ANNA UNIVERSITY, CHENNAI
UNDRGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus **:** Alagappa College of Technology

Department **:** Chemical Engineering

Programme **:** B.Tech. Chemical Engineering

Regulations **:** 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	OEC	SDC	UC	SLC	Total
I			7	11			3	1		22
II	3			14			4	1		22
III	14		4	4				2		24
IV	22						3			25
V	11	3			3		3	3		23
VI		9			3	3	3	3	1	22
VII	12	6				3	2	1		24
VIII							8			8
Total	**62**	**18**	**11**	**29**	**6**	**6**	**26**	**11**	**1**	**170**
% of Category	**36.47**	**10.59**	**6.47**	**17.06**	**3.53**	**3.53**	**15.29**	**6.47**	**0.59**	**100**

CATEGORY OF COURSES

PCC – Professional Core Course
PEC – Professional Elective Course
ETC – Emerging Technology Course
OEC – Open Elective Course
SLC – Self Learning Course
ESC – Engineering Science Course
HSMC – Humanities Science and Management Course
SDC – Skill Development Course
UC – University Course

**For Honours & Minor Degree, please refer the Regulations 2023 (Revised 2024).*

SEMESTER – I							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2.	MA23C01	Matrices and Calculus	LIT	3-1-0	4	4	HSMC
3.	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
4.	CS23C02	Computer Programming in Python	LIT	3-0-2	5	4	ESC
5.	EE23C03	Basics of Electrical and Electronics Engineering	LIT	2-0-2	4	3	ESC
6.	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
7.	UC23H01	தமிழர்மரபு /Heritage of Tamils	T	1-0-0	1	1	UC
8.	-	NCC/NSS/NSO/YRC		0-0-2	2	-	UC
9.	-	Audit Course – I	-	-	-	-	UC
TOTAL CREDITS						**22**	

*** TCP –** Total Contact Period(s)

#TYPE OF COURSE

LIT – Laboratory Integrated Theory
T – Theory
L – Laboratory Course
IPW – Internship cum Project Work
PW – Project Work
CDP – Capstone Design Project

SEMESTER – II							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2.	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
3.	CY23C08	Organic Chemistry	T	3-0-0	3	3	HSMC
4.	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
5.	ME23C01	Engineering Drawing & 3D Modeling	LIT	2-0-4	6	4	SDC
6.	CH23C01	Introduction to Chemical Engineering	T	3-0-0	3	3	PCC
7.	UC23H02	தமிழரும் தொழில் நுட்பமும் / Tamils and Technology	T	1-0-0	1	1	UC
TOTAL CREDITS						**22**	

SEMESTER – III							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	MA23C08	Numerical Methods	T	3-1-0	4	4	HSMC
2.	CH23301	Mechanical Engineering for Technologists	LIT	3-0-2	5	4	ESC
3.	CH23302	Chemical Technology	T	3-0-0	3	3	PCC
4.	CH23303	Chemical Process Calculation	T	3-0-0	3	3	PCC
5.	CH23304	Fluid Mechanics	LIT	3-0-2	5	4	PCC
6.	CH23305	Mechanical Operations	LIT	3-0-2	5	4	PCC
7.	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
TOTAL CREDITS						**24**	

SEMESTER – IV							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CH23401	Chemical Engineering Thermodynamics	T	3-1-0	4	4	PCC
2.	CH23402	Chemical Engineering Computing	LIT	1-0-4	5	3	PCC
3.	CH23403	Heat Transfer	LIT	3-0-2	5	4	PCC
4.	CH23404	Process Data Analytics	T	3-0-0	3	3	PCC
5.	CH23405	Mass Transfer I	LIT	3-0-2	5	4	PCC
6.	CH23406	Chemical Reaction Engineering I	LIT	3-0-2	5	4	PCC
7.	-	Industry Oriented Course I	-	-	-	1	SDC
8.	-	Audit Course–II	-	-	-	-	UC
9.	-	Skill Development Course I	-	-	-	2	SDC
TOTAL CREDITS						**25**	

SEMESTER – V							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CH23501	Process Dynamics and Control	LIT	3-0-2	5	4	PCC
2.	CH23502	Mass Transfer II	LIT	3-0-2	5	4	PCC
3.	CH23503	Chemical Reaction Engineering II	T	3-0-0	3	3	PCC
4.	CH23U02	Perspectives of Sustainable Development	T	2-0-2	4	3	UC
5.	**-**	Professional Elective I	T	3-0-0	3	3	PEC
6.	-	Industry Oriented Course II	-	-	-	1	SDC
7.	-	Emerging Technology Course I	-	-	-	3	ETC
8.	-	Skill Development Course II	-	-	-	2	SDC
TOTAL CREDITS						**23**	
COURSES FOR HONOURS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CH23D01	Capstone Design Project – Level I	CDP	0-0-12	12	6	SDC
(OR)							
1.	-	Honours Elective – I	T	3-0-0	3	3	PEC
2.	-	Honours Elective – II	T	3-0-0	3	3	PEC
COURSES FOR MINOR DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	-	Minor Elective – I	T	3-0-0	3	3	PEC
2.	-	Minor Elective – II	T	3-0-0	3	3	PEC

SEMESTER – VI (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	UC23E01	Engineering Entrepreneurship Development	LIT	2-0-2	4	3	UC
2.	CH23L01	Self-Learning Course	T	1-0-0	1	1	SLC
3.	-	Professional Elective II	T	3-0-0	3	3	PEC
4.	-	Professional Elective III	T	3-0-0	3	3	PEC
5.	-	Professional Elective IV	T	3-0-0	3	3	PEC
6.	-	Open Elective I	T	3-0-0	3	3	OEC
7.	-	Industry Oriented Course III	-	-	-	1	SDC
8.	-	Emerging Technology Course II	-	-	-	3	ETC
9.	-	Skill Development Course III	-	-	-	2	SDC
10.	CH23601	Internship*	IPW	-		-	SDC
				TOTAL CREDITS		**22**	

Internship* - Students will undergo four weeks during this period, evaluation in seventh semester.

S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CH23D02	Capstone Design Project – Level II	CDP	0-0-12	12	6	SDC
		(OR)					
1.	-	Honours Elective – III	T	3-0-0	3	3	PEC
2.	-	Honours Elective – IV	T	3-0-0	3	3	PEC
		COURSES FOR MINOR DEGREE					
1.	-	Minor Elective – III	T	3-0-0	3	3	PEC
2.	-	Minor Elective – IV	T	3-0-0	3	3	PEC

SEMESTER – VII							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CH23701	Transport Phenomena	T	3-0-0	3	3	PCC
2.	CH23702	Process Equipment Design	T	3-0-0	3	3	PCC
3.	CH23703	Safety in Process Industries	T	3-0-0	3	3	PCC
4.	CH23704	Process Modelling and Simulation	T	3-0-0	3	3	PCC
5.	CH23U01	Standards – Chemical Engineering		1-0-0	1	1	UC
6.		Professional Elective V	T	3-0-0	3	3	PEC
7.		Professional Elective VI	T	3-0-0	3	3	PEC
8.		Open Elective II	T	3-0-0	3	3	OEC
9.	CH23705	Internship*	IPW	0-0-2	2	2	SDC
TOTAL CREDITS						**24**	
1.	CH23D03	Capstone Design Project – Level III	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – V	T	3-0-0	3	3	PEC
2.		Honours Elective – VI	T	3-0-0	3	3	PEC
COURSES FOR MINOR DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.		Minor Elective – V	T	3-0-0	3	3	PEC
2.		Minor Elective – VI	T	3-0-0	3	3	PEC

SEMESTER – VIII							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1.	CH23801	Project Work / Internship cum Project Work	PW/IPW	0-0-16	16	8	SDC
TOTAL CREDITS						**8**	

PROFESSIONAL ELECTIVE COURSES: VERTICALS

Vertical I	Vertical II	Vertical III	Vertical IV	Vertical V	Vertical VI
Computational Chemical Engineering	**Process Plant Design**	**Biochemical Engineering**	**Energy Engineering**	**Environmental and Safety Engineering**	**Petroleum Process Technology**
Chemical Process Design	Chemical Plant Design	Biochemistry	Bioenergy	Air Pollution Engineering	Crude upstream processing
Optimization of Chemical Processes	Plant Layout	Bioprocess Technology	Renewable Energy	Waste Water Treatment	Petroleum Refining I
Finite Element Method	Design Safety	Fermentation and Bio Processing	Energy Technology	Solid Waste Management	Petroleum Refining II
Machine Learning in Chemical Engineering	Materials of Construction	Bio Separation and Downstream Processing	Electrochemical Engineering	Environmental Impact Assessment	Petrochemical Technology
Chemical Process Flow Sheeting	Statutory Requirements and Customer Care	Enzyme Immobilization Technology	Power Plant Engineering	Process Safety Management	Natural Gas Engineering
Computational Fluid Dynamics	Process Plant Utilities	Bioreactor Design	Non-Renewable Energy Sources	Risk and Hazop Analysis	Environmental regulations, health & safety in petroleum industries

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL I: COMPUTATIONAL CHEMICAL ENGINEERING

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	CH23001	Chemical Process Design	T	3-0-0	3	3	PEC
2	CH23C02	Optimization of Chemical Processes	T	3-0-0	3	3	PEC
3	CH23002	Finite Element Method	T	3-0-0	3	3	PEC
4	CH23003	Machine Learning in Chemical Engineering	T	3-0-0	3	3	PEC
5	CH23004	Chemical Process Flow Sheeting	T	3-0-0	3	3	PEC
6	CH23005	Computational Fluid Dynamics	T	3-0-0	3	3	PEC

