statistical formulations.	2	3	2	2	2	1	1	1	2	1	2	1	2	1	2	2
CO5	Apply the various phase equilibrium models in practical situations	3	2	3	3	3	2	2	1	3	2	2	2	3	2	1	2
CO6	Apply in the area of thermodynamics principles to various chemical engineering processes	3	3	3	3	3	1	3	1	3	3	3	2	2	2	2	2
Over all		3	3	3	3	2	1	2	1	2	2	2	2	2	2	2	2

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

CL5203 MODELING OF CHEMICAL PROCESSES

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

To develop steady state and transient models for processes and unit operations and to understand lumped and distributed parameter models and to seek solution of models using analytic and numerical techniques and to construct data driven models and estimate the parameters.

UNIT I **9**

Need for developing models for a process - Incentives of process modeling and simulation - classification of mathematical models, conservation equations and auxiliary relations - Closed form of solution – Well posedness of Models.

UNIT II **9**

Degree of freedom analysis - Design and Control degrees of Freedom - Degrees of Freedom Analysis for flowsheets involving single and multiple process units - Flowsheeting - Models yielding linear and non-linear algebraic equations - Solution to linear and non-linear algebraic equations - Convergence - Types of Convergence - Wegstein's Algorithm - Levenberg-Marquadt Method, Application of algebraic models to dimensional analysis and determination of independent species in a set of reactions.

UNIT III **9**

Models yielding ODE - Classification of ODE - Solution of ODE - analytical methods using matrices and numerical methods - Stiff ODE's - Gear's algorithm - Stability analysis of Euler's algorithm, Runge- Kutta methods of various orders, Predictor - Corrector methods - Adaptive stepsize algorithm - Perturbation methods, Mathematical models with Initial and or Boundary conditions of surge tank, Transient isothermal and nonisothermal Mixed flow reactor, separation systems such as distillation, flashing, Coiled and Jacketed heaters.

UNIT IV **9**

Models yielding PDE's - Characteristics and differences between Lumped and Distributed Parameter systems - classification and solution of partial differential equations – Characteristic curves for parabolic, Elliptic and Hyperbolic equations - Mathematical models of Heat Exchanger, Packed bed reactor, Monolith Reactor Modeling – Pseudohomogeneous and Heterogeneous models for catalytic reactors, plug flow reactor, Convection-Diffusion-Reaction (CDR) model, packed bed adsorption- solution of ODE boundary value problems – Method of Characteristics - shooting Method.

UNIT V **9**

Empirical modeling, parameter estimation, principle of linear and non-linear least squares - Population balance and stochastic modeling- Application of population balance models in crystallization, particle comminution, RTD in reactors - Principal Component Analysis - Kernel PCA - Singular Value Decomposition.

TOTAL: 45 PERIODS

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 relevant solution methods for the mathematical models with relevant initial and/or boundary conditions

CO6: Appreciate the applicability of stochastic, population balance model and data driven models

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

REFERENCES

1. Golub G.H. and van Loan C.F., *Matrix Computations*, Johns Hopkins University Press, 3rd Edition, 1996
2. Ogunnaike B. and W. Harmon Ray. *Process Dynamics, Modeling, and Control*, Oxford University Press, 1995
3. Chapra S.C. and Canale R.P. *Numerical Methods for Engineers*, McGraw Hill, 2001
4. 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
5. Ramirez, W.; " Computational Methods in Process Simulation ", 2nd Edn., Butterworths Publishers, New York, 2000.
6. Luyben, W.L., " Process Modelling Simulation and Control ",2nd Edn, McGraw-Hill Book Co., 1990

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	PSO 4
CO1	Understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibria kinetics	2	2	3	2	-	-	1	-	3	3	3	3	3	3	3	2
CO2	Associate the model with constitutive relations such as phenomenological laws, rate equations, equations of state, property estimation methods	2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2
CO3	Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns	2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2
CO4	Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems	2	2	3	3	3	-	1	-	3	3	1	3	3	3	3	2
CO5	Apply relevant solution methods for the mathematical models with relevant initial and/or boundary conditions	2	2	3	3	3	-	1	-	3	3	2	3	3	3	3	2
CO6	Appreciate the applicability of stochastic, population balance model and data driven models	2	2	3	3	3	-	1	-	3	3	1	3	3	3	3	2
	Over all	2	2	3	3	3	-	1	-	3	3	3	3	3	3	3	2

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

CL5211 **SEPARATION LABORATORY**

L	T	P	C
0	0	4	2

OBJECTIVE

To understand the basics of various separation techniques and to select appropriate separation methodology, to determine the mass transfer coefficient for designing the size of the separator, to understand the preparatory and analytical chromatographic techniques.

List of Experiments:

1. Determination of VLE for a binary mixture at different temperatures
2. Determination of VLE & VLLE for a ternary mixture (azeotropic binary mixture and entrainer)
3. LLE of Extraction system of Type I, II and Type III systems
4. Study of extraction efficiency for the extraction of essential oils
5. Aqueous Two Phase Extraction and Design of ATPE using Hofmeister Series
6. Cross flow filtration using Microfiltration to characterize Specific cake resistance and filter medium resistance of membranes
7. Tangential flow filtration using Ultrafiltration for finding flux in membranes and to characterize concentration polarization and fouling
8. Verification of Vant Hoff Equation and design of reverse osmosis systems
9. Adsorption Equilibria and fixed bed adsorption studies for generation of breakthrough curves
10. Gas Hold up studies in sparged column, bubble column, wetted wall column
11. Determination of mass transfer coefficient in a wetted wall column
12. Preparative HPLC
13. Thin Layer and paper chromatography
14. Calculation of yield in crystallization process
15. Simulation of refinery operations (catalytic cracking, hydrocracking) using ASPEN HYSYS

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Determine the VLE for binary and VLLE for ternary mixtures

CO2: Determine LLE for Type I, II, III L-L or L-S ternary mixtures

CO3: Understand and apply chromatographic techniques

CO4: Assess the performance in Cross Flow and Tangential Flow Filtration

CO5: Design RO systems based on Vant Hoff Equation

CO6: Simulate Industrial processes using ASPEN HYSYS

REFERENCES

1. Seader, J. D., Henley, E. J., & Roper, D. K. (1998). Separation process principles.
2. Wankat, P. C. (2006). *Separation process engineering*. Pearson Education.
3. Wankat, P. C. (1990). Rate-controlled separations.
4. Braithwaite, A., & Smith, J. F. (2012). *Chromatographic methods*. Springer Science & Business Media.
5. Baker, R. W. (2012). *Membrane technology and applications*. John Wiley & Sons.

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	PSO 3	PSO4
CO1	Determine the VLE for binary and VLLE for ternary mixtures	1	3	3	2	-	-	1	-	3	3	3	3	3	3	3	2
CO2	Determine LLE for Type I, II, III L-L or L-S ternary mixtures	1	3	3	3	3	-	1	-	3	3	3	3	3	3	3	2
CO3	Understand and apply chromatographic techniques	2	3	3	3	3	-	1	-	3	3	3	3	3	3	3	2
CO4	Assess the performance in Cross Flow and Tangential Flow Filtration	2	3	3	3	3	-	1	-	3	3	1	3	3	3	3	2
CO5	Design RO systems based on Vant Hoff Equation	2	3	3	3	3	-	1	-	3	3	2	3	3	3	3	2
CO6	Simulate Industrial processes using ASPEN HYSYS	2	3	3	3	3	-	1	-	3	3	1	3	3	3	3	2
	Over all	2	3	3	3	3	-	1	-	3	3	3	3	3	3	3	2

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

CL5212

COMPUTATIONAL LABORATORY

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

To develop and apply modern numerical methods to problems arising in chemical engineering. The overall aim is to shorten the development period from research bench to the industrial production stage by providing insight into the underlying processes to industrial level.

