Puducherry Technological University,
Puducherry –605014
(A Technological University of Government of Puducherry)

Curriculum and Syllabi

for

B.Tech.(Chemical Engineering)

(Effective from Academic year 2024-25)

(Subject to the Approval of the Fifth Academic Council meeting of PuducherryTechnological University)

CURRICULUM AND SYLLABUS

The Curriculum of B.Tech. (Chemical Engineering) is designed to fulfill the Program Educational Objectives (PEO) and the Program Outcomes (PO) listed below.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO1	The overall educational objective of our program is to develop effective practitioners in chemical and allied engineering fields.
PEO2	We expect that our graduates will contribute to the advancement of their chosen field, while remaining mindful of the ethical and social implications of their work
PE03	They will confidently apply knowledge in the basic sciences, mathematics, engineering analysis, and design to address problems in a broad range of disciplines.
PE04	In keeping with the continuously evolving nature of the field of chemical engineering, we expect that our alumni will effectively communicate, engage in lifelong learning, and that many of them, inspired by research experiences as undergraduates, will continue their education in advanced degree programs.
PEO5	Our educational mission is to provide students with the initial foundation knowledge and skills they will need to become, and remain, leaders in their professional careers

PROGRAM OUTCOMES (PO)

PO1	Apply the knowledge of Basic sciences and Engineering Sciences to provide solutions for complex engineering problems
PO2	Identify, formulate research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.
PO3	Develop creative solutions for complex engineering problems and design/develop systems/ process to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.
PO4	Conduct investigations of complex engineering problems using research based knowledge including design of experiments , modelling, analysis & interpretation of data to provide valid conclusions
PO5	Creat,select and apply appropriate techniques,resources and modern engineering IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.
PO6	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.
PO7	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws
PO8	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams
PO9	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO10	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments

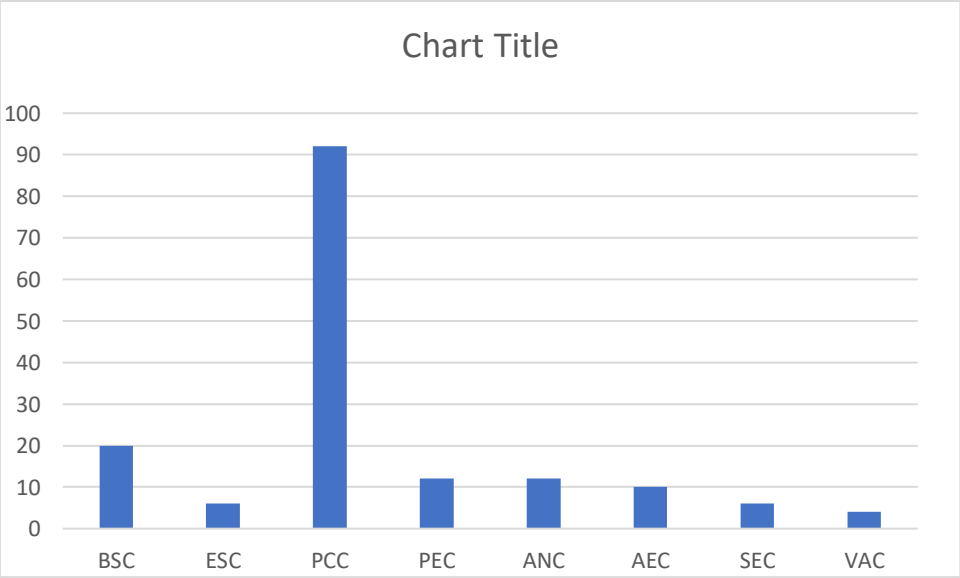
PO11	Recognize the need for and have the preparation and ability for i) independent and life long learning ii) adaptability to new and emerging technologies, and iii) critical thinking in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1	Graduates will develop a strong foundation in science, mathematics, biology, computational tools, and engineering principles to analyze and solve complex chemical engineering problems.
PSO2	Graduates will be equipped to communicate effectively, work collaboratively in multidisciplinary teams, and take on leadership roles in industry, academia, and government while adhering to ethical, environmental, and safety standards.
PSO3	Graduates will engage in lifelong learning through advanced studies, professional development, and research while contributing to solving societal and global challenges in chemical engineering and related fields.

Distribution of credits among the subjects grouped under various categories:
Courses are grouped under various categories and the credits to be earned in each category of courses are as follows:

Sl. No.	Category	Credits	Course Category Code (CCC)
1	Basic science courses	20	BSC
2	Engineering science courses	6	ESC
3	Professional core courses	92	PCC
4	Professional elective courses	12	PEC
5	Ancillary Stream Courses	12	ANC
6	Ability enhancement courses	10	AEC
7	Skill enhancement courses	6	SEC
8	Value added courses	4	VAC
	Total	**162**	



Semester Wise Courses and Credits

Semester I

Group-I (EC1, EC2, ME1, ME2, MT1, CH1)

Course Code	Course	CCC	Periods			Credits
			L	T	P	
	3 weeks compulsory Induction Program					
MAUC101	Mathematics I	BSC	3	1		4
CHUC101	Basics of Chemical Engineering	PCC	3	1		4
PHUC101	Physics	BSC	3			3
MEUC101	Engineering Graphics	ESC	1		4	3
HSUA101	English for Communication	AEC	2			2
GEUS101	Basic Engineering Skills Laboratory - I	SEC	1		4	3
GEUV101	NSS, Yoga and Health	VAC			2	1
PHUC102	Physics Laboratory	BSC			2	1
Total			13	2	12	-
			27			21

Semester II

Group-I (EC1, EC2, ME1, ME2, MT1, CH1)

Course Code	Course	CCC*	Periods			Credits
			L	T	P	
MAUC102	Mathematics II	BSC	3	1		4
CHUC102	Process Calculations	PCC	3	1		4
CYUC101	Chemistry	BSC	3			3
CSUC101	Programming for Problem Solving	ESC	2			2
HSUA101	Professional English	AEC	2			2
GEUS102	Basic Engineering Skills Laboratory - II	SEC	1		4	3
GEUV102	Essence of Indian Traditional Knowledge	VAC	1			1
CYUC102	Chemistry Laboratory	BSC			2	1
CSUC102	Computer Programming Laboratory	ESC			2	1
Total			15	2	8	
			25			21

Note: Exit Option for the students who opt to exit after completion of first year of B.Tech Programme and have secured a minimum of 42 credits will be awarded a UG certificate in a discipline if, in addition they complete one vocational course of 4 credits during the summer vacation of the first year

CCC - Course Category Code, L-Lecture, T – Tutorial, P – Practical

XX – Department Code;xx- serial number

Semester III

Course Code	Course	CCC	Periods			Credits
			L	T	P	
MAUC103	Transforms and Partial Differential Equations	PCC	3	1		4
CHUC103	Chemical Engineering Thermodynamics	PCC	3	0		3
CHUC104	Chemical Engineering Fluid Mechanics	PCC	3	1		4
CHUC105	Process Heat Transfer	PCC	3			3
CHUC106	Mechanical Operations	PCC	3			3
HSUA103	Entrepreneurship	AEC	2			2
GEUV103	Environmental Education	VAC	1			1
CHUC107	Chemical Engineering Fluid Mechanics and Mechanical Operations lab	PCC			3	1.5
CHUC108	Process Heat Transfer Lab	PCC			3	1.5
Total			18	2	6	-
			26			23

Semester IV

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHUC109	Basics of Mass Transfer	PCC	3			3
CHUC110	Chemical Reaction Engineering-I	PCC	3			3
CHUC111	Chemical Process Industry	PCC	3			3
CHUC112	Chemical Engineering Practice	PCC	3	1		4
HSUA104	Modern Indian Language/Foreign language (or) Design Thinking (or) Cybercrime and laws	AEC	2			2
GEUV104	Universal Human values	VAC	1			1
CHUC113	Mass Transfer Operations Lab	PCC			3	1.5
CHUC114	Chemical Engineering Plant Simulation Lab	PCC			3	1.5
Total			15	1	6	
			22			19

Course Code	Course	CCC	Periods			Credits
			L	T	P	
	Ancillary stream course 1	ASC	3			3
CHUH101	Introduction to Frontiers of Chemical Engineering	HNC	3	1		4

Exit Option for the students who opt to exit after completion of second year of B.Tech Programme and have secured a minimum of 87 credits will be awarded a UG Diploma in a discipline if, in addition they complete one vocational course of 4 credits during the summer vacation of the second year.

Semester V

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHUC115	Mass Transfer Operations	PCC	3	1		4
CHUC116	Chemical Reaction Engineering -II	PCC	3	1		4
CHUC117	Process Equipment and Design	PCC	3			3
HSUA105	Industrial Economics and Management	AEC	2			2
CHUE101	Professional Elective 1	PEC	3	1		4
CHUC118	Chemical Engineering Equipment Design of Lab	PCC			3	1.5
CHUC119	Chemical Reaction Engineering Lab	PCC			3	1.5
Total			14	3	6	
			23			20

Course Code	Course	CCC	Periods			Credits
			L	T	P	
	Ancillary stream course 2	ASC	3			3
CHUH102	Advanced topics in chemical process synthesis and fluid flow operations	HNC	3	1		4

Semester VI

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHUC120	Computational Methods for Chemical Engineers	PCC	3			3
CHUC121	Process Dynamics and Control	PCC	3	1		4
CHUC122	Pollution Control in Process Industries	PCC	3			3
CHUE101	Professional Elective 2	PEC	3	1		4
CHUC123	Chemical Engineering Computational Lab	PCC			3	1.5
CHUC124	Process Dynamics and Control Lab	PCC			3	1.5
CHUC125	Internship	SEC				2
Total			12	2	6	
			20			19

Course Code	Course	CCC	Periods			Credits
			L	T	P	
	Ancillary stream course 3	ASC	3			3
CHUH103	Advanced topics in chemical thermodynamics, heat and mass transfer	HNC	3	1		4

Exit Option for the students who opt to exit after completion of third year of B.Tech Programme and have secured a minimum of 132 credits will be awarded a B.Sc. (Engg.) in a discipline.

Semester VII

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHUC126	Transport Phenomena	PCC	3	1		4
CHUC127	Process Engineering & Economics	PCC	3	1		4
CHUC128	Bio Process Engineering	PCC	3	1		4
CHUE101	Professional Elective 3	PEC	3	1		4
CHUC129	Mini project	PCC			4	2
CHUC130	Comprehensive viva	PCC				1
Total			12	4	4	
			20			19

Course Code	Course	CCC	Periods			Credits
			L	T	P	
	Ancillary stream course 4	ASC	3			3
CHUH104	Advanced topics in chemical reaction engineering and process dynamics	HNC	3	1		4

Semester VIII

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHUC131	Project work	PCC			16	8
Total					16	
			16			8

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHUH105	Seminar	HNC				2

List of Professional Elective Courses

Professional Elective	Course code	Course	**Semester**
Professional Elective I/ Professional Elective II/ Professional Elective III	CHUE101	Energy Engineering	**V/ VI/ VII**
	CHUE102	Nuclear Technology	
	CHUE103	Polymer Science and Technology	
	CHUE104	Petroleum Refinery Engineering	
	CHUE105	Petrochemical Technology	
	CHUE106	Fluidization Engineering	
	CHUE107	Semiconductor Processing	
	CHUE108	Dairy Process Technology	
	CHUE109	Chemical Process Optimization	
	CHUE110	Risk and Safety Engineering	

COURSES OFFERED UNDER HONORS

CCC	**Course Code**	**Course**	**Semester**	**Credit**	**Total Credit**
HNC	CHUH101	Introduction to frontiers in chemical engineering	IV	4	18
	CHUH102	Advanced topics in chemical process synthesis and fluid flow operations	V	4	
	CHUH103	Advanced topics in chemical thermodynamics, heat and mass transfer	VI	4	
	CHUH104	Advanced topics in chemical reaction engineering and process dynamics and control	VII	4	
	CHUH105	Seminar	VIII	2	
Total					18

Ancillary stream Elective courses:

Ancillary Stream Electives **Theam: ENERGY** (**For other Department Students**)	
Course code	Course Name
CHUN101	Renewable Energy
CHUN102	Conventional Energy
CHUN103	Energy Conservation and Management in Process Industries
CHUN104	Green and Sustainable Energy Engineering

Ancillary Stream Electives **Theam: ENVIRONMENT** (**For other Department Students**)	
Course code	Course Name
CHUN105	Air Pollution Control
CHUN106	Waste Water Engineering

CHUN107	Solid Waste Management
CHUN108	Unit Operations and Process in Environmental Engineering

Ancillary Stream Electives: **Theam: SEPARATION PROCESS TECHNOLOGY** (**Interdisciplinary-For Students of CHEMICAL Department**)	
Course code	Course Name
CHUI101	Basics of New Separation Techniques
CHUI102	Membrane Separation Technology
CHUI103	Process Integration
CHUI104	Process Modelling and Simulation

Courses offered under various categories:

CCC	Course Code	Course	Semester	Credit	Total Credit
BSC	MAUC101	Mathematics – I	I	4	20
	PHUC101	Physics	II	3	
	CYUC101	Chemistry	I	3	
	PHUC102	Physics laboratory	II	1	
	CYUC102	Chemistry Laboratory	I	1	
	MAUC102	Mathematics –II	II	4	
	MAUC103	Transforms, Partial Differential Equations and Statistics	III	4	
ESC	MEUC101	Engineering Graphics	II	3	6
	CSUC101	Programming for Problem Solving	I	2	
	CSUC102	Computer Programming Laboratory	I	1	
PCC	CHUC101	Basics of chemical engineering	I	4	92
	CHUC102	Process Calculations	II	4	
	CHUC103	Chemical Engineering Thermodynamics	III	3	
	CHUC104	Chemical Engineering Fluid Mechanics	III	4	
	CHUC105	Process Heat Transfer	III	3	
	CHUC106	Mechanical Operations	III	3	
	CHUC107	Chemical Engineering Fluid Mechanics and Mechanical Operations lab	III	1.5	
	CHUC108	Process Heat Transfer Lab	III	1.5	
	CHUC109	Basics of Mass Transfer	IV	3	
	CHUC110	Chemical Reaction Engineering-I	IV	3	
	CHUC111	Chemical Process Industries	IV	3	
	CHUC112	Chemical Engineering Practice	IV	4	
	CHUC113	Mass Transfer Operations Lab	IV	1.5	
	CHUC114	Chemical Engineering Plant Simulation Lab	IV	1.5	
	CHUC115	Mass Transfer Operations	V	4	

	CHUC116	Chemical Reaction Engineering -II	V	4	
	CHUC117	Process Equipment and Design	V	3	
	CHUC118	Chemical Engineering Equipment Design of Lab	V	1.5	
	CHUC119	Chemical Reaction Engineering Lab	V	1.5	
	CHUC120	Computational Methods for Chemical Engineers	VI	3	
	CHUC121	Process Dynamics and Control	VI	4	
	CHUC122	Pollution Control in Process Industries	VI	3	
	CHUC123	Chemical Engineering Computational Lab	VI	1.5	
	CHUC124	Process Dynamics and Control Lab	VI	1.5	
	CHUC125	Internship	VI	2	
	CHUC126	Transport Phenomena	VII	4	
	CHUC127	Process Engineering & Economics	VII	4	
	CHUC128	Bio Process Engineering	VII	4	
	CHUC129	Mini project	VII	2	
	CHUC130	Comprehensive viva	VII	1	
	CHUC131	Project work	VIII	8	
PEC	CHUE1xx	Professional Elective – I	VI	4	**12**
	CHUE1xx	Professional Elective – II	VI	4	
	CHUE1xx	Professional Elective – III	VII	4	
AEC	HSUA101	English for Communication	I	2	**10**
	HSUA102	Professional English	II	2	
	HSUA103	Modern Indian/Foreign Language (or) Digital Technologies	III/IV	2	
	HSUA104	Entrepreneurship	II/IV	2	
	HSUA105	Industrial Economics and Management	V/VI	2	
SEC	GEUS101	Basic Engineering Skills Laboratory - I	I/II	3	6
	GEUS102	Basic Engineering Skills Laboratory - II	I/II	3	
VAC	GEUV101	NSS, Yoga and Health	I/II	1	**4**
	GEUV102	Essence of Indian Traditional Knowledge	I/II	1	
	GEUV103	Environmental Education	III/IV	1	
	GEUV104	Universal Human Values	III/IV	1	
ANC		Ancillary Stream Elective course	**IV-VII**	12	**12**
Total					**162**

Department : **Mathematics**		Programme: **B.Tech.**						
Semester : **Third**		Course Category Code: **BSC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
MAUC104	**Transforms and Partial Differential Equations**	3	1	-	4	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Explain the concept of Laplace Transform and its inverse.						
	CO2	Utilize Laplace Transform to solve the ODEs.						
	CO3	Analyze various methods of solving first order PDE.						
	CO4	Determine the solution of higher order PDE and applying the method of variable separation to solve wave equation.						
	CO5	Make use of Fourier series method to solve heat equations.						

UNIT-I	**Laplace transforms**	**Periods: 12**
Definition of Laplace Transform, Inverse Laplace Transform, Linearity property, Laplace transform of unit step function, Unit impulse function and some elementary functions, Change of scale and first shifting property, Laplace transform of Periodic functions.		**CO1**
UNIT-II	**Applications of Laplace transforms**	**Periods: 12**
Derivatives and integrals of Laplace transform, Transform of derivatives and integrals, Application: Solution of single ordinary linear differential equation with constant coefficients, Initial and Final value theorem.		**CO2**
UNIT-III	**Partial differential equations**	**Periods: 12**
General and Singular solution of PDE, Complete Solution of First order linear and Non-linear PDE, First order linear PDE - method of grouping and Lagrange's multipliers method.		**CO3**
UNIT-IV	**Higher order pde and boundary value problems**	**Periods: 12**
Homogeneous linear PDE of higher order with constant coefficients. Solution of partial differential equation by the method of separation of variables. Application of PDE: Variable separable solutions of the one dimensional wave equation, Transverse vibration of a stretched string.		**CO4**
UNIT-V	**One dimensional and two dimensional heat flow equation**	**Periods: 12**
Heat Equation, Solution of one dimensional heat equation by the method of separation of variables, Temperature distribution with zero and non-zero boundary values, Two dimensional heat flow under steady state conditions(Cartesian).		**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1. Veerarajan T, Engineering Mathematics I & II, McGraw-Hill Education(India) Private Limited, 2019
2. Veerarajan T, Transforms and Partial Differential Equations, Third Edition, McGraw-Hill Education(India) Private Limited, 2016.
3. Venkataraman M.K., Engineering Mathematics, Third Year, Part-B, The National Publishing Company, Chennai, 2008.
4. Erwin Kreyszig, Advanced Engineering Mathematics (9 th Ed), John Wiley & Sons, New Delhi, 2011.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, Eleventh Reprint, 2010.
6. Bali N. and Goyal M., Advanced Engineering Mathematics, Laxmi Publications Pvt. Ltd., New Delhi, 9thEdition, 2011.
7. B.S. Grewal "Higher Engineering Mathematics" (44th Ed), Khanna Publishers, 2018.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1	-	1	2	1	2			
CO2	3	3	2	3	3	1	-	1	2	1	2			
CO3	3	3	2	3	3	2	-	1	2	1	2			
CO4	3	3	2	3	3	2	-	1	2	1	2			
CO5	3	3	2	3	3	2	-	1	2	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Third**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC103	**Chemical Engineering Thermodynamics**		3	-	-	3	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the concepts of ideal gas, non ideal gas, compressibility factor, critical properties, equations of state and PVT behaviour of fluids to both unit operations and unit processes (Understand & Apply – L2 & L3)							
	CO2	Analyze the first and second laws of thermodynamics in solving practical flow problems							
	CO3	Apply the various thermodynamic properties and relations between them such as Maxwell relations in the construction of thermodynamic diagrams (Apply – L3)							
	CO4	Evaluate and compare the properties of ideal and non-ideal solutions, partial molar properties, chemical potential, fugacity, fugacity coefficient, activity and activity coefficient (Evaluate – L5)							
	CO5	Understand and apply the concepts of Chemical Equilibria(Understand & Apply – L2 & L3)							
UNIT-I	**Introduction to Fluids and Equation of state**					**Periods:**			
The behaviour of fluids - PVT properties of fluids, equations of state, ideal and non-ideal gas, the and compressibility factor, critical properties, generalized equations of state.									**CO**
UNIT-II	**First law and Second law of thermodynamic**					**Periods:**			
First law of thermodynamics - Types of energy, work, heat and energy changes, application of first law to different processes. Second law of thermodynamics and its applications - Entropy, reversible and irreversible processes, Carnot cycle, refrigeration.									**CO**
UNIT-III	**Thermodynamic functions**					**Periods:**			
Thermodynamic properties and relations among them, mathematical relationships among basic properties, Maxwell relations, changes in properties, temperature and pressure effects, thermodynamic diagrams, construction of thermodynamic diagrams									**CO**
UNIT-IV	**Solution thermodynamics**					**Periods:**			
Solution properties - partial molal properties and chemical potential, concept of fugacity and activity and their calculations, ideal and non-ideal solutions, Gibbs - Duhem equations, property change of mixing and excess properties. Phase equilibria - Phase rule, fundamentals of vapour - liquid equilibrium, Vanlaar, Margules and Wilson equations for binary mixture, liquid - liquid, solid - liquid and solid - vapour equilibria.									**CO**
UNIT-V	**Equilibrium thermodynamics**					**Periods:**			
Chemical Equilibria - Free energy and chemical reactions, feasibility of chemical reaction, calculation of free energy of homogeneous reactions, equilibrium constants and evaluation from thermodynamic data, effect of different variables on reaction equilibria, calculation of equilibrium composition for single and multiple reactions, equilibria of heterogeneous reactions									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									