VERTICAL II: PROCESS PLANT DESIGN

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	CH23006	Chemical Plant Design	T	3-0-0	3	3	PEC
2	CH23007	Plant Layout	T	3-0-0	3	3	PEC
3	CH23008	Design Safety	T	3-0-0	3	3	PEC
4	CH23009	Materials of Construction	T	3-0-0	3	3	PEC
5	CH23010	Statutory Requirements and Customer Care	T	3-0-0	3	3	PEC
6	CH23011	Process Plant Utilities	T	3-0-0	3	3	PEC

VERTICAL III
BIO CHEMICAL ENGINEERING

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CH23012	Biochemistry	T	3-0-0	3	3	PEC
2.	CH23013	Bio Process Technology	T	3-0-0	3	3	PEC
3.	CH23014	Fermentation and Bio Processing	T	3-0-0	3	3	PEC
4.	CH23015	Bio Separation and Downstream Processing	T	3-0-0	3	3	PEC
5.	CH23016	Enzyme Immobilization Technology	T	3-0-0	3	3	PEC
6.	CH23017	Bio Reactor Design	T	3-0-0	3	3	PEC

VERTICAL IV
ENERGY ENGINEERING

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CH23018	Bioenergy	T	3-0-0	3	3	PEC
2.	CH23019	Renewable Energy	T	3-0-0	3	3	PEC
3.	CH23020	Energy Technology	T	3-0-0	3	3	PEC
4.	CH23021	Electrochemical Engineering	T	3-0-0	3	3	PEC
5.	CH23022	Power Plant Engineering	T	3-0-0	3	3	PEC
6.	CH23023	Non-Renewable Energy Sources	T	3-0-0	3	3	PEC

VERTICAL V
ENVIRONMENTAL AND SAFETY ENGINEERING

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CH23024	Air Pollution Engineering	T	3-0-0	3	3	PEC
2.	CH23025	Waste Water Treatment	T	3-0-0	3	3	PEC
3.	CH23026	Solid Waste Management	T	3-0-0	3	3	PEC
4.	CH23027	Environmental Impact Assessment	T	3-0-0	3	3	PEC
5.	CH23028	Process Safety Management	T	3-0-0	3	3	PEC
6.	CH23029	Risk and HAZOP Analysis	T	3-0-0	3	3	PEC

VERTICAL VI
PETROLEUM PROCESS TECHNOLOGY

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CH23030	Crude upstream processing	T	3-0-0	3	3	PEC
2.	CH23031	Petroleum Refining I	T	3-0-0	3	3	PEC
3.	CH23032	Petroleum Refining II	T	3-0-0	3	3	PEC
4.	CH23033	Petrochemical Technology	T	3-0-0	3	3	PEC
5.	CH23034	Natural Gas Engineering	T	3-0-0	3	3	PEC
6.	CH23035	Environmental regulations, health & safety in petroleum industries	T	3-0-0	3	3	PEC

LIST OF MINOR COURSES – CHEMICAL PROCESS PLANTS

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	CH23303	Chemical Process Calculation	T	3-0-0	3	3	PEC
2	CH23009	Materials of Construction	T	3-0-0	3	3	PEC
3	CH23C02	Optimization of Chemical processes	T	3-0-0	3	3	PEC
4	CH23011	Process Plant Utilities	T	3-0-0	3	3	PEC
5	CH23001	Chemical Process Design	T	3-0-0	3	3	PEC
6	CH23036	Modern Separation Technique	T	3-0-0	3	3	PEC

LIST OF EMERGING TECHNOLOGY COURSES

S. NO.	CODE NO.	COURSE TITLE	Course Type#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	CH23E01	Artificial Intelligence and Machine learning for Chemical Engineering	T	3-0-0	3	3	ETC
2	CH23E02	Process Intensification in Chemical Industries	T	3-0-0	3	3	ETC
3	CH23E03	Sustainable Material and Electronic Waste Recycling	T	3-0-0	3	3	ETC
4	CH23E04	Hydrogen Storage and Fuel Cell Technology	T	3-0-0	3	3	ETC

LIST OF SKILL DEVELOPMENT COURSES

S. NO.	CODE NO.	COURSE TITLE	Course Type#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	CH23S01	Business Analytics	T	2-0-0	2	2	SDC
2	CH23S02	Digital Marketing	T	2-0-0	2	2	SDC
3	CH23S03	Artificial Intelligence and Data Science	T	2-0-0	2	2	SDC
4	CH23S04	Additive Manufacturing	T	2-0-0	2	2	SDC
5	CH23S05	Reverse Engineering	T	2-0-0	2	2	SDC
6	CH23S06	Fundamentals in Data Science	T	2-0-0	2	2	SDC

COURSES TO BE OFFERED AS OPEN ELECTIVE (OEC)

S. NO.	CODE NO.	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	CH23901	Polymer Technology	T	3-0-0	3	3	OEC
2	CH23902	Frontiers of Chemical Engineering	T	3-0-0	3	3	OEC

COURSES OFFERED FOR LATERAL ENTRY/B.Sc. STUDENTS

S. NO.	SEM	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1	ME23C01	Engineering Drawing & 3D Modeling	T	3-0-0	3	3	
2	CH23C01	Introduction to Chemical Engineering	T	3-0-0	3	3	PCC

COURSES OFFERED FOR LATERAL ENTRY/DIPLOMA STUDENTS

S. NO.	SEM	COURSE TITLE	COURSE TYPE#	PERIODS/WEEK		CREDITS	CATEGORY
				L-T-P	TCP*		
1.	CY23C01	Engineering Chemistry	T	3-0-0	3	3	HSMC
2.	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-0-0	3	3	PCC

EN23C01	FOUNDATION ENGLISH	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION 6

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: 6

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION 6

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: 6

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION 6

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: 6

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST 6

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: 6

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS 6

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: 6

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab assessment
- Listening
- Speaking

External Assessment
- End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume I by Orient Blackswan, 2022
2. “English for Science & Technology - I” by Cambridge University Press, 2023

REFERENCES

1. “Interchange” by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.

2. “English for Academic Correspondence and Socializing” by Adrian Wallwork, Springer, 2011.
3. “The Study Skills Handbook” by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

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

MA23C01	MATRICES AND CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES 9+3

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS 9+3

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS 9+3

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals- Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS 9+3

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.
CO 2 :Use differential calculus ideas on several variable functions.
CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.
CO 4 :Apply multiple integral ideas in solving areas and volumes problems.
CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., "Advanced Engineering Mathematics", Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics",Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., "Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.

5. Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Co. Ltd., 11tReprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

CY23C01 ENGINEERING CHEMISTRY L T P C

3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion- measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.
3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.
4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE International Publishers, 2009.
4. Vogel’s Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	3	-	-	-	-	-
CO2	3	-	2	-	2	-	3	-	-	-	-	-
CO3	3	3	2	-	2	-	3	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-
CO5	3	-	-	-	-	-	3	-	-	-	-	-
Avg	3	3	-	-	-	-	3	-	-	-	-	-

1’ = Low; ‘2’ = Medium; ‘3’ = High

CS23C02 COMPUTER PROGRAMMING IN PYTHON

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

- To understand fundamental structural programming concepts and problem-solving process.
- To solve problems using modular programming and decomposition techniques.
- To solve problems using data structures and abstraction techniques.
- To create programming solutions using libraries and packages.
- To design solutions to domain problems using programming problem-solving techniques.

UNIT I – STRUCTURED PROGRAMMING 9+6

Problem-Solving Strategies. Basic Problem-Solving Tools: Flowcharts, Pseudocode. Introduction to Programming Languages and Development Environments. Programming. Basic Concepts and Syntax: Variables, Identifiers, Data Types: Primitive Types and Strings, Statements, Operators, Expressions and its evaluation, Operator Precedence, Basic Arithmetic Operations. Principles of Structured Programming – Control Structures: Sequence, Selection, Iteration and Branching.

PRACTICALS:

- Design algorithms for simple computational problems
- Create Pseudo-code and Flow charts for simple computational problems
- Create Python programs using simple and nested selective control statements
- Create Python programs using simple and nested sequence & iterative control statements
- Create Python programs to generate series/patterns using control statements

UNIT II – MODULARITY AND DECOMPOSITION 9+6

Principles of Modular and Decomposition. Functions: Defining functions –Argument types – Function Name-spaces – Scoping: Global and Non-local. Principles of Recursion: Base case and Recursive cases – Develop and Analyze Recursive functions: Factorial, Fibonacci. Principles of First-Class and Higher-Order functions: Lambda functions – Functions as arguments.

PRACTICALS:

- Create Python programs using functions
- Create python program using recursion

- Create Python programs using lambda functions
- Create Python programs using first-class functions
- Create Python programs using higher-order functions

UNIT Ill – DATA STRUCTURES AND ABSTRACTIONS **9+6**

Principles of Data Structures and Abstractions. String Methods and Manipulations,.Lists: List Operations and Methods, List comprehensions, Nested List comprehensions, Matrix operations using Lists. Tuples and sequences. Sets and Operations. Dictionaries: Dictionary operations, Dictionary comprehensions, Nested Dictionary comprehensions. Comparing Data Structures. Search and Sort Data Structures. Principle of Functional Programming and Tools : map, filter, and reduce.

PRACTICALS:

- Create Python programs for strings manipulations.
- Design Python programs using Lists, Nested Lists and Lists comprehensions
- Create Python programs using Tuples, Nested Tuples, and Tuple comprehensions
- Create Python programs creating Sets and performing set operations
- Create Python programs using Dictionary, Nested Dictionary and comprehensions
- Create Python programs by applying functional programming concepts

UNIT IV – LIBRARIES AND MODULES **9+6**

Exceptions: Syntax errors, Exceptions, Exception types, Handling exceptions, Raising exceptions. Files: File Path, Type of files, opening modes, Reading and Writing text files, Handling other format Data files. Modules: Creating Modules, import and from statements, Executing modules as scripts, Standard modules. Packages and Importing from packages

PRACTICALS:

- Design Python programs to handle errors and exceptions
- Create, import, and use pre-defined modules and packages
- Create, import, and use user-defined modules and packages
- Create Python programs to perform various operations on text files
- Create Python programs to perform various operations on other data file formats.