List of Experiments:

1. Practice in Computer simulation and mathematical modeling
2. Computational modeling of catalysts and materials
3. Computationally investigate the fundamental transport and kinetic properties
4. Symbiotic relationships of microbes and engineering the process
5. Development of predictive theories of Electro catalysis
6. Development of predictive theories of Photocatalysis.
7. Computational chemistry and modeling of elementary reaction
8. Computational modeling mechanisms and structure-function relationships
9. Mathematical Modeling and Computer Simulation for Oil Spills
10. Mathematical Model and Computer Simulation for petroleum reserves

TOTAL: 60 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand about the various software's used in chemical engineering industries and its applications

CO2: Learn about computing the laboratory data and analysis

CO3: Understand about Microsoft excel for solving various chemical engineering problems

CO4: Learn about the role of MATLAB in various chemical industries and its applications

CO5: Have basic knowledge about ASPEN and its application in various chemical industries

CO6: Learn about HYSYS and its application in chemical and petroleum refining industries

REFERENCES:

1. Mathematical Modelling And Simulation In Chemical Engineering 1st Edition, M. Chidambaram Cambridge University Press; 1 edition (March 9, 2018).
2. A Step by Step Approach to the Modeling of Chemical Engineering Processes- **Ferrareso Lona**, Liliane Maria,Springer,2018
3. Mathematical Modelling - J.N. Kapur, New Interantional Publications, 2015

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	PSO 4
CO1	Understand about the various software's used in chemical engineering industries and its applications	1	1	2	2	2	-	1	-	1	1	-	1	-	2	1	1
CO2	Learn about computing the laboratory data and analysis	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO3	Understand about Microsoft excel for solving various chemical engineering problems	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO4	Learn about the role of MATLAB in various chemical industries and its applications	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO5	Have basic knowledge about ASPEN and its application in various chemical industries	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO6	Learn about HYSYS and its application in chemical and petroleum refining industries	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
	Over all	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1

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

CL5213 **MINI PROJECT WITH SEMINAR**

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

To provide exposure to the recent developments, and to improve the student's presentation skills.

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basic mathematical calculations for project

CO2: Understand chemical properties and use it effectively in design of project work

CO3: Obtain knowledge on theoretical approach to utilize it in practical analysis

CO4: Gain knowledge on practical based work and use it to computational methods

CO5: Analyze data on CFD and other softwares

CO6: Take the lab data and analyze with real time problems to bring solutions

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	PSO 4
CO1	Understand the basic mathematical calculations for project	3	3	2	3	3	1	2	3	2	1	3	3	2	1	2	3
CO2	Understand chemical properties and use it effectively in design of project work	2	2	3	3	2	2	3	1	3	1	2	2	3	1	3	3
CO3	Obtain knowledge on theoretical approach to utilize it in practical analysis	3	2	3	3	1	2	1	3	1	3	1	3	2	2	2	3
CO4	Gain knowledge on practical based work and use it to computational methods	2	2	3	3	2	3	2	1	3	2	2	3	3	3	3	3
CO5	Analyze data on CFD and other softwares	3	2	3	2	3	2	3	2	3	2	3	2	3	3	3	3
CO6	Take the lab data and analyze with real time problems to bring solutions	1	3	3	2	3	3	1	1	3	1	3	1	3	1	3	3
	Over all	3	3	3	3	2	1	2	2	2	2	3	3	3	3	3	3

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

CL5311 **PROJECT PHASE I**

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

- To identify a specific problem related to Chemical Engineering and carrying out a detailed literature review.
- To identify the materials and methods required to carry out the project.
- To guide the students in preparing project reports, to present their findings in reviews and viva-voce examination.

COURSE OUTCOMES:

The students will be able to

CO1: Demonstrate a depth of knowledge of Chemical Engineering.

CO2: Implement knowledge, processes, concepts, tools and techniques through literature review.

CO3: Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements.

CO4: Interact with team in a professional manner to ensure a collaborative project environment.

CO5: Experimental/Conceptual studies chosen based on area.

CO6: Ability to express clearly the findings and relate to theoretical background.

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	PSO 4
CO1	Demonstrate a depth of knowledge of Chemical Engineering	3	3	2	3	3	1	2	3	2	1	3	3	2	1	2	3
CO2	Implement knowledge, processes, concepts, tools and techniques through literature review.	2	2	3	3	2	2	3	1	3	1	2	2	3	1	3	3
CO3	Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements.	3	2	3	3	1	2	1	3	1	3	1	3	2	2	2	3
CO4	Interact with team in a professional manner to ensure a collaborative project environment.	2	2	3	3	2	3	2	1	3	2	2	3	3	3	3	3
CO5	Experimental/Conceptual studies chosen based on area.	3	2	3	2	3	2	3	2	3	2	3	2	3	3	3	3
CO6	Ability to express clearly the findings and relate to theoretical background.	2	3	3	2	3	3	1	1	3	1	3	1	3	1	3	3
	Over all	3	3	3	3	2	1	2	2	2	2	3	3	3	3	3	3

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

CL5411 **PROJECT PHASE II**

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

- To execute the proposed procedure to solve the identified problem.
- To develop skills to analyze and discuss the results obtained and make conclusions.

COURSE OUTCOMES:

The students will be able to

CO1: Utilize technology and software tools for support.

CO2: Relate the findings to existing systems and priority for novel outcomes

CO3: Complete an independent research project, resulting in demonstration in Indian/International Conference

CO4: Research output by means of publications in Indian/International Journals

CO5: Research output by means of publications in proceedings and patents proposal.

CO6: Demonstrate an ability to present and defend their research work to a panel of experts.

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	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	Utilize technology and software tools for support.	3	3	2	3	3	1	2	3	2	1	3	3	2	1	2	3
CO2	Relate the findings to existing systems and priority for novel outcomes	2	2	3	3	2	2	3	1	3	1	2	2	3	1	3	3
CO3	Complete an independent research project, resulting in demonstration in Indian/International Conference.	3	2	1	3	1	2	1	3	1	3	1	3	2	2	2	3
CO4	Research output by means of publications in Indian/International Journals	2	2	3	3	2	3	2	1	3	2	2	3	3	3	3	3
CO5	Research output by means of publications in proceedings and patents proposal.	2	2	3	3	2	3	2	1	3	2	2	3	3	3	3	3
CO6	Demonstrate an ability to present and defend their research work to a panel of experts.	3	3	3	2	3	3	1	1	3	1	3	1	3	1	3	3
	Over all	3	3	3	3	2	1	2	2	2	2	3	3	3	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]

Program Elective -I

CL5071 **COMPUTATIONAL FLUID DYNAMICS**

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

To educate engineering graduates in the principles of computational fluid dynamics modeling 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 **9**

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 **9**

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 OUTCOMES:

The students 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 discreitization 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															
		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	PSO 4
CO1	Understand the basics of CFD and governing equations for conservation of mass momentum and energy	2	2	-	1	2	3	2	1	-	-	-	-	2	1	1	1
CO2	Understand mathematical characteristics of partial differential equations.	3	2	-	2	2	2	2	2	-	-	-	-	1	1	1	1
CO3	learn computational solution techniques for time integration of ordinary differential equations	2	1	-	2	1	1	1	1	-	-	-	-	1	-	-	1
CO4	Understand various discreitization techniques used in CFD	2	1	-	1	1	1	1	1	-	-	-	-	1	-	-	1
CO5	Understand flow field computation techniques for steady and unsteady flows	3	2	-	2	1	1	1	1	-	-	-	-	1	1	1	1
CO6	Understand various turbulence models and grid generation techniques.	2	1	-	2	2	2	2	1	-	-	-	-	1	1	1	1
	Over all	3	2	-	2	2	2	2	1	-	-	-	-	1	1	1	1

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

CL5001

DISTILLATION COMPONENTS AND ITS PROCESSES

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

To instruct Post graduates in the principles of Multi component Distillation and in designing.

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:

Students will understand

CO1: Basic thermodynamics properties such as fugacity coefficient ,activity coefficient with respect to multi component mixtures

CO2: Basic principle involved in separation multi component mixture and MC distillation

CO3: The general considerations in designing a multi component distillation column and different methods of column sequencing

CO4: The available methods for calculating minimum reflux ratio in a multi component distillation column

CO5: Different methods used in designing a multi component distillation column

CO6: The application of multi component distillation in petroleum industries

REFERENCES

1. Holland, C. D. (1981). Fundamentals of multicomponent distillation. McGraw-Hill,
2. Petlyuk, F. B. (2004). Distillation theory and its application to optimal design of separation units. Cambridge University Press.
3. Kister, H. Z., Haas, J. R., Hart, D. R., & Gill, D. R. (1992). Distillation design (Vol. 1). New York: McGraw-Hill.
4. Towler, G., &Sinnott, R. K. (2012). Chemical engineering design: principles, practice and economics of plant and process design. Elsevier.
5. Winkle, M. V. (1967). Distillation. Chem. Eng. Series, McGraw-Hill.
6. Holland, C. D. (1963). Multicomponent distillation. Prentice-Hall

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes															
		PO 1	PO2	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	PSO 4
CO1	Basic thermodynamics properties such as fugacity coefficient ,activity coefficient with respect to multi component mixtures	3	2	3	2	3	1	1	-	-	1	-	1	2	2	1	1
CO2	Basic principle involved in separation multi component mixture and MC distillation	3	3	2	2	3	-	1	-	-	1	-	1	1	1	1	1
CO3	The general considerations in designing a multi component distillation column and different methods of column sequencing	3	3	3	2	3	-	-	-	-	1	-	1	2	1	2	1
CO4	The available methods for calculating minimum reflux ratio in a multi component distillation column	3	2	3	1	2	-	-	-	-	-	-	1	2	2	2	1
CO5	Different methods used in designing a multi component distillation column	3	3	3	2	2	-	1	-	-	1	-	1	3	2	2	1
CO6	The application of multi component distillation in petroleum industries	2	2	2	2	2	1	2	-	-	1	-	1	3	2	2	2
Over all		3	3	3	2	3	1	1	-	-	1	-	1	2	2	2	1

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

CL5002	BUSINESS ANALYTICS	L	T	P	C
OBJECTIVE		**3**	**0**	**0**	**3**

To enable the Engineers to gain authority as Business analyst.