1. J.M. Smith,H.C.Van Ness and M.M.Abbot adapted by B.I.Bhatt, Introduction to Chemical Engineering Thermodynamics (In SI Units), McGraw-Hill,7th Edition, 2013.
2. K.V.Narayanan, A textbook of Chemical Engineering Thermodynamics, PHI learning private limited, 2nd Edition, 2013.
3. J.Richard Elliot, Carl T Lira, Introductory Chemical Thermodynamics, Prentice Hall International Series, 2nd Edition, 2012.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	3	3	2
CO2	3	2	1	1	3	3	1	-	1	1	3	3	3	2
CO3	3	2	2	3	3	2	-	2	3	2	2	3	3	3
CO4	3	2	2	3	3	2	-	3	3	2	2	3	3	3
CO5	3	2	1	1	1	3	3	-	1	1	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Third**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC104	**Chemical Engineering Fluid Mechanics**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the principle of fluid pressure, hydrostatic equilibrium, buoyancy and their applications in gravity and centrifugal separators.							
	CO2	Understand and apply the basic laws governing the flow of non viscous and viscous fluids and their rheological behaviour							
	CO3	Apply momentum balance equations for different flow geometries and calculate pressure drop and friction factor.							
	CO4	Understand knowledge of various flow measuring devices and pumps used for transportation of fluids							
	CO5	Apply force balances to systems involved in flow past immersed bodies that includes packed and fluidised beds							
UNIT-I	**Fluid statics**					**Periods:**			
Fluid Statics – Fluid density, compressible and incompressible fluids; Pressure, relationship between pressure and density for ideal gas; Hydrostatic equilibrium in gravitational and centrifugal force fields; Gravity decanters and centrifuge ; Pascal's law, hydraulic lever; Measurement of fluid pressure, manometers, Archimedes principle and buoyancy									**CO**
UNIT-II	**Fluid dynamics**					**Periods:**			
Fluid Dynamics – ideal flow of fluids (non-viscous and incompressible fluids), Continuity equation and energy equation (Bernoulli's equation), applications. Flow of viscous fluids - Shear rate, Shear stress, Newton's law of fluid motion, Viscosity, concept of momentum transfer, Rheology of fluids - Newtonian and non-Newtonian fluids, laminar and turbulent flow, Reynolds number and transition from laminar to turbulent flow.									**CO**
UNIT-III	**Fluid flow basics and applications**					**Periods:**			
Momentum balance equation, Hagen-Poiseulle equation , Flow of fluids through circular pipe, Annulus, Flow between parallel plates, , flow through non circular cross section – equivalent diameter, Correction of Bernoulli's equation for velocity and friction, friction factor, friction factor Vs Reynold's number for laminar flow, Friction factor correlations for turbulent flow through pipes, Dimensional analysis- Rayliegh's and Buckinham Pi methods, friction loss across sudden expansion, contraction, valves and fittings.									**CO**
UNIT-IV	**Transportation and metering of fluid**					**Periods:**			
Transportation and metering of fluid - Orifice meter, Venturimeter, Pitot tube, Rotameter, Weirs and Notches, Pumps and Compressors, Performance and characteristics of centrifugal pumps, NPSH, Cavitation , Priming									**CO**
UNIT-V	**Flow past immersed bodies**					**Periods:**			
Flow past immersed bodies - Boundary layer, drag and drag coefficient, Stokes law and terminal settling velocity. Flow of fluids through bed of solids - Darcy's law, Ergun's equation, Fluidization, minimum fluidization velocity, pneumatic transport.									**CO**
Lecture Periods:		**Tutorial Periods:**			**Practical Periods:**			**Total Periods:**	
Reference Books:									
1. Noel de Nevers, Fluid mechanics for Chemical Engineers, TATA McGraw- Hill edition,3rd Edition 2011. 2.W.L.Mc.Cabe, J.C.Smith and P.Harriot, Unit Operations of Chemical Engineers, McGraw Hill International edition, 7th Edition, 2009. 3.Coulson J.M and Richardson J.F., Chemical Engineering - Volume 1, Elsevier Press, 6th Edition, 2006. 4.F.Holland, R. Bragg, Fluid flow for Chemical Engineers, Butterworth Heinemann,2nd edition,1995.									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO2	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	1	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Third**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC105	**Process Heat Transfer**		3	-	-	3	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the fundamental principles of heat transfer, including conduction, convection, and radiation, to analyze heat transfer systems. (Understand &Apply – L2 & L3)							
	CO2	Analyze heat transfer mechanisms in different engineering applications and evaluate the influence of material properties, boundary conditions, and phase change on heat transfer rates. (Analyze – L4)							
	CO3	Apply heat transfer correlations and dimensionless numbers to solve practical problems involving fluid flow, heat exchangers, and industrial heat transfer equipment. (Apply – L3)							
	CO4	Evaluate and compare the performance of different heat transfer equipment, such as heat exchangers and evaporators, using empirical methods. (Evaluate – L5)							
	CO5	Assess the impact of insulation, extended surfaces, and phase change processes on heat transfer efficiency and performance in industrial applications. (Evaluate – L5)							
UNIT-I	**Conduction basics**					**Periods:**			
Steady state conduction – Fourier's law, thermal conductivity, conduction through composite multilayer plane walls, spherical walls and cylindrical walls, insulation and critical thickness of insulation, heat conduction in rods with heat generation. Introduction to Heat transfer in extended surfaces ,fin effectiveness and fin efficiency.									**CO**
UNIT-II	**Convection basics**					**Periods:**			
Principles of heat transfer in fluids - laminar flow and boundary layer theory in heat transfer, heat transfer in turbulent flow, Dimensional analysis in heat transfer, Correlations for the calculation of heat transfer coefficients, heat transfer coefficient for flow through a pipe, flow through a non circular conduit, flow past flat plate, Heat transfer by natural convection.									**CO**
UNIT-III	**Convection applications**					**Periods:**			
Heat transfer from condensing vapours, drop wise and film wise condensation, Nusselt equation for vertical tubes, condensation of superheated vapours, effect of non-condensable gases on rate of condensation. Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.									**CO**
UNIT-IV	**Radiation basics**					**Periods:**			
Radiation heat transfer - Emissive power, Black body radiation, Emissivity, Stefen - Boltzman law, Plank's law, radiation between surfaces, View factor calculations - view factor for infinitely parallel grey planes, view factor from a plane to a hemisphere, Radiation in absorbing gases.									**CO**
UNIT-V	**Heat exchange equipment's**					**Periods:**			
Heat exchange equipment's - Double pipe and shell and tube heat exchangers, concept of log mean temperature difference (LMTD), LMTD correction factor, overall heat transfer coefficient, dirt factor, Evaporators - single effect evaporators, heat balance , evaporation equipments.									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. Binay K.Dutta , Heat Transfer, Prentice Hall Publications, 2006.
2. W.L.Mc.Cabe, J.C.Smith and P.Harriot, Unit operations of Chemical Engineers, McGraw Hill International edition, 7th edition, 1995.
3. Holman.J.P, Heat Transfer, 9 th Edition, McGraw Hill International, 2004.
4. Kern D.Q, Process Heat Transfer, McGraw Hill, 1950.
5. Krieth, Fundamentals of Heat Transfer, Harper and Row Publishers, 6th Edition, 1986.

6. C.J.Geankoplis, Transport Processes and Unit Operations, Prentice Hall, 3rd Edition, 1993.
7. Coulson J.M and Richerdson J.F, Chemical Engineering - Volume 1, Elsevier Press, 6th Edition, 2006.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1	1	1	1	2	3	1	1
CO2	3	3	2	3	2	2	1	1	1	1	2	3	2	2
CO3	3	3	2	3	3	2	1	1	1	1	2	3	2	2
CO4	3	3	3	3	3	2	1	1	1	2	2	3	2	2
CO5	3	3	3	2	2	3	2	1	1	2	3	3	2	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Third**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC106	**Mechanical Operations**		3	-	-	3	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the fundamental principles of Particle Size Analysis (Understand & Apply – L2 & L3)							
	CO2	Analyse size reduction techniques. (Analyse – L4)							
	CO3	Apply force balance to solve practical problems involving solid-fluid handling equipment. (Apply – L3)							
	CO4	Evaluate and compare the performance of various filtration methods. (Evaluate – L5)							
	CO5	Assess the principals involved in Froth flotation, Mixing and agitation. (Evaluate – L5)							
UNIT-I	**Particle Size Analysis and handling**					**Periods:**			
Particle Size Analysis - Methods of representation of size analysis, shape factor, sub sieve methods of analysis, surface area determination. Industrial screening - Theory of screening, screen efficiency, types of screening equipments, Storage and Conveyance of solids - Bunkers, silos, bins and hoppers, transportation of solids in bulk, conveyer selection, different types of conveyers.									**CO**
UNIT-II	**Size reduction**					**Periods:**			
Size reduction - Energy relationships in size reduction, size reduction equipment and selection, closed circuit and open circuit operation. Size enlargement - Principle of granulation, briquetting, pelletisation, flocculation.									**CO**
UNIT-III	**Equipments**					**Periods:**			
Classification - Application of Stoke's equation, types of classifiers - gravity settling, settling tanks, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation - Principles, separation of solids from fluids, continuous centrifuges, cyclones and hydro cyclones. Gas cleaning - Gravity and momentum separators, cyclone separators.									**CO**
UNIT-IV	**Solid - Liquid operations**					**Periods:**			
Solid - Liquid separation-Filtration, flow through filter cake and filter media, compressible and incompressible filter cakes, filtration equipments - selection, operation and design of filters and optimum cycle of operation, filter aids. Thickening - Batch and continuous thickeners, design of continuous thickeners.									**CO**
UNIT-V	**Solid - Liquid operations and energy requirements**					**Periods:**			
Froth flotation - Principles and theories of collection, flotation cell and typical circuit. Sorting (separation of solids) , Principles of jiggers, Types of jiggers, Mixing and agitation - Mixing of liquids without solids, mixing of liquids with solids, mixing of powders, selection of suitable mixers, power requirement for mixing.									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. Anup K Swain, Hemlata Patra and G.K.Roy ,Mechanical Operations, Tata McGraw-Hill Education Private Limited, 2011.
2. Badger and Banchero, Introduction to Chemical Engineering, Tata McGraw-Hill, 2006.
3. McCabe, J.C.Smith and P.Harriot, Unit Operations of Chemical Engineers, McGraw Hill International Edition, VII edition, 2009.
4. Foust Wenzel, Principle of Unit Operations, John Wiley and sons, II Edition, 1980.
5. Coulson J.M and Richerdson J.F, Chemical Engineering - Volume 2, Elsevier Press, V Edition, 2006.
6. C.M.Narayan and B.C.Bhattacharya, Mechanical operations for Chemical Engineers,Khanna Publishers,1990

7. G.C.Sekhar, Unit Operations in Chemical Engineering Theory & Problems , Pearson Education (Singapore) pVT.LTD,2005

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1	1	1	1	2	3	1	1
CO2	3	3	2	3	2	2	1	1	1	1	2	3	2	2
CO3	3	3	2	3	3	2	1	1	1	1	2	3	2	2
CO4	3	3	3	3	3	2	1	1	1	2	2	3	2	2
CO5	3	3	3	2	2	3	2	1	1	2	3	3	2	3

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Third**			Course Category Code: **AEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
HSUA103	**Entrepreneurship**		2	-	-	2	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand entrepreneurial mindset, problem identification, customer segmentation, and value proposition development.							
	CO2	Develop and validate business models, test solutions, and create a Minimum Viable Product (MVP) through iterative feedback.							
	CO3	Analyze financial planning, revenue models, pricing strategies, and investor expectations for startup funding.							
	CO4	Apply sales, branding, digital marketing, automation, and teamwork strategies to successfully launch and scale a venture.							
UNIT-I	**Problem Identification and Customer Discovery**					**Periods: 6**			
Entrepreneurial mindset – Identifying business opportunities – Effectuation principles – Design Thinking for problem-solving – Consumer segmentation and customer persona – Value Proposition Canvas (VPC) – Unique Value Proposition (UVP) – Market research techniques – Emerging trends: AI in market research.									**CO1**
UNIT-II	**Business Model and Lean Startup**					**Periods: 6**			
Types of business models – Lean Canvas vs. Business Model Canvas – Competitor analysis – Blue Ocean Strategy – Building and testing Minimum Viable Product (MVP) – Build-Measure-Learn feedback loop – Digital Prototyping tools – Rapid Experimentation – Agile startup methodology.									**CO1, CO2**
UNIT-III	**Revenue Models, Costing, and Financial Planning**					**Periods: 6**			
Revenue models: Subscription, Freemium, and Pay-per-use – Unit economics: Cost structures and pricing strategies – Funding sources: Bootstrapping, Crowdfunding, Venture Capital – Investor expectations and funding rounds – Pitching to investors – Financial forecasting and break-even analysis – Government startup incentives.									**CO2, CO3**
UNIT-IV	**Digital Marketing and Sales Strategies**					**Periods: 6**			
Brand positioning and storytelling – Social media marketing and digital presence – SEO, SEM, and paid advertising – Data-driven marketing strategies – Sales funnels – Unique Sales Proposition (USP) – B2B vs. B2C sales – CRM tools for customer engagement – Customer retention strategies.									**CO3, CO4**
UNIT-V	**Team Building, Compliance, and Scaling**					**Periods: 6**			
Building and managing startup teams – Remote collaboration tools – Business registration and legal compliance – Intellectual Property Rights (IPR) for startups – Growth hacking and automation – Scaling strategies: Expansion and franchising – Emerging trends: AI in entrepreneurship, blockchain applications – Exit strategies: Mergers, acquisitions, IPOs.									**CO5**
Lecture Periods: 30	**Tutorial Periods:**		**Practical Periods:**				**Total Periods: 30**		

Reference Books:

1. Eric Ries, The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Crown Business, 1st Edition (2011).
2. Alexander Osterwalder & Yves Pigneur, Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Wiley, 1st Edition (2010).
3. Ash Maurya, Running Lean: Iterate from Plan A to a Plan That Works, O'Reilly Media, 2nd Edition (2019).
4. Steve Blank and Bob Dorf, The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch, 1st Edition (2012).

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	3	2	1	3	2	2	2	2	1	1
CO2	3	3	3	2	3	2	2	3	3	2	2
CO3	1	2	3	3	2	1	1	2	3	3	2
CO4	2	2	2	3	2	2	2	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Humanities and Social Sciences**		Programme: **B.Tech.**						
Semester : **Third**		Course Category Code: VAC				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
GEUC103	**Environmental Education**	1	-	-	1	100	-	100
Prerequisite:	**-**							
Course Outcome	**CO1**	Recall the concept of environment ecology and Education.						
	CO2	Summarise the effect of population explosion, degradation of environment and global problem due to the anthropogenic activities.						
	CO3	Justify the need of pollution control and sustainable development for future.						
UNIT-I	**Introduction to Environmental Education**				**Periods: 5**			
Concept, scope and importance of Environmental Education - Objectives of Environmental Education - Concept of an Ecosystem: Structure and functions, Types of ecosystem (aquatic and terrestrial) - Biodiversity: Levels, values, threats and conservation - Natural resources: Renewable and Non-renewable resources.								**CO1**
UNIT-II	**Environmental degradation and impact**				**Periods: 5**			
Human population growth and its impact on environment - Deforestation: Causes and effects due to expansion of agriculture, firewood, mining and building of new habitats - Pollution: Definition, different types of Pollution - Air and water pollution: Causes and effect on environment - Climate change, Global warming, Ozone layer depletion and impacts on human communities.								**CO2**
UNIT-III	**Conservation of environment**				**Periods: 5**			
Control measures for various types of Pollution: use of renewable and alternate source of energy - Environmental laws: Environmental Protection Act (1986), Water Act (1974), Air Act (1981) - International agreements: Montreal and Kyoto Protocol, Paris Agreement - Concept of sustainable development and SDGs - Role of government, NGOs and individual in environmental conservation.								**CO3**
Lecture Periods: 15	**Tutorial Periods:**	**Practical Periods:**			**Total Periods:**			
Reference Books:								

1. Singh, J.S., Singh, S.P. and Gupta, S.R., 2014. "Ecology, Environmental Science and Conservation", S. Chand Publishing, New Delhi.
2. Sharma, P. D., 2011. "Ecology and Environment", Rastogi Publications.
3. Erach Bharucha, 2010. "Text Book of Environmental Studies", University Grants Commission, Universities Press (India) Pvt.Ltd., Hyderabad.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	1					3	1				1
CO2	1					3	1				1
CO3					1	3	2	1			2
CO4	1					3	1				1
CO5	1					3	1				1

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**					
Semester : **Third**			Course Category Code: PCC			Semester Exam Type: **Lab**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUC107	**Chemical Engineering Fluid Mechanics and Mechanical Operations lab**	-	-	3	1.5	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Applying Bernoulli's equation for calculating friction factor						
	CO2	Assess flow meters and measuring devices						
	CO3	Evaluate and compare pressure drop across packed and fluidised bed						
	CO4	Applying energy laws in estimating energy required for size reduction equipment's						
	CO5	Applying Solid-fluid separation techniques for estimating the performance of different filters and thickener design.						
		Periods:						
1.Laminar flow of Newtonian and non Newtonian fluids 2.Flow through pipes and fittings 3.Flow through annulus								**CO1**
4.Orifice meter 5.Venturi meter 6.Rotameter 7.Weirs and notches 8.Centrifugal Pump Characteristics								**CO2**
9.Packed bed; 10.Fluidized bed;								**CO3**
11.Sieve Analysis 12.Ball Mill 13.Jaw Crusher								**CO4**
14.Plate and Frame Filter Press 15.Vacuum Filter 16.Beaker Decantation								**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**		

Reference Books:

1. Garlapati Chandrasekhar, Low-cost experiments in chemical and allied Engineering, Department of Chemical Engineering, Pondicherry Engineering College, Puducherry, 2018
2. Lab Manual, Department of Chemical Engineering, Pondicherry Engineering College, Puducherry, 2018

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO2	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO3	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO4	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO5	3	2	1	1	3	-	-	1	1	1	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Third**			Course Category Code: **PCC**				Semester Exam Type: **Lab**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC108	**Process Heat Transfer Lab**		-	-	3	1.5	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Applying basic heat transfer laws							
	CO2	Assess heat convection and radiation relations							
	CO3	Evaluate and compare heat exchangers							
	CO4	Applying heat transfer design concepts to evaluate packed bed							
	CO5	Applying heat transfer design concepts to evaluate to condensers							
			Periods:						
1. Heat Transfer through Composite Wall 2. Transient Heat Conduction-I 3. Transient Heat Conduction-II									**CO1**
4. Heat Transfer with Natural Convection 5. Heat Transfer by Radiation									**CO2**
6. Heat Transfer in a Shell and Tube Heat Exchanger 7. Heat Transfer in a Double Pipe Heat Exchanger									**CO3**
8. Heat Transfer through Packed Bed									**CO3**
9. Heat Transfer in a Vertical Condenser 10. Heat Transfer in a Horizontal Condenser									**CO3**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. Garlapati Chandrasekhar, Low-cost experiments in chemical and allied Engineering, Department of Chemical Engineering, PENRAM International Publications, 2108
2. Lab Manual, Department of Chemical Engineering, Pondicherry Engineering College, Puducherry, 2018

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	3	3	1	2	2	1	3	3	3	2
CO2	3	3	1	2	3	3	1	2	2	1	3	3	3	2
CO3	3	3	2	3	3	2	-	3	3	2	3	3	3	2
CO4	3	3	2	3	3	2	-	3	3	2	3	3	3	2
CO5	3	3	1	1	1	3	3	1	3	1	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical engineering**			Programme: **B.Tech.**					
Semester : **Fourth**			Course Category Code: BSC			Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks	
			L	T	P	C	CA	SE	TM
CHUC109	**Basics of Mass Transfer**		3	-	-	3	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Understand the concepts of molecular diffusion and basic analogy, (Understand – L2)						
	CO2	Understand and analyze the concept of mass transfer coefficient (Understand-and Analyze – *L2 &* L4)						
	CO3	Understand the basics of Gas-Liquid/ Liquid-Liquid / Fluid-Solid transfer operations (Understand- L2)						
	CO4	Understand the basics of Simultaneous heat and mass transfer operations (Understand-L2)						
	CO5	Understand the basics of various mass transfer equipment's (Understand- L2)						
UNIT-I	**Diffusion**					**Periods: 12**		
Definition of mass transfer, Molecular diffusion, Convective transfer, Fick's laws, momentum,heat and mass transfer analogy. Determination Diffusion coefficients								**CO1**
UNIT-II	**Mass transfer coefficient**					**Periods: 12**		
Definition of mass transfer coefficient, Various mass transfer coefficients, interphase mass transfer relation between individual mass transfer coefficient and overall mass transfer coefficient, Determination Mass transfer coefficients								**CO2**
UNIT-III	**Gas-Liquid/ Liquid-Liquid / Fluid-Solid operations**					**Periods: 12**		
Principles of Gas-Liquid/ Liquid-Liquid / Fluid-Solid operations: Absorption, Stripping, Distillation, Extraction, Leaching, Adsorption								**CO3**
UNIT-IV	**Simultaneous heat and mass transfer**					**Periods: 12**		
Principles of various simultaneous heat and mass transfer operations: Humidification, Drying, Crystallization								**CO4**
UNIT-V	**Equipment**					**Periods: 12**		
Equipment used in Absorption, Stripping, Distillation, Extraction, Leaching, Adsorption, Humidification, Drying, Crystallization								**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**		

Reference Books:

1. R.E. Treybal, Mass Transfer Operations, McGraw Hill, 3rd Edition, 1981.
2. Alean S. Foust et al. Principles of Unit operation, Willy,2nd Edition 1981,
3. Binay K Dutta, Principles of Mass Transfer and Separation Process, PHI learning private limited, 2007.
4. C.J.Geankoplis, Transport Processes and Unit Operations, Prentice Hall, 4th Edition, 2003.
5. Badger and Banchero, Introduction to Chemical Engineering, Tata McGraw Hill, 2006.
6. Coulson J.M and Richerdson J.F, Chemical Engineering - Volume 2, Elsevier Press, V Edition, 2006.
7. W.L.McCabe, J.C.Smith and P.Harriot, Unit Operations of Chemical Engineers, McGraw Hill InternationalEdition, 7th Edition, 2009.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1	-	1	2	1	2	3	3	2
CO2	3	3	2	3	3	1	-	1	2	1	2	3	3	2
CO3	3	3	2	3	3	2	-	1	2	1	2	3	3	3
CO4	3	3	2	3	3	2	-	1	2	1	2	3	3	3
CO5	3	3	2	3	3	2	-	1	2	1	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**					
Semester : **Fourth**			Course Category Code: PCC			Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks	
			L	T	P	C	CA	SE	TM
CHUC110	**Chemical Reaction Engineering-I**		3	-	-	3	40	60	100
Prerequisite:								
Course Outcome	**CO1**	**Understand and apply** the principles of kinetics to homogeneous reactions using differential and integral methods of analysis (Understand &Apply – L2 & L3)						
	CO2	**Analyze** the design of single ideal batch and flow reactors *(Analyze – L4)*						
	CO3	**Apply** the performance equation of ideal reactors to analyze the reactors connected in series or parallel (Apply – L3)						
	CO4	**Evaluate and compare** the yield and product distributions in case of series/parallel reactions carried out in ideal CSTRs and PFRs (Evaluate – L5)						
	CO5	**Assess** the performance of non-ideal flow reactors and models for the same *(Evaluate – L5)*						
UNIT-I	**Reaction Kinetcs**					**Periods:**		
Kinetics of homogeneous reactions - introduction, single and multiple reactions, elementary and non-elementary reactions, rate equations, kinetic models for non-elementary reactions, testing kinetic models, temperature dependence of rate - Arrhenius, collision and activated complex theories, Interpretation of batch reactor data for single and complex reactions under constant volume and variable volume conditions, differential and integral analysis, half life period.								**CO1**
UNIT-II	**Homogeneous reactors**					**Periods:**		
Design of single homogeneous reactors - ideal reactors, design equations for ideal batch reactor, PFR and CSTR, size comparison of single reactors.								**CO2**
UNIT-III	**Multiple reactor systems**					**Periods:**		
Multiple reactor systems - plug flow reactors in series and / or parallel, CSTRs in series, reactors of different types in series, recycle reactor, auto catalytic reactions, optimum recycle ratio for an auto catalytic reaction.								**CO3**
UNIT-IV	**Multiple reaction systems - series and parallel reactions**					**Periods:**		
Multiple reaction systems - series and parallel reactions in CSTRs and PFRs, product distribution, fractional yields, maximization of fractional yield in multiple reactions, series - parallel reactions.								**CO4**
UNIT-V	**Flow Behaviour of Reactors**					**Periods:**		
Flow Behaviour of Reactors: Non - ideal flow: Residence time distribution studies: C, E, F and I curves, conversion calculations directly from tracer studies. Models for non-ideal flow - dispersion and tanks in series multi-parameter models								**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**		

Reference Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley Publications Ltd., 3rd Edition, 2007.
2. Lanny D. Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 2nd Edition, 2010.
3. H.S.Fogler, Elements of Chemical Reaction Engineering, Prentice Hall of India Ltd., 4th Edition, 2009.
4. J.M.Smith, Chemical Engineering Kinetics, McGraw Hill, III Edition, 1981.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	2	2	2	2	2	2	1	1	2	1
CO2	1	1	1	1	2	2	2	2	2	2	1	1	2	1
CO3	1	1	1	1	2	2	2	2	2	2	1	1	2	1
CO4	1	1	1	1	2	2	2	2	2	2	1	1	2	1
CO5	1	1	1	1	2	2	2	2	2	2	1	1	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fourth**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC111	**Chemical Process Industries**		3	-	-	3	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand Water Conditioning methods (Understand– L2)							
	CO2	Understand and analyze Chlor-alkali Industries (Understand and Analyze – L2&L4)							
	CO3	Understand manufacturing process involved Cement, Glass and Paper (Understand– L2)							
	CO4	Understand process involved in manufacturing Sugars and Paints (Understand– L2)							
	CO5	Understand process involved in manufacturing fertilisers and assess Fertilisers (Understand and Evaluate –L2& L5)							
UNIT-I						**Periods:**			
Water Conditioning methods, Demineralisation, Precipitation Process. Industrial Gases: Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene.									**CO**
UNIT-II						**Periods:**			
Alkalies : Chlor-alkali Industries: Manufacture of Soda ash, Manufacture of Caustic Soda and chlorine-common salt. Sulphur and Sulphuric acid: Mining of Sulphur and manufacture of Sulphuric acid. Manufacture of hydrochloric acid and Nitric Acid.									**CO**
UNIT-III						**Periods:**			
Cement, Glass and Paper; Cement: Types and Manufacture of Portland cement, Glass: Manufacture of Glasses and Special Glasses, Ceramics: Refractories									**CO**
UNIT-IV						**Periods:**			
Sugars and Paints: Manufacture of sugar, Manufacture of paints – Pigments. Production of Pulp, Paper and rayon, Vegetable oil by Solvent Extraction.									**CO**
UNIT-V						**Periods:**			
Fertilisers: Nitrogen Fertilisers: Synthetic Ammonia, Urea, Ammonium chloride, CAN, Ammonium Phosphate. Phosphorus fertilizers: Phosphate rock, Phosphoric, Acid, Super Phosphate and Triple Super phosphate –MAP, DAP.									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									
1. N.Shreve, Chemical Process Industries , 5th Edition, McGraw Hill, New York, 1984. 2. R.Gopal and M.Sittig, Dryden's outlines of Chemical Technology, 2nd Edition, 1965. 3. S.D.Shukla and G.N.Pandey,Textbook of Chemical Technology, Volume I, 1977.									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO2	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	1	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fourth**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC112	**Chemical Engineering Practice**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	**Demonstrate** an understanding of process engineering documentation, including flow diagrams, equipment specifications, and industrial standards. (Understand – L2)							
	CO2	**Analyze and select** appropriate engineering materials based on mechanical properties, corrosion resistance, and suitability for chemical processes. (Analyze – L4)							
	CO3	**Evaluate** the performance of fluid-handling equipment such as pumps, blowers, compressors, and piping systems for efficient process operations. (Evaluate – L5)							
	CO4	**Apply** principles of thermal insulation, tracing, and valve selection to optimize process safety, energy efficiency, and operational reliability. (Apply – L3)							
	CO5	**Assess and integrate** plant utilities and auxiliary systems, ensuring optimal functionality, safety, and sustainability in chemical process industries. *(Evaluate – L5)*							
UNIT-I	**Process flow sheet**					**Periods:**			
Role of a process Engineer, Process documentation, flow sheets – types, preparation, flow sheet presentation, symbols, line and equipment symbols, Piping and Equipment identification, Standards and codes, time planning and Scheduling.									**CO1**
UNIT-II	**Engineering materials**					**Periods:**			
Materials selection: mechanical properties, materials- metals, polymeric materials, ceramic materials, graphite, glasses, Corrosion, Factors affecting corrosion, Causes and cures, types, material selection for corrosion resistances, novel engineering materials.									**CO2**
UNIT-III	**Pumps, Blowers and Compressors**					**Periods:**			
Pumps classification and types, Pump performance characteristics and selection of pumps, packing and mechanical seals, pumping systems design, pump priming. Fans, blowers, compressor, ejectors and mechanical vacuum systems.									**CO3**
UNIT-IV						**Periods:**			
Piping calculations, available piping, tubing and other flow conduits, economical sizing of pipe, Valves: types, sizing and selection Thermal insulation, usages for thermal insulation, types of insulation, recommended thickness of insulation, Tracing- steam tracing, electric tracing, jacketing.									**CO4**
UNIT-V						**Periods:**			
Utilities of a chemical plant, Boilers, Cooling tower, DM water plants, Industrial water Treatment, Turbines, Chillers, Process Safety and Pressure relieving devices, Storage tanks.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									

1. Henry J. Sandler, Edward T. Luckiewicz, Practical process engineering – A working approach to plant design, McGraw Hill Book Company,1987.
2. Ernest E. Ludwig, Applied Process Design, Vol. I, II & III, 3rd Edition, Gulf Professional Publishing, 1999.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	1	1	2	1	3	3	2	1
CO2	3	3	2	2	2	3	2	1	1	1	2	3	1	3
CO3	3	3	2	2	3	2	1	2	1	2	2	3	3	2
CO4	2	3	3	2	2	3	3	2	1	2	2	3	3	3
CO5	3	3	3	2	3	3	3	2	1	2	3	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department : HSS			Programme: **B.Tech.**						
Semester : Fourth			Course Category Code:				Semester Exam Type:		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
HSUA106	**Foreign Language - FRENCH**		2	-	-	2	40	60	100
Prerequisite:									
Course Outcome	**CO1**	To acquire the basics of the French language							
	CO2	To apply the acquired basics of the language in expressing oneself							
	CO3	To develop basic conversation skills							
	CO4	To communicate their student life in the University context							
	CO5	To equip the students to communicate within technical contexts							
UNIT-I	**INTRODUCTION TO FRENCH AND BASICS**					**Periods: 6**			
French alphabets and pronunciation – Greetings and Introductions (Bonjour ça va?) – Numbers, days of the week, months, seasons – Classroom expressions and instructions – Articles (Definite and Indefinite) – Basic sentence structure (Subject – Verb Agreement)									**CO 1**
UNIT-II	**PERSONAL IDENTITY AND EXPRESSIONS**					**Periods: 6**			
Introducing oneself and others (Je me présente……) – Nationalities and Professions – Describing people (Physical appearance and Personality) – Possessive adjectives (mon, ma, mes…) – Gender and number agreement of adjectives									**CO 2**
UNIT-III	**DAILY LIFE AND ROUTINES**					**Periods: 6**			
Talking about daily activities and schedules (Je me lève à 7 heures…) – Telling the time and discussing time tables – Common verbs in the present tense (ER, IR, RE verbs) – Reflexive verbs (Se lever, s'habiller…)									**CO 3**
UNIT-IV	**DIRECTIONS AND UNIVERSITY LIFE**					**Periods: 6**			
Asking for and giving directions (Où est….? A gauche, A droite…) – Describing locations (Près de, loin de….)- Talking about University courses and subjects (J'éudie l'ingénierie…) - Prepositions of place (sur, sous, devant….) – Using Il y a and C'est for descriptions									**CO 4**
UNIT-V	**FUTURE PLANS, BASIC TECHNICAL PRESENTATIONS AND TECHNICAL AND ENGINEERING CONTEXTS**					**Periods: 6**			
Talking about future career goals (Je veux devenir ingénieur…..) Using future proche for near future plans- Vocabulary related to Engineering disciplines – Talking about machines and materials (Acier, moteur, circuit….) – Giving simple presentations on technical topics – Introduction to passive voice (La machine est réparée….)									**CO 5**
Lecture Periods: 30	**Tutorial Periods: -**		**Practical Periods:-**				**Total Periods: 30**		

Reference Books:

1. Nouvelle Generations A1, Luca Giachino, Carla Baracoo, Didier FLE, 2020, Paris
2. Tech French – French for Science and Technology, Ingrid Le Gargasson, Shariva Naik et Claire Chaize, Goyal Publishers, 1 April 2011.
3. Écho – Méthode de Français, A1 , Girardet, Pecheur, CLE International,2013.
4. Écho Cahier personnel d'apprentissage, A1, Girardet, Pecheur, CLE International, 2013.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1								3	3		3
CO2								3	3		3
CO3								3	3		3
CO4								3	3		3
CO5								3	3		3

Score: 3 – High; 2 – Medium; 1 – Low

Department :Common to all			Programme: **B.Tech.**						
Semester : Fourth			Course Category Code: VAC				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
GEUC104	**Universal Human Values**		1	0	0	1	100	0	100
Prerequisite:	-								
Course Outcome	**CO1**	Develop a Holistic Understanding of Value Education							
	CO2	Foster Personal and Social Harmony							
	CO3	Enhance Awareness of Universal Co-existence							
	CO4	Apply Ethical and Humanistic Principles in Professional and Personal Life							
Module--**I**	Introduction to Value Education					**Periods: 3**			
Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education) Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, Happiness and Prosperity – Current Scenario, Method to Fulfil the Basic Human Aspirations									**CO1**
Module-**II**	Harmony in the Human Being					**Periods: 3**			
Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to ensure self-regulation and Health									**CO2**
Module-**III**	Harmony in the Family and Society					**Periods: 3**			
Harmony in the Family – the Basic Unit of Human Interaction, 'Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Other Feelings, Justice in Human-toHuman Relationship, Understanding Harmony in the Society, Vision for the Universal Human Order									**CO2**
Module-**IV**	Harmony in the Nature/Existence :					**Periods: 3**			
Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence									**CO3**
Module-**V**	Implications of the Holistic Understanding					**Periods: 3**			
A Look at Professional Ethics : (3 hours) Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession									**CO4**
Lecture Periods: 15	**Tutorial Periods: 0**		**Practical Periods:0**				**Total Periods: 15**		

Reference Books:

1.Student Induction Program Handbook v2 by AICTE NCC-IP sub-committee: Dr. Rajneesh Arora, Chairman NCC-IP, Dr. Shishir Gaur, Convener NCC-IP, Dr. Ruchir Gupta, Member NCC-IP.

2. R R Gaur R Asthana G P Bagaria ,A foundation course in HUMAN VALUES and professional ethics ,

3.Understanding Human Being, Nature and Existence Comprehensively By UHV Team (https://uhv.org.in/uhve)

4. RR Gaur, R Asthana, GP Bagaria , Teachers' Manual for A Foundation Course in Human Values and Professional Ethics

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1						3	3	2	2	2	3
CO2						3	3	3	3	2	3
CO3						3	3	2	2	2	3
CO4						3	3	2	2	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : Fourth			Course Category Code: PCC				Semester Exam Type: TY		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC113	**Mass Transfer Operations Lab**		-	-	3	1.5	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply basics of mass transfer (Understand &Apply – L2 & L3)							
	CO2	Analyze various mass transfer operation. (Analyze – L4)							
	CO3	Evaluate the performance mass transfer operations. (Evaluate – L5)							
			Periods:						
1. Stefan's tube experiment-diffusivity of vapour in air 2. Liquid- liquid diffusion - Diffusivity of salt in water 3. Surface Evaporation 4. Sublimation of naphthalene ball									**CO1**
4. Packed bed absorber 5. Wetted Wall Column 6. Adsorption isotherm 7. Multistage adsorption									**CO1, CO2**
8. Vapour Liquid Equilibrium 9. Basic Simple distillation 10. Steam distillation 11.HETP									**CO2 CO3**
12. Liquid - Liquid equilibrium 13. Liquid- Liquid extraction cross current 14. Liquid- Liquid counter current									**CO2 CO3**
15. Leaching cross current 16. Leaching counter current									**CO2 CO3**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									

3. Garlapati Chandrasekhar, Low-cost experiments in chemical and allied Engineering, Department of Chemical Engineering, PENRAM International Publications, 2108
4. Lab Manual, Department of Chemical Engineering, Pondicherry Engineering College, Puducherry, 2018

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1	1	1	1	2	3	1	1
CO2	3	3	2	3	2	2	1	1	1	1	2	3	2	2
CO3	3	3	2	3	3	2	1	1	1	1	2	3	2	2
CO4	3	3	3	3	3	2	1	1	1	2	2	3	2	2
CO5	3	3	3	2	2	3	2	1	1	2	3	3	2	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**		Programme: **B.Tech.**						
Semester : Fourth		Course Category Code: PCC				Semester Exam Type: **Lab**		
CHUC114	**Chemical Engineering Plant Simulation Lab**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
		-	-	3	1.5	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Demonstrate proficiency in using DWSIM for setting up and simulating process flowsheets, selecting appropriate thermodynamic models, and performing basic mass balance calculations. (Level 3 - Application)						
	CO2	Analyze the performance of pumps, heat exchangers, cooling towers, and other unit operations through simulation, and interpret the results to identify operational challenges and solutions. (Level 4 - Analysis)						
	CO3	Design and simulate distillation columns, DM water plants, and chemical process units to optimize operating conditions and improve efficiency. (Level 5 - Evaluation)						
	CO4	Evaluate reactor performance under various conditions using batch reactor simulations and apply the principles of reaction kinetics and thermodynamics to optimize conversion. (Level 4 - Analysis)						
	CO5	Implement process control systems using PID controllers for temperature and pressure regulation, and assess system stability through dynamic simulations. (Level 5 - Evaluation)						
					Periods:			
DWSIM-Based Practical Exercises 1. Basic Introduction to DWSIM • Learn how to set up a flowsheet • Select thermodynamic models (Peng-Robinson, SRK, NRTL) • Add unit operations: Mixers, separators, heat exchangers, pumps • Solve a simple mass balance problem 2. Pump Performance and Cavitation Study • Simulate a centrifugal pump operation • Analyze the impact of suction pressure, discharge pressure, and flow rate • Identify cavitation conditions and propose solutions								**CO1**
3. Heat Exchanger Analysis • Simulate a Shell & Tube Heat Exchanger • Vary hot and cold stream flow rates and observe temperature changes • Compare performance with plate heat exchangers 4. Cooling Tower Simulation • Create a model for an industrial cooling tower • Set inlet and outlet water temperatures • Analyze evaporation losses, cooling efficiency, and blowdown rate								**CO2**
5. Distillation Column for Separation of Ethanol-Water Mixture • Design a binary distillation column • Set feed composition, reflux ratio, number of trays • Observe changes in product purity with varying operating conditions								**CO3**

6. DM (Deionized) Water Plant Simulation • Model an ion-exchange process for demineralization • Set up cation and anion exchange resins • Compare performance at different flow rates and regeneration cycles	
7. Process Flow Simulation of a Simple Chemical Plant • Simulate a small-scale petroleum refining or fertilizer plant • Include reactors, separators, heat exchangers, pumps, and storage tanks • Observe the effect of feed rate and operating conditions on efficiency 8. Batch Reactor Performance Study • Set up a batch reactor for a simple reaction (e.g., saponification of NaOH & ethyl acetate) • Analyze the effect of temperature, catalyst concentration, and residence time • Compare conversion rates for isothermal vs. non-isothermal conditions	**CO4**
9. Steam Generation & Boiler Efficiency Analysis • Simulate a boiler system • Calculate steam generation rate, fuel consumption, and efficiency • Analyze energy losses and propose improvements 10. Process Control Simulation • Set up a PID controller for temperature/pressure control • Implement feedback control for a distillation column or reactor • Observe process stability under different disturbances	**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1. DWSIM open-source software
2. Lab Manual, Department of Chemical Engineering, Pondicherry Engineering College, Puducherry, 2018

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	1	1	1	2	2	1	3	2	1
CO2	3	3	3	3	3	2	2	1	2	3	2	3	3	2
CO3	3	3	3	3	3	2	2	2	2	3	2	3	3	3
CO4	3	3	3	3	2	2	2	1	2	3	2	3	3	2
CO5	3	3	3	3	3	3	2	1	2	3	2	3	3	2