UNIT V – SIMPLE PROBLEM SOLVING TECHNIQUES IN PROGRAMMING 9+6

Data Structures for Problem Solving: Stack, Queue. Principles of Divide and Conquer: Binary Search. Principles of Greedy Algorithms: Minimum Coin Change Problem. Case studies on programming application of problem-solving techniques in different fields of engineering.

PRACTICALS:

- Create python programs to implement stack and queue.
- Create python programs to implement binary search.
- Create python programs to solve minimum coin change problem.
- Case study on developing python solution to a domain specific problems.

TOTAL = 45 + 30 = 75 PERIODS

COURSE OUTCOMES

1. Understand fundamental structural programming concepts and problem-solving process.
2. Solve problems using modular programming and decomposition techniques.
3. Solve problems using data structures and abstraction techniques.
4. Create programming solutions using libraries and packages.
5. Design solutions to domain problems using programming problem-solving techniques.

TEXT BOOKS

1. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, First Edition, 2017.
2. S. Sridhar, J. Indumathi, V. M. Hariharan, Python Programming, Pearson Education, First Edition, 2023

REFERENCE BOOKS

1. Paul Deitel, Harvey Deitel, Python for Programmers, Pearson Education, 2020.
2. John V Guttag. Introduction to Computation and Programming Using Python, With Application to Computational Modeling and Understanding Data. Third Edition, The MIT Press, 2021
3. Mark Lutz, Learning Python, 5th Edition, O'Reilly Media, Inc.
4. Python official documentation and tutorial, https://docs.python.org/3/
5. Numerical Python official documentation and tutorial, https://numpy.org/

CO's-PO's & PSO's MAPPING

CO	PO1	PO2	PO3	PO4	POS	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2		2		1								1	1	
2	2		2		1								1	1	
3	2	1	2		1								1	1	
4	2	1	2	1	1								1	1	
5	2	1	2	1	1								1	1	
Avg	2	1	2	1	1								1	1	

1 - low, 2 - medium, 3 - **high,** '-' - **no correlation**

ME23C01	ENGINEERING DRAWING AND 3D MODELING	L	T	P	C
		2	0	4	4

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **'**BIS' specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the 'A3' size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

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UNIT 1: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

(6+12 = 18 Hours)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT 2: PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

(6+12 = 18 Hours)

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches

UNIT 3: 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS

Free hand sketching – I & III angle projections of engineering parts and components

Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum

Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

(6+12 = 18 Hours)

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT 4: SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane ('On the axis' and 'from the axis' conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

(6+12 = 18 Hours)

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT 5: LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

(6+12 = 18 Hours)

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

COURSE OBJECTIVES

After successful completion of this course, the students will be able to:

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D modeling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.
5. Develop skills in lateral surface development and sheet metal design.

COURSE OUTCOMES

After successful completion of the course, the students will be able to:

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD software

CO4: Determine the true shape of a sectioned solid and draft the assembled parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

Text book

1. “Engineering Drawing” by N S Parthasarathy and Vela Murali, Oxford University Press; UK ed. Edition, 2015.
2. “Engineering Drawing + Auto CAD” by Venugopal K, V. Prabhu Raja, New Age International Publishers, Sixth edition (1 January 2022).

References

1. "Basic Engineering Drawing: Mechanical Semester Pattern" by Mehta and Gupta, Charotar Publishing House, 2nd edition, 2018.
2. "Engineering Drawing" by Basant Agrawal and C M Agrawal, Vikas Publishing House, 3rd edition, 2020.
3. "Engineering Drawing With Auto CAD" by B V R Gupta, McGraw Hill Education, 4th edition, 2019.
4. "Engineering Drawing" by P S Gill, Tata McGraw Hill Education, 5th edition, 2018.
5. "Engineering Drawing with an Introduction to AutoCAD" by Dhananjay Jolhe, Cengage Learning, 2nd edition, 2020.
6. "Engineering Drawing" by M B Shah, Charotar Publishing House, 3rd edition, 2019
7. "Fundamentals of Engineering Drawing" by Imtiaz Hashmi, Pearson Education, 2nd edition, 2018.
8. "Computer Aided Engineering Drawing" by S Trymbaka Murthy, Scitech Publications, 3rd edition, 2020.
9. "CAED: Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses" by Reddy K B, CBS Publishers & Distributors, 2nd, 2019.
10. "Computer-Aided Engineering Drawing" by Subrata Pal, Oxford University Press, 2nd, 2020.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

ME23C04	MAKERSPACE	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.
ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.
iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.
iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.
ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.
iii. Hands-on session of preparing base material & Joint groove for welding.
iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.
ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,
iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.
iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.
ii. Dis-assembly and assembly of Computers.

iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.
iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.
v. Hands-on session of integration of sensors and actuators with a Microcontroller.
vi. Demonstration of Programmable Logic Control Circuit.

(E).Contemporary Systems

i. Demonstration of Solid Modelling of components.
ii. Demonstration of Assembly Modelling of components.
iii. Fabrication of simple components / parts using 3D Printers.
iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Assemble and dis-assemble various items / equipment.
CO2: Make simple parts using suitable welding processes.
CO3: Setup wiring of distribution boards, machines, etc.
CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.
CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.
2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.
5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

UC23H01	தமிழர் மரபு	L	T	P	C
		1	0	0	1

அலகு I மொழி மற்றும் இலக்கியம் **3**

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை **3**

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: **3**

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: **3**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: **3**

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H01 **HERITAGE OF TAMILS** **L T P C**
1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India-Dravidian Languages–Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - TamilEpicsandImpactofBuddhism&JainisminTamilLand-BakthiLiteratureAzhwarsandNayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyarand Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts-Art of temple car making - Massive Terracotta sculptures, Villagedeities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments-Mridhangam,Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, VilluPattu, KaniyanKoothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAICONCEPTOFTAMILS 3

Flora and Fauna of Tamils&AhamandPuramConceptfromTholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import duringSangamAge -Overseas Conquestof Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils toIndian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - RoleofSiddhaMedicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15
PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).

3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

NCC Credit Course Level 1*

UC23P01	(ARMY WING) NCC Credit Course Level - I	L	T	P	C
		2	0	0	2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour 'Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P02	**(NAVAL WING) NCC Credit Course Level – I**	**L T P C**
		2 0 0 2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	(AIR FORCE WING) NCC Credit Course Level – I	L	T	P	C
		2	0	0	2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02	PROFESSIONAL COMMUNICATION	L T P C 2 0 2 3

COURSE OBJECTIVES:

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT 6

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: 6

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION 6

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: 6

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION 6

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: 6

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT 6

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: 6

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW 6

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: 6

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab Assessment
- Group discussion (Peer assessment)
- Listening

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to
- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume 2 by Orient Blackswan, 2022
2. “English for Science & Technology - II” by Cambridge University Press, 2023.

REFERENCES:

1. “Communicative English for Engineers and Professionals” by Bhatnagar Nitin, Pearson India, 2010.

2. ”Take Off – Technical English for Engineering” by David Morgan, Garnet Education, 2008. 3. “Advanced Communication Skills” by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

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

MA23C02 ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES

L	T	P	C
3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.
Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

TEXT BOOK:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.
CO2 :Apply Laplace transform techniques in solving linear differential equations.
CO3 :Apply Fourier series techniques in engineering applications.
CO4 :Understand the Fourier transforms techniques in solving engineering problems.
CO5 :Understand the Z-transforms techniques in solving difference equations.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

CY23C08 **ORGANIC CHEMISTRY** **L T P C**
3 0 0 3

OBJECTIVE:

The course is aimed to

- Learn various reaction mechanisms, preparation of organic compounds and their properties.
- This will be a precursor for the study on Chemical Reaction Engineering

UNIT I **9**

Introduction – various definitions and classifications of carbohydrates – Configurations of aldoses and ketoses upto six carbon atoms- D and L configurations – Anomerism- Epimerism- Preparation, Chemical properties, different structures (Fisher, Haworth, Pyranose and Furanose) and Uses of Monosaccharides (Glucose & Fructose). Ascending in carbohydrate series – (Aldo pentose to aldo hexose by Kiliani- Fischer, Improved Kiliani Fischer, Wolfrom and Sowden methods) – Descending in carbohydrate series (Aldo hexose to aldo pentose by Ruff, Wohl and Mac Donald methods) - aldose to isomeric Ketose – Ketose to isomeric Aldose – Aldose to epimer

UNIT II **9**

Different preparative methods, Physical & Chemical properties (Oxidation, reduction, Electrophilic and nucleophilic) and Uses of Pyrrole, Furan, Furfural, Tetrahydro Furan, Thiophene, Indole, Pyridine, Quinoline and Isoquinoline. Conversion of THF into Nylon 6-6

UNIT III **9**

Preparations of Benzil from benzyl aldehydes - Furyl from furfural, Vannilin from catechol through guaiacol, Gramine from indole, N-actetyl-5- bromoindoline from indole, Salol from phenol, Alanine from propionic acid, Heteroauxin from indole - Uses, Preparation of Chlorampenicol (by Baltz and Long's method)- Uses

Reaction and mechanism of acyloin condensation, Baeyer-Villigar reaction, Gabriel's synthesis of phthalimide, Bartoli Indole synthesis

UNIT IV **9**

Preparation and Synthetic utilities of Grignard reagent, Ethyl aceto acetate and Malonic ester for obtaining possible higher alkanes, alkenes, alkynes, acids, esters, aldehydes, ketones, alcohols, higher normal dicarboxylic acids, diketones and cyclic compounds etc.