UNIT I BUSINESS ANALYTICS **9**

Terminology – Business Analytics Process – Relationship of BA Process and Organization – Decision Making Process – Business Analytics Important– Strategy for Competitive Advantage.

UNIT II SUPPORT BUSINESS ANALYTICS **9**

Business Analytics Personnel – Business Analytics Data – Categorizing Data – Data Issues – Business Analytics Technology.

UNIT III BUSINESS ANALYTICS BE APPLIED **9**

Organization Structures Aligning Business Analytics – Organization Structures – Teams – Management Issues – Establishing an Information Policy – Outsourcing Business Analytics – Ensuring Data Quality – Measuring Business Analytics Contribution – Managing Change.

UNIT IV DESCRIPTIVE ANALYTICS **9**

Visualizing and Exploring Data – Descriptive Statistics – Sampling and Estimation – Sampling Methods – Sampling Estimation – Probability Distributions – Business Analytics Case Problems.

UNITV PREDICTIVE ANALYTICS **9**

Predictive Analytics Overview – Predictive Analytics – Logic Driven Models – Data Driven Models – A Simple Illustration of Data Mining – Data Mining Methodologies – Prescriptive Modeling – Prescriptive Modeling – Business Analytics Case Problems.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Identify and describe complex business problems in terms of analytical models.

CO2: Apply appropriate analytical methods to find solutions to business problems that achieve stated objectives.

CO3: Translate results of business analytic projects into effective courses of action.

CO4: Demonstrate ethical decision-making in structured or unstructured and ambiguous situations.

CO5: Communicate technical information to both technical and non-technical audiences in speech, in writing, and graphically.

CO6: Exhibit effective collaboration and leadership skills.

REFERENCE BOOKS

1. Fundamentals of Business Analytics, 2ed Kindle Editionby Seema Acharya R N Prasad
2. Business Analytics: Applications To Consumer Marketing Hardcover – 1 Mar 2015by SandhyaKuruganti (Author), HindolBasu (Author)

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes															
		PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	Identify and describe complex business problems in terms of analytical models.	2	2	3	2	3	3	2	2	2	2	2	3	3	3	3	3
CO2	Apply appropriate analytical methods to find solutions to business problems that achieve stated objectives.	2	2	3	3	3	2	1	3	3	1	2	3	3	3	3	3
CO3	Translate results of business analytic projects into effective courses of action.	1	1	3	1	2	3	3	-	3	1	1	1	1	3	3	3
CO4	Demonstrate ethical decision-making in structured or unstructured and ambiguous situations.	2	1	3	2	3	-	2	-	3	-	2	2	3	3	3	3
CO5	Communicate technical information to both technical and non-technical audiences in speech, in writing, and graphically.	1	3	3	3	3	-	3	-	3	1	3	3	3	3	3	3
CO6	Exhibit effective collaboration and leadership skills.	2	3	3	3	3	-	3	-	3	1	3	3	3	3	3	3
overall		2	2	3	2	3	1	2	1	3	1	2	3	3	3	3	3

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

CL5003 BIOCHEMICAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To discuss mainly on the role of enzymes and microbes in biotechnology sectors.
- To understand the design parameters in designing biochemical reactors.

UNIT I ENZYME CATALYSIS 9

Overview of biotechnology, Principles of Enzyme catalysis, Enzyme inhibition, Immobilized enzyme kinetics, internal mass transfer effects in immobilized enzyme kinetics.

UNIT II MICROBIAL GROWTH 9

Stoichiometry and energetics of microbial growth, Metabolic pathways and energetics of the cell, concept of energy coupling, ATP and NAD, Unstructured models of microbial growth, Structured models of microbial growth.

UNIT III BIOREACTOR DESIGN AND ANALYSIS 9

Bioreactors: CSTR, Plug flow and packed bed bioreactors, Fed batch reactors, Mass balances for two phase reactors, Power requirements, sterilization

UNIT IV PRODUCT RECOVERY 9

Bioproduct recovery- Centrifugation, Filtration, Ultra filtration, Precipitation of Protein, Chromatography, Fixed bed adsorption, Phase theory of chromatography, Electrophoresis, Crystallization,

UNIT V BIOPRODUCTS AND ECONOMICS 9

Manufacturing of biological products, Economic analysis of bioprocesses, Capital costs and manufacturing costs, case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES

The students will be

CO1: The students would develop the ability to design novel bioprocesses for their research.
CO2: The students will have the ability to improce skills in engineering aspects of biological systems
CO3: Students will find solutions to the problems with biomaterials and processes
CO4: Students will gain knowledge in bioreactors
CO 5: Students will study economy of biobased industries.

REFERENCES

1. Shuler M.L. and Kargi F. Bioprocess Engineering: Basic Concepts, 1st Edition, Prentice Hall, New Jersey, 1992.
2. Lee J., Biochemical Engineering, Prentice Hall Englewood Cliffs, 1992.
3. Blanch H.W and Clark D.S, Biochemical Engineering, Marcel Dekker, 1997.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes														
		PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	The students would develop the ability to design novel bioprocesses for their research.	1	2	1	-	-	2	2	-	1	-	-	1	1	-	2
CO2	The students will have the ability to improce skills in engineering aspects of biological systems	1	1	2	3	2	2	2	-	3	-	2	3	3	3	2
CO3	Students will find solutions to the problems with biomaterials and processes	1	2	2	2	1	2	2	1	1	-	2	3	3	3	2
CO4	Students will gain knowledge in bioreactors	1	2	3	1	2	1	-	-	3	-	1	3	3	3	1
CO5	Students will study economy of biobased industries.	1	2	3	2	1	2	1	-	2	1	2	3	3	3	2
CO6		2	2	3	3	3	2	1	1	3	1	3	3	3	3	3
	Overall	1	2	3	2	2	2	2	1	3	1	2	3	3	3	2

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

CL5072 **DESIGN OF EXPERIMENTS**

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

To introduce the student to the principles and methods of statistical analysis of designed experiments, understand hypothesis testing, perform factorial designs for experiments and model using response surface techniques.

UNIT I **9**

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments. Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

UNIT II **9**

Experiments with Single Factor; An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparameteric methods in the analysis of variance, Problems.

UNIT III **9**

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments. Parameter Estimation

UNIT IV **9**

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems

UNIT V **9**

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand sampling and sampling distribution

CO2: Apply Hypothesis testing with different confidence intervals

CO3: Perform ANOVA and regression analysis

CO4: Perform statistically designed experiments with and without blocking

CO5: Model the given data using Response Surface Methodology

CO6: Perform optimized experimentation like Plackett Burman design, Youden square

TEXT BOOKS

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5 th Edition, 2010.

REFERENCES

1. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995
2. Anderson, V. L., & McLean, R. A. (2018). *Design of experiments: a realistic approach*. Routledge.

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	PSO 4
CO1	Understand sampling and sampling distribution	1	1	2	3	2	-	2	-	1	1	1	1	2	3	2	2
CO2	Apply Hypothesis testing with different confidence intervals	1	1	2	1	2	-	2	-	1	1	1	1	3	3	2	2
CO3	Perform ANOVA and regression analysis	1	1	2	3	3	-	2	-	1	1	1	1	3	3	2	2
CO4	Perform statistically designed experiments with and without blocking	1	1	2	3	3	-	2	-	1	1	1	1	3	2	2	2
CO5	Model the given data using Response Surface Methodology	1	1	2	3	3	-	2	-	1	1	1	1	2	1	2	2
CO6	Perform optimized experimentation like Plackett Burman design, Youden square	1	1	2	3	3	-	2	-	1	1	1	1	3	3	2	2
Over all		1	1	2	3	3	-	2	-	1	1	1	1	3	3	2	2

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

Program Elective -II

CL5004 **MULTIPHASE FLOW**

L	T	P	C
3	0	0	3

OBJECTIVE

- To analyze, characterize the multiphase systems and appreciate the role of structure in multiphase flows.
- To understand the limitations of modeling 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:

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

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														
		PO1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO 1	PSO 2	PSO 3
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	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

CL5005 **NANO COMPOSITES**

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

- Students will gain some knowledge of the main types of nanocomposite materials and their specific physical and chemical properties required in applications.