Score: 3 – High; 2 – Medium; 1 – Low

Department :Chemical engineering			Programme: **B.Tech.**						
Semester : **Fifth**			Course Category Code: PCC			Semester Exam Type: TY			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC115	**Mass Transfer Operations**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the concepts absorption to column process design (Understand & Apply – L2 & L3)							
	CO2	Analyze various distillation design methods (Analyze – L4)							
	CO3	Understand and Analyze extraction and leaching operations (Understand & Analyze – L2& L3)							
	CO4	Evaluate and Analyze various simultaneous heat and mass transfer equipment's (Evaluate – L5)							
	CO5	Understand, Evaluate and Analyze adsorption phenomena and adsorption columns (Evaluate – L5)							
UNIT-I	**Absorption**					**Periods: 12**			
Gas Absorption - Tray tower absorber, absorption factor, calculation number of theoretical stages, Packed tower absorber - HETP, HTU and NTU, absorption with chemical reaction.									**CO1**
UNIT-II	**Distillation**					**Periods: 12**			
Calculation of number of ideal stages by McCabe-Thiele method, Ponchan - Savarit method, Total reflux, minimum reflux ratio, optimum reflux ratio.									**CO2**
UNIT-III	**Extraction and Leaching**					**Periods: 12**			
Liquid - liquid extraction, stage wise contact - cross current and counter current extraction, continuous contact extraction, packed bed extraction with reflux. Leaching - multi stage continuous cross current and counter current leaching, stage calculations, stage efficiency.									**CO3**
UNIT-IV	**Simultaneous heat and mass transfer**					**Periods: 12**			
Humidification operations - cooling towers and spray chambers. Theory and calculation of humidification processes - gas liquid interaction, conditions in the top and bottom of cooling towers, design of cooling towers and dehumidifiers. Drying – Drying time calculations- cross-circulation drying, through circulation drying. Continuous drying - material and energy balances in continuous dryers, rotary dryer - design of rotary dryer. Crystallization-Principles of crystallization, mass balance, heat balance, MSMPR Crystallizer.									**CO4**
UNIT-V	**Adsorption**					**Periods: 12**			
Adsorption operation – stage wise operations, steady state moving bed absorbers, unsteady state fixed bed adsorbers, break through curves, rate of adsorption in fixed beds, design of fixed bed adsorbers.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1. R.E. Treybal, Mass Transfer Operations, McGraw Hill, 3rd Edition, 1981.
2. Binay K Dutta, Principles of Mass Transfer and Separation Process, PHI learning private limited, 2007.
3. C.J.Geankoplis, Transport Processes and Unit Operations, Prentice Hall, 4th Edition, 2003.
4. Badger and Banchero, Introduction to Chemical Engineering, Tata McGraw Hill, 2006.
5. Coulson J.M and Richerdson J.F, Chemical Engineering - Volume 2, Elsevier Press, V Edition, 2006.
6. W.L.McCabe, J.C.Smith and P.Harriot, Unit Operations of Chemical Engineers, McGraw Hill International Edition, 7th Edition, 2009.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO2	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	1	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fifth**			Course Category Code: PCC			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC116	**Chemical Reaction Engineering -II**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and Analyze factors effecting Non-isothermal reactions (Understand & Apply – L2 & L4)							
	CO2	Analyze RTD studies of various non-ideal reactors (Analyze – L4)							
	CO3	Apply the material balance to analyse Fluid-solid non-catalytic reactions (Apply & Analyze– L3&L4)							
	CO4	Evaluate and compare various models that describe Gas-liquid non-catalytic reactions (Evaluate – L5)							
	CO5	Evaluate and compare the rates, effectiveness factors of solid catalysed reactions (Evaluate – L5)							
UNIT-I	Non-isothermal reactions					**Periods: 12**			
Non-isothermal reactions - temperature effects on chemical reaction rates, design procedures for adiabatic and non-isothermal operation of batch and flow reactors, optimum temperature progression, operating temperature for favourable product distribution in multiple reactions.									**CO1**
UNIT-II	Non-ideal reactors					**Periods: 12**			
Non-ideal reactors - Reasons for non-ideal flow behaviours, concept of mixing - micro and macro mixing, residence time distribution (RTD) functions, C, E and F curves, calculation of mean residence time from E and F curves, Tanks in series models, Axial dispersion model, segregated flow model, conversion in non-ideal reactors, introduction to multi-parameter models.									**CO2**
UNIT-III	Fluid-solid non-catalytic reactions					**Periods: 12**			
Fluid-solid non-catalytic reactions - shrinking core model, determination of the rate controlling step, conversion in reactors with constant fluid composition, fixed bed reactor, Conveyor type /Tubular reactors.									**CO3**
UNIT-IV	Gas-liquid non-catalytic reactions					**Periods: 12**			
Gas-liquid non-catalytic reactions - models for transfer at gas-liquid interface, enhancement factor, Hatta number, Derivation of overall rate equation for first order irreversible reaction and instantaneous reaction.									**CO4**
UNIT-V						**Periods: 12**			
Kinetics of solid catalysed reactions - Langmuir-Hinshelwood-Hougen-Watson mechanism, Reaction and diffusion in porous catalysts - effectiveness factor, Thiele modulus.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley Sons Ltd., 3rd Edition, 2007.
2. J.M.Smith, Chemical Engineering Kinetics, McGraw Hill, 3rd Edition, 1981.
3. H.S.Fogler, Elements of Chemical Reaction Engineering, PHI learning private limited, 4thEdition, 2012.
4. S.Sundaramurthy, S Suresh, Green Chemical Engineering: An Introduction to Catalysis, Kinetics, and Chemical Processes, CRC press, Taylor and Francis group,2014
5. G.F.Froment and K.B.Bischoff, Chemical Reactor Analysis and Design, John Wiley and Sons, 3ndEdition 2011.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO2	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	1	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fifth**			Course Category Code: **PCC**			Semester Exam Type: TY			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC117	**Process Equipment Design**		3	-	-	3	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Apply the principles of heat transfer to design equipment's like heat exchangers, condensers and evaporators (Level 3 - Application)							
	CO2	Apply the principles of mass transfer to design equipment's like for absorption towers, distillation columns, dryers, and cooling towers. (Level 3 - Application)							
	CO3	Analyze (Level 4) the mechanical design aspects of reactors, storage tanks, and tall columns. (Level 4 - Analysis)							
	CO4	Evaluate the performance and efficiency of heat transfer and mass transfer equipment. (Level 5 – Evaluate)							
	CO5	Develop the practice of using standard design codes and practices. (Level 3 – Develop)							
UNIT-I	Heat Exchangers					**Periods: 12**			
Process Design of Heat Exchangers- Double Pipe and Shell and Tube Condensers – Vertical and Horizontal									**CO1**
UNIT-II	Evaporators					**Periods: 12**			
Process Design of Evaporators – Multiple Effect – Forward feed and Backward feed (with and without boiling point rise									**CO2**
UNIT-III	Absorber					**Periods: 12**			
Process Design of Packed Bed and Plate Type Absorption Towers									**CO3**
UNIT-IV	Distillation					**Periods: 12**			
Process Design of Packed Bed and Plate Type Distillation columns									**CO4**
UNIT-V	**Dryer and Cooling tower**					**Periods: 12**			
Process Design of the following equipments: Rotary Drier, Cooling Tower Mechanical Design of Reactors, Storage Tanks and Tall Columns									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1. S.B.Thakore and BI Bhatt, Introduction to Process Engineering and Design, McGraw-Hill Education (India) Private Limited, 2013.
2. Kern D.Q, Process Heat Transfer, McGraw Hill, 1950.
3. J.M.Coulson and J.F.Richardson, Chemical Engineering - Volume VI, Elsevier Press, 6thEdition, 2006.
4. R.H.Perry and Don Green, Chemical Engineer's Handbook, McGraw Hill, 8th Edition, 2009.
5. R.E. Treybal, Mass Transfer Operations, McGraw Hill, II Edition, 1981.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	1	1	2	1	2	3	2	1
CO2	3	3	2	3	3	2	1	1	2	2	3	3	3	2
CO3	3	3	2	3	3	3	1	1	2	2	3	3	3	2
CO4	3	3	3	3	3	3	1	1	2	3	3	3	3	3
CO5	3	2	2	2	3	2	1	1	2	2	2	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department: **Humanities & Social Sciences**		Programme: **B.Tech.**						
Semester : **Fifth**		Course Category Code: AEC				Semester Exam Type: **TY**		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
HSUA105	**Industrial Economics and Management**	2	-	-	2	40	60	100
Pre-requisite	**Nil**							
Course Outcome	**CO1**	Demonstrate economic theories, revenue and cost concepts and set of analytical techniques applied to a variety of economic (and non-economic) and financial management issues.						
	CO2	Implement various management techniques based on the needs						
	CO3	Apply financial planning and Interpret company's income statements and balance sheets to ascertain the financial position of a company.						
	CO4	Apply production planning, project scheduling and financial analysis to economic investment and project management problems.						
	CO5	Understand fundamental marketing concepts, apply them to real-world scenarios, and develop effective marketing strategies.						

UNIT-I	**Micro and Macro Economics and its Applications**	**Periods:6**
Nature and Scope of Economic science – Micro Economics: Economic decisions and Technical decisions, Demand and Supply concepts, Market Equilibrium, Elasticity of Demand, Various concepts of Cost – Break Even Analysis – Market structure. Macro Economics: Measures of National Income – Inflation – Business Cycle.		**CO1**
UNIT-II	**Management Techniques**	**Periods:6**
Introduction to Management – Functions of Management – F.W.Taylor's Scientific Management – Henry Fayol's Principles of Management. Forms of Business Organization, and Types of (Ownership) of a firm.		**CO2**
UNIT-III	**Industrial Finance**	**Periods:6**
Need for Finance –Types of finance – Sources of finance. Final Accounts - Preparation of Trading, Profit and loss Account and Balance Sheet.		**CO3**
UNIT-IV	**Production Management**	**Periods:6**
Types of Production system – Production Planning and control: Planning, Routing, Scheduling, Inspection and Dispatches. Concepts of Productivity – Measurement of Productivity.		**CO4**
UNIT-V	**Marketing Management**	**Periods:6**
Core Concepts of Marketing – Marketing Vs Selling – Channels of Distribution – Promotion Vs. Advertising – Market Research Vs Marketing Research.		**CO5**

Lecture Periods: 30	**Tutorial Periods:** –	**Practical Periods:** –	**Total Periods: 30**

Reference Books

1. Varshney Maheswari, Managerial Economics, S Chand & Co, New Delhi, 2011.
2. Dutt & Sundaram, Indian Economy, S Chand & Co, New Delhi, 2015.
3. Pandey I.M, Elements of Financial Management Wiley Eastern Ltd, New Delhi, 2015.
4. H.L. Ahuja, Macro Economics for Business and Management, S Chand & Company Ltd, 2011.
5. O.P Khanna, Industrial Engineering and Management, Dhanpat Rai and Sons, 2009.
6. Philip B Kotler, Marketing Management, Mac Millan, NewYork, 2011.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1		1				3					2
CO2										3	2
CO3		1								3	2
CO4										3	2
CO5										3	2

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**		Programme: **B.Tech.**						
Semester : **Fifth**		Course Category Code: **PCC**				Semester Exam Type: **Lab**		
Course Code	**Couse Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUC118	**Process Equipment Design Lab**	3	-	-	1.5	40	60	100
Prerequisite:								

Course Outcome	**CO1**	Apply computational tools like GNU-OCTAVE, Matlab, or Scilab for the design and simulation of heat exchangers and condensers. (Level 3 - Application)
	CO2	Analyze the performance of multiple effect evaporators with and without boiling point rise using computational methods. (Level 4 - Analysis)
	CO3	Simulate and compare packed bed and plate type absorbers for chemical processes using software tools. (Level 4 - Analysis)
	CO4	Evaluate the performance of cooling towers and rotary dryers using computer-aided simulations. (Level 5 - Evaluation)
	CO5	Apply mechanical design principles to reactors, tall columns, and storage vessels through simulations. (Level 3 - Application)

	Periods:	
Computer Aided Design and Simulation of Heat Exchangers and Condensers using GNU-OCTAVE/Matlab/Scilab Computer Aided Design and Simulation of Multiple effect evaporators without boiling point rise using GNU-OCTAVE//Matlab/Scilab Computer Aided Design and Simulation of Multiple effect evaporators with boiling point rise using GNU-OCTAVE/Matlab/Scilab Computer Aided Design and Simulation of Packed Bed and Plate Type Absorbers using GNU-OCTAVE/Matlab/Scilab Computer Aided Design and Simulation of Cooling tower and Rotary drier using GNU-OCTAVE/ Matlab/Scilab Computer Aided Design and Simulation of mechanical design of equipments like reactors, tall columns and storage vessels using GNU-OCTAVE/ Matlab/Scilab		**CO1, CO2, CO3, CO4, CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

3. S.B.Thakore and BI Bhatt, Introduction to Process Engineering and Design, McGraw-Hill Education (India) Private Limited, 2013.
4. Kern D.Q, Process Heat Transfer, McGraw Hill, 1950.
5. J.M.Coulson and J.F.Richardson, Chemical Engineering - Volume VI, Elsevier Press, 6thEdition, 2006.
6. R.H.Perry and Don Green, Chemical Engineer's Handbook, McGraw Hill, 8th Edition, 2009.
7. R.E. Treybal, Mass Transfer Operations, McGraw Hill, II Edition, 1981.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	1	1	2	2	2	3	2	1
CO2	3	3	3	3	3	2	1	1	2	2	2	3	3	2
CO3	3	3	2	3	3	2	1	1	2	2	3	3	3	2
CO4	3	3	2	3	3	2	1	1	2	2	3	3	3	2
CO5	3	3	2	3	3	2	1	1	2	2	3	3	3	2

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fifth**			Course Category Code: **PCC**			Semester Exam Type: **Lab**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC119	**Chemical Reaction Engineering Lab**		3	-	-	1.5	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the fundamental principles of kinetics. (Understand &Apply – L2 & L3)							
	CO2	Analyse reactors performances using reactions. (Analyze – L4)							
	CO3	Apply basic principles to analyse reactors. (Apply – L3)							
	CO4	Evaluate and compare the performance of different reactors. (Evaluate – L5)							
	CO5	Assess the performance of reactors. (Evaluate – L5)							
UNIT-I						**Periods:**			
1. Batch Reactor I– Determination of order and reaction rate constant 2. Batch Reactor I– Determination of order and reaction rate constant 3. Semi Batch Reactor- Determination of conversion and reaction rate constant 4. CSTR- Determination of Conversion and reaction rate constant 5. PFR- Determination of conversion and reaction rate constant; 6. PFR and CSTR in series - Comparison of conversion 7. CSTR's in Series - Comparison of conversion 8. Determination of Activation Energy 9. Residence Time Distribution Studies in CSTR 10. Kinetics of Heterogeneous Catalytic Reaction									**CO1, CO2, CO3, CO4, CO5**
Lecture Periods:		**Tutorial Periods:**			**Practical Periods:**			**Total Periods:**	
Reference Books:									
8. Lab Manual, Department of Chemical Engineering, Puducherry Technological University, Puducherry, 2025.									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO2	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO3	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO4	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO5	3	2	1	1	3	-	-	1	1	1	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical engineering**			Programme: **B.Tech.**						
Semester : **Sixth**			Course Category Code: **PCC**			Semester Exam Type: TY			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC120	**Computational Methods for Chemical Engineers**		3	-	-	3	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply matrix methods to chemical engineering (Understand & Apply – L2 & L3)							
	CO2	Understand and analyze techniques employed in dealing non -linear algebraic equations (Understand & Analyze – L2& L4)							
	CO3	Apply Numerical integration and interpolation in chemical engineering problems (Apply – L3)							
	CO4	Evaluate and compare various ODE techniques in chemical engineering (Evaluate – L5)							
	CO5	Understand and apply various PDE techniques in chemical engineering (Understand & Apply – L2 & L3)							
UNIT-I	Solutions to linear algebraic Equations					**Periods: 12**			
Solutions to linear algebraic Equations : Gauss Elimination iterative methods (Jacobi, Gauss-Seidel), Tri diagonal matrices and Thomas algorithm, Polynomial regression and least square.									**CO1**
UNIT-II	Solutions of non -linear algebraic equations					**Periods: 12**			
Solutions of non -linear algebraic equations: Bisection methods, direct substitution (fixed point) method, Picard's methods, Regula-Falsi Method, Wegstein Method, Newton-Raphson method, system of non-linear equation.									**CO2**
UNIT-III	Numerical integration and interpolation					**Periods: 12**			
Numerical integration and interpolation: Trapezoidal Rule, Simpson 1/3 rule, Linear interpolation, quadratic and cubic Spline interpolation.									**CO3**
UNIT-IV	Ordinary differential equations					**Periods: 12**			
Solution of ordinary differential equations (Initial value problems) : Explicit Euler method, implicit Euler method, predictor- corrector method, Runge- Kutta method (2^{nd} order and 4^{th} order), system of ODEs, stiffness.									**CO4**
UNIT-V	Partial differential equations					**Periods: 12**			
Types of partial differential equations, method of lines, simple case studies.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1.Numerical methods with Chemical Engineering Applications, K.D. Dorfmam, P.Daoutidis, Cambridge University Press, 2017.

2.Introduction to Chemical Engineering Computing, B.A.Finlayson, Wiley India 2010

3.Computational Methods in Chemical Engineering, O.T. Hanna, O.C. Sandall, Prentice Hall 1995.

4.S.K.Guptha, Numerical methods for engineers,4^{th} edition,New Age interational publication,2019.

5.P.Ahuja, introduction to numerical methods in chemical engineering,1^{st} edition,PHI,2019.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO2	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO3	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO4	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO5	3	2	1	1	3	-	-	1	1	1	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department :**Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Sixth**			Course Category Code: **PCC**			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC121	**Process Dynamics and Control**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the concepts of mathematics to process control systems (Understand & Apply – L2 & L3)							
	CO2	Understand and analyze Dynamic behaviour of systems chemical systems (Understand &Apply – L2 & L3)							
	CO3	Understand and analyze Dynamic behaviour of systems chemical systems (Understand &Apply – L2 & L3)							
	CO4	Apply stability techniques to assess process control systems (Apply – L3)							
	CO5	Evaluate process control systems using frequency response technique (Evaluate – L5)							
UNIT-I	**Basics of process contol**					**Periods:**			
Introduction - Control system, components of a feed back control system, Lags in the control system – transfer lag, transportation lag, Pneumatic PID controller, control valve, valve characteristics. Laplace transforms - properties of Laplace transform, solution of linear differential equations using Laplace transform techniques.									**CO**
UNIT-II	Dynamic behaviour of systems					**Periods:**			
Dynamic behaviour of systems - derivation of transfer functions for first and second order systems, liquid level, temperature, pressure, flow and concentration control processes, linearization of nonlinear systems, interacting and non-interacting systems.									**CO**
UNIT-III	Transient response of closed loop control systems					**Periods:**			
Transient response of first and second order systems, natural frequency, damping factor, overshoot, decay ratio, rise time and settling time. Transient analysis of control systems - block diagram algebra, overall transfer function of closed loop control systems, regulator and servo problems, transient response of first and second order systems with P, PI and PID controller.									**CO**
UNIT-IV	Stability of control systems					**Periods:**			
Definition of stability of control systems, Routh test , limitations of Routh test, Pade's approximation of time delay systems. Root-locus technique - rules for plotting the root locus diagram, application of root locus to control systems.									**CO**
UNIT-V	Introduction to frequency response					**Periods:**			
Introduction to frequency response - Bode diagrams, Bode diagrams for first and second order systems, P, PI, PID controllers, transportation lag. Bode stability criteria, phase margin and gain margin,									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1. D.R. Coughanour, Process Systems analysis and Control, McGraw Hill Education (India), 3rdEdition, 2013.
2. Stephanopoulos, Chemical Process Control – Theory and Practice, Pearson education, 2018.
3. B.Wayne Bequette, Process Control Modelling, Design and Simulation, Pearson education , 2018.
4. D.W.Seborg, T.F.Edger, and D.A.Millichamp, Process Dynamics and Control, John Wiley and Sons,4nd Edition, 2021.
5. Thomas E. Marlin, Process Control Designing Processes and Control Systems for Dynamic Performance, TATA McGraw-Hill, 2nd Edition, 2012.
6. Peter Harriot, Process Control, Tata McGraw Hill Publishing Co., 1964.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO2	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	1	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Sixth**			Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC122	**Pollution Control in Process Industry**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand the basic concepts of pollution, pollution control and to identify sources, techniques and monitoring of air pollution. (Understand – L2)							
	CO2	Understand and Assess the degree of treatment required for waste water by analysis its characteristics. (Understand & Apply – L2 & L3)							
	CO3	Understand the sources of solid wastes and to manage them. (Understand – L2)							
	CO4	Analyze the concepts involved in control techniques of noise pollution and to give in-depth information about laws, policies and acts related to environmental system. (Analyze – L4)							
	CO5	Evaluate various industries with respective to their pollution emissions (Evaluate – L5)							
UNIT-I	**Introduction to air pollution**					**Periods:**			**CO**
Man and Environment, Types of pollution, Pollution control aspects, Pollution monitoring and analysis of pollutant. Air pollution: Sources and effects, particulate control, control of gaseous pollutants (SOx, NOx, oxides of carbon, hydrocarbon pollutants), Air Quality Management, Carbon Trading.									**CO**
UNIT-II	**Water pollution**					**Periods:**			
Types of water pollution, sources, water pollution control. Waste water treatment technologies and Recycle.									**CO**
UNIT-III	**Solid waste management**					**Periods:**			
Sources, processing methods, waste disposal methods, energy recovery from solid waste and land pollution									**CO**
UNIT-IV	**Noise Pollution**					**Periods:**			
Hazardous noise exposure, noise measuring instruments and noise pollution control technology. Regulations: ISO 14000, 9000, pollution Acts and Regulations.									**CO**
UNIT-V	**Case studies**					**Periods:**			
Pollution (Air, Water & Solid) control in the following process industries - Fertilizers, Petroleum Refinery and Petrochemical, Pulp and Paper, Cane Sugar, Tannery, Distilleries and Pharmaceutical Industry .									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. S.C. Bhatia, Environmental Pollution and control in chemical process Industries, Khanna Publishers, 1st edition, 2001
2. C.S.Rao, Environmental Pollution Control Engineering, Wiley Eastern, 1992.
3. S.P.Mahajan, Pollution control in Process Industries, Tata McGraw Hill, 1990.
4. F. P. Lees, Loss prevention in process industries, 2nd edition., Butter worth- Heinemann, 1996.
5. Martin Crawford, Pollution Control Theory, McGraw Hill, 1976.
6. Marell, Solid Wastes, John Wiley, 1975.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO2	3	3	3	3	2	2	3	2	1	1	2	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	1	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	1	2	2	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department : Chemical Engineering			Programme: **B.Tech.**						
Semester : **Sixth**			Course Category Code: PCC				Semester Exam Type: TY		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC123	**Chemical Engineering Computational Lab**		-	-	3	1.5	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply the fundamental principles of heat transfer, including conduction, convection, and radiation, to analyze heat transfer systems. (Understand & Apply – L2 & L3)							
	CO2	Analyze heat transfer mechanisms in different engineering applications and evaluate the influence of material properties, boundary conditions, and phase change on heat transfer rates. (Analyze – L4)							
	CO3	Apply heat transfer correlations and dimensionless numbers to solve practical problems involving fluid flow, heat exchangers, and industrial heat transfer equipment. (Apply – L3)							
	CO4	Evaluate and compare the performance of different heat transfer equipment, such as heat exchangers and evaporators, using empirical methods. (Evaluate – L5)							
	CO5	Assess the impact of insulation, extended surfaces, and phase change processes on heat transfer efficiency and performance in industrial applications. (Evaluate – L5)							
UNIT-I						**Periods:**			
1.Calculation of vapour pressure and latent heat using Antoine's equation 2.Calculation of specific heat and enthalpy 3.Reading data from steam table									**CO1**
UNIT-II						**Periods:**			
1.Solve Material Balance of process flow sheets 2.Fit Mass transfer, heat transfer and friction factor correlations 3.Interstage Composition in multistage absorption column 4.Balanced chemical reaction equations									**CO**
UNIT-III						**Periods:**			
1.Calculate boiling point at given pressure 2.Bubble point and dew point calculations 3.Flash calculation 4.Calculation of equilibrium conversion and selectivity of multiple reactions									**CO**
UNIT-IV						**Periods:**			
1.Compute concentration in a batch reactor 2.Obtain dynamic response of a liquid level process 3.Obtain dynamic response of a CSTR. 4.Concentration profile in a PFR 5.Compute temperature profile in steady state heat conduction									**CO**
UNIT-V						**Periods:**			
1.Compute Final composition in simple distillation 2.NTU in a Packed bed absorber 3.Mean specific heat over a temperature range 4.Interpolate VLE data 5.Calculate mean residence time and variance from tracer test									**CO**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									