UNIT V **9**

Synthesis of Malonyl urea, Phenacetin, Isoniazid, Para amino benzoic acid (PABA), Tryptophan Isopentaquine, chloroquine (precursors from m-chloroaniline and Ethyl aceto acetate) - Sulphaniliamide from aniline, chloro benzene, and p- toluene sulphonamide - Sulphapyridine from N- ASC and p-nitrochlorobenzene

TOTAL: 45 PERIODS

OUTCOMES:

On the completion of the course students are expected to

CO1: Understand the preparation and classifications of carbohydrates

CO2: Understand the physical and chemical properties of heterocyclic compounds

CO3: Understand the various methods for preparing synthetic intermediates

CO4: Understand the various synthesis mechanisms

CO5: Understand the procedure for synthesizing alkanes, alkynes and various cyclic compounds

CO6: Understand the basic chemistry in pharmaceutical industry

TEXT BOOKS:

1. R.T. Morrison and R.N. Boyd “Organic Chemistry” VI Edition Prentice Hall Inc (1996) USA.
2. K.S. Tiwari, N.K. Vishnoi and S.N. Malhotra “A text book of Organic Chemistry” Second Edition, Vikas Publishing House Pvt. Ltd. (1998) New Delhi.

REFERENCES:

1. Chemistry in Engineering and Technology, Vol.2, TMH Publishing Co Ltd., New Delhi, 1994.
2. I L Finar “Organic Chemistry” ELBS (1994).

Course Articulation Matrix:

Course	Statements	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO
CO1	Understand the preparation and classifications	2	-	2	-	-	1	1	1	-	2	3	2	2	2	2
CO2	Understand the physical and chemical	2	3	1	2	-	1	2	1	1	1	2	3	3	2	2
CO3	Understand the various methods for preparing	3	2	-	3	1	2	2	2	1	1	3	3	2	3	2
CO4	Understand the various synthesis	2	3	1	3	1	1	2	2	1	2	3	2	2	3	2
CO5	Understand the procedure for synthesizing	3	2	-	3	1	2	2	2	1	1	3	3	2	3	2
CO6	Understand the basic chemistry in pharmaceutical	3	2	2	2	-	2	3	3	-	2	3	2	2	2	3
Overall CO		3	2	1	3	-	1	2	2	1	-	3	3	2	2	3

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

PH23C01	ENGINEERING PHYSICS	L	T	P	C
	(Common to all branches of B.E/B.Tech Programmes)	3	0	2	4

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS 9+6

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS 9+6

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

1. Non-uniform bending -Determination of Young's modulus of the material of the beam.
2. Uniform bending -Determination of Young's modulus of the material of the beam
3. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS 9+6

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber -Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

1. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
2. Melde's string experiment - Standing waves.
3. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS 9+6

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

1. Laser - Determination of the width of the groove of the compact disc using laser.
   Laser Parameters
   Determination of the wavelength of the laser using grating
2. Air wedge -Determination of the thickness of a thin sheet/wire
3. Optical fibre - Determination of Numerical Aperture and acceptance angle
   -Determination of bending loss of fibre.
4. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves– de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

1.Photoelectric effect – Determination of Planck's constant.

2.Black Body Radiation (Demonstration)

3.Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

After completion of the course, the students will be able to

CO1: Understand the significance of crystal structure and bonding. Learn to grow crystals.
CO2: Obtain knowledge on important mechanical and thermal properties of materials and determine them through experiments.

CO3: Conceptualize and visualize the oscillations and sound.
CO4: Grasp optical phenomenon and their applications in real life.
CO5: Appreciate and evaluate the quantum phenomenon.
CO6 Develop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students, Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

EE23C03 BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING LT P C
2 0 2 3

UNIT-I BASIC ELECTRICAL CIRCUITS 6

Basic Elements: R,L,C- DC Circuits: Ohm's Law - Kirchhoff's Laws –Mesh and Nodal Analysis(Only Independent Sources). AC Circuits: Average Value, RMS Value, Impedance Instantaneous Power, Real Power, Reactive Power and Apparent Power, Power Factor-Steady state Analysis of RL,RC and RLC circuits.

UNIT II AC AND DC MACHINES 6

Magnetic Circuit Fundamentals -DC Machines - Construction and Working Principle, Types and Application of DC generator and Motor, EMF and Torque Equation. AC Machines: Principle, Construction, Working and Applications of Transformer -Three phase Alternator - Three Phase Induction Motor.

UNIT III ANALOG AND DIGITAL ELECTRONICS 6

Operation and Characteristics of electronic devices: PN Junction Diodes, Zener Diode and BJT Applications: Diode Bridge Rectifier and Shunt Regulator. Introduction to Digital Electronics: Basics Logic Gates-Flip Flops.

UNIT IV SENSORS AND TRANSDUCERS 6

Solenoids, electro-pneumatic systems, proximity sensors, limit switches, Strain gauge, LVDT, Piezo electric transducer, optical and digital transducers, Smart sensors, Thermal Imagers.

UNIT V MEASUREMENTS AND INSTRUMENTATION 6

Functional Elements of an Instrument, Operating Principle of Moving Coil and Moving Iron Instruments,Power Measurement, Energy Meter, Instrument Transformers - CT and PT, Multimeter- DSO - Block Diagram Approach.

TOTAL 30

LAB COMPONENET:

1. Verification of ohms and Kirchhoff's Laws.
2. Load test on DC Shunt Motor.
3. Load test on Single Phase Transformer.
4. Load test on 3 Phase Induction Motor.
5. Uncontrolled diode bridge Rectifiers.
6. Application of Zener diode as shunt regulator.
7. Verification of truth table of logic gates and flip flops.
8. Characteristics of LVDT.
9. Three phase power measurement using two wattmeter method.
10. Study of DSO.

COURSE OUTCOMES:

Students will be able to

CO1 Compute the electric circuit parameters for simple circuits.
CO2 Understand the working principles and characteristics of electrical machines.
CO3 Understand the basic electronic devices.
CO4 Understand the basic operating principles of sensors and transducer.
CO5 Understand the operating principles measuring devices

TEXT BOOKS:

1. Kotharai DP and Nagarath IJ, “Basic Electrical and Electronics Enigneering”, McGraw Hill Education, Second Edition, 2020.
2. Bhattacharya SK, “Basic Electrical and Electronics Engineering”, Pearson Education, Second Edition, 2017.

REFERENCES:

1. Mehta V.K. & Mehta Rohit, “Principles of Electrical Engineering and Electronics”, McGraw Hill Education, Second Edition, 2020.
2. Mehta V.K. & Mehta Rohit, “Principles of Electrical Machines”, S. Chand Publishing, second edition 2006.
3. Albert Malvino & David Bates, “Electronic principles”, McGraw Hill Education, Seventh Edition, 2017.

Mapping COs and POs:

COs	Pos												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1														
CO2	2	1														
CO3	2	1														
CO4	2	1														
CO5	2	1														
Avg	2	1														

CH23C01	INTRODUCTION TO CHEMICAL ENGINEERING	L T P C 3 0 0 3

COURSE OBJECTIVES

1. To introduce the history and development of chemical engineering domain
2. To educate on basic calculations and transfer operations in chemical engineering.
3. To enlighten various unit processes and thermodynamic principles.
4. To impart flow sheeting to represent a chemical industry in terms of process flow diagram.
5. Make aware of software usage and applications of chemical engineering in diversified fields.

UNIT I HISTORY, EVOLUTION AND ACHIEVEMENTS OF CHEMICAL ENGINEERING 6

Chemistry, Chemical Engineering and Chemical Technology; Historical overview of Chemical Engineering; Range of scales in Chemical Engineering; Evolution of an Industry; Chemical Engineering in everyday life; Greatest achievements of Chemical Engineering.

UNIT II UNIT OPERATIONS AND BASIC CHEMICAL CALCULATIONS 12

Units and dimensions; Fundamental concepts of stoichiometry; Ideal gases and gas mixtures; Concepts of fluid flow, Heat and mass transfer operations and its equipments; Basic material & energy balance.

UNIT III UNIT PROCESSES, THERMODYNAMICS AND REACTION KINETICS 9

Description of different Unit Processes; Basics of Thermodynamics – Definitions, Thermodynamic laws, reversibility, energy, work and heat; Chemical Kinetics – Reaction rates and Reactor types; Process dynamics and control – Basic principles.

UNIT IV CHEMICAL PROCESS INDUSTRIES AND FLOW SHEETS 9

Representation of different Unit Processes and Unit Operations; Designing of equipments; Flow sheet representation of process plants; Sulphuric acid and Soda ash manufacture; Plant visit to a chemical industry.

UNIT V SOFTWARES AND APPLICATIONS OF CHEMICAL ENGINEERING IN ALLIED FIELDS 9

Chemical Engineering Software – Computational tools like MATLAB, ASPEN PLUS, ANSYS CFD, DWSIM etc. Applications of Chemical Engineering in various fields like Energy, Environment, Food, Medical and Agriculture.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understand the history and development of chemical industry since origin.
CO2: Understand basic calculations and transfer operations in chemical engineering.
CO3: Understand various unit processes and thermodynamic principles.
CO4: Understand flow sheeting to represent a chemical industry in terms of process flow diagram.
CO5: Understand the usage of softwares and applications of chemical engineering in diversified fields

TEXT BOOKS

1. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", 6th Edition, Tata McGraw Hill, 1997. ISBN 10: 0070850275 / ISBN 13: 9780070850279
2. Ghosal, S.K, Sanyal S.K. and Dutta.S, "Introduction to Chemical Engineering" TMH Publications, New Delhi, 1998. ISBN 10: 0074601407 / ISBN 13: 978-0074601402
3. Sittig M. and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010. ISBN: 8185938792

REFERENCES

1. McCabe, W.L., Smith, J. C. and Harriot, P. "Unit operations in Chemical Engineering", McGraw Hill, 7th Edition, 2001.
2. Finlayson, B. A., "Introduction to Chemical Engineering Computing", John Wiley & Sons, New Jersey, 2006.
3. Randolph Norris Shreve, George T. Austin, "Shreve's Chemical Process Industries", 5th edition, McGraw Hill, 1984.
4. Pushpavanam, S, "Introduction to Chemical Engineering", PHI Learning Private Ltd, New Delhi, 2012.
5. Bhatt B. I. and Vora, S. M, "Stoichiometry", 4th edition, McGraw Hill, 2004.