UNIT I **9**

Definition- importance of nanocomposites- nano composite materials-classification of composites-metal/ceramics, metal / polymer, Carbon-carbon composites, nano composites ,influence of size, shape and role of interface in composites applications.

UNIT II **9**

Hydroxyapatite composites with zirconia, alumina and titania – preparation and properties. SiC whisker reinforced hydroxyapatite and bioactive glass ceramics composites, zirconia toughened and bioactive glass ceramics composites, bioglass-hydroxyapatite composites, carbon composites

UNIT III **9**

Elastic and strength properties – fracture behavior – fibre matrix load transfer – failure of a composite – criteria, damage of composites from physical and mechanisms to modeling, long term behavior of composite materials, high temperature stability – wear and friction.

UNIT IV **9**

Nanotubes, nanoparticles and inorganic-organic hybrid systems: Single walled carbon nanotubes in epoxy composites; Fullerene/carbon nanotube (CNT) composites; Filled polymer nanocomposites containing functional nanoparticles; Polymer/calcium carbonate nanocomposites; Magnetic polymer nanocomposites; Phenolic resin/SiO2 organic-inorganic hybrid nanocomposites; Polymer/graphite nanocomposites; Wear resisting polymer nanocomposites: Preparation and properties

UNIT V **9**

Natural nanocomposites: Nanocomposites synthesized biologically; Nanocomposites synthesized by mimicking natural processes; Packaging proteins. Nanocomposite materials modeling: current issues. Multiscale modeling. Multi-physics modeling.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand importance of nano composite materials in engineering applications.

CO2: Understand various metal oxide nano composite preparation

CO3: Understand estimation of physical and chemical properties of nano composites

CO4: Understand polymeric nano composite synthesis

CO5: Understand biological synthesis of nano composites

CO6: Understand Multiscale modeling of nano composites

REFERENCES

1. Yiu-Wing Mai Zhong-Zhen Yu, , Polymer Nanocomposites, 1st Edition, Woodhead Publishing
2. Krishan Kumar Chawla, Composite Materials: Science and Engineering, springer
3. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
4. Ajayan P.M. Nanocomposite Science and Technology, Wiley Verlag GmbH, Weinheim, 2003, ISBN 3-527-30359-6

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 importance of nano composite materials in engineering applications.	1	1	2	2	-	-	2	-	-	-	-	3	3	3	-
CO2	Understand various metal oxide nano composite preparation	1	1	2	2	2	-	-	-	-	-	-	3	3	3	-
CO3	Understand estimation of physical and chemical properties of nano composites	2	2	3	2	-	1	1	-	-	-	-	3	3	3	-
CO4	Understand polymeric nano composite synthesis	2	2	3	2	2	1	1	-	-	-	- -	3	3	3	-
CO5	Understand biological synthesis of nano composites	2	2	3	2	-	1	1	-	-	-	-	3	3	3	-
CO6	Understand Multiscale modeling of nano composites	2	3	3	2	2	1	2	-	-	-	-	3	3	3	-
Over all		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

CL5006 **PIPING AND INSTRUMENTATION**

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

- The students will be able to learn the key concepts in piping and instrumentation of process plants.

UNIT I **9**

Types of fluid flow, Friction factor, line sizing, pressure drop and velocity calculation, selection of material under various condition, codes and standards, selection of pipe fittings, flanges, fasteners, and gaskets

UNIT II **9**

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

UNIT III **9**

Block flow diagram, process flow diagram, symbols, P&ID, P&ID symbols, line and valve numbering concept, equipment identification, detailed engineering of the process.

UNIT IV **9**

P&ID control and safety systems, Distributed Control Systems, signal lines, instruments used for pressure, temperature, flow.

UNIT V **9**

Final Control Elements; application of P&ID in HAZOP, what – if, Fault tree analysis, Event tree analysis, & Risk analysis, Management of Change, cost approach.

TOTAL: 45 PERIODS

COURSE OUTCOME :

The students will be able to

CO1 : Recognize the materials, codes &standards used for piping the process plants.

CO2 : Explain the piping design principle & importance of utilities in industrial process plants.

CO3 : Understand the use of block diagram, process flow diagram and the detailed engineering concept.

CO4 : Understand the importance of safety control systems during piping instrumentation

CO5 : Explain the importance control elements for the efficient design of process control loops for process engineering plants.

CO6 : Draw a complete Process & Instrumentation Diagram with effective plant wide control strategies using appropriate heuristics and its application.

TEXT BOOKS

1. Piping Handbook, 6 th edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook edited by Johan J McKetta, CRC Press, 1992.
3. Luyben, W. L.," Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.

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	PSO 4
CO1	Recognize the materials, codes &standards used for piping the process plants.	1	1	1	1	3	2	-	2	1	-	1	1	3	-	-	-
CO2	Explain the piping design principle & importance of utilities in industrial process plants.	2	1	1	1	3	-	-	2	1	-	1	2	3	-	-	-
CO3	Understand the use of block diagram, process flow diagram and the detailed engineering concept.	1	2	2	-	3	-	-	-	-	-	1	1	-	-	-	-
CO4	Understand the importance of safety control systems during piping instrumentation\	2	2	3	3	2	3	1	2	-	-	2	2	3	-	-	-
CO5	Explain the importance control elements for the efficient design of process control loops for process engineering plants.	2	2	3	3	3	3	1	2	-	-	2	3	3	-	-	-
CO6	Draw a complete Process & Instrumentation Diagram with effective plant wide control strategies using appropriate heuristics and its application.	2	3	3	3	3	3	1	2	-	-	2	3	3	1	1	1
Over all		2	2	3	2	3	2	1	2	1	-	2	3	3	-	-	1

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

CL5007

CHEMICAL PROCESSES AND POLLUTION CONTROL

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

- This course introduces the principles and methods to control air, water and soil pollution

UNIT I **8**

Introduction: Environment and environmental pollution from chemical process industries, characterization of emission and effluents, environmental Laws and rules, standards for ambient air, noise emission and effluents.

UNIT II **9**

Pollution Prevention: Process modification, alternative raw material, recovery of by co-product from industrial emission effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission/effluents and leakages and their control-housekeeping and maintenance

UNIT III **10**

Air Pollution Control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption, Design of cyclones,ESP, fabric filters and absorbers.

UNIT IV **8**

Water Pollution Control: Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation.

UNIT V **10**

Biological Treatment& Solids Disposal: Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying. Solids waste disposal - composting, landfill, briquetting / gasification and incineration

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand importance of environment and different types of pollution

CO2: Explain causes and preventive measures against air pollution

CO3: Select and design Pollution control equipments

CO4: Describe causes and preventive measures against water pollution.

CO5: Design anaerobic treatment devices

CO6: Understand solids disposal and their effective handling

TEXT BOOKS

1. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985
2. Theodore L and Buomlore A.J Air pollution control equipments. Prentice Hall Inc, NY. 1982.

REFERENCES

1. "Pollution Control Acts, Rules, Notifications issued there under" CPCB, Ministry of Env. and Forest, G.O.I., 3rd Ed. 2006
2. Eckenfelder W.W;"Industrial Water Pollution Control", 2 Ed; McGraw Hill
3. Kreith F. and Tchobanoglous G.,"Handbook of Solid Waste Management", 2 Ed; Mc Graw Hill.

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 importance of environment and different types of pollution	3	3	2	1	1	2	2	1	2	2	1	2	1	1	-
CO2	Explain causes and preventive measures against air pollution	2	1	2	1	2	2	1	1	1	2	2	2	-	2	-
CO3	Select and design Pollution control equipments	3	3	2	2	1	2	2	1	2	1	2	1	2	2	-
CO4	Describe causes and preventive measures against water pollution.	1	1	1	2	1	1	2	1	1	2	2	2	-	-	2
CO5	Design anaerobic treatment devices	3	2	1	2	2	2	2	1	2	2	1	2	2	-	-
CO6	Understand solids disposal and their effective handling	2	1	3	2	2	2	1	1	2	2	2	2	1	2	2
Over all		3	2	2	2	2	2	2	1	2	2	2	2	1	2	-

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

Program Elective -III

CL5008 POLYMER PROCESSING TECHNOLOGY

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

- Students will gain knowledge about mechanism of polymer process and its application

UNIT I GENERAL ASPECTS OF POLYMERS 9

Classification of polymers, Types and mechanism of polymerization, Functionality-degree of polymerization, Techniques of polymerization, properties - molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II MIXING AND MOULDING TECHNIQUES 9

Mixing process, different types of mixing devices, Types of moulds – ejector system – ejection techniques – mould cooling – CAD / CAM, Extrusion Moulding, Injection Moulding, Special Moulding Techniques.