1K.D. Dorfman, P.Daoutidis ,Numerical methods with Chemical Engineering Applications, , Cambridge University Press, 2017.
2.B.A.Finlayson ,Introduction to Chemical Engineering Computing, , Wiley India 2010
3.O.T. Hanna, O.C. Sandall, Computational Methods in Chemical Engineering, Prentice Hall 1995.
4.S.K.Guptha, Numerical methods for engineers,4th edition,New Age interational publication,2019.
5.P.Ahuja, introduction to numerical methods in chemical engineering,1st edition,PHI,2019.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO2	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO3	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO4	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO5	3	2	1	1	3	-	-	1	1	1	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Sixth**			Course Category Code: PCC				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC124	**Process Dynamics and Control Lab**		-	-	3	1.5	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Applying control principles for determining time constant of various systems (Apply – L3)							
	CO2	Understand and analyse transient response of various systems (Understand – L2)							
	CO3	Applying control strategies for the Online control of temperature and level controllers (Apply – L3)							
	CO4	Evaluate process control systems using modern tools (Evaluate – L5)							
						Periods:			
1. Time constant of thermometer 2. Time constant of pressure vessel system 3. Two-Tank non interacting system 4. Two -Tank interacting system									**CO1**
UNIT-II						**Periods:**			
5. Transient response of a mercury manometer 6. Transient response of a mixing vessel									**CO2**
UNIT-III						**Periods:**			
7. Control valve characteristics 8. On –Off Control system behaviour 9. Level controller 10. Temperature controller									**CO3**
UNIT-IV						**Periods:**			
11. CSTR dynamic modelling using modern tools 12.									**CO4**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									
1. Lab manual, Department of chemical engineering,2018									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO2	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO3	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO4	3	2	1	1	3	-	-	1	1	1	3	3	2	2
CO5	3	2	1	1	3	-	-	1	1	1	3	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Sixth**			Course Category Code: PCC				Semester Exam Type: -		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC125	**Internship**					2	100		100
Prerequisite:									
Course Outcome: At the end of the course the student will be able to	**CO1**	Apply theoretical knowledge gained during coursework to real-world projects and tasks.							
	CO2	Develop soft skills such as communication, teamwork, problem-solving, and time management.							
	CO3	Demonstrate proficiency in relevant industry technologies or platforms.							
	CO4	Handle the demands and challenges of a professional setting							
The student is required to undergo 'internship' in industry / research laboratory / higher learning institution for a period of at least 4 weeks in a maximum of 2 spells during vacations. Each spell of internship shall be for a period of not less than 2 weeks. The main purpose of internship is to enhance the general professional outlook and capability of the student to advance his chances of improving the career opportunities. The student should get prior approval from the Head of the Department before undertaking the internship and submit a detailed report after completion for the purpose of assessment. A departmental committee shall evaluate the performance of the students.									CO1, CO2, CO3, CO4

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO2	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO3	3	3	3	3	3	2	-	3	3	3	3	3	2	1
CO4	3	3	3	3	3	2	-	3	3	3	3	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical engineering**		Programme: **B.Tech.**						
Semester : S**eventh**		Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUC126	**Transport phenomena**	3	1	-	4	40	60	100
Prerequisite:								

Course Outcome		
	CO1	Understand and apply the momentum transport phenomena and perform calculations using shell balance for different momentum flow geometries (Understand & Apply – L2 & L3)
	CO2	Understand and Analyze the equation of continuity and equation of motion in different coordinate systems (Understand &Analyze – L2 & L4)
	CO3	Apply the principles of heat transfer and perform calculations using shell balance for different heat flow geometries (Apply – L3)
	CO4	Evaluate and compare the profiles of velocity, temperature and concentration using the equations of change (Evaluate – L5)
	CO5	Assess the transport of mass and perform calculations using shell balance with and without chemical reaction (Evaluate – L5)

UNIT-I	**Momentum Transfer**	**Periods: 12**
Viscosity, temperature effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport, Velocity distribution in laminar flow- shell momentum balance-flow through tubes-surfaces-flow of Newtonian fluid.		**CO1**
UNIT-II	**Equation of change**	**Periods: 12**
Equation of change for isothermal process – one dimensional equation of motion and continuity – Euler and Navier Stokes equation, Simple application		**CO2**
UNIT-III	**Heat Transfer**	**Periods: 12**
Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport, shell energy balance, temperature distribution in solids and laminar flow with electrical, nuclear, viscous heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.		**CO3**
UNIT-IV	**Equation of energy**	**Periods: 12**
Energy equations, special forms, use of equations of change		**CO4**
UNIT-V	**Mass transfer**	**Periods: 12**
Diffusivity, temperature and pressure effect, Fick's law, mechanism of mass transport, theory of diffusion in gases and liquids, shell mass balances, concentration distribution in solids and in laminar flow: Stagnant gas film, heterogeneous and homogeneous chemical reaction systems.		**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1.R.B.Bird, W.E.Stewart and E.N.Lightfoot, Transport Phenomena, John Wiley and Sons, 2nd Edition, 2003.

2.Willim Thomas, Introduction to Transport phenomena, Pearson Education, 1st Edition, 2000.

3.R.S.Brodkey and H.C. Herskey, Transport Phenomena, McGraw Hill, 1988.

4.J.R.Welty, C.E.Wicks, R.E.Wilson and Roggers , Fundamentals of Momentum, Heat and Mass transfer, John Wiley and Sons, 5th Edition, 2007.

5.Willim Deen, Analysis of Transport Phenomena, Oxford University Press, 2nd Edition, 2007

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	1	3	2	2	3	3	3
CO2	3	3	1	1	3	1	1	1	3	2	3	3	3	2
CO3	3	3	1	3	3	1	1	2	3	2	3	3	2	2
CO4	3	3	1	2	3	3	1	2	2	2	3	3	2	2
CO5	3	3	1	2	3	2	1	2	2	2	2	3	2	2

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical engineering**		Programme: **B.Tech.**						
Semester : **Seventh**		Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUC127	**Process Engineering Economics**	3	1	-	4	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Apply the concept of time value of money and evaluate the financial implications of bonds and investment decisions. (Level 3 - Application)						
	CO2	Analyze and compare different methods of depreciation and amortization for effective tax planning and financial management. (Level 4 - Analysis)						
	CO3	Evaluate and select the most economical alternatives using appropriate economic criteria like annual cost, present worth, and rate of return. (Level 5 - Evaluation)						
	CO4	Develop cost estimation models and perform financial analysis for project evaluation using PERT and CPM techniques. (Level 4 - Analysis)						
	CO5	Optimize operational costs using single and multi-variable optimization techniques and perform break-even analysis for process systems. (Level 5 - Evaluation)						
UNIT-I	**Time value of money**				**Periods: 12**			
Time value of money - simple and compound interest - discrete, nominal and continuous rate of return and their relationships, issue and evaluation of bonds, concept of equivalence.								**CO1**
UNIT-II	**Depreciation and amortization**				**Periods: 12**			
Depreciation and Amortization - classification of depreciation and methods of uniform, rapid and slow write off techniques and their comparison, depreciation accounting procedures, taxes and insurance, implication of taxes in selecting alternates								**CO2**
UNIT-III	**Economics of selection of alternates**				**Periods: 12**			
Economics of selection of alternates - criteria, annual cost, present worth, rate of return, capitalized cost methods, extra investment analysis, mutually exclusive basis, replacement economy.								**CO3**
UNIT-IV	**Cost estimation and bookkeeping**				**Periods: 12**			
Cost estimation - equipment costs, cost indices, William's point sixth rule, methods of estimation of fixed capital, product cost estimation. Bookkeeping - ledgers and journals, financial statements, balance sheet, principles and application of project execution techniques, PERT and CPM, preparation of project feasibility reports, selection of plant location and layout.								**CO4**
UNIT-V	**Optimization**				**Periods: 12**			
Optimization - procedure involving single and two variables, optimum number of units required for maximum profit and minimum cost, determination of optimum parameters in selected unit operations - fluid flow (optimum pipe diameter), heat transfer (optimum thickness of insulation), evaporation, filtration, break-even analysis.								**CO5**
Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**			**Total Periods:**			
Reference Books:								

1. Max S. Peters, Klaus D Timmerhaus and Ronald E. West, Plant Design and Economics for Chemical Engineers, McGraw Hill (Indian Edition), 5th Edition 2013.
2. Jelen's, Cost and Optimization Engineering, McGraw Hill, 2nd Edition, 1992.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	2	1	1	1	2	1	3	2	1
CO2	3	3	2	2	2	3	2	1	1	2	2	3	3	2
CO3	3	3	3	3	3	3	2	2	2	3	2	3	3	3
CO4	3	3	3	3	3	3	2	1	2	3	2	3	3	2
CO5	3	3	3	3	3	3	2	2	2	3	3	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical engineering**			Programme: **B.Tech.**						
Semester : S**eventh**			Course Category Code: **PCC**			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC128	**Bioprocess Engineering**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand basics of bioprocess engineering (Understand– L2)							
	CO2	Understand various types of enzymes (Understand– L2)							
	CO3	Understand and compare various methabolic pathways (Understand– L2 & Evaluate – L5)							
	CO4	Understand and evaluate principles of fermentation (Understand– L2 & Evaluate – L5)							
	CO5	Understand and evaluate Traditional Industrial Bioprocess (Understand– L2 & Evaluate – L5)							
UNIT-I	**Introduction to bioprocess engineer**					**Periods: 12**			
Introduction to bioprocess engineer, story of Penicillin, regulatory constraints of bioprocess engineering, microbial diversity, biomolecules, Recombinant DNA technology, Cell Mutation.									**CO1**
UNIT-II	**Enzymes**					**Periods: 12**			
Enzymes: Introduction, types, industrially and medically important enzymes, Enzyme kinetics for SSSE system, Methods of Enzyme Immobilisation.									**CO2**
UNIT-III	**Metabolic Pathways**					**Periods: 12**			
Metabolic Pathways: Bioenergetics , glucose metabolism, glucolysis, TCA cycle, Respiration, Anaerobic Metabolism, Batch Cellular growth kinetics, cell growth nutrients									**CO3**
UNIT-IV	**Principles of Fermentation**					**Periods: 12**			
Principles of Fermentation: types of industrial fermentation, fermentation media, sterilization, inoculums development, instrumentation and control of Fermentor, bioreactor types, downstream processing.									**CO4**
UNIT-V	**Traditional Industrial Bioprocess**					**Periods: 12**			
Traditional Industrial Bioprocess: Ethanol Production, Bakers Yeast production, Penicillin Production, Beer Production, wine production and cheese production.									**CO5**
Lecture Periods:		**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**		
Reference Books:									

1. Michael Shuler and F.Kargi, Bio Process Engineering Basic Concepts, PHI learning private limited,2nd Edition,2002 .
2. Biswajit Mukherjee, Bio process Engineering, Black Prints,2012.
3. Doran, Bioprocess Engineering Principles, Elsevier India private LTD,2011.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	2	1	1	1	2	1	3	2	1
CO2	3	3	2	2	2	3	2	1	1	2	2	3	3	2
CO3	3	3	3	3	3	3	2	2	2	3	2	3	3	3
CO4	3	3	3	3	3	3	2	1	2	3	2	3	3	2
CO5	3	3	3	3	3	3	2	2	2	3	3	3	3	3

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical engineering**			Programme: **B.Tech.**						
Semester : **Seventh**			Course Category Code:				Semester Exam Type: -		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC129	**Mini Project**				4	2	100		100
Prerequisite:									
Course Outcome: At the end of the course the student will be able to	CO1	Carry out literature survey, understand state of art techniques.							
	CO2	Identify and apply appropriate tools to solve a problem.							
	CO3	Transform knowledge into an algorithmic/experimental process.							
	CO4	Prepare and present reports on the project work.							
The objective of this course is to enable the students to carry out the mini-project in a group. The topic shall be chosen in consultation with the Faculty coordinators. Each group of students is expected to make a detailed review of the literature, formulate the problem, carry out the mini project and prepare a report on the work done. The mini project can be a small project work or it can be a part of the work planned for the main project. The students should present the results of the work in the review committee meetings. A departmental committee shall evaluate the performance of the students.									**CO1, CO2, CO3, CO4**

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO2	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO3	3	3	3	3	3	2	-	3	3	3	3	3	2	1
CO4	3	3	3	3	3	2	-	3	3	3	3	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Seventh**			Course Category Code: PCC			Semester Exam Type: -			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUC130	**Comprehensive viva**					1	100		100
Prerequisite:									
Course Outcome: At the end of the course the student will be able to	**CO1**	Demonstrate a broad understanding of the subject area							
	CO2	Present complex concepts in an easy-to-understand way, answering questions confidently.							
	CO3	Handle unexpected and challenging questions.							
	CO4	Respond thoughtfully to feedback, and participate actively in discussions.							
Comprehensive viva is an oral examination conducted to evaluate the critical thinking, analytical abilities, and how well a student can discuss and apply concepts learned throughout their studies. A committee comprising of five faculty members will conduct the comprehensive viva examination and evaluate the students. Experts from the industry may also be included in this committee. The Head of the Department shall constitute this committee									CO1, CO2, CO3, CO4

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO2	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO3	3	3	3	3	3	2	-	3	3	3	3	3	2	1
CO4	3	3	3	3	3	2	-	3	3	3	3	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester : **Eighth**		Course Category Code: PCC				Semester Exam Type: -		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUC131	**Main Project**			16	8	60	40	100
Prerequisite:								

Course Outcome At the end of the course the student will be able to		
	CO1	Carry out literature survey, understand state of art techniques.
	CO2	Identify and apply appropriate tools to solve a problem.
	CO3	Transform knowledge into an algorithmic/experimental process.
	CO4	Prepare and present reports on the project work.

In this project work, the team would solve the problem taken up for study. Simulation studies and/or hardware development would be completed. Necessary inferences have to be drawn from the studies carried out and the same should be presented before the committee members. If the project involves intensive analytical procedure, the analysis has to be completed and suitable comparison to existing methodologies reported in literature should be done to validate the correctness as well as effectiveness of the work. Rigorous review by the committee will be carried out in the process to ascertain whether the work qualifies as a suitable project at the graduate level. Each team is expected to present their work at National/International conferences or at the students' technical symposiums. Team that has come out with novel contribution will be encouraged to publish their work in any referred journals.	**CO1, CO2, CO3, CO4**

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO2	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO3	3	3	3	3	3	2	-	3	3	3	3	3	2	1
CO4	3	3	3	3	3	2	-	3	3	3	3	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

PROGRAMME ELECTIVES

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE101	**Nuclear Technology**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand nuclear energy fundamentals (Understand-L2)							
	CO2	Evaluate nuclear reactions and radiations (Evaluate-L5)							
	CO3	Understand and apply nuclear engineering fundamentals to reactor design (Understand &Apply -L2 & L3)							
	CO4	Understand engineering aspects of power generation with nuclear reactor (Understand-L2)							
	CO5	Understand and assess safety aspects of reactors and reactive waste (Understand Evaluate-L2 &L5)							
UNIT-I	**Nuclear energy fundamentals**					**Periods: 12**			
Nuclear energy fundamentals: Atomic structure, and radio isotopes, radio activity, nuclear fission, nuclear fission reactors. History of reactor development, reactors for power production.									**CO1**
UNIT-II	**Nuclear reactions and radiations**					**Periods: 12**			
Nuclear reactions and radiations: Radio activity, interaction of alpha and beta particles, with matter, interaction of beta particles with matter, interaction of neutrons with matter, neutron cross section.									**CO2**
UNIT-III	**Nuclear reactor theory**					**Periods: 12**			
Nuclear reactor theory: The neutron cycle, critical mass, neutron diffusion, the diffusion equation, slowing down of neutrons, reactor period, transient conditions and reflectors.									**CO3**
UNIT-IV	**Nuclear Power**					**Periods: 12**			
Engineering Considerations of Nuclear Power: Extension of theory to design, design criteria, selection of materials, reactor fuel, moderator materials, coolant system, reactor control and operation, fuel preparation, reprocessing of spent fuel.									**CO4**
UNIT-V	**Environmental effects and safety**					**Periods: 12**			
Environmental effects and safety: Radiation hazards, radiation monitoring, radio waste treatment systems, reactor shielding. General principles of reactor safety, reactor protection system, reliability and risk assessment.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. Samuel Glasstone and Alexander Seasonske, Nuclear reactor engineering , 3rd Edition, CBS Publishers, USA.
2. Glenn Murphy, Elements of Nuclear Engineering, John Wiley and sons Inc.
3. K.Sriram, Basic Nuclear Engineering, Wiley eastern Ltd., 1990.
4. W.Marshall, Nuclear Power Technology, Vol. 1,2 & 3, Oxford University Press, New York, 1983.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	1
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE102	**Polymer Science and Technology**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Explain the definitions, concepts, and importance of polymers, including molecular weight, molecular weight distribution, and polymer structure. (Understand-L2)							
	CO2	Analyze various types of polymerization mechanisms and kinetics, including different types of polymers and their applications. (Analyze- L4)							
	CO3	Apply knowledge of polymerization techniques like mass, solution, emulsion, and suspension for producing specific polymer products. (Apply-L3)							
	CO4	Evaluate the processing methods for plastics, fibers, and elastomers, including molding, extrusion, casting, spinning, and vulcanization. *(Evaluate-L5)*							
	CO5	Analyze the finishing and post-treatment methods for plastics, fibers, and elastomers, such as dyeing, sizing, cross-linking, and curing. *(Analyze - L4)*							
UNIT-I	**Fundamentals of polymerisation**					**Periods: 12**			
Introduction - Definitions and concepts, polymerisation reactions, polymer structure, functionality , Characterisation of polymers.									**CO1**
UNIT-II	**Types of polymers**					**Periods: 12**			
Different types of polymers - natural and modified natural products, synthetic polymers and various types of polymerisation reactions.									**CO1**
UNIT-III	**Methods of polymerisation**					**Periods: 12**			
Methods of polymerisation - mass, solution, emulsion and suspension polymerisation processes, various polymer products and their preparations, Degradation of polymers. Equipments used									**CO2**
UNIT-IV	**Processing methods for Plastics**					**Periods: 12**			
Processing methods for Plastics - Moulding, Extrusion, Casting, Calendaring, Forming, compounding, foaming, Reinforced fibre plastics. Finishing methods for Plastics .Post treatment of plastics. Fillers, Plasticizers, antioxidants, retardants , stablizers.									**CO3**
UNIT-V	**Processing methods for fiber and elastomers**					**Periods: 12**			
Processing methods for Fibre and Elastomers – Spinning and Vulcanisation. Pre-treatment and post-treatment of elastomers: sintering, scouring, bleaching Finishing methods for fibre and Elastomers: dyeing, sizing, narcerizing, lubrication, curing, cross linking.									**CO3**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. Fred.W.Billmeyer, Text Book of Polymer Science, John Wiley and sons, 1980.
2. V.R.Gowarikar, Polymer Science, New Age International, Second Edition,2006.
3. David J. Williams, Polymer Science and Engineering, Prentice Hall, 1971.
4. Stanley Middleman, Fundamentals of Polymer Processing, McGraw Hill, 1977.
5. Herman S. Kaufman and Joseph J Falcetta, Introduction to Polymer Science and Technology, JohnWiley and sons, 1977.
6. Rakesh K. Gupta and Anil Kumar, Fundamentals of Polymers, International edition, 1998

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE103	**Petrochemical Technology**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand history, economics and energy aspects of petrochemical industry (Understand-L2)							
	CO2	Understand first generation petrochemicals (Understand-L2)							
	CO3	Understand second generation petrochemicals (Understand-L2)							
	CO4	Understand third generation petrochemicals (Understand-L2)							
	CO5	Understand miscellaneous petrochemicals (Understand-L2)							
UNIT-I	**Introduction**					**Periods: 12**			
General Introduction - History, economics and future of petrochemicals, energy crisis and petrochemical industry, sources and classification of petrochemicals.									**CO1**
UNIT-II	**First generation petrochemicals**					**Periods: 12**			
First generation petrochemicals - alkanes - C1, C2, C3, C4 petrochemicals, alkenes - C2,C3,C4 petrochemicals, alkynes - C2,C3,C4 petrochemicals, B-T-X aromatics, diene based petrochemicals.									**CO2**
UNIT-III	**Second generation petrochemicals**					**Periods: 12**			
Second generation petrochemicals - synthesis gas, methanol, formaldehyde chloromethanes, ethanol, acetaldehyde, acetic acid, acetic anhydride, isopropyl alcohol, ethylene oxide, propylene oxide, acetone, vinyl chloride, phenol, aniline and styrene.									**CO3**
UNIT-IV	**Third generation petrochemicals**					**Periods: 12**			
Third generation petrochemicals - plastics, rubbers and fibres, olefinic polymers, polyethylene, polypropylene, polyisobutylene, diene polymers - polybutadiene, neoprene, polyisoprene, SBR, synthetic fibres									**CO4**
UNIT-V	**Miscellaneous petrochemicals**					**Periods: 12**			
Miscellaneous petrochemicals - petroleum proteins, synthetic detergents, resin and rubber chemicals, explosives - TNT and RDX.									**CO5**
Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**				**Total Periods:**			

Reference Books:

1. S.Maiti, Introduction to petrochemicals, Oxford and IBH publishing Co., 1992.
2. H.Steines, Introduction to petrochemical Industry, Pergamon, 1961.
3. G.D.Hobson and W.Pohl, Modern Petroleum Technology, Applied Science Publisher,4th Edition,1975.
4. Richard Frank Goldsten and A.Lawrence Waddams, The Petroleum Chemical Industry, E & FN Spon Ltd.,1967.
5. G.T.Austin, Shreves Chemical Process Industries, 5th Edition, McGraw-Hill, 1986.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE104	**Petroleum Refinery Engineering**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand basics of refining and crude oil nature (Understand-L2)							
	CO2	Understand breakdown and rebuilding process (Understand-L2)							
	CO3	Understand various treatment processes (Understand-L2)							
	CO4	Understand various petrochemical (Understand-L2)							
UNIT-I	**Introduction**					**Periods: 12**			
Introduction – genesis, occurrence, drilling of crude oil, composition and Evaluation of crude oil. Testing of petroleum products. History of Refining.									**CO1**
UNIT-II	**Crude oil and Refining**					**Periods: 12**			
Separation: Pre-treatment of crude oil – Handling – Heating of crudes Refining of petroleum- Atmospheric and vacuum distillation–Design aspects, blending process.									**CO1**
UNIT-III	**Breakdown and Rebuilding Process**					**Periods: 12**			
Breakdown Process: Cracking, Visbreaking, Coking – types and operation Rebuilding Process: Isomerisation, Alkylation, Polymerisation, Reforming – types and operation Asphalt Technology.									**CO2**
UNIT-IV	**Treatment processes**					**Periods: 12**			
Treatment Techniques for the removal of Sulphur Compounds to improve the performance, storage and stability Product Treatment processes–various solvent treatment processes, Dewaxing , clay treatment, hydro fining.									**CO3**
UNIT-V	**Introduction to Petrochemical**					**Periods: 12**			
Introduction to Petrochemical – generation, Cracking of Naphtha and gas for the Production of ethylene, propylene, isobutylene and butadiene. Production of acetylene from methane. Extraction of aromatics..									**CO4**
Lecture Periods:		**Tutorial Periods:**	**Practical Periods:**				**Total Periods:**		
Reference Books:									

1. B.K.Bhaskara Rao, Modern Petroleum Refining processes, 5th Edition, Oxford and IBH Publishing Co.Pvt.Ltd, New Delhi,2008.
2. J.H.Harker and J.R.Backhurst,"Fuel and Energy, Academic Press Inc.(London) Ltd, 1981.
3. W.L.Nelson, Petroleum Refinery Engineering, 4th edition, McGraw Hill, New York, 1985.
4. Robert. A.Meyers, Handbook of Petroleum Refining Processes, McGraw Hill, New York, 1986.
5. G.D.Hobson and W.Phol, Modern Petroleum Technology, Applied Science Publishers, 4thedition, 1975.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE105	**Fluidization Engineering**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand various fluidization regimes (Understand-L2)							
	CO2	Understand and Evaluate various hydrodynamic parameters (Understand & Evaluate- L2 &L4)							
	CO3	Critically analyze solids mixing and segregation (Analyse-L4)							
	CO4	Understand Heat and Mass Transfer in Fluidization Systems (Understand-L2)							
	CO5	Understand various multiphase systems (Understand-L2)							
UNIT-I	**Fluidization regimes**					**Periods: 12**			
Introduction: Fluidized state, nature of hydrodynamic suspension, regimization of the fluidized state, operating models for fluidization systems									**CO1**
UNIT-II	**Hydrodynamics of Fluidisation Systems**					**Periods: 12**			
Hydrodynamics of Fluidisation Systems: General bed behaviour, pressure drop, empirical correlations for solid holdup, flow models.									**CO2**
UNIT-III	**Solid Mixing and Segregation**					**Periods: 12**			
Solid Mixing and Segregation: Degree of Segregation, operation shifts, reversal points, mixing-segregation equilibrium generalized fluidization of poly systems, liquid phase mixing and gas phase mixing									**CO3**
UNIT-IV	**Heat and Mass Transfer**					**Periods: 12**			
Heat and Mass Transfer in Fluidization Systems: Mass Transfer-Gas-liquid Mass Transfer, liquid-solid mass transfer and wall to bed mass transfer. Heat Transfer-Column wall to bed Heat Transfer.									**CO4**
UNIT-V	**Miscellaneous Systems**					**Periods: 12**			
Miscellaneous Systems: Moving bed, slurry bubble column, two phase and three phase inverse fluidized bed, typical applications.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									
1. Kunii D and Levenspiel .O, Fluidization Engineering, Elsevier Publication,2005. 2. Leva M, Fluidization, McGraw Hill Publications,1959. 3. Davidson J.F and Harrison D, Fluidization, Academic Press,1971.									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE106	**Risk and Safety Management in Process Industries**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Apply various hazard identification and risk assessment methods like PHA, HAZOP, ETA, and FTA for analyzing industrial processes. (Understand & Apply-L2 & L3)							
	CO2	Evaluate workplace hazards caused by improper housekeeping, fire incidents, and multi-floor industrial settings, and recommend safety guidelines. (Evaluate-L5)							
	CO3	Assess the risks associated with hazardous chemicals by understanding their properties, TLVs, and appropriate handling, storage, and safety methods. (Analysis-L4)							
	CO4	Analyze the industry-specific hazards in sectors like fertilizers, petrochemicals, pulp and paper, and propose methods for personnel safety and pollution control. (Analyze-L4)							
	CO5	Demonstrate knowledge of safety management systems, legal aspects, safety audits, and best practices to promote industrial safety. (Apply-L3)							
UNIT-I						**Periods: 12**			
Hazard identification methodologies, risk assessment methods - PHA, HAZOP, MCA, ETA, FTA, consequence analysis, probit analysis.									**CO1**
UNIT-II						**Periods: 12**			
Hazards in work places - nature and type of work places, types of hazards, hazards due to improper house-keeping, hazards due to fire in multi-floor industries and buildings, guidelines and safe methods in the above situations.									**CO2**
UNIT-III						**Periods: 12**			
Workers' exposures to hazardous chemicals, TLVs of chemicals, physical and chemical properties of chemicals leading to accidents like fire explosions, ingestion and inhalation, pollution in work places due to dangerous dusts, fumes and vapours, guidelines, fundamentals of pressure relief devices and safe methods in chemicals handling, storage and entry into confined spaces.									**CO3**
UNIT-IV						**Periods: 12**			
Hazards peculiar to industries like fertilizer, heavy chemicals, petroleum, pulp and paper, tanneries, dyes, paints, pesticides, glass and ceramics, dairy and sugar industries, guidelines for safeguarding personnel and safeguarding against water, land and air pollution in the above industries									**CO4**
UNIT-V						**Periods: 12**			
Safety education and training - safety management, fundamentals of safety tenets, measuring safety performance, motivating safety performance, legal aspects of industrial safety, safety audit. Process Safety and management Systems									**CO5**
Lecture Periods:		**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**		

Reference Books:

1. F. P. Lees, Loss prevention in process industries, 2nded, Butterworth-Heinemann, 1996.
2. W. Handley, Industrial safety handbook, 2nd ed., McGraw-Hill, 1977.
3. S. P. Levine, 1985, Protecting personnel at hazardous waste sites, Martin- Butterworth, 1971.
4. R. P. Blake, Industrial safety, Prentice Hall, 1953.
5. D. Patterson, Techniques of safety management, McGraw-Hill, 1978.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	1
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE107	**Energy Engineering**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand the global and Indian energy scenario and identify different forms of energy (Understand-L2)							
	CO2	Understand and identify various conventional energy resources and their applications (Understand & Apply-L2 & L3)							
	CO3	Understand and identify various Renewable energy resources ways of harnessing energy from them along with merits and demerits (Understand& Apply-L2 & L3)							
	CO4	Understand and appreciate Biomass as a source of energy and understand different methods of conversion of biomass into energy (Understand & Apply-L2 & L3)							
	CO5	Apply the basic skills required for energy auditing and to make action plans and conservation policies. (Understand & Evaluate -L2 & L5)							
UNIT-I	**Energy**					**Periods: 12**			
Introduction to energy- Global energy scene- Indian energy scene- Units of energy, conversion factors, general classification of energy, energy crisis, energy alternatives.									**CO1**
UNIT-II	**Conventional Energy**					**Periods: 12**			
Conventional energy resources, Thermal, hydro and nuclear reactors, thermal, hydro and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.									**CO2**
UNIT-III	**Non Conventional Energy**					**Periods: 12**			
Solar energy; solar thermal systems; flat plate collectors, focusing collectors, solar water heating, solar thermal power generation, solar energy application in India, energy plantations. Wind energy: types of windmills, types of wind rotors, wind electric power generation, wind power in India, economics of wind farm, Ocean energy: ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.									**CO3**
UNIT-IV	**Biomass**					**Periods: 12**			
Biomass Origin - Resources estimation. Thermo chemical conversion- Biological conversion. Chemical conversion- Hydrolysis & hydrogenation, solvolysis, bio crude, bio diesel power generation gasifier, biogas, integrated gasification.									**CO4**
UNIT-V	**Energy Management**					**Periods: 12**			
Energy Conservation act, Energy Management duties and responsibilities, Energy Audit-Types, methodology and reports. Thermal energy Management.									**CO5**
Lecture Periods:		**Tutorial Periods:**	**Practical Periods:**				**Total Periods:**		

Reference Books:

1. Rao,S. and Parulekar, B.B., Energy Technology, Khanna Publishers 2005.
2. Rai, G.D., Non conventional Energy Sources, Khanna Publishers, New Delhi, 1984.
3. Nagpal, G.R., Power Plant Engineering, Khanna Publishers 2008.3. Energy Management, Paul W.O. Callaghan McGraw – Hill, 1993.
4. Nejat Vezirog, Alternate Energy Sources, IT, McGraw Hill, New York.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	1	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	1	1	1	3	2	2	1
CO3	3	2	2	3	3	2	1	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	1	3	3	2	2	2	2	1
CO5	3	2	1	1	1	3	3	1	1	1	2	2	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester :		Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUE108	**Semiconductor Processing**	3	1	-	4	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Understand the concept involved in chip manufacturing process and various terminology related to it (Understand-L2)						
	CO2	Understand various physical and electrochemical vapour deposition techniques for chip manufacturing (Understand-L2)						
	CO3	Understand the basics of chemical vapour deposition and atomic layer deposition and their deposition techniques (Understand-L2)						
	CO4	Understand various removal methods involved in chip manufacturing (Understand-L2)						
	CO5	Understand various surface modification methods and characterization methods (Understand-L2)						

UNIT-I	**Overview**	**Periods: 12**
Overview of Chip Manufacturing Process, FEOL and BEOL Concepts, Lithography basics, layout, hierarchy vs flat file, levels and layers in layout file, Projection printing, dark field mask, positive resist and its advantages.Process details including resist coating, pre-exposure bake, exposure, soft bake, developing and hard bake, Stepper vs scanner, Resolution, numerical aperture, Production Issues		**CO1**
UNIT-II	**Physical Vapour Deposition**	**Periods: 12**
Deposition Techniques - Physical Vapour Deposition (PVD) basics, equipment description and operation details, RF/magnetron sputtering, long throw, ionized metal plasma (IMP) sputtering, collimated beam, sputtering yield. Electrochemical deposition, Electro-migration vs grain size, conformal, anti conformal and super fill.Suppressor, accelerator, levelers, effect of seed layer, spin on coating		**CO2**
UNIT-III	**Chemical vapor deposition**	**Periods: 12**
Chemical vapor deposition (CVD) basics, Atmospheric pressure (APCVD), low pressure (LPCVD), plasma enhanced (PECVD), mass transfer control and reaction kinetics control. Reactor description and operation, deposition of silicon, poly silicon, oxide, nitride and tungsten, brief introduction to atomic layer deposition (ALD) and molecular beam epitaxy (MBE).		**CO3**
UNIT-IV	**Etching**	**Periods: 12**
Wet etching: Isotropic etch, selectivity, anisotropic Si etch in KOH, cleaning, Chemicals for oxide and nitride removal.**Dry etching :** Plasma, anisotropic etch, equipment details and operation, Reactive ion etching (RIE), veil formation and de-veil, electrostatic discharge (ESD), aluminum etch, Chemical Mechanical planarization (CMP) basics, Front end of line (FEOL) basics, transistor structure and operation.		**CO4**
UNIT-V	**Modification methods**	**Periods: 12**
Material modification methods (diffusion, ion implantation, oxidation), process integration, testing and yield, relevant tools and techniques (FIB,SEM,AFM,ellipsometry)		**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1. The Science and Engineering of Microelectronic Fabrication (2nd Edition) by S.A. Campbell, Oxford University Press, 2001.
2. Introduction to Microelectronic Fabrication, Vol. 5 of Modular Series on Solid State Devices (2nd Edition) by Richard C. Jaeger, Prentice Hall, 2001.
3. Microchip Fabrication: (5th Edition) by Peter Van Zant, McGraw Hill, 2004.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUE109	**Chemical Process Optimization**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and formulate the objective functions for constrained and unconstrained optimization problems (Understand& Apply-L2 & L3)							
	CO2	Able to apply and analyze different optimization strategies (Evaluate- L5)							
	CO3	Understand and able to use of different optimization techniques for problem solving (Understand& Apply-L2 & L3)							

UNIT-I	**Introduction**	**Periods: 12**
Process optimization, Formulation of various process optimization problems and their classification, Basic concepts of optimization-convex and concave functions, Necessary and sufficient conditions for stationary points.		**CO1**
UNIT-II	**Optimization of one-dimensional functions**	**Periods: 12**
Unconstrained multivariable optimizationdirect search methods, Bracketing methods: Exhaustive search, Bounding phase, Region elimination methods- Interval halving, Fibonacci search, Golden section search, PointEstimation, Successive quadratic estimation methods.		**CO2**
UNIT-III	**Indirect first order and second order methods**	**Periods: 12**
Gradient-based methods-NewtonRaphson, Bisection, Secant, Cubic spline, Root-finding using optimization Techniques.		**CO3**
UNIT-IV	**Multivariable optimization algorithms**	**Periods: 12**
Optimality criteria, Unidirectional search, Direct search Methods- Evolutionary optimization, Simplex search, Powell's conjugate direction, Gradient-based methods- Cauchy's (steepest descent) method, Newton's method		**CO4**
UNIT-V	**Constrained optimization algorithms**	**Periods: 12**
Kuhn-Tucker conditions, Transformation methods, Penalty function method, Method of multipliers, Sensitivity analysis, Direct search for constraint Minimization-Variable elimination method, Complex search method, Successive linear and quadratic programming, Optimization of staged and discrete processes.		**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1. Edgar, T. F., Himmelblau, D. M. and Lasdon, L.S. Optimization of Chemical Processes, McGraw-Hill (2001).
2. Babu, B.V., Process Plant Simulation, Oxford University Press (2004).
3. Kalyanmoy, D., Optimization for Engineering Design, Prentice Hall (1998).
4. Reklaitis, G. V., Ravindran, A., and Ragsdell, K. M., Engineering Optimization - Methods and Applications, John Wiley (1983).
5. Pike, R. W., Optimization for Engineering Systems, Van Nostrand Reinhold (1986).
6. Box, G. E. P., Hunter, W. G., Hunter, J. S., Statistics for Experimenters - An Introduction to Design, Data Analysis, and Model Building, John Wiley (1978).

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	1
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester :		Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUE110	**Dairy Process Technology**	3	1	-	4	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Understand about dairy processing techniques (Understand -L2)						
	CO2	Understand the manufacturing processes of various dairy products (Understand -L2)						
	CO3	Understand various techniques used in storage sanitation and effluent treatment (Understand -L2)						

UNIT-I	**Milk**	**Periods: 12**	
Milk-Types-Composition-Physical-Chemical and Thermal Properties-Heat Capacity, DensityFreezing-Boiling point-Expansion-Agitation-Viscosity-Classification of milk Market and Special Milk Handling-effects of Merits on Milk-toxicity of metals.			**CO1**
UNIT-II	**Processing and quality parameters of milk**	**Periods: 12**	
Processing of Milk- Pasteurization-HTST, UHT, sterilization, Homogenization, Filtering and Clarification of Milk-cream separation-Methods and Equipment's-Emulsification – Fortification, packaging of milk and milk products, judging and grading of milk, national and international standards of milk and milk products.			**CO2**
UNIT-III	**Milk products**	**Periods: 12**	
Traditional dairy products, Manufacturing of Yogurt, Cheese, Butter, Ghee, Ice-cream, malted products, evaporated milk products - properties, Classification-processing Methods, Equipment used, standards and quality parameters.			**CO3**
UNIT-IV	**Milk powder processing and milk substitutes**	**Periods: 12**	
Processing of Milk Powder- Composition - Properties- methods of drying, substitutes for milk and milk products – casein, lactose and other by-products, weaning foods, therapeutic foods, fortification and enrichment.			**CO4**
UNIT-V	**Storage sanitation and effluent treatment**	**Periods: 12**	
Storage of Milk in Tanks-Storage of ice cream and other milk products - in cold storage - Cleaning and Sanitation-Importance-Detergents-Properties-Cleaning procedures-Cleaning in place-Dairy effluent treatment and disposal.			**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1. Ananthakrishnan, C.P., and Sinha, N.N., "Technology and Engineering of Dairy Plant Operations, Laxmi Publications, New Delhi, 1984.
2. Warner, J.N., "Principles of Dairy Processing", Wiley Eastern Pub. Co., New York, 1975.
3. Walstra, P., "Diary Technology: Principles of Milk Properties and Processes". Marcel Dekker, 1999
4. Spreer, Edgar "Milk and Diary Product Technology". Marcel Dekker, 2005.
5. Tufail Ahmed., "Dairy Plant Engineering and Management", KitabMahal Publishers, Allahabad, 1997.
6. Lampert, Lincoln M. "Modern Dairy Products: Composition, Food Value, Processing, Chemistry, Bacteriology, Testing, Imitation Dairy Products". Chemical Publishing Company, 1998.
7. Selia, Jane dos Reis Coimbra and Jose A. Teixeir "Engineering Aspects of Milk and Dairy Products". Jane Selia dos Reis Coimbra & Jose A. Teixeir, CRC Press, 2009

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO2	3	2	1	1	3	3	1	-	1	1	3	2	2	1
CO3	3	2	2	3	3	2	-	2	3	2	2	2	2	1
CO4	3	2	2	3	3	2	-	3	3	2	2	2	2	1
CO5	3	2	1	1	1	3	3	-	1	1	2	2	1	1

Score: 3 – High; 2 – Medium; 1 – Low

HONOR COURSES

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fourth**			Course Category Code: **BSC**			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUH101	**Introduction to Frontiers of Chemical Engineering**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand Chemical Engineering history and developments and its frontier areas							
	CO2	Understand the application of nanomaterials in various fields							
	CO3	Understand potential uses of polymer composites and blends as engineering materials							
	CO4	Understand the application of Chemical Engineering in Controlled Drug Delivery Systems							
	CO5	Apply the fundamentals of chemical Engineering in the fields of Quantitative Biosciences and Tissue Engineering							
UNIT-I	**Frontier chemical engineering areas**					**Periods: 12**			
History and development of Chemical Engineering, Chemical Engineering present status, Challenges , Frontier areas- An overview									**CO1**
UNIT-II	**Nanotechnology**					**Periods: 12**			
Introduction to nanotechnology and nano materials, Synthesis Procedures for nano materials – Physical vapour deposition, Chemical Vapour deposition, Electrochemical deposition,Nano material applications: waste water treatment, nanobiotechnology, nanocomposites, biological nanomaterials, ,nanotechnology in food, medicine and health sciences.									**CO2**
UNIT-III	**Polymers**					**Periods: 12**			
Polymer composite materials: Physico-mechanical properties of conventional fibre and particulate polymer composites, advanced polymer composites, polymer nano composites, fillers used for polymer composites, polymer composites structure, characterisation, physical and chemical modification of polymer composites. Polymer blends : Definition of polymer blends and alloys, Advantages of polymer blends over conventional polymers, Thermo dynamical aspects of polymer blend miscibility, mixing, structure, properties and application of polymer blends in emerging technology – photovoltaic , Light emitting diode, supercritical fluids, Lithium battery and fuel cells									**CO3**
UNIT-IV	**Drug delivery**					**Periods: 12**			
Polymer basics, Drug delivery systems (reservoir, matrix, bio-erodible systems) Pharmacokinetics and bio distribution of drug delivery systems, Drug elimination and fate, Externally controlled systems, Micro- and nano-particle based delivery Cell and gene delivery, Delivery of vaccines (oral, pulmonary, transdermal) Relevant FDA regulations									**CO4**
UNIT-V	**Bioscience and Tissue Engineering**					**Periods: 12**			
Quantitative Bioscience: Chemistry of biological system, molecular and cellular system, physiology and behaviour, ecology, evolution, earth systems Tissue Engineering: The present and future role of chemical engineering in tissue Engineering, Principle of tissue engineering, Stem cells, Cell matrix, cell-cell interaction, Biologic scaffold for tissue engineering, Natural polymers in tissue engineering applications									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									
1. Morton M.Denn, Chemical Engineering – An Introduction, Cambridge University Press, 2012.									