Course Articulation Matrix:

PO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	3	-
CO2	3	3	2	-	-	-	-	-	-	-	-	3	3	3	-
CO3	3	3	2	-	-	-	-	-	-	-	-	3	3	3	-
CO4	3	3	2	-	-	-	-	-	-	-	-	3	3	3	-
CO5	3	3	2	-	2	-	2	-	2	-	-	3	3	3	2
Avg	3	2.4	1.6	-	0.4	-	0.4	-	0.4	-	-	2.4	3	3	0.4

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

UC23H02	தமிழரும் தொழில்நுட்பமும்	L T P C 1 0 0 1

அலகு I <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்</u>: **3**

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</u>: **3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு-சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III <u>உற்பத்தித் தொழில் நுட்பம்</u>: **3**

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</u>: **3**

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</u>: **3**

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).

8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H02 TAMILS AND TECHNOLOGY L T P C
1 0 0 1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

Designing and Structural construction House & Designs in household materials during Sangam Age -Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period -Type study (Madurai Meenakshi Temple)- Thirumalai NayakarMahal -ChettiNadu Houses, Indo-Saracenic architecture at Madras during British Period.

UNIT III MANUFACTURING TECHNOLOGY 3

Art of Ship Building - Metallurgical studies -Iron industry - Iron smelting, steel -Copper and gold- Coins as source of history - Minting of Coins – Beads making-industries Stonebeads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean -KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
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8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

MA23C08 **NUMERICAL METHODS**

L	T	P	C
3	1	0	4

OBJECTIVES:

- To provide the mathematical foundations of numerical techniques for solving Eigen value problems and linear system of equations.
- To apply the interpolation techniques for equal and unequal intervals for the given data.
- To understand the techniques of numerical integration and differentiation for solving ordinary differential equations.
- To provide the mathematical tool in solving initial value problems and boundary value problems.
- To demonstrate the utility of Numerical techniques for solving Partial Differential Equations in Heat and Fluid problems.

UNIT I SOLUTION OF EQUATIONS AND EIGENVALUE PROBLEMS 9+3

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton-Raphson method- Solution of linear system of equations-Gauss elimination method – Pivoting - Gauss-Jordan methods – Iterative methods of Gauss-Jacobi and Gauss-Seidel - Matrix Inversion by Gauss-Jordan method – Eigen values of a matrix using Power method and Jacobi's method.

UNIT II INTERPOLATION AND APPROXIMATION 9+3

Interpolation with unequal intervals - Lagrange interpolation – Newton's divided difference interpolation – Cubic Splines - Interpolation with equal intervals - Newton's forward and backward difference formulae – Least square method - Linear curve fitting.

UNIT III NUMERICAL DIFFERENTATION AND INTEGRATION 9+3

Approximation of derivatives using interpolation polynomials - Numerical integration using Trapezoidal, Simpson's 1/3 and Simpson's 3/8 rules – Romberg's method - Two point and three point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal and Simpson's rules.

UNIT IV INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS 9+3

Single step-methods - Taylor's series method - Euler's method - Modified Euler's method - Fourth order Runge-Kutta method for solving first and second order differential equations - Multi-step methods - Milne's and Adams-Bashforth predictor-corrector methods for solving first order differential equations.

UNIT V BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS **9+3**

Finite difference methods for solving two-point linear boundary value problems - Finite difference techniques for the solution of two dimensional Laplace's and Poisson's equations on rectangular domain – One dimensional heat-flow equation by explicit and implicit (Crank-Nicholson) methods - One dimensional wave equation by explicit method.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

1. Solution of algebraic and transcendental equations
2. Newton-Raphson method
3. Iterative methods of Gauss-Jacobi and Gauss-Seidel
4. Matrix Inversion by Gauss-Jordan method
5. Eigen values of a matrix by Power method and by Jacobi's method
6. Interpolation with equal and unequal intervals
7. Numerical differentiation and integration
8. Solution of ODE by Taylor series and 4^{th} order R-K method
9. Solution of one-dimensional heat and wave equation
10. Solution of Laplace and Poisson Equations

OUTCOMES:

CO1: Understand the common numerical methods and how they are used to obtain approximate solutions to the algebraic and transcendental equations.
CO2: Apply numerical methods to obtain approximate solutions to mathematical problems using interpolation.
CO3: Apply numerical interpolation techniques in solving various mathematical problems.
CO4: Apply and find accurate solutions to ODE of First and Second order equations.
CO5: Understand various numerical techniques for solving PDE.

TEXT BOOKS:

1. Grewal, B.S. and Grewal,J.S., "Numerical Methods in Engineering and Science (C, C++, and MATLAB)", Stylus Publishing, LLC, 2018.
2. Burden, R.L and Faires, J.D, "Numerical Analysis", 9th Edition, Cengage Learning, 2016.

REFERENCES:

1. Gerald. C. F. and Wheatley. P. O., "Applied Numerical Analysis", Pearson Education, Asia, 6th Edition, New Delhi, 2006.
2. Mathews, J.H. "Numerical Methods for Mathematics, Science and Engineering", 2nd Edition, Prentice Hall,1992.
3. Brian Bradie, "A Friendly Introduction to Numerical Analysis", Pearson Education, Asia, New Delhi,2007.
4. Sastry, S.S, "Introductory Methods of Numerical Analysis", PHI Learning Pvt. Ltd, 5th Edition,2015.
5. Sankara Rao . K, "Numerical Methods for Scientists and Engineers", PHI Learning Pvt Ltd., New Delhi, 2007.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

CH23301	MECHANICAL ENGINEERING FOR TECHNOLOGISTS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To impart knowledge on thermodynamics and thermal engineering power generating units such as engines and theory of machines
2. Develop skills for material selection for different devices/ components.
3. Gain knowledge of steam formation and properties of steam.
4. To understand thermodynamic application
5. To study about working principles of different types of machines.

UNIT I LAWS OF THERMODYNAMICS AND ITS APPLICATION 9

Basic concepts and hints; Zeroth law; First Law of Thermodynamics - Statement and application; Steady flow energy equation-problems. Second law of Thermodynamics – Kelvin - Plank statement and Clausius statement- problems; Limitations; Heat Engine, Refrigerator and Heat Pump, Available energy, Equivalence entropy; Reversibility: Entropy charts; Third law of Thermodynamics - Statement.

UNIT II INTERNAL ENERGY AND THERMODYNAMIC PROCESSES 9

Expressions for work done, Internal energy and heat transfer for Constant Pressure, Constant Volume, Isothermal, Adiabatic and Polytropic Processes-Derivations and problems; Free expansion and Throttling process.

UNIT III AIR STANDARD CYCLES 9

Carnot cycle; Stirling's cycle; Joule cycle; Otto cycle; Diesel cycle; Dual Combustion Cycle - Derivations and problems.

UNIT IV IC ENGINES AND PROPERTIES OF STEAM 9+30

Engine nomenclature and classification; SI Engine; CI Engine; Four Stroke cycle, Two stroke cycle; Performance of IC Engine; Brake power, Indicated power, Brake thermal efficiency, Indicated Thermal Efficiency, Volumetric efficiency, Specific fuel consumption.
Steam - Properties of steam; Dryness fraction; latent heat; Total heat of wet steam; Dry steam; Superheated steam. Use of steam tables; volume of wet steam, volume of superheated steam; External work of evaporation; Internal energy; Entropy of vapor, Expansion of vapor, Rankine cycle.

1. Port timing diagram
2. Valve timing diagram
3. Load test on 4-stroke petrol engine
4. Performance test on 4-stroke single cylinder diesel engine
5. Performance test on 4-stroke twin cylinder diesel engine
6. Heat balance test on diesel engines

UNIT V SIMPLE MECHANISM, FLYWHEEL AND DRIVES 9

Definition of Kinematic Links, Pairs and Kinematic Chains; Working principle of Slider Crank mechanism and inversions; Double slider crank mechanism and inversions. Flywheel-Turning moment Diagram – Single cylinder and Multi Cylinder Engines; Fluctuation of Energy. Belt and rope drives; Velocity ratio; Slip; Creep; Ratio of tensions; Length of belt; Power Transmitted; Gear trains-types.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: Understand the basic concepts and Laws of thermodynamics and its applications
CO2: Understand the various processes with its derivation and gaining knowledge of various processes in Chemical Industries
CO3: Understand the various thermodynamic cycles with its derivation
CO4: Understand the Engine applications used in Chemical Process Industries and to estimate the heat distribution, engine performance with Mechanical loading / Electrical loading
CO5: Understand the applications of various drives like belts, gear drives in Chemical Process Industries

TEXT BOOKS

1. Nag, P.K., “Engineering Thermodynamics ", Fourth Edition, Tata McGraw Hill Publishing Co., Ltd., 2008. ISBN 9780070591141
2. Cengel, Y. A., and Boles, M.A., “Thermodynamics: An Engineering Approach", Ninth Edition, McGraw Hill, 2019. ISBN10: 1266664483
3. Claus Borgnakke, and Richard E. Sonntag, “Fundamentals of Thermodynamics ", Wiley, 2020, ISBN 1119723655, 9781119723653