UNIT III PROCESSING AND TESTING OF POLYMER MATERIALS 9

Processing additives, plasticzer, antiaging additives, Catalysts, Analytical tests: determination of specific gravity, water absorption, Non-destructive testing: ultrasonic testing, X-ray fluorescence, Acoustic emission (AE) testing.

UNIT IV ELASTOMERS AND APPLICATION ORIENTED POLYMERS 9

Natural Rubber, Styrene – butadiene, Polyisopropane – Neoprene, Silicone rubber, Thermoplastic elastomers, Resins – PVC, Silicon Oil and resins, fibrous Polymers – Nylon 66, Polyacrylonitrile.

UNIT V POLYMER COMPOSITES 9

Fibrous and Laminated Composites - Hybrid Composites - Matrix Resins - Unsaturated Polyester - Vinyl Ester - Epoxy- Phenol Formaldehyde - Urea Formaldehyde.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamentals of polymers and mechanism of polymerization techniques.

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

CO3: Understand the knowledge of developing new formulations and products from elastomers.

CO4: Understand the knowledge of polymer stability and unique definition of the product by evaluating molecular weight

CO5: Understand the manufacture and properties of application oriented industrial polymers.

CO6: Acquire knowledge on different tests for characterization of polymer for applications in R & D work

TEXT BOOKS

1. Birley, Haworth, Batchelor, Physics of Plastics – Processing Properties and Materials Engineering, Hamer Publication, 1992.
2. F.W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
3. Richard G.Griskey, Polymer Process Engineering, Chapman and Hall, 1995.
4. Vishu Shah, Hand book of Plastics Testing and Failure Analysis, 3rd Edition, John-Willey &Sons, New York, 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	PSO 1	PSO 2	PSO 3	PSO 4
CO1	Understand the fundamentals of polymers and mechanism of polymerization techniques.	3	2	3	2	3	3	2	2	2	2	2	3	3	3	3	3
CO2	Apply the mechanism and effectiveness of polymerization in making finished materials.	3	2	3	3	3	2	1	3	3	1	2	3	3	3	3	3
CO3	Understand the knowledge of developing new formulations and products from elastomers.	3	2	3	1	2	3	3	-	3	1	1	1	1	3	3	3
CO4	Understand the knowledge of polymer stability and unique definition of the product by evaluating molecular weight	3	2	3	2	3	-	2	-	3	-	2	2	3	3	3	3
CO5	Understand the manufacture and properties of application oriented industrial polymers.	3	2	3	3	3	-	3	-	3	1	3	3	3	3	3	3
CO6	Acquire knowledge on different tests for characterization of polymer for applications in R & D work	3	2	3	3	3	-	3	-	3	1	3	3	3	3	3	3
	Overall	3	2	3	2	3	1	2	1	3	1	2	3	3	3	3	3

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

CL5009

RISK ANALYSIS AND MANAGEMENT

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

- To gain knowledge on the various risks encountered in the chemical industries to analyze its cause and how it can be effectively managed.

UNIT I **9**

General: Risk types, Completion, Permitting, Resource, Operating, Environmental, Manageable, Insurable, Risk Causes, Risk Analysis types and causes.

UNIT II **9**

Techniques: General, Risk adjusted discounted rate method, Certainty Equivalent Coefficient method, Quantitative Sensitivity analysis, Probability distribution, Coefficient of variation method, Simulation method, Crude Procedures, Payback period, Expected monetary value method, Refined procedures, Shackle approach, Hiller's model, Hertz model, Goal programming.

UNIT III **9**

Risk Management: Emergency relief Systems, Diers program, Bench scale experiments, Design of emergency relief systems, Internal emergency planning, Risk management plan, mandatory technology option analysis, Risk management alternatives, risk management tools, risk management plans, Risk index method, Dowfire and explosion method, Mond index Method.

UNIT IV **9**

Risk Assurance and Assessment: Property Insurance, Transport insurance, Liability insurance, Pecunious insurance, Risk Assessment, Scope Canvey study, Rijimond pilot study, Low Probability high consequence events. Fault tree analysis, Event tree analysis, Zero Infinity dilemma.

UNIT V **9**

Risk Analysis in Chemical Industries: Handling and storage of Chemicals, Process plants, Personnel protection equipments. Environmental risk analysis, International environmental management system, Corporate management system, Environmental risk assessment, Total quality management, Paradigms and its convergence.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Investigate characteristics of risk management system

CO2: Learn techniques such as Quantitative Sensitivity Analysis, Goal programming for Risk Management.

CO3: Design Risk management systems

CO4: Perform Risk Assurance and Assessment

CO5: Perform Fault tree analysis and Event tree analysis

CO6: Assess Risk in Process industries and manage the risks

TEXT BOOKS

1. Srivastav, S., “Industrial Maintenance Management”, Sultan Chand & Co., 1998.
2. Rao, P. C. K., “Project Management and Control”, Sultan Chand & Co., Ltd., 1996
3. Sincero, A. P. and Sincero, G. A., “Environmental Engineering – A DesignApproach”, Prentice Hall of India, 1996.

REFERENCES

1. Pandya, C. G., “Risks in Chemical Units”, Oxford and IBH Publishers, 1992.
2. Fawcett, H. H., “Safety and Accident Prevention in Chemical Operations by John Wiley & Sons, 1982.
3. Kind, R. W., “Industrial Hazard and Safety Handbook” Butterworth, 1982.
4. 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	PSO 1	PS O2	PSO 3	PSO 4
CO1	Investigate characteristics of risk management system	1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1
CO2	Learn techniques such as Quantitative Sensitivity Analysis, Goal programming for Risk Management.	1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1
CO3	Design Risk management systems	1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1
CO4	Perform Risk Assurance and Assessment	1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1
CO5	Perform Fault tree analysis and Event tree analysis	1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1
CO6	Assess Risk in Process industries and manage the risks	1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1
Over all		1	2	2	2	2	-	1	-	2	1	3	3	-	1	2	1

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

CL5010

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	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	Obtain basic knowledge on subject and various graphical representations of a process plant	1	3	3	2	1	3	-	1	-	2	2	1	1	3	3	2
CO2	Carry out the primary techno-economic feasibility of project.	3	2	3	3	3	3	1	3	3	3	3	3	3	2	3	3
CO3	Understand the sequential process in starting a Chemical Plant	3	1	3	1	2	1	-	1	1	1	2	3	3	1	3	1
CO4	Gain knowledge on Safety, Environmental and Legal aspects of Process Plants	3	1	3	3	3	3	3	3	3	1	2	3	3	1	3	3
CO5	Obtain knowledge on various procedures involved in Taxes, Export/ Import, Licensing etc.,	3	3	3	3	3	3	1	2	2	2	3	3	3	3	3	3
CO6	Select appropriate process for a project.	3	1	3	3	3	3	3	2	3	2	2	2	3	1	3	3
Over all		3	2	3	3	3	3	1	2	2	2	3	3	3	2	3	3

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

CL5011 RESOURCE MANAGEMENT TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVE

- To develop the Expertise for optimization in various decision making.

UNIT I LINEAR MODELS 9

The phase of an operation research study – Linear programming – Graphical method– Simplex algorithm – Duality formulation – Sensitivity analysis.

UNIT II TTRANSPORTATION MODELS AND NETWORK MODELS 9

Transportation Assignment Models –Traveling Salesman problem-Networks models – Shortest route – Minimal spanning tree – Maximum flow models –Project network – CPM and PERT networks – Critical path scheduling – Sequencing models

UNIT III INVENTORY MODELS 9

Inventory models – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

UNIT IV QUEUEING MODELS 9

Queueing models - Queueing systems and structures – Notation parameter – Single server and multi server models – Poisson input – Exponential service – Constant rate service – Infinite population – Simulation.

UNIT V DECISION MODELS 9

Decision models – Game theory – Two person zero sum games – Graphical solution- Algebraic solution– Linear Programming solution – Replacement models – Models based on service life – Economic life– Single / Multi variable search technique – Dynamic Programming – Simple Problem.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: To use the optimization techniques for use of Technology and Business problems

CO2: Acquire knowledge in resource management techniques and tools and have the capability apply in any systems concerned, like, computer system or electrical system or mechanical system, or so.

CO3: Have the capability to apply mathematical knowledge, data structure and algorithmic principles in design and development for software system

CO4: Acquire leadership/managerial capabilities in decision making, analyse the alterable and mange the digital assets.