2. Laurent Simon, Control of biological and drug delivery system for Chemical, biomedical and pharmaceutical Engineering, Wiley ,2013
3. Xiaoling Li, Bhaskara Jasti, Design of controlled release drug delivery systems, Mc graw Hill Chemical Engineering, First Edition,2006.
4. Lloyd M. Robson, Polymer Blends – A comprehensive review, Hanser Publications.
5. D R Paul and S Newman, Polymer Blends , Vol I & II, Academic Press, 1976
6. G. Lubin, Handbook of composites, second edition, Van Nostrand Reinhold,NY,1982.
7. Brain Munsky, Quantitative Biology: theory, Computational methods and models, MIT Press, 2018.
8. Hayser,Fussenegger, Tissue Engineering, Springer,2017.Veerarajan T, Engineering Mathematics I & II, McGraw-Hill Education(India) Private Limited, 2019

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1	-	1	2	1	2	3	2	1
CO2	3	3	2	3	3	1	-	1	2	1	2	3	2	2
CO3	3	3	2	3	3	2	-	1	2	1	2	3	2	1
CO4	3	3	2	3	3	2	-	1	2	1	2	3	2	2
CO5	3	3	2	3	3	2	-	1	2	1	2	3	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Fifth**			Course Category Code: **BSC**			Credit	Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUH102	**Advanced topics in chemical process synthesis and fluid flow operations**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand the principals involved in process flow sheet calculations.							
	CO2	Analyse various chemical process synthesis methods.							
	CO3	Understand the concepts relevant to compressible fluids.							
	CO4	Apply the concepts of turbulent flow in velocity profile calculations.							
	CO5	Analyse power law for non- Newtonian fluids.							
UNIT-I	**Introduction to Chemical Process Synthesis**					**Periods: 12**			
Choice of raw materials, writing balanced chemical reactions, generation-consumption analysis, Leblanc process, Solvay process, ammonia synthesis, atom economy, process economy process capacities and product values, case study – six carbon chemistry.									**CO1**
UNIT-II	**Introduction to Process Flow sheet Calculations**					**Periods: 12**			
Linear equations and chemical reactions, using matrices to balance chemical reactions, using matrices in generation – consumption analysis, using matrices to find linearly independent chemical reactions, linear models of process flow sheets : mixers, splitters, reactor (single and multiple reactions), separators, process topology, linear models with multiple process units and recycle, tearing algorithm.									**CO2**
UNIT-III	**Compressible fluids**					**Periods: 12**			
Flow of Compressible fluids – Thermodynamics of ideal gas, isentropic process, wave propagation through compressible fluids, sonic velocity, Mach number, flow through variable area conduits (Nozzle), Equations for isentropic flow, Equations for isothermal frictional flow.									**CO3**
UNIT-IV	**Turbulent flow**					**Periods: 12**			
Turbulent flow - Velocity fluctuations in turbulent flow, statistical nature of turbulence, Reynold's stresses, empirical theories, eddy viscosity, Prandtl's mixing length theory, Velocity distribution for turbulent flow – 1/7th power law, Logarithmic velocity distribution, Universal velocity distribution; Relationship between friction factor and Reynold's number, Von karman correlation.									**CO4**
UNIT-V	**Non-Newtonian**					**Periods: 12**			
Laminar flow of non-Newtonian (power law) fluids through circular pipe, friction factor and Reynold's number for power law fluid, Metzner Reed's approach, capillary tube experiment, Power Law of fluids and Bingham Plastics									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1.Introduction to chemical processes – principles, analysis, synthesis, Regina M Murphy, McGraw Hill (India), 2013. Chapter 1, chapter 3.

2. Noel de Nevers, Fluid mechanics for Chemical Engineers, TATA McGraw- Hill Edition, 3rdEdition 2011.

3. W.L.Mc.Cabe, J.C.Smith and P.Harriot, Unit Operations of Chemical Engineers, McGraw Hill International edition, 7th Edition, 2009.

4.Coulson J.M and Richardson J.F., Chemical Engineering - Volume 1, Elsevier Press, 6th Edition, 2006.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1	-	1	2	1	2	3	2	1
CO2	3	3	2	3	3	1	-	1	2	1	2	3	2	2
CO3	3	3	2	3	3	2	-	1	2	1	2	3	2	1
CO4	3	3	2	3	3	2	-	1	2	1	2	3	2	2
CO5	3	3	2	3	3	2	-	1	2	1	2	3	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **sixth**			Course Category Code: **BSC**			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUH103	**Advanced topics in chemical thermodynamics, heat and mass transfer**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand thermodynamic properties using equation of state principles.							
	CO2	Understand and apply unsteady state heat and mass transfer concepts to real world situations.							
	CO3	Understand and analyse heat transfer devices and their designs.							
	CO4	Understand and apply the concepts of theories of mass transfer.							
	CO5	Analyse Momentum, Heat and Mass Transfer analogies.							
UNIT-I	**Thermodynamic properties**					**Periods: 12**			
Thermodynamic properties from volumetric data. Thermodynamic properties with independent variables P and T. Fugacity of a component in a mixture at moderate pressures. Fugacity of a pure liquid or solid. Thermodynamic properties with independent variables V and T. Fugacity of a component in a mixture according to van der Waals' equation, phase equilibrium from volumetric properties.									**CO1**
UNIT-II	**Unsteady state heat conduction and diffusion**					**Periods: 12**			
Unsteady state heat conduction. Exact analytical solutions and charts, one-dimensional and multidimensional systems-Use of transient heat conduction charts. Unsteady state diffusion mass transfer. Exact analytical solutions and charts. Lumped parameter method of transient analysis									**CO2**
UNIT-III	**Heat transfer**					**Periods: 12**			
Heat transfer through extended surfaces, heat exchanger design, introduction to plate heat exchangers.									**CO3**
UNIT-IV	**Theories of Mass Transfer**					**Periods: 12**			
Theories of Mass Transfer. film theory, penetration theory, surface renewal theory, and their applications.									**CO4**
UNIT-V	**Analogies of Momentum, Heat and Mass Transfer**					**Periods: 12**			
Analogies of Momentum, Heat and Mass Transfer, Reynolds analogy, Prandtl -Taylor analogy and Colburn analogy. Analogy applications									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1. James Sucec, Heat Transfer, Jaico Publishing House, 1999.
2. C.O.Bennett, J.E.Myers, Momentum, Heat and Mass transfer, McGraw Hill Publication, Third edition.
3. Anthony L.Hines, Robert N. Maddox, Mass Transfer: Fundamentals and Applications, Prentice Hall,1985.
4. R.E. Treybal, "Mass Transfer Operations", McGraw Hill, 3rd Edition, 1981.
5. John M.Prausnitz, Rudiger N. Lichtenthaler, edmundo Gomes de Azevedo, ,Molecular Thermodynamics of Fluid-Phase equilibria, Third Edition, Prentice Hall PTR, New Jersey

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1	-	1	2	1	2	3	2	1
CO2	3	3	2	3	3	1	-	1	2	1	2	3	2	2
CO3	3	3	2	3	3	2	-	1	2	1	2	3	2	1
CO4	3	3	2	3	3	2	-	1	2	1	2	3	2	2
CO5	3	3	2	3	3	2	-	1	2	1	2	3	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester : **Seventh**			Course Category Code: **BSC**			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUH104	**Advanced topics in chemical reaction engineering, process dynamics and control**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand and apply polymath to reactor design.							
	CO2	Understand basics of polymerization and reactors used in industry							
	CO3	Understand advance control systems							
	CO4	Understand controller tuning							
UNIT-I	**Reactor design using polymath**					**Periods: 12**			
Chemical reactors, PFR , CSTR using polymath									**CO1**
UNIT-II	**Polymerization**					**Periods: 12**			
Ideal Addition Polymerization – Kinetics , Design Equations for PFR , CSTR ; Chain Reactions and Polymer Size Distribution ; Free - Radical Polymerization – Kinetics									**CO2**
UNIT-III	**Reactors**					**Periods: 12**			
Batch Reactor / PFR Design Equation Catalytic Polymerization, Condensation Polymerization, Fisher – Tropsch Polymerization									**CO3**
UNIT-IV	**Introduction to advanced control**					**Periods: 12**			
Introduction to advance control: Feed forward Control, Ratio Control, Cascade Control, Time Delay Compensation , Inferential Control , Selective / Override Control , Adaptive Control , Model Predictive Control.									**CO3**
UNIT-V	**Controller Tuning**					**Periods: 12**			
Performance Criteria for Closed Loop System, PID Controller Tuning Methods – Direct Synthesis Method, Internal Model Control (IMC) Tuning Relationship, Tuning Relations Based on integral error Criteria,									**CO4**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			
Reference Books:									
1. Robin smith, Chemical process design and integration' Wiley INDIA, 2005.									
2. Lanny.D. Schmidt , Engineering of chemical reactions , , Oxford university press , 2005.									
3. D.E.Seborg, T.F.Edgar , D.A.Mellichamp , Process dynamics and control,. 4th edition Wiley INDIA, 2019									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	1	-	1	2	1	2	3	2	1
CO2	3	3	2	3	3	1	-	1	2	1	2	3	2	2
CO3	3	3	2	3	3	2	-	1	2	1	2	3	2	1
CO4	3	3	2	3	3	2	-	1	2	1	2	3	2	2
CO5	3	3	2	3	3	2	-	1	2	1	2	3	1	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester : **Eighth**		Course Category Code:				Semester Exam Type:		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUH105	**Seminar**				2	100		100
Prerequisite:								

Course Outcome: At the end of the course the student will be able to	**CO1**	Carry out literature survey, understand state of art techniques.
	CO2	Apply theoretical knowledge to real-world scenarios or case studies
	CO3	Take initiative in exploring topics beyond the curriculum and developing self-directed research habits
	CO4	Present complex ideas concisely and clearly

The objective of the seminar is to enable the students to present a seminar on any chosen topic related to their field of study. The topic shall be chosen in consultation with the Faculty coordinators. The student will present a Seminar on a topic in an emerging area in his/her discipline of Engineering. The student will make the presentation for duration of 20 to 25 minutes and also submit a brief report on the seminar topic for the purpose of evaluation. A departmental committee shall evaluate the performance of the students.	CO1, CO2, CO3, CO4

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO2	3	3	3	3	3	3	-	3	3	2	3	3	2	1
CO3	3	3	3	3	3	2	-	3	3	3	3	3	2	1
CO4	3	3	3	3	3	2	-	3	3	3	3	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Annexure II

Ancillary Stream Electives Syllabi for Non-Chemical and Chemical Engineering Students of the B.Tech. Programme effective from the Academic year 2024-25

ANCILLARY STREAM ELECTIVE

(***OFFERED TO OTHER DEPARTMENT STUDENTS***)

THEAM: ENERGY

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester :		Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUN101	**Renewable Energy**	3	1	-	4	40	60	100
Prerequisite:								

Course Outcome	**CO1**	Explain the sources, types, Conventional, non-conventional renewable and non-renewable sources. (Understand- L2)
	CO2	Understand and analyze solar energy (Understand & Analyze-L2 & L4)
	CO3	Understand and analyze wind energy (Understand & Analyze-L2 & L4)
	CO4	Understand the basics of biomass energy. (Understand – L2)
	CO5	Understand Ocean energy Evaluate hydrogen energy (Understand & Evaluate-L2 & L5)

UNIT-I	**Energy sources and availability**	**Periods: 12**
Conventional, non-conventional, renewable and non- renewable sources of energy prospects, perceptive and advantages. Introduction to different types of non-conventional sources of energy, solar, wind, biomass, Ocean Thermal Energy Conversion, hydrogen energy, fuel cell.		**CO1**
UNIT-II	**Solar energy**	**Periods: 12**
Fundamentals of solar energy, Solar constant, Solar radiation, radiation measurement, radiation on geometry, solar data, charts, solar energy applications, solar photovoltaic system		**CO2**
UNIT-III	**Wind energy**	**Periods: 12**
Introduction, wind turbine types and performance curves , wind turbine operation and aerodynamics, wind power potential, wind power density, wind turbine efficiency, Electricity production from wind turbine, wind power costing.		**CO3**
UNIT-IV	**Biomass energy**	**Periods: 12**
Biomass resources, Conversion of biomass to biofuels, anaerobic digesters, Thermal Gasification, Electricity and heat production by biomass.		**CO4**
UNIT-V	**Other energy**	**Periods: 12**
Introduction to ocean energy, ocean thermal energy conversion, wave energy, tidal energy, Hydrogen an energy carrier and fuel cell technology,		**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1.Mehmet Kanoğlu,Yunus A. Çengel, John M. Cimbala, Fundamentals and applications of renewable, McGraw-Hill Education, 2020.

2. Dr S.Rao and Dr. B. B. Parulekar, Energy Technology, Khanna Publisher, New Delhi, 2024

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUN102	**Conventional energy**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Explain the sources, types, Conventional fuels (Understand-L2)							
	CO2	Understand and analyze liquid fuels (Understand & Analyze- L2 & L4)							
	CO3	Understand and analyze gaseous fuels (Understand & Analyze- L2 & L4)							
	CO4	Describe the basics of hydropower energy. (Understand & Analyze- L2 & L4)							
	CO5	Understand and evaluate nuclear energy (Understand & Evaluate- l2&L5)							
UNIT-I	**Introduction**					**Periods: 12**			
Conventional Fuels – classification, Solid fuels – Coal -Origin, classification, proximate and ultimate analysis, storage and handling, carbonization, briquetting, liquefaction									**CO1**
UNIT-II	**Liquid fuels**					**Periods: 12**			
Liquid fuels – petroleum-based fuels, synthetic fuels, sources, classification, Analysis, storage and handling, processing: Refining, cracking and rebuilding.									**CO2**
UNIT-III	**Gaseous fuels**					**Periods: 12**			
Gaseous fuels: types, storage, Gaseous fuel-Natural gas, composition and analysis, uses of producer gas-water gas-carbureted water gas-oil gas-coal gas-bio gas/Gober gas, LPG and blast furnace gas. Combustion equipment's - stoichiometry & heat balance calculations.									**CO3**
UNIT-IV	**Hydropower**					**Periods: 12**			
Introduction to hydropower, analysis of hydropower plant, Impulse turbines, reaction turbines, Turbine specific speed, Run-of- river plants waterwheels									**CO4**
UNIT-V	**Nuclear power**					**Periods: 12**			
Fundamentals of Nuclear Power. Introduction of nuclear energy · Radioactivity and nuclear Reactions. Radioactivity and nuclear reactions, Nuclear fission, thermal reactor, Nuclear power plant.									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									

1.Mehmet Kanoğlu,Yunus A. Çengel, John M. Cimbala, Fundamentaks and applications of renewable, McGraw-Hill Education, 2020.

2. S.Sarkar, Fuels and Combustion, Universities press (India) private limited, 3rd edition 2009, reprinted 2010, 2012, 2016.

3. G.D.Rai, Non-conventional energy sources, Khanna Publishers New Delhi, 6th edition, 2017.

4. S.P.Sharma and ChanderMohan, Fuels and Combustion, Tata McGraw Hill, 2010.

5. Dr S.Rao and Dr. B. B. Parulekar, Energy Technology,Khanna Publisher,New Delhi, 2024

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUN103	**Energy Management in Process Industries**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand the basics of energy scenario (Understand- L2)							
	CO2	Understand energy conservation and waste heat recovery techniques and enegy auditing (Understand -L2)							
	CO3	Evaluate the performance of industrial boilers and furnaces (Evaluate- L5)							
	CO4	Understand and analyze electrical energy conservation (Understand & Analyze - L2& L4)							
	CO5	Understand and assess recycle and reuse of water (Understand & Assess - L2& L3)							
UNIT-I	**Introduction to Energy Scenario**					**Periods: 12**			
Introduction: Energy scenario - supply and demand, Energy intensive industries, Industrial use of energy, Importance of energy in industrial promotion and employment.									**CO1**
UNIT-II	**Energy Audit**					**Periods: 12**			
Energy Audit: Definition, need and objectives; Types of energy audit; Basic components of energy audit; preparing for audit, Energy audit instruments, Data collection, safety considerations. Methodologies of conducting energy audit; Preliminary questionnaire, Review of previous records, Walk through audit, Energy flow diagram (Shankey diagram).									**CO2**
UNIT-III	**Energy Conservation**					**Periods: 12**			
Energy Conservation: Analysis of scope and potential for energy conservation, Good housekeeping practice, Thermal insulation, Efficiency improvement in boilers, furnaces and heat recovery techniques, Energy conservation in HVAC systems,									**CO3**
UNIT-IV	**Electrical energy conservation**					**Periods: 12**			
Electrical energy conservation; analysis of motor, analysis of pumps, Process integration as a measure of energy conservation, Optimization of steam system, Energy saving opportunities with compressed air systems and cooling towers.									**CO4**
UNIT-V	**Water Management**					**Periods: 12**			
Water Management: Sources of water, importance of water in industrial applications, Flow monitoring devices, Quality and cost of water, Water distribution in process industries and scope for water conservation, Reuse and recycle of water									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									
1. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, Guide to energy management, The Fairmont Press (2008). 2. Nagabhushan Raju, K., Industrial Energy Conservation Techniques: Concepts, Applications and Case Studies, Atlantic Publishers & Distributors (2007). 3.Kenney, W.F., Energy Conservation in the Process Industries, Academic Press, (1984). 4. Reay, D.A., Industrial Energy Conservation, Pergamon Press (1979).									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUN104	**Sustainable Engineering**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand the concept of sustainability (Understand- L2)							
	CO2	Understand and analyze Risk and Life cycle Frameworks for sustainability (Understand & Analyze-L2 & L4)							
	CO3	Understand environmental law and regulation (Understand -L2)							
	CO4	Understand Green, sustainable materials (Understand – L2)							
	CO5	Understand and Evaluate sustainability with case study (Understand & Evaluate-L2 & L5)							
UNIT-I	**Introduction to sustainability**					**Periods: 12**			
Introduction, The magnitude of the sustainability challenge, energy, material use: minerals, metals organics and water, Environmental emissions: ozone depletion in the stratosphere, global warming, regional and local air quality, summary of air quality, water quality waste in india									**CO1**
UNIT-II	**Risk and Life cycle Frameworks for sustainability**					**Periods: 12**			
Introduction, definitions, risk assessment, risk based environmental law, Life cycle frameworks: defining life-cycles, life-cycle assessment, life cycle-based environmental law, Life -cycle assessment tools: process based life cycle assessments, input-output LCA, Hybrid approach									**CO2**
UNIT-III	**Environmental law and regulation**					**Periods: 12**			
Introduction, US federal environmental statutes, evolution of regulatory and voluntary programs from end-of-pipe to pollution prevention and sustainability, pollution prevention concepts and terminology, environmental law and sustainability.									**CO3**
UNIT-IV	**Green, sustainable materials**					**Periods: 12**			
Introduction, environmental and natural resource use footprints of material extraction and refining, tracking material flows in engineered systems, Environmental release: Using property estimates to evaluate environmental partitioning, persistence and measure of exposure, direct use of properties to categorize the environmental risk of chemicals									**CO4**
UNIT-V	**Design for sustainability: economic, environmental and social indicators**					**Periods: 12**			
Introduction, sustainable engineering design principles, economic performance indicators: definitions, estimates of environmental costs, a framework for evaluating environmental costs; Environmental performance indicators, life cycle impact assessment, social performance indicators, Case study: Biofuels for transportation									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		
Reference Books:									
1.David T.Allen, David R Shonnard, Sustainable Engineering concepts, design and case studies, Prentice Hall, NJ, 2012.									

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

ANCILLARY STREAM ELECTIVES

(***OFFERED TO OTHER DEPARTMENT STUDENTS***)

THEAM: ENVIRONMENT

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUN105	**Air and Noise Pollution**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Explain the sources, types, and effects of air pollution on humans, animals, plants, and materials, and describe global effects and air quality standards. (Understand-L2)							
	CO2	Analyze the role of meteorological parameters in the dispersion of pollutants and apply air quality monitoring techniques for effective air pollution management. (Analyze-L4)							
	CO3	Apply the principles of air pollution control to design and evaluate appropriate devices for the removal of gaseous pollutants and particulate matter. (Apply-L3)							
	CO4	Describe the basics of acoustics, identify sources of noise pollution, and analyze its effects on humans and the environment. (Understand & Analyze-L2 & L4)							
	CO5	Evaluate noise control techniques, propose appropriate control measures, and apply regulatory standards for noise management and monitoring. (Evaluate-L5)							
UNIT-I	**Sources and Effects of Air Pollution**					**Periods: 12**			
Introduction: Definition and classification of air pollution, Sources of air pollutants: Natural and anthropogenic sources, Types and characteristics of air pollutants (primary and secondary pollutants), Effects of air pollution on human health, plants, animals, and materials, Global effects: Greenhouse effect, Ozone depletion, Acid rain, and Smog formation, Air quality and emission standards (National and International regulations), Historical air pollution episodes and lessons learned.									**CO1**
UNIT-II	**Meteorology and Air Quality Management**					**Periods: 12**			
Meteorological factors influencing pollutant dispersion (wind speed, wind direction, temperature inversion, humidity, etc.), Atmospheric stability, lapse rate, and plume behavior under different atmospheric conditions, Scavenging processes: Wet and dry deposition, Plume rise models and air dispersion modeling (Gaussian plume model), Air quality monitoring: Ambient air sampling, stack monitoring, and measurement techniques									**CO2**
UNIT-III	**Control of Gaseous Pollutants and Particulate Matter**					**Periods: 12**			
Principles of air pollution control: Source control, process modification, and end-of-pipe treatments, Control of gaseous pollutants using adsorption, absorption, and chemical reactions, Particulate matter control devices: Settling chambers, Cyclone separators, Wet scrubbers, Fabric filters, Electrostatic precipitators (ESPs), Design considerations and operational challenges of control devices									**CO3**
UNIT-IV	**Noise Pollution – Sources, Effects, and Measurement**					**Periods: 12**			
Basics of acoustics and noise pollution, Sound properties: Intensity, pressure level, and frequency, Sources of noise pollution: Industrial, transportation, and community noise, Noise propagation: Indoor and outdoor noise propagation models, Effects of noise on human health and the environment (hearing loss, stress, and sleep disturbance), Noise standards and permissible exposure limits (National and International guidelines)									**CO4**
UNIT-V	**Noise Control and Management**					**Periods: 12**			
Noise measurement instruments and monitoring procedures, Noise mapping and prediction models, Noise control techniques: Source control (modifications and enclosures), Path control (barriers and absorbents), Receiver protection (earplugs, earmuffs), Noise control legislation and compliance monitoring, Documentation and reporting of noise levels.									**CO5**

Lecture Periods:	Tutorial Periods:	Practical Periods:	Total Periods:
Reference Books:			
1.C. S. Rao, "Environmental Pollution Control Engineering", Wiley Eastern Limited, 2000. 2. M. N. Rao, H. V. N. Rao, Air pollution, Tata McGraw Hill Pvt. Ltd, New Delhi, 1993. 3. G.K. Nagi, M.K. Dhillon, G.S. Dhaliwal, Commonwealth Publishers, Noise Pollution.			