REFERENCES

1. Bansal, R.K. and Brar, J.S.,“A Text book of Theory of Machines", Sixth Edition. Laxmi publications (P) Ltd, 2023.
2. Khurmi R.S., and Gupta J.K, “A text book of Thermal Engineering”, S.Chand & Company (P) Ltd., 2020.
3. Dhomkundwar. S., Kothandaraman.C.P., and Dhomkundwar. A.V., “A Course in Thermal Engineering (SI Units)”, Dhanpat Rai and Sons, Delhi (2004)
4. Smith, “Chemical Thermodynamics", Reinhold Publishing Co., 1977
5. Ganesan, V, “Thermodynamics – Basic and Applied", McGraw Hill Education (India) Private Limited, 2018.
6. Rajput, R . K, “Thermal Engineering”, Sixth Edition, Laxmi publications (P) Ltd, 2010.
7. Khurmi R.S., and Gupta J.K, “Theory of Machines”, Eurasia Publishing House (P) Ltd., 2017

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	1	1	-	1	1	1	2	3	2	3	3	3	2
CO2	3	3	3	2	1	2	2	1	3	2	1	3	3	2	3
CO3	2	2	3	2	3	2	-	3	3	3	3	2	3	3	3
CO4	3	2	3	2	2	3	2	2	2	2	3	2	2	3	3
CO5	3	3	3	3	2	3	3	2	3	2	3	3	3	3	3
average CO	2 . 2.	2.4	2.6	2.0	1.6	2.2	1.6	1.8	2.6	2.4	2.4	2.6	2.8	2.8	2.8

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23302	CHEMICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge about unit process and unit operations in various industries
2. To develop understanding of manufacturing process flow drawing for the manufacturing chemical processes
3. To describe its applications encountering major engineering problems in the process industries.
4. To determine process aspects like yield, byproducts formed, generation of waste
5. To draw and explain process flow diagrams for a given process

UNIT I SUGAR AND WOOD BASED INDUSTRIES 9

Introduction to chemical processing; symbolic representation of different unit operations and unit processes to build a flow sheet; Production of pulp and paper, Manufacture of sugar, starch and starch derivatives.

UNIT II ALKALIES AND ACIDS INDUSTRIES 9

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.

UNIT III CEMENT, OIL, PAINT AND PETROCHEMICAL INDUSTRIES 9

Cement-Types and Manufacture of Portland cement, Refining of edible oils and fats, fatty acids, Manufacture of Soaps and detergents; Manufacture of paints and Varnishes–Pigments, Petroleum refining-physical and chemical conversion products, lubricating oil, petrochemical precursors, chemicals from aromatics.

UNIT IV FIBERS, SILICA AND GAS INDUSTRIES 9

Natural and synthetic fibers- Manufacture of nylon 6,6 and nylon 6 fibers, viscose rayon and polyester fibers; PET, Nature, types, composition and uses of glass-its manufacture, melting, shaping, annealing and finishing operations; ceramics and refractories:Fuel gases-producer gas, coke oven gas, natural gas, LNG Industrial gases-carbon dioxide, hydrogen, nitrogen and oxygen.

UNIT V FERTILIZER INDUSTRIES 9

Nitrogen Fertilizers; Synthetic ammonia, nitric acid, Urea, Phosphorous Fertilizers: Phosphate rock, phosphoric acid, super phosphate and Triple Super phosphate, ammonium phosphate, potassium chloride, potassium phosphate.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: classify the various unit operations and processes with their symbols. and manufacture of pulp, paper sugar, starch and their derivatives.

CO2: demonstrate the various manufacturing process and major engineering problems related to chlor-alkalis and acids, sulphur and sulphuric acid, glasses, ceramics and refractories.

CO3: choose the manufacturing process involved in cement, soaps, detergents, paints and petrochemicals.

CO4: analyze process flowsheet and major engineering problems encountered in the processes of natural, synthetic fibre, industrial gases and fuel gases.

CO5: Familiarize with the manufacturing processes of different types of fertilizers.

TEXT BOOKS

1. Dryden, C. E., “Outlines of Chemicals Technology”, Edited and Revised by Gopala Rao, M.and M. Sittig, Second Edition, Affiliated East-West press, 1993, ISBN NO: 9788185938790
2. Austin, G. T., “Shreve’s Chemical Process Industries”, Fifth Edition, McGraw Hill, Singapore, 1984, ISBN NO: 9781259029455:
3. PATEL H.J. "Handbook For Chemical Process Industries" , TAYLOR & FRANCIS, CRC Press,2024, ISBN NO: 10-1032534826

REFERENCES

1. B.K.Baskararao, “Text book on Petrochemicals” 5th edition, Khanna Publishers,2004
2. Robert O. Ebewele, “Polymer Science and Technology” 1st Edition, CRC Press,2000
3. Brahma Mishra, “Fertilizer Technology and Management” Published by I.K. International Publishing House, 2012.
4. Smith W, "Chemical Process Industries, Volume 1: Organic Chemicals and Allied Industries", CBS Publishers & Distributors Pvt Ltd, India, 2017
5. Smith W and Chapman R, "Chemical Process Industries, Volume 2: Inorganic Chemicals and Allied Industries", CBS Publishers & Distributors Pvt Ltd, India, 2018

Course Articulation Matrix

Course Outcomes	Program Outcomes														
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	1	3	2	1	2	2	1	1	0	1	2	3	3	3
CO2	3	1	3	2	1	2	2	1	1	0	1	2	3	3	3
CO3	3	1	3	2	1	2	2	1	1	0	1	2	3	3	3
CO4	3	1	3	2	1	2	2	1	1	0	1	2	3	3	3
CO5	3	1	3	2	1	2	2	1	1	0	1	2	3	3	3
Average	3	1	3	2	1	2	2	1	1	0	1	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23303	CHEMICAL PROCESS CALCULATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To teach basic concepts of chemical engineering calculations that lays the foundation for subsequent courses in thermodynamics, unit operations, kinetics, and process dynamics and control.
2. To impart knowledge on process flow sheet, writing mass and energy balance to establish the relations between known and unknown process variables.
3. To formulate the material and energy balances on chemical processes and to obtain solutions using appropriate methods.
4. To utilize stoichiometry and thermodynamics in the analysis and design of chemical processes
5. Apply problem-solving skills to real-world chemical engineering scenarios, ensuring safety, efficiency, and sustainability in process operations.

UNIT I INTRODUCTION TO CHEMICAL CALCULATIONS AND FUNDAMENTALS OF STOICHIOMETRY **9**

Systems of Units and Dimensions, Conversion of Units, Dimensional Homogeneity and Data Analysis, Numerical Calculation and Estimation Computational Techniques, Processes and Process Variables; Use of Molal Quantities, Densities and Specific gravity, Composition of solids, liquids and gases, other expression for concentration

UNIT II MATERIAL BALANCES **9**

Flow-sheet - degrees of freedom and its importance in flow-sheet, Material Balance Calculations for unit operations; Balances on Multiple Unit Processes, Recycle, bypass, and purge calculations; Chemical Reaction Stoichiometry, Balances on Reactive Processes, Combustion Reactions; computer-based calculations.

UNIT III SINGLE AND MULTIPHASE SYSTEMS **9**

Single-Phase Systems - Liquid and Solid Densities, Ideal Gases, Equations of State for Non-ideal Gases, The Compressibility Factor Equation of State; Multiphase Systems - Single-Component Phase Equilibrium, The Gibbs Phase Rule; Gas-Liquid Systems - One Condensable Component, Multicomponent Gas-Liquid Systems; Solutions of Solids in Liquids; Equilibrium Between Two Liquid Phases

UNIT IV ENERGY AND ENERGY BALANCES **9**

Forms of Energy - The First Law of Thermodynamics, Kinetic and Potential Energy; Energy Balances on Closed Systems, Energy Balances on Open Systems at Steady State; Tables of Thermodynamic Data; Energy Balance Procedures; Balances on Nonreactive Processes - Elements of Energy Balance Calculations, Changes in Pressure at Constant Temperature, Changes in Temperature, Phase Change Operations, Mixing and Solution

UNIT V BALANCES ON REACTIVE AND TRANSIENT PROCESSES 9

Heats of Reaction - Measurement and Calculation of Heats of Reaction, Hess's Law, Formation Reactions and Heats of Formation, Heats of Combustion, Energy Balances on Reactive Processes, Fuels and Combustion; Transient Processes - The General Balance Equation, Material Balances, Energy Balances on Single-Phase Nonreactive Processes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Perform the basic chemical calculations, systems of units and measurement scales and methods of analysis.

CO2: Describe process flow diagrams and perform steady-state mass balance calculations f for batch and continuous processes.

CO3: Analyze the single and multiphase systems, determine the physical and chemical properties of flows and stream component.

CO4: Assess energy balance procedures, Develop and solve energy balance calculations for nonreactive processes.

CO5: Formulate and Solve material and energy balance for reactive and unsteady state processes.

TEXT BOOKS

1. Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard, “Elementary Principles of Chemical Processes”, 4th edition., John Wiley & Sons, New York, 2016, ISBN: 978-1-119-19210-7
2. David M. Himmelblau and James B. Riggs, “Basic Principles and Calculations in Chemical Engineering”, Eighth Edition, Prentice Hall Inc., 2014, ISBN-13: 978-0132346603 ISBN-10: 0132346605
3. Bhatt, B.I and Vora, S.M., “Stoichiometry “, 4th Edition,Tata McGraw-Hill (2004), ISBN ISBN 10: 0070964041 ISBN 13: 9780070964044.