CO5: Acquire knowledge in the area of computer networks, including wireless mobile networks, with the due experience

CO6: Ability to write object oriented programs in linear models.

REFERENCES:

1. Taha H.A., “Operations Research”, Sixth Edition, Prentice Hall of India, 2003.
2. Shennoy G.V. and Srivastava U.K., “Operation Research for Management”, Wiley Eastern,1994.
3. Bazara M.J., Jarvis and Sherali H., “Linear Programming and Network Flows”, John Wiley,
4. Philip D.T. and Ravindran A., “Operations Research”, John Wiley, 1992.
5. Hillier and Libeberman, “Operations Research”, Holden Day, 1986
6. Budnick F.S., “Principles of Operations Research for Management”, Richard D Irwin, 1990.
7. Tulsian and Pasdey V., “Quantitative Techniques”, Pearson Asia, 2002.

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	To use the optimization techniques for use of Technology and Business problems	1	2	2	2	-	-	2	2	3	2	3	3	3	3	2
CO2	Acquire knowledge in resource management techniques and tools and have the capability apply in any systems concerned, like, computer system or electrical system or mechanical system, or so.	1	1	3	2	2	-	-	1	2	1	3	3	3	3	3
CO3	Have the capability to apply mathematical knowledge, data structure and algorithmic principles in design and development for software system	1	1	3	2	-	1	1	2	2	2	3	3	3	3	2
CO4	Acquire leadership/managerial capabilities in decision making, analyse the alterable and mange the digital assets.	1	2	3	2	2	1	1	3	2	2	3	3	3	3	3
CO5	Acquire knowledge in the area of computer networks, including wireless mobile networks, with the due experience	1	2	3	2	-	1	1	1	2	2	2	3	3	3	2
CO6	Ability to write object oriented programs in linear models.	1	1	3	2	2	1	2	1	3	2	2	3	3	3	2
Over all		1	2	3	3	2	1	2	2	2	2	3	3	3	3	3

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

CL5012 **Program Elective -IV**

PROCESS OPTIMIZATION

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

- To develop the Expertise for optimization in various decision making.

UNIT I INTRODUCTION **5**

Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, Types of optimization problem.

UNIT II LINEAR PROGRAMMING **10**

Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III NONLINEAR UNCONSTRAINED OPTIMIZATION **10**

Convex and concave functions unconstrained NLP, Newton's method Quasi-Newton's method, Examples.

UNIT IV CONSTRAINED OPTIMIZATION **10**

Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT V MULTI OBJECTIVE OPTIMIZATION **10**

Weighted Sum of Squares method, Epsilon constrain method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basics problem formulation and optimization.
CO2: Understand mathematical characteristics of Linear programming.
CO3: Learn computational solution techniques for nonlinear unconstrained optimization.
CO4: Understand various techniques used in constrained optimization
CO5: Understand the optimal and dynamic optimization.
CO6: Understand constrained and unconstrained related design problems.

REFERENCES

1. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes",2nd Ed., McGraw Hill, New York, 2003.
2. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer, 2003.
3. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
4. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 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	PSO 4
CO1	Understand the basics problem formulation and optimization.	1	2	3	3	3	1	-	1	3	3	2	3	1	2	3	1
CO2	Understand mathematical characteristics of Linear programming.	1	2	3	3	3	1	-	1	3	-	2	-	1	2	2	-
CO3	Learn computational solution techniques for nonlinear unconstrained optimization.	2	2	3	3	3	1	-	1	2	-	2	-	1	2	2	-
CO4	Understand various techniques used in constrained optimization	1	3	3	3	3	1	-	1	2	-	2	-	1	2	2	-
CO5	Understand the optimal and dynamic optimization.	2	2	3	3	3	1	-	1	2	-	1	-	1	2	2	-
CO6	Understand constrained and unconstrained related design problems.	2	2	3	3	3	1	-	1	3	-	1	-	1	2	2	-
Overall		2	2	3	3	3	1	-	1	3	3	2	3	1	2	2	-

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

CL5013 SOFTWARE APPLICATIONS IN CHEMICAL INDUSTRIES L T P C
3 0 0 3

OBJECTIVE

- To introduce computer and its application to solve problems in Chemical Engineering operation thro required software.

UNIT I INTRODUCTION TO C LANGUAGE 6

Introduction on Programming languages, C and C++, Review on operating system commands. Use of C programs to solve chemical engineering problems.

UNIT II MICROSOFT EXCEL 12

Application in Density, molecular weight, mole and percentage compositions, Empirical and Molecular formula calculations, Heat of mixing, Gas laws, Vapour pressure, Chemical Kinetics calculations. Application in data processing, Statistical analysis of data, Regression. Analysis of variance, Interpolation, Graphical representations of various Chemical Engineering problem.

UNIT III MATLAB 9

Introduction to MATLAB, workspace environment, variable and data entry, matrix operations, MATLAB functions, Programming in MATLAB to solve Chemical engineering problems. Introduction to Simulink

UNIT IV ASPEN 9

Introduction to ASPEN, application of ASPEN in chemical engineering problems, simulation of Individual process equipment and flow sheet using Aspen Plus and property analysis and estimation using Aspen Properties.

UNIT V HYSYS 9

Introduction to HYSYS, process modelling and simulation using HYSYS, design performance monitoring using HYSYS, application of HYSYS in petroleum industries, case studies

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students will

CO1: Understand about the various software's used in chemical engineering industries and its applications

CO2: Learn about C and C++ language and its application in chemical engineering industries

CO3: Understand about Microsoft excel for solving various chemical engineering problems

CO4: Learn about the role of MATLAB in various chemical industries and its applications

CO5: Have basic knowledge about ASPEN and its application in various chemical industries

CO6: Learn about HYSYS and its application in chemical and petroleum refining industries

TEXT BOOKS

1. Hanna, O.T. Scandell, O.C. Computational Methods in Chemical Engineering, Prentice Hall, 1995.
2. R.K. Taxali, T.K. dBase IV made simple, Tata McGraw-Hill 1991. 80
3. Finlayson, B. A., Introduction to Chemical Engineering Computing, John Wiley & Sons, New Jersey, 2006.

REFERENCES

1. Jerry, O., Breneman, G.L. Spreadsheet Chemistry, Prentice Hall, Englewood Cliffs, 1991.
2. Myers, A.L. Seider W.D. Introduction to Chemical engineering and Computer Calculations.

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	PSO 4
CO1	Understand about the various software's used in chemical engineering industries and its applications	1	1	2	2	2	-	1	-	1	1	-	1	-	2	1	1
CO2	Learn about C and C++ language and its application in chemical engineering industries	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO3	Understand about Microsoft excel for solving various chemical engineering problems	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO4	Learn about the role of MATLAB in various chemical industries and its applications	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO5	Have basic knowledge about ASPEN and its application in various chemical industries	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
CO6	Learn about HYSYS and its application in chemical and petroleum refining industries	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1
	Over all	2	2	3	3	2	-	1	-	1	1	-	1	1	2	1	1

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

CL5014 THERMAL PROCESSING OF FOOD PRODUCTS

	L	T	P	C
	3	0	0	3

OBJECTIVE

Students develop a sound working knowledge on different types of thermal processing of food products.

UNIT I PRINCIPLES OF MASS AND ENERGY BALANCE 9

Transport phenomena with respect to foods; Factors affecting heat and mass transfer; Study of heat transfer and its application in the design of thermal processes and freezing. Thermal processing; calculation of process time temperature-schedules.