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester :		Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUN106	**Waste Water Engineering**	3	1	-	4	40	60	100
Prerequisite:								

Course Outcome	**CO1**	Explain the importance of water and wastewater management, interpret water quality standards, and assess pollution impacts. (Understand - L 2)
	CO2	Analyze and design primary and secondary treatment processes for effective water and wastewater management. (Analyze - L 4)
	CO3	Evaluate tertiary and advanced treatment technologies for water reclamation, reuse, and safe disposal. (Evaluate - L 5)
	CO4	Analyse the industrial wastewater treatment solutions using case studies from various sectors. (Create – L 4)
	CO5	Apply advanced and emerging technologies such as bio-remediation, constructed wetlands, and radiation management for environmental protection. (Apply -L3)

UNIT-I	**Sources and Effects of Air Pollution**	**Periods: 12**
Introduction: Definition and importance of water and wastewater, Water requirements for various sectors: Domestic, Institutional, Industrial, Public, and Agricultural, Characteristics of water and wastewater: Physical, chemical, and biological parameters, Water and wastewater quality standards: Indian and International standards (BIS, WHO, EPA, CPCB), Effects of water pollution and contamination.		**CO1**
UNIT-II	**Meteorology and Air Quality Management**	**Periods: 12**
Pretreatment processes: Screening, grit removal, oil and grease separation, and equalization, Primary Treatment: Sedimentation, coagulation, and flocculation, Secondary Treatment: Biological treatment processes - Activated Sludge Process (ASP), Trickling Filters, Rotating Biological Contactors (RBC), Sequential Batch Reactors (SBR), and Moving Bed Biofilm Reactors (MBBR), Concept of sludge generation and management.		**CO2**
UNIT-III	**Control of Gaseous Pollutants and Particulate Matter**	**Periods: 12**
Need for tertiary treatment and its significance, Advanced treatment technologies: Membrane Filtration (UF, NF, RO), Adsorption, Ion Exchange, Advanced Oxidation Processes (AOPs), Sludge Processing: Thickening, dewatering, digestion (aerobic and anaerobic), and sludge disposal, Nutrient removal techniques: Nitrogen and phosphorus removal. Disinfection methods: Chlorination, UV, and Ozonation.Concepts of Zero Liquid Discharge (ZLD) and water reclamation.		**CO3**
UNIT-IV	**Noise Pollution – Sources, Effects, and Measurement**	**Periods: 12**
Detailed process flow sheets and treatment systems for industries: Textile, Tannery, Pharmaceuticals, Electroplating, Pulp and Paper, Refineries, Fertilizer, Thermal Power Plants, Case studies on effluent management, Concept of Effluent Treatment Plants (ETP) and Common Effluent Treatment Plants (CETP).		**CO4**
UNIT-V	**Noise Control and Management**	**Periods: 12**
Advanced technologies for industrial wastewater reuse and recycle, Treatment of radioactive wastewater: Low and high activity radiation management, Application of radioactive techniques for wastewater treatment, Bio-remediation of contaminated soil and water, Emerging technologies: Constructed wetlands, Algal treatment, and Phytoremediation. Compliance with Pollution Control Board (PCB) standards.		**CO5**

Lecture Periods:	Tutorial Periods:	Practical Periods:	Total Periods:

Reference Books:

1. Metcalf and Eddy Inc., Wastewater Engineering - Treatment and Reuse, 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi,2003.

2. Karia G.L., and Christian R.A., Wastewater Treatment Concepts and Design Approach, 2001, Prentice Hall of India Pvt. Ltd., New Delhi,2001.

3.Rao M.N., Datta A.K., Wastewater Treatment, 3rd edition, (2008), Oxford & IBH Publishing Co. New Delhi,2008.

4.Eckenfelder, Industrial Water pollution Control, McGraw hill Company, New Delhi American Chemical Society, Washington D.C. USA,2000

5.S.P Mahajan, Pollution control in Process industries". TMH, New Delhi,1984.

6.Rao C.S., Environmental Pollution Control Engineering, 3 rd ed., New Age International Publishers, India, 2018.

7.Bhatia S.C., Environmental Pollution and Control in Chemical Process Industries, 2 nd ed.,Khanna publishers, India, 2013.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **PEC**				Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUN107	**Solid Waste Management**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	State solid waste characteristics and its sources. (Understand - L 2)							
	CO2	Identify and analyze different methods of treatment of solid waste (Understand & Analyze - L 2 & L3)							
	CO3	Illustrate Industrial practices in solid waste management (Understand - L 2)							
	CO4	Discuss the significance of recycling reuse and reclamation of solid wastes (Understand & Analyze - L 2 & L3)							
	CO5	Assess the relationships between environmental guidelines, human activities and quality of impacted soil, water and air (Evaluate - L5)							
UNIT-I	**Introduction**					**Periods: 12**			
Solid waste history: economics and solid waste, legislation and regulations material flow: reduction, reuse, recycling, recovery, disposal of solid waste in landfills, energy conservation. the need of integrated solid waste management: municipal solid waste generation, municipal solid waste characteristics: composition by identifiable items, moisture content, particle size, chemical composition, heat value, bulk and material density, mechanical properties, biodegradability.									**CO1**
UNIT-II	**Solid waste collection and landfill**					**Periods: 12**			
Refuse collection systems, commercial wastes, transfer stations, collection of recyclable materials; landfill processes: Biological degradation, leachate production, gas production									**CO2**
UNIT-III	**Solid waste characteristics and processing**					**Periods: 12**			
Refuse physical characteristics, storing Municipal solid waste, conveying, compacting; shredding: Use of shredders in solid waste processing, types of shredders used for solid waste processing, health and safety Pulping, roll crushing, granulating.									**CO3**
UNIT-IV	**Thermal conversion**					**Periods: 12**			
Thermal conversion: Combustion or incineration systems, factors affecting efficiency of incinerators, problems associated with incinerator operations, pyrolysis, gasification, pelletization.									**CO4**
UNIT-V	**Biological processing**					**Periods: 12**			
Biological processing: Composting (aerobic conversion), critical design parameters in composting, types of composting systems, properties of compost, anaerobic conversion, vermiculture, chemical processing									**CO5**
Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**				**Total Periods:**			
Reference Books:									

1.William A. Worrell, P. Aarne Vesilind Solid Waste Engineering, 2nd edition, Cengage, 2012.

2.Iqbal H Kahn, Naveed Ahsan “Text book of Solid Waste Management”, CBS Publishers, 2013

3. Cheremisinoff N.P, Handbook of Solid waste management and waste minimization technologies, Butterworth-Heinemann Publisher, 2003.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**				Programme: **B.Tech.**				
Semester :				Course Category Code: **PEC**			Semester Exam Type: **TY**	
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUN108	**Unit Operations and Process in Environmental Engineering**	3	1	-	4	40	60	100
Prerequisite:								
Course Outcome	**CO1**	Understands basic concepts related to chemical, physical, biological and mass balances (Understand-L2)						
	CO2	Understand water and waste water treatment methods (Understand-L2)						
	CO3	Understand and analyze preliminary unit operations and sedimentation (Understand & Analyze -L2 & L4)						
	CO4	Understand and evaluate adsorption and ion exchange methods (Understand & Evaluate -L2 & L5)						

UNIT-I	**Basic concepts**	**Periods: 12**
Chemical concepts: inorganic Chemistry, Physical Chemistry, Organic Chemistry, Priority Pollutants; Biological concepts: Bacteria, Other Microbes and some Large Organisms, Pathogens and waterborne Communicable Diseases, Bacterial Analyses, Biochemical Kinetics, Growth Kinetics, and Temperature Effects; Mass Balances, Flow Models, and Reactors: Mass Balances, Flow Models, Reactors.		**CO1**
UNIT-II	**Water and waste water treatment**	**Periods: 12**
Water Quantities and Water Quality, Wastewater Quantities, Wastewater Quality, Measurement of Waste Organic Materials, Effluent Requirements, Water Treatment Plants, Wastewater Treatment Plants, Design Flow Rates and Parameters.		**CO2**
UNIT-III	**Preliminary unit operations and Sedimentation**	**Periods: 12**
Preliminary unit operations and Processes: Water Treatment, Wastewater Treatment, Coagulants, Coagulant Aids, Jar Tests, Chemical Feeders, Rapid Mixing and Flocculation, Lime-Soda Softening, Coagulation and Flocculation in Water Treatment, Coagulation and Flocculation in Wastewater Treatment. Sedimentation: Type I Settling, Type II Settling, Type III and Type IV Settling, Actual sedimentation Basins, Sedimentation in Water Treatment Plants, Sedimentation in Wastewater Treatment Plants, Inclined-Settling Devices, Inlet and Outlet Hydraulics.		**CO3**
UNIT-IV	**Physical Separation Methods**	**Periods: 12**
Filtration: Single-Medium Filters, Multimedia Filters, Filter Layout, Appurtenances, and Details, Filtration in Water Treatment, Filtration in Wastewater Treatment, Up flow Filtration, Miscellaneous Filters. Ammonia Removal: Physical Operations, Chemical Processes, Biological Processes. Membrane Processes: Dialysis, Electrodialysis, Reverse Osmosis.		**CO4**
UNIT-V	**Adsorption and Ion Exchange**	**Periods: 12**
Adsorption: Adsorption, Column Contacting Techniques and Equipment, Fixed-Bed Adsorption Columns, Moving-Bed Countercurrent Adsorption Columns, Fluidized Beds, Test Columns, Design Considerations. Ion Exchange: Contacting Techniques and Equipment, Design Procedures, Softening and Demineralization, Ammonia Removal, Design Considerations		**CO4**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1.Reynolds. Richard, Unit Operations and Processes in Environmental Engineering, Cengage Learning,1st Edition, New Delhi, 2009.
2. Robert Noyes, Unit Operations in Environmental Engineering, Jaico Publishing House; 1st Edition, New Delhi, 2008.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2			
CO2	3	2	1	1	1	1	-	-	1	1	2			
CO3	3	2	2	2	1	1	-	-	2	2	2			
CO4	3	2	2	2	1	1	-	-	2	2	2			
CO5	3	2	1	1	1	1	-	-	1	1	2			

Score: 3 – High; 2 – Medium; 1 – Low

ANCILLARY STREAM ELECTIVES

(***OFFERED TO CHEMICAL DEPARTMENT STUDENTS***)

THEAM: SEPARATION PROCESS TECHNOLOGY

Department : **Chemical Engineering**		Programme: **B.Tech.**						
Semester :		Course Category Code: **BSC**				Semester Exam Type: **TY**		
Course Code	**Course Name**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
CHUI101	**Basics of New Separation Techniques**	3	1	-	4	40	60	100
Prerequisite:								

Course Outcome	**CO1**	Explain the fundamental concepts and mathematical models of adsorption and chromatography-based separation processes. (Understan-L2)
	CO2	Analyse membrane separation processes using theoretical concepts and apply them to industrial separation applications. (Analyse-L4)
	CO3	Evaluate mathematical models to predict membrane system performance and interpret factors like concentration polarization and fouling. (Evaluate-L5)
	CO4	Apply the principles of surfactant-based separations in liquid membrane permeation, micellar separations, and foam separations. (Apply-L3)
	CO5	Assess the thermodynamic and physicochemical principles of supercritical fluid extraction for effective process design. (Evaluate-L5)

UNIT-I	**Adsorption**	**Periods: 12**
Adsorption separations - Review of fundamentals, mathematical modelling of column contactors, pressure swing adsorption, ion chromatography, affinity chromatography, gradient chromatography, parametric pumping, counter-current, simulated counter-current and multidimensional chromatography.		**CO1**
UNIT-II	**Membrane separation processes**	**Periods: 12**
Membrane separation processes – basic concepts, membrane modules, structure and characteristics of membranes, design considerations of Reverse Osmosis, Ultra Filtration, Electro Dialysis, Gas permeation membranes, Pervaporation, Nano filtration and micro filtration.		**CO2**
UNIT-III	**Theories for membrane separations**	**Periods: 12**
Detailed theories for membrane separations – concentration polarization, gel formation and fouling, mathematical models for membrane systems with and without concentration polarization, Transport inside the membranes, solution diffusion membranes, porous membranes.		**CO3**
UNIT-IV	**Surfactant separations**	**Periods: 12**
Surfactant based separations - fundamentals of surfactants at surfaces and in solution, liquid membrane permeation, and foam separations, micellar separations.		**CO4**
UNIT-V	**Supercritical fluids**	**Periods: 12**
Supercritical fluid extraction - Physicochemical principles, thermodynamic modelling, process synthesis and energy analysis		**CO5**

Lecture Periods:	**Tutorial Periods:**	**Practical Periods:**	**Total Periods:**

Reference Books:

1. R.T. Yang, Gas Separation by Adsorption Processes, Imperial College Press, 1997.
2. P.C. Wankat, Rate Controlled Processes, Springer Publications, 2005.
3. Seader and Henley, Separation Process Principles, Wiley Publication, Second Edition, 2008.
4. P. C. Wankat, Large scale adsorption and chromatography, CRC Press, 1986.
5. R. W. Rousseau, Handbook of separation process technology, John Wiley and Sons, 1987.
6. M. C. Porter, Handbook of industrial membrane technology, Noyes publication, Park Ridge, New Jersey, 1990.
7. J. F. Scamehorn and J. H. Harwell, Surfactant based separation processes, T. A. Hatton in Vol. 23 of Surfactant science series, Marcel-Dekker., 1989.
8. M. A. McHugh and V. J. Krukonis, Supercritical fluid extraction, Butterworth, 1985.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO2	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO3	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO4	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO5	3	2	1	1	1	1	-	-	1	1	2	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **BSC**			Credit	Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week				Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUI102	**Membrane Separation Technology**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand the fundamental concepts and mathematical models of adsorption and chromatography-based separation processes. (Understad-L2)							
	CO2	Analyse membrane separation processes using theoretical concepts and apply them to industrial separation applications. (Analysis-L4)							
	CO3	Evaluate mathematical models to predict membrane system performance and interpret factors like concentration polarization and fouling. (Evaluate-L5)							
	CO4	Apply the principles of surfactant-based separations in liquid membrane permeation, micellar separations, and foam separations. (Apply-L3)							
	CO5	Assess the thermodynamic and physicochemical principles of supercritical fluid extraction for effective process design. (Evaluate-L5)							
UNIT-I	**Adsorption**					**Periods: 12**			
Adsorption separations - Review of fundamentals, mathematical modelling of column contactors, pressure swing adsorption, ion chromatography, affinity chromatography, gradient chromatography, parametric pumping, counter-current, simulated counter-current and multidimensional chromatography.									**CO1**
UNIT-II	**Membrane separation processes**					**Periods: 12**			
Membrane separation processes – basic concepts, membrane modules, structure and characteristics of membranes, design considerations of Reverse Osmosis, Ultra Filtration, Electro Dialysis, Gas permeation membranes, Pervaporation, Nano filtration and micro filtration.									**CO2**
UNIT-III	**Theories for membrane separations**					**Periods: 12**			
Detailed theories for membrane separations – concentration polarization, gel formation and fouling, mathematical models for membrane systems with and without concentration polarization, Transport inside the membranes, solution diffusion membranes, porous membranes.									**CO3**
UNIT-IV	**Surfactant separations**					**Periods: 12**			
Surfactant based separations - fundamentals of surfactants at surfaces and in solution, liquid membrane permeation, and foam separations, micellar separations.									**CO4**
UNIT-V	**Supercritical fluids**					**Periods: 12**			
Supercritical fluid extraction - Physicochemical principles, thermodynamic modelling, process synthesis and energy analysis									**CO5**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**				**Total Periods:**		

Reference Books:

1. R.T. Yang, Gas Separation by Adsorption Processes, Imperial College Press, 1997.
2. P.C. Wankat, Rate Controlled Processes, Springer Publications, 2005.
3. Seader and Henley, Separation Process Principles, Wiley Publication, Second Edition, 2008.
4. P. C. Wankat, Large scale adsorption and chromatography, CRC Press, 1986.
5. R. W. Rousseau, Handbook of separation process technology, John Wiley and Sons, 1987.
6. M. C. Porter, Handbook of industrial membrane technology, Noyes publication, Park Ridge, New Jersey, 1990.
7. J. F. Scamehorn and J. H. Harwell, Surfactant based separation processes, T. A. Hatton in Vol. 23 of Surfactant science series, Marcel-Dekker., 1989.
8. M. A. McHugh and V. J. Krukonis, Supercritical fluid extraction, Butterworth, 1985.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO2	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO3	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO4	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO5	3	2	1	1	1	1	-	-	1	1	2	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**						
Semester :			Course Category Code: **BSC**			Semester Exam Type: **TY**			
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks		
			L	T	P	C	CA	SE	TM
CHUI103	**Process Integration**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand of the fundamentals of process integration (Understand-L2)							
	CO2	Perform pinch analysis (Analyse-L4)							
	CO3	Evaluate design heat exchanger networks (Evaluate-L5)							
	CO4	Minimize the water consumption and waste generation. (Apply-L3)							
UNIT-I	**Introduction**					**Periods: 12**			
Introduction: Process integration, Role of thermodynamics in process design, Concept of pinch technology and its application.									**CO1**
UNIT-II	**Heat exchanger networks**					**Periods: 12**			
Heat exchanger networks: Heat exchanger networks analysis, Simple design for maximum energy recovery, Loop Breaking & Path Relaxation, Targeting of energy, area, number of units and cost, Trading off energy against capital.									**CO2**
UNIT-III	**Network Integration**					**Periods: 12**			
Network Integration: Super targeting, maximum energy recovery (MER), Network for multiple utilities and multiple pinches, Grand Composite curve (GCC).									**CO3**
UNIT-IV	**Mass and heat integration**					**Periods: 12**			
Mass integration: Distillation sequences. Heat and Power Integration: Columns, Evaporators, Dryers, and reactors.									**CO4**
UNIT-V	**Case studies**					**Periods: 12**			
Case studies: Waste and waste water minimization, Flue gas emission targeting									**CO5**
Lecture Periods:		**Tutorial Periods:**			**Practical Periods:**			**Total Periods:**	

Reference Books:

1.Linnhoff, D.W., User Guide on Process Integration for the Efficient Use of Energy, Institution of Chemical Engineers (1994).
2. Smith, R., Chemical Process Design and Integration, John Wiley & Sons(2005)
3.Shenoy, V. U., Heat Exchanger network synthesis, Gulf Publishing (1995).
4. Kumar, A., Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1977).

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO2	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO3	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO4	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO5	3	2	1	1	1	1	-	-	1	1	2	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low

Department : **Chemical Engineering**			Programme: **B.Tech.**					
Semester :			Course Category Code: **BSC**			Semester Exam Type: **TY**		
Course Code	**Course Name**		Periods / Week			Credit	Maximum Marks	
			L	T	P	C	CA	SE	TM
CHUI104	**Process Modelling and Simulation**		3	1	-	4	40	60	100
Prerequisite:									
Course Outcome	**CO1**	Understand of the fundamentals of process modelling (Understand-L2)							
	CO2	Perform models analysis (Analyse-L4)							
	CO3	Evaluate separations (Evaluate-L5)							
	CO4	Apply numerical methods (Apply-L3)							
UNIT-I	**Introduction**					**Periods: 12**			
Introduction to process modelling and simulation, tools of simulation, approaches of simulation, planning of calculation in a plant simulation. Parameter estimation techniques in theoretical as well as numerical models.									**CO1**
UNIT-II	**Models**					**Periods: 12**			
Models, need of models and their classification, models based on transport phenomena principles, alternate classification of models, population balance, stochastic, and empirical models, unit models. Development of detailed mathematical models of evaporators, use of Newton Raphson method for solving evaporator problems.									**CO2**
UNIT-III	**Separations**					**Periods: 12**			
Separation of multicomponent mixtures by use of a single equilibrium stage, flash calculation under isothermal and adiabatic conditions. Tridiagonal formulation of component material balances and equilibrium relationships for distillation, absorption and extraction of multicomponent. Thiele and Geddes method plus θ - method and Kb method, models of absorbers, strippers and extractors.									**CO3**
UNIT-IV	**Fixed bed**					**Periods: 12**			
Classification of fixed bed reactor models, one dimensional and two-dimensional fixed bed reactor models, fluidized bed reactor models, bioreactor models.									**CO3**
UNIT-V	**Numerical methods**					**Periods: 12**			
Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, method of weighted residuals. Orthogonal collocation to solve PDEs with their application to chemical engineering systems models.									**CO4**
Lecture Periods:	**Tutorial Periods:**		**Practical Periods:**			**Total Periods:**			

Reference Books:

1.Denn M. M. Process Modelling, Longman, 1986.
2. Holland C. D. Fundamentals and Modelling of Separation Processes, Prentice Hall., 1975.
3. Luyben W. L. Process Modelling Simulation and Control for Chemical Engineers, 2nd Ed., McGraw Hill, 1990.
4. Najim K. Process Modelling and Control in Chemical Engineering, CRC, 1990.
5. Aris R. Mathematical Modelling. 1: A Chemical Engineering Perspective (Process System Engineering), Academic Press, 1999.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO2	3	2	1	1	1	1	-	-	1	1	2	3	2	1
CO3	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO4	3	2	2	2	1	1	-	-	2	2	2	3	2	1
CO5	3	2	1	1	1	1	-	-	1	1	2	3	2	1

Score: 3 – High; 2 – Medium; 1 – Low