REFERENCES

1. Hougen O A, Watson K M and Ragatz R A, “Chemical process principles” Part 1: Material and Energy Balances, 2nd Ed., John Wiley & Sons, 2004 ISBN-13: 978-8123909530 ISBN-10: 8123909535
2. V.Venkataramani, N.Anantharaman and K.M. Meera Sheriffa Begum, “Process Calculations”, 2 nd Edn., Prentice Hall of India Ltd, New Delhi. 2013, ISBN-13: 978-8120341999
3. K V Narayanan and B Lakshmikutty, “Stoichiometry and Process Calculations”, 2 nd Edn., Prentice Hall of India Ltd, 2016, ISBN-10: 8120352890, ISBN-13: 9788120352896

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	1	2	1	2	1	3	2	1	3	3	3	1
CO2	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
CO3	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
CO4	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
CO5	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
Overall	3	3	2.6	2.6	2	1	2	1	3	2	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23304	FLUID MECHANICS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To attain knowledge on behavior of fluid under various forces and at different atmospheric conditions
2. To analyze and calculate basic analytical problems on static and dynamic conditions of fluid flow.
3. To estimate pressure drop under various flow situations.
4. To measure the rate of flow using constant and variable head meters.
5. To know on pumps, valves and pipes its function and characteristics.

UNIT I INTRODUCTION TO TYPES OF FLUIDS 9

Fluids - Properties, Methods of analysis and description - fluid as a continuum – Velocity and stress field - Newtonian and non-Newtonian fluids – Classification of fluid motion.

UNIT II DIMENSIONAL ANALYSIS AND SIMILITUDE 9

The principle of dimensional homogeneity – dimensional analysis, Rayleigh method and the Pi-theorem - non-dimensional action of the basic equations - similitude – relationship between dimensional analysis and similitude - use of dimensional analysis for scale up studies

UNIT III FLUID STATICS AND KINEMATICS 9

Fluid statics – basic equation - equilibrium of fluid element – pressure variation in a static fluid - application to manometer – Differential analysis of fluid motion – continuity, equation of motions, Bernoulli equation and Navier- Stokes equation.

UNIT IV CHARACTERISTICS OF INTERNAL AND EXTERNAL FLOWS 9+20

Reynolds number regimes, internal flow - flow through pipes – pressure drop under laminar and turbulent flow conditions – major and minor losses; External flows - boundary layer concepts, boundary layer thickness under laminar and turbulent flow conditions- Flow over a sphere – friction and pressure drag - flow through fixed and fluidized beds.

PRACTICALS:

1. Flow through pipes (Straight pipe / Annular pipe)
2. Flow through helical coil and spiral coil
3. Pressure drop studies in packed bed columns
4. Pressure drop studies in fluidized bed column

UNIT V FLOW MEASUREMENTS AND METERING 9+10

Flow measurement - Constant and variable head meters; Velocity measurement techniques; Type and characteristics of valves; Classification, performance characteristics of pumps.

PRACTICALS:

Calibration of variable head flow meters (Orifice meter / Venturi meter)

Characteristic curves of pumps (Centrifugal / Reciprocating)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: Demonstrate the fundamental properties of fluids, stress-strain relationship in fluids, and its characteristics under static conditions and establish force balance in static systems.

CO2: Evaluate dimensional analysis to derive relationships among process or system variables.

CO3: Apply Bernoulli principle, Navier - Stokes equation and compute pressure variation in static fluid

CO4: Design the different types of flow conditions in pipes, fixed bed and fluidized beds

CO5: Describe function of flow metering devices, apply Bernoulli equation to determine the performance of flow-metering devices and also analyze the performance aspects of fluid machinery such as pumps and valves

TEXT BOOKS

1. Y. Cengel and J. Kimbala, Fluid Mechanics: Fundamentals and Applications, McGraw Hill Publication, 3rd Ed., 2014. ISBN 978-1-259-69653-4
2. Noel de Nevers, “Fluid Mechanics for Chemical Engineers “, Second Edition, McGraw-Hill, (1991). ISBN-13: 978-0071008303 ISBN-10: 0071008306.
3. R. W. Fox and A. T. McDonald, Introduction to Fluid Mechanics, Wiley India Edition, John Wiley & Sons, 2015. ISBN-10. 9780470547557 ; ISBN-13. 978-0470547557

REFERENCES

1. W. M. Deen, Introduction to Chemical Engineering Fluid Mechanics, Cambridge University Press, New York, 2016.
2. F. M. White, Fluid Mechanics, 8th Ed., McGraw Hill Publications, 2017.
3. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Ed., McGraw - Hill, International Edition, 2014.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	-	-	-	-	-	-	-	1	2	-	3	1	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	3	2	-
CO3	-	3	3	3	2	-	2	-	-	3	1	2	-	-	2
CO4	3	-	3	3	2	-	2	-	-	-	-	3	3	-	-
CO5	2	3	-	3	-	2	1	1	-	-	-	-	-	2	2
Over all	2.6	3	3	3	2	2	1.6	1	-	2	1.5	2.5	3	2 .5	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23305	MECHANICAL OPERATIONS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To make students learn about properties of particulate solids
2. To develop an understanding of size analysis, size reduction and associated equipments
3. To make students understand separation methods such sedimentation and elutriation.
4. To develop an understanding on filtration operations.
5. To make student learn about pollution control equipments.

UNIT I PARTICULATE PROPERTIES AND SCREENING 9+6

General characteristics of solids; Characterization of solid particles; Differential and cumulative size analysis; Screening methods and equipment; Screen efficiency.

PRACTICALS: Screen efficiency determination by sieve analysis

UNIT II SIZE REDUCTION 9+6

Laws of size reduction and applicability; Energy relationship in size reduction; Power requirement; Work index; Method of size reduction; Types, classification and selection of size reduction equipments.

PRACTICALS: Work index, various constants and reduction ratio determination in Jaw Crusher/ Roll Crusher/ Ball mill/ Drop weight crusher

UNIT III SEDIMENTATION AND ELUTRIATION 9+6

Theory and operation: Gravity settling; Sedimentation; Thickening; Elutriation.

PRACTICALS: Batch Sedimentation studies; Characteristics of Elutriator

UNIT IV FILTRATION 9+6

Theory of filtration; classification of process; Flow through filter cake and filter media; filtration equipments – selection and operation.

PRACTICALS: Filter characteristics of Plate and Frame Filter press / Leaf filter

UNIT V UNIT OPERATIONS FOR AIR POLLUTION CONTROL 9+6

Industrial dust removing equipment; Electrostatic precipitators; Cyclone; Bag filters; Scrubbers.

PRACTICALS: Efficiency calculation of cyclone separator

TOTAL:75 PERIODS

COURSE OUTCOMES:

CO1: Determining various properties of particulates and screening applications

CO2: Evaluation of Size reduction techniques

CO3: Studying separation and purification techniques employed in solid particles

CO4: Describing filtration and to analyze the applicability of filtration operations

CO5: Enhancing knowledge on unit operations used in controlling air pollution

CO6: Understanding the handling and processing of small sized solid particles

TEXT BOOKS:

1. McCabe, W.L., Smith,J.C., and Harriot,P., "Unit Operations in Chemical Engineering", 7th Edition., McGraw-Hill, 2005. ISBN: 9780072848236
2. Badger W.L. and Banchero J.T.,"Introduction to Chemical Engineering",Indian edition, TataMcGrawHill, 2017. ISBN: 9780074630501
3. Martin Rhodes, " Introduction to particle technology", wiley , 2nd edition., 2013. ISBN: 9781118681541

REFERENCES:

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I,6th Edition., Elsevier,1999. ISBN: 0750644443
2. Green, Don W., and Marylee Z. Southard, "Perry's Chemical Engineers' Handbook" 9th edition. McGraw hill, 2019. ISBN: 9780071834087
3. C M Narayanan and B.C. Bhattacharya: "Mechanical Operation for Chemical Engineers (with computer aided analysis)" 3rd Edition, Khanna publishers. 1990. ISBN: 9788174090362.
4. Foust,A.S.,Wenzel,L.A.,Clump,C.W.,Naus,L.,and Anderson,L.B.,"Principles of Unit Operations",2nd edition, Wiley.,2008. ISBN:978-8126518296
5. Brown, G.G. and associates, "Unit operations" 1st edition, Wiley, 1950. ISBN: 978-8123910994

Course articulation matrix:

Course Outcome	Program Outcome														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	1	1	-	3	3	1	2	3	3	3
CO2	3	3	1	2	1	2	3	1	3	3	1	2	3	3	3
CO3	3	3	-	2	1	-	1	1	3	3	1	2	3	3	3
CO4	3	3	3	2	1	2	3	1	3	3	1	2	3	3	3
CO5	3	3	3	2	1	2	3	1	3	3	1	2	3	3	3
CO6	3	3	2	2	1	2	2	1	3	3	1	2	3	3	3
Average	3	3	1.7	2	1	1.5	2.2	0.8	3	3	1	2	3	3	3

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**
1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

Module I: Introduction **(3L,6P)**

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

Module II: Harmony in the Human Being **(3L,6P)**

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

Module III: Harmony in the Family and Society **(3L,6P)**

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence

as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Practical Session*: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives*

Module IV: Harmony in the Nature and Existence (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

Practical Session: *Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

Module V: Implications of Harmony on Professional Ethics (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

Practical Session: *Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

By the end of the course, the students will be able to:

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.

2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1	1	1	3			3
CO2						1	1	1	3			3
CO3						3	3	2	3		1	3
CO4						3	3	2	3		1	3
CO5						3	3	3	3		2	3

CH23401	CHEMICAL ENGINEERING THERMODYNAMICS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

1. To understand and be able to use the laws of thermodynamics for open and closed systems
2. To evaluate thermodynamic properties of pure substances with special emphasis on fluids.
3. To be able to use various sources of thermodynamic data and properties, including graphs and tables.
4. To understand the interrelationships between different thermodynamic properties and become familiar with these interrelationships.
5. To be able to understand the processes involving phase changes and reactions.