UNIT II PROCESSING AND PRESERVATION BY LOW TEMPERATURE METHODS 9

Use of low temperature – Principles, equipment and effect on quality: Chilling, cold storage. Principles of food freezing: freezing point of foods, Psychrometric chart, Freeze concentration, freeze drying, IQF. New direction in freeze bed drying, cyclic pressure freeze drying, types of dryers including Microwave drying and vacuum drying, efficient drying systems, freezing of foods, types of freezing equipments, freezing point curves, phase diagrams, methods of freeze concentration, design problems

UNIT III DRYING 9

Principles of drying, drying rate, factors affecting heat and mass transfer during drying; different drying methods including tray, drum, foam mat, spray, freeze and other newer drying methods; construction and design of drying equipment; adiabatic driers, influence of drying on pigments and enzymes; Dehydration of fruits, vegetables, milk, animal products etc. Design parameters of different type of dryers; properties of air-water mixtures

UNIT IV ASEPTIC PROCESSING 9

Canning and Retort treatment of foods; spoilage of canned foods, storage of canned foods; Influence of canning on the quality of food; improvement in canning technology ; Pasteurization, TST and UHT treatment of milk, fruit juices and other liquid foods. In Package and In flow thermal processing equipments- plate, spiral and shell and tube heat exchangers

UNIT V EMERGING PROCESSING TECHNOLOGIES 9

High Pressure Processing – principles, mechanism of action, advantages and disadvantages over conventional processing; Equipment and applications in food industry, Pulsed electric field processing - principles, mechanism of action, advantages and disadvantages over conventional processing; Equipment and applications in food industry. Ohmic heating of foods - principles, mechanism of action, advantages and disadvantages over conventional processing; Equipment and applications in food industry, Infra – red heating – principles, mechanism of action food application. Principles of radiation processing, applications like disinfestation, pasteurization and sterilization, extending shelf life of plant products, advantages and limitations

TOTAL: 45 PERIODS

COURSE OUTCOMES

The students will be able to

CO1: Understand and apply engineering principle to food processing

CO2: Develop problem solving ability on types of loads and capability to design cold storage systems for food products

CO3: Understand the role of drying in preservation of different foods

CO4: Understand the principles of aseptic processing of foods

CO5: Gain knowledge on the recent developments in food processing techniques

CO6: Apply heat transfer principles for processing and preserving food

TEXT BOOKS

1. Toledo, R.M. “Fundamentals of Food Process Engineering”, 3rd Edition, Springer, 2007
2. Fellows, P. J. “Food Processing Technology: Principles and Practices”, Wood Head Publishing, 1997
3. Barbosa-Canovas, Gustavo et al., “Novel Food Processing Technologies”, Marcel Dekker/CRC, 2005

REFERENCES

1. Lopez, G.A. and Barbosa, C.G.V. “Food Plant Design”, Taylor & Francis, 2005
2. S. Yanniotis, B. Sunden, Heat Transfer in Food Processing, Recent Developments and Applications, WIT Press, Southampton, 2007
3. Ranganna, S. “Handbook of Canning and Aseptic Packaging” Vol. I, II & III, Tata McGraw – Hill, 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	PSO 4
CO1	Understand and apply engineering principle to food processing	-	-	2	1	2	1	-	1	-	1	-	1	3	3	2	1
CO2	Develop problem solving ability on types of loads and capability to design cold storage systems for food products	-	-	3	1	1	-	-	1	1	1	-	1	1	2	1	-
CO3	Understand the role of drying in preservation of different foods	-	-	2	1	1	-	-	1	-	-	-	1	-	2	1	1
CO4	Understand the principles of aseptic processing of foods	-	-	2	1	1	-	-	1	-	-	-	1	1	3	2	2
CO5	Gain knowledge on the recent developments in food processing techniques	-	-	2	1	1	-	1	1	-	-	1	3	1	3	3	1
CO6	Apply heat transfer principles for processing and preserving food	-	-	1	1	-	1	1	1	-	-	-	1	1	2	3	1
	Over all	-	-	3	2	2	1	1	2	1	1	1	2	2	3	3	2

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

CL5015 **ENERGY FROM WASTE**

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

- Students will gain knowledge about valuing the needs of energy saving and how to convert waste to wealth.

UNIT I **9**

Waste to energy-an introduction-energy supply and waste management-Importance of energy management, Energy auditing; methodology and analysis of past trends (plant data)- Sources of energy-renewable and non-renewable sources of energy

UNIT II **9**

Lighting- lighting levels, efficient options, fixtures, day lighting, timers, Energy efficient windows.Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems. Waste heat recovery: recuperators, heat wheels, heat pipes, heat pumps. Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy

UNIT III **9**

Environmental and social impacts of waste to energy conversion plants- greenhouse gas profile of WTE (waste to energy) – health and safety aspects of WTE- compatibility of WTE with recycling-Lifecycle assessment (LCA) and its application to sustainable waste management-Feedstock for WTE systems; Climates and buildings. Thermal properties and energy content of building materials, Psychometric, Comfort conditions, Air-conditioning systems. Energy conservation techniques in Air-conditioning systems. Lighting (Day lighting and Electric lighting).Passive and active methods of heating and cooling. Estimation of building loads.

UNIT IV **9**

Municipal solid waste(MSW) combustion plants- Pre processing and treatment of MSW-Waste firing in large combustion plants-Types of combustion methods of MSW-Energy produced through combustion; Measurement of solar radiation and sunshine hours, Measurement of albedo, UV & IR radiation, Measurement of emissivity, reflectivity, transmittivity, Performance testing of solar flat plate water heater.

UNIT V **9**

Pollution control systems for waste to energy technologies-transformation of waste combustion facilities from major polluters to pollution sinks- Air quality equipment and systems for waste to energy conversion plants; case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the knowledge of Valuing energy sources

CO2: Defining the concept of various energy saving technologies

CO3: Reviews the waste hierarchy and waste to energy systems options along with the environmental and social impact of WTE conversion plants

CO4: Explores the engineering and technology behind WTE systems including considerations of municipal solid waste (MSW) its treatment, combustion and gasification

CO5: Considers pollution control systems for WTE technologies including the transformation of wast combustion facilities from major polluters to pollution sinks

TEXT BOOKS

Waste to energy conversion Technology by M Castaldi, N Klinghoffer, Woodhead Publishing

REFERENCE BOOKS

1. L.C.Witte, P.S.Schmidt, D.R.Brown , Industrial Energy Management and Utilisation, Hemisphere Publ, Washington,1988.
2. W.C.Turner, Wiley, Energy Management Handbook, New York, 1982.
3. M.S.Sodha, N.K. Bansal, P.K. Bansal, A. Kumar and M.A.S. Malik, Solar Passive Building, Science and Design, Pergamon Press, 1986.
4. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcomes																		
		PEO1	**PEO2**	**PEO3**	**PEO4**	**PEO5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	Understand the knowledge of Valuing energy sources	1	1	1	3	2	3	2	3	2	3	2	2	3	2	3	2	2	3	2
CO2	Defining the concept of various energy saving technologies	2	2	1	2	3	-	-	2	2	3	2	3	-	-	2	2	3	2	3
CO3	Reviews the waste hierarchy and waste to energy systems options along with the environmental and social impact of WTE conversion plants	2	2	2	3	2	3	-	3	-	2	2	3	2	3	-	-	-	-	-
CO4	Explores the engineering and technology behind WTE systems including considerations of municipal solid waste (MSW) its treatment, combustion and gasification	2	2	3	2	3	2	-	-	-	2	2	2	3	2	3	2	2	3	3
CO5	Considers pollution control systems for WTE technologies including the transformation of wast combustion facilities from major polluters to pollution sinks	2	2	2	3	2	3	-	3	-	2	2	3	2	3	-	2	2	3	3
	overall	2	2	2	3	3	3	1	3	2	2	2	2	2	2	2	2	2	3	3

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

Program Elective V

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

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	PSO 4
CO1	Understand the basics of fluidization and know the various industrial applications of fluidization	-	-	3	-	-	-	-	-	-	-	1	1	2	3	3	3
CO2	Learn the concepts of hydrodynamics in fluidized bed	-	-	2	1	1	-	-	-	-	-	-	1	2	3	2	3
CO3	Comprehend the formation and growth of bubble dynamics	1	-	2	1	2	-	-	-	-	-	-	1	2	2	3	3
CO4	Understand the bed behavior for various geometries of fluidized beds	1	-	2	2	1	-	-	-	-	-	-	1	3	2	3	3
CO5	Identify with the transport processes of fluidized beds	1	-	1	1	2	-	-	-	-	-	-	1	2	3	2	2
CO6	Gain knowledge on the fundamentals, transport processes and applications of fluidized beds.	1	-	2	2	2	1	1	1	1	1	1	1	3	3	3	2
Over all		1	-	3	2	3	1	1	1	1	1	1	1	3	3	3	3

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

CL5016 SAFETY AND ENVIRONMENT IN CHEMICAL INDUSTRIES L T P C
3 0 0 3

OBJECTIVE

- To have a complete knowledge about industrial safety of a chemical process plant.

UNIT I **9**

Safety, safety responsibility and organization, OHS, safety policy, safety inspection, employees participation in safety, safety legislation, plant siting and layout, regulatory agencies with safety in India and Abroad, types of accidents in industry, case study.

UNIT II **9**

Industrial hazard, hazard management program, hazard identification and assessment, Material hazard : Toxicity, Radiation, Flammability, fires, explosion, runaway chemical reaction, MSDS sheet, list of industries involving hazardous process, Factory Act, 1948

UNIT III **9**

Environment, Need for environment control, lighting, importance of adequate lighting, lighting design, colour codes used in industry, heat control, ventilation and air conditioning, legal requirements, noise, noise measurement and control, vibration, industrial fatigue, EIA

UNIT IV **9**

Industrial waste, waste classification, waste water treatment, waste disposal, storage, occupational health problems, medical examination in industry, PPE, Training & Maintenance of PPE.

UNIT V **9**

Quality standards, ISO 9000, ISO 9000 : 2000 Quality Management principles, Benefits, workplace emergency, emergency planning, on –site and offsite planning, fire emergency procedure, safety symbols, safety signs and colour at work, training.

TOTAL: 45 PERIODS

COURSE OUTCOME :

The students will be able to

CO1 : Understand the importance of industrial safety and safety regulations all over the world.
CO2 : Analyse the effect of material hazard
CO3 : Evaluate the importance of EIA in chemical industries
CO4 : Classify the industrial waste and recommend the relevant PPE.
CO5 : Be familiar with quality management principles and the importance of emergency planning.
CO6 : Have a complete knowledge on industrial safety, environmental impact, rules and regulations.

TEXT BOOKS:

1. Industrial Safety and Environment, Amit Kumar Gupta, Laxmi Publications Ltd., 2006
2. Chemical process industrial safety, KSN Raju, McGraw Hill, 2014

REFERENCE:

1. Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Volume 1, edited by Sam Mannan, third edition, 2005

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	PSO 4
CO1	Understand the importance of industrial safety and safety regulations all over the world.	1	1	2	1	2	3	2	3	-	1	2	1	3	1	2	-
CO2	Analyse the effect of material hazard	2	2	-	2	3	1	1	-	-	-	1	1	2	-	2	-
CO3	Evaluate the importance of EIA in chemical industries	2	2	2	2	3	3	3	3	1	-	3	1	3	-	2	-
CO4	Classify the industrial waste and recommend the relevant PPE.	1	2	2	2	3	3	2	3	1	-	3	1	2	-	2	-
CO5	Be familiar with quality management principles and the importance of emergency planning.	2	3	2	3	2	3	3	3	3	2	3	2	3	-	2	-
CO6	Have a complete knowledge on industrial safety, environmental impact, rules and regulations.	3	2	3	3	2	3	3	3	3	2	3	2	3	-	2	1
Over all		2	2	2	2	2	3	3	3	2	2	3	2	3	-	2	1

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

CL5017 MEMBRANE TECHNOLOGY FOR WATER AND WASTEWATER TREATMENT

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

The objective of the course is to give the students the technical background on membrane technology and to provide wide level of understanding that will allow them to design, using appropriate combinations of unit processes and water treatment plant.

UNIT I INTRODUCTION 10

Solid Liquid separation systems-Filtration systems- Theory of Membrane separation – mass Transport Characteristics, Cross Flow filtration-Membarne Filtration- Types and choice of membranes, porous, non porous, symmetric and asymmetric, Membrane modules – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

UNIT II MEMBRANE PROCESSES AND SYSTEMS 10

Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis- Pervaporation -Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

UNIT III MEMBRANE BIOREACTORS 9

Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies.

UNIT IV PRETREATMENT SYSTEMS 8

Membrane Fouling – Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning, Biofoulant control

UNIT V CASE STUDIES 8

Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants

TOTAL: 45 PERIODS

COURSE OUTCOMES

On successful completion of the course, the students will be able to

CO1: Understand the basic principle, different types of membrane and membrane modules.

CO2: Understand the various membrane process and design of membrane systems

CO3: Understand the concepts of MBRs, Configuration and their design aspects

CO4: Understand operational issues, limitations and System Configuration.

CO5: Design, using appropriate combinations of unit processes and waste water treatment plant.

CO6: Select appropriate membrane separation technique for intended problem.

REFERENCES

1. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005
2. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment, Elservier, 2006
3. K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000
4. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision2, Osmonics Inc., 2001
5. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
6. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elsevier, 1995
7. Judd S., B.Jafferman, Membranes for Industrial Waste Water Recovery and Re-use, Elsevier Publications, 2003.
8. M. C. Porter, Handbook of industrial membrane technology, Noyes publication, Park Ridge, New Jersey, 1990.

Course Articulation Matrix:

Course Outcomes	Statement	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	PSO 4
CO1	Understand the basic principle, different types of membrane and membrane modules.	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3
CO2	Understand the various membrane process and design of membrane systems	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3
CO3	Understand the concepts of MBRs, Configuration and their design aspects	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3
CO4	Understand operational issues, limitations and System Configuration.	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3
CO5	Design, using appropriate combinations of unit processes and waste water treatment plant.	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3
CO6	Select appropriate membrane separation technique for intended problem.	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3
	overall	3	3	3	2	1	1	1	1	1	-	1	1	3	3	3	3

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

CL5018 **BIOPROCESS TECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVE

- To introduce fundamental concept of Bioprocesses to Chemical Engineers to deal with the design and construction of unit processes that involve biological organisms or molecules.

UNIT I FRONTIERS OF BIOPROCESSING **9**

Defining Bioprocessing, Current and Emerging Trends in Bioprocess Engineering, Materials Advances, Nanoscale advances, Bioprocessing for Chemical and Biologic Product Manufacturing, Bioprocessing Leaders Worldwide Economic Predictions and Careers in Bioprocess Engineering, Skills Needed for Future Bioprocess Engineers.

UNIT II INTRODUCTION TO CELLULAR MICROBIOLOGY **9**

DNA Structure, RNA Structure, Protein Structure and Function, Carbohydrates, Lipids, Fats, and Steroids, Basic Metabolic Pathways, General Cell Structure Eukaryotes, Prokaryotes, Archaea, and Viruses, Intracellular Organelles, Cellular Transport.

UNIT III REACTION STOICHIOMETRY, THERMODYNAMICS, AND KINETICS **9**

Mass and Energy Balances, Fundamentals of Chemical Reactions, Basic Mass Transfer: Diffusion and Convection, Basic Fluid Dynamics, Basic Thermodynamics, Basic Reaction Kinetics.

UNIT IV Upstream Processing **9**

Bioreactors, Batch Culture, Continuous Culture, Fed-Batch Culture, Perfusion Culture, Suspension Culture, Microcarrier Support ,Roller Bottle Culture System, Spinner Flask Culture, Other Scale up Options, Wave Bioreactor, Cell Cube Technology, Rotary Culture System ,Media

UNIT V DOWN STREAM PROCESSING **9**

Purification Processes - Centrifugation, adsorption, Electrophoresis, Crystallization Protein Properties, Chromatography, Scale-up and Optimization,

.**TOTAL : 45 PERIODS**

COURSE OUTCOMES

CO1: Understand all Bioprocesses and need of chemical basics in bioprocesses.
CO2: To study the basic of cell and its internal constituents
CO3: To express reaction mechanisms in terms of chemical kinetics.
CO4: To utilize all unit operations in upstream process in manufacturing Industries.
CO5: Understand the downstream processing and industrial bioreactors
CO6: To apply theoretical knowledge to industrial production.

TEXT BOOKS

1. Bioprocess engineering principles, Pauline M. Doran, 2nd ed, Academic Press, 2012.
2. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2nd ed, 1986, McGraw Hill.
2. Bioprocess Engineering by Michael L. Shuler and Fikret Kargi, 2nd edition, Pearson education.

REFERENCES

1. Biochemical engineering by James M.Lee – Prentice-Hall-1992.
2. Fundamentals of Modern Bioprocessing by Sarfaraz K. Niazi, Justin L. Brown, CRC Press, 2017.
3. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997.

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	PSO 4
CO1	Understand all Bioprocesses and need of chemical basics in bioprocesses.	1	2	2	2	2	1	-	2	-	1	2	3	3	3	3	3
CO2	To study the basic of cell and its internal constituents	2	3	2	2	3	1	-	2	-	1	2	3	3	3	3	3
CO3	To express reaction mechanisms in terms of chemical kinetics.	1	2	3	2	2	1	-	2	-	1	2	3	3	3	3	3
CO4	To utilize all unit operations in upstream process in manufacturing Industries.	1	3	3	2	3	1	-	2	-	1	2	3	3	3	3	3
CO5	Understand the downstream processing and industrial bioreactors	1	2	3	2	2	1	-	2	-	1	2	3	3	3	3	3
CO6	To apply theoretical knowledge to industrial production	2	2	3	3	2	2	3	3	-	2	3	3	3	3	3	3
Over all		2	2	3	2	2	1	-	2	-	1	2	3	3	3	3	3

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.

	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

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

	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

	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

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.
- Identify the 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.

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.

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.

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 explaina critical understanding of key concepts in disaster riskreduction and humanitarian response.
CO3: Ability to illustratedisaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describean understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to developthe strengths and weaknesses of disaster management approaches

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

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.

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

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.