UNIT I BASIC CONCEPTS OF THERMODYNAMICS AND EQUATION OF STATE 12

Preliminary concepts of thermodynamics- Characteristics of systems and processes, the variables and quantities of thermodynamics, energy classifications, energy in transition work and heat. Gibbs Phase rule, statements of first law for the flow and non-flow processes., PVT behavior of fluids; Mathematical representation of PVT behavior, generalized compressibility factor correlation; generalized equations of state.

UNIT II LAWS OF THERMODYNAMICS AND THERMODYNAMIC PROPERTY RELATIONS 12

Statements of the second law of thermodynamics, Carnot cycle and theorems, thermodynamic temperature scale, entropy and its calculation, Applications to Laws of Thermodynamics: Flow through pipes and nozzles, Thermodynamic Properties of Pure Fluids- Classification of Thermodynamic properties -Work function and Gibb's Free energy-Fundamental Property relations-Maxwell's equations-Entropy Heat capacity relationship-Differential equations of Entropy-Relationship between Cp and Cv -Effect of pressure and volume on Cp and Cv.

UNIT III PHASE EQUILIBRIA 12

Introduction to fugacity and activity, fugacity Coefficient and activity coefficient -Partial molar properties-Chemical potential as a partial molar property-Lewis Randall rule- Raoult's and Henry's law. Gibbs Duhem Equation- Excess properties of mixtures, pure species and liquids. Phase Equilibria - Criteria for phase equilibrium, Phase equilibrium in ideal solution, Phase equilibria applications-Phase diagrams for homogeneous systems and for systems with a miscibility gap.

UNIT IV PROPERTIES OF SOLUTIONS AND VLE 12

Criterion of stability, Phase equilibria in single and multiple component systems, Duhem's theorem, VLE for Ideal solutions, Calculation of activity coefficients. Classes of VLE calculations, Vapor-Liquid Equilibrium at low, moderate and high pressures; bubble and dew point calculation, Flash calculation. Thermodynamic consistency test of VLE data, Azeotropes, VLE Activity coefficient models.

UNIT V CHEMICAL REACTION EQUILIBRIA 12

Chemical reaction equilibrium of single and multiple reactions, Standard state Gibbs energy of reaction, Effects of temperature and pressure, Inerts and feed ratios, Homogeneous gas and liquid phase reactions, Multiple reactions Equilibria, Simultaneous Reactions.

TOTAL: 60 PERIODS

COURSE OUTCOMES

CO1: Apply the important concepts of thermodynamics and its related functions correlating PVT behavior of fluids and the real gas behavior

CO2: Apply second law and analyze the feasibility of system/devices also the thermodynamic property relations and their application to fluid flow

CO3: Determine the relationship connecting T, P and composition originating from the concept of chemical potential and fugacity coefficient

CO4: Access the concept of equilibrium between combination of two co existing phases other than liquid and vapor and derive the relationship that connects the composition of two co existing phases as function of temperature and pressure

CO5: Evaluate the principle of chemical reaction thermodynamics for the prediction of equilibrium conversion.

TEXT BOOKS

1. M.D. Koretsky, Engineering and Chemical Thermodynamics, 2nd edition, Wiley; 2nd edition, 2012. ISBN: 978-0-470-25961-0
2. J.M. Smith, H.C.Van Ness, Michael M. Abbott, Introduction to Engineering Thermodynamics, McGraw Hill, New York, 8th Edition, 2018. ISBN 9781259696527
3. Y. V. C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997. ISBN 8173710481, 9788173710483

REFERENCES

1. Sandler, S.I.,"Chemical and Engineering Thermodynamics", I Edition,Wiley,1989
2. J. Richard elliot, Carl. T.Lira, 'Introductory Chemical Engineering Thermodynamics', 2nd Edition Pearson Education, Inc, 2012.
3. Noel De Nevers, Physical & Chemical Equilibrium Wiley - 2nd Edition, 2012 ISBN:9780470927106 |Online ISBN:9781118135341 |DOI:10.1002/9781118135341
4. https://archive.nptel.ac.in/courses/103/101/103101004/

Course articulation matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	-	1	-	2	-	-	2	1	-	3	3	3
CO2	3	2	-	2	1	-	-	-	1	1	-	1	3	3	3
CO3	3	3	3	2	-	2	2	1	3	2	1	1	3	3	3
CO4	2	2	2	2	2	1	1	2	3	1	2	2	3	3	3
CO5	2	2	1	-	-	1	1	2	1	1	2	-	3	3	3
	2.6	2.2	1.8	2	2	2	1.5	1.7	2	1.4	2	2	3	3	3

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

CH23402 CHEMICAL ENGINEERING COMPUTING L T P C

COURSE OBJECTIVES 1 0 4 3

1. To enable the students to develop solving skill using numerical techniques.
2. To enable the students to solve simple numerical problem using different software tool
3. To enable the students to understand the usage of process simulation software tool for the chemical engineering
4. To enable the students to understand the usage of different chemical engineering software tools for solving numerical problems
5. To enable the students to do simple steady state process simulation using Process simulator

List of suggested Exercises:

1. Friction factor, pressure drop, minimum fluidization velocity calculations
2. Settling velocity, drag coefficient, Reynolds number estimations
3. Equation of state, activity coefficient, VLE data, equilibrium conversion calculations
4. Empirical equation in fluid flow, heat and mass transfer operations
5. Solving a simple flow sheet by simultaneous approach
6. One-, two- and three-dimensional heat conduction equations
7. Differential equation for reactors in series, non-isothermal reactors, dispersion models, gravity tank
8. Partial differential equation involved in heat transfer, mass transfer, reaction engineering
9. First order and second order system in control system
10. Simulation of heat exchangers, Distillation, Absorber, Extraction column, reactors.
11. Simulation of process plant/simple flow sheet

List of Specific Exercise

1. Solving chemical Engineering Numerical problems (fluid flow, mechanical operations, heat transfer, mass transfer, thermodynamics and reaction Engineering problems) using Goal seek, solver, Regression function of Microsoft office Excel.
2. Solve simultaneous equation in chemical engineering by Matrix method using Microsoft office Excel.
3. Solve differential equation in chemical engineering by Runge Kutta method using Microsoft office Excel
4. Solving simultaneous equations, linear and non linear equations and differential equations in Chemical Engineering using problem solving software tool/Polymath
5. Solving Simultaneous equations, Differential equations and Partial differential Equations in Chemical Engineering using MATLAB.
6. Apply MATLAB Simulink tool to simulate Chemical process control systems with suitable examples.
7. Predictions thermodynamics properties using Process Simulation Software Tool
8. Steady state simulation of Heat Exchanger using Process Simulation Software Tool
9. Steady state simulation of different types of Reactors using Process Simulation Software Tool
10. Steady state simulation of Distillation Column using Process Simulation Software Tool
11. Steady state simulation of an Absorption column using Process Simulation Software Tool
12. Dynamic simulation of Heat Exchanger using Process Simulation Software Tool
13. Dynamic simulation of different types of Reactors using Process Simulation Software Tool

14. Dynamic simulation of Distillation Column using Process Simulation Software Tool

TOTAL: 75 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Solve chemical engineering problems using different tools available in the excel software.

CO2: Solve simultaneous equation and differential equation using polymath

CO3: Solve simultaneous equation and differential equation using Matlab

CO4: Simulate simple chemical process with controller using simulink tool

CO5: Estimate fluid property and understand the unit operation simulation using Aspen Plus

TEXT BOOKS

1. Finlayson, B. A., Introduction to Chemical Engineering Computing, John Wiley & Sons, New Jersey, 2012 ISBN:9781118309599
2. Michael B. Cutlip, Mordechai ShachamProblem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB, 2nd Edition, Prentice Hall, 2008 ISBN: 978-0-13-148204-3
3. H.S. Fogler, Elements of Chemical Reaction Engineering, Third Edition, Prentice Hall of India, 1998 ISBN-10 : 0135317088

REFERENCES

1. Pradeep Ahuja Introduction to Numerical Methods in Chemical Engineering PHI New delhi, 2010.
2. Amiya K.Jana, Process Simulation and Control using Aspen , PHI New delhi, 2012

Course Articulation Matrix:

Course Outcomes	Program Outcomes													
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	-	1	-	-	-	3	3	-
CO2	3	3	3	3	3	-	-	-	1	-	-	-	3	3	-
CO3	3	3	3	3	3	-	1	-	1	-	-	-	3	3	-
CO4	3	3	3	3	3	-	1	1	1	-	--	--	3	3	-
CO5	3	2	3	3	3	-	1	1	1	-	-	-	3	3	-
Overall	3	3	3	3	3	-	2	1	1	-	-	-	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23403 **HEAT TRANSFER** **L T P C**
3 0 2 4

COURSE OBJECTIVES

1. To enable students to understand and apply the fundamental concepts of heat transfer by conduction, convection, and radiation.
2. To equip students with the ability to analyze and solve complex problems involving heat transfer in various geometries and systems.
3. To teach students how to design and optimize heat exchangers for industrial applications.
4. To familiarize students with the principles of heat transfer with phase change, including boiling and condensation, and their practical applications.
5. To develop students' skills in conducting laboratory experiments related to heat transfer and interpreting experimental data for validation of theoretical concepts.

UNIT I **CONDUCTION** **9+6**

Introduction to heat transfer-General heat conduction equation, One dimensional steady state conduction in rectangular coordinate, One dimensional steady state conduction in cylindrical and spherical coordinate ;Critical and optimum insulation; Extended surface heat transfer; Transient heat flow - Analysis of lumped parameter model – application in food processing.

LIST OF EXPERIMENTS

1. Measurement of thermal conductivity
2. Heat transfer studies through composite wall
3. Heat transfer in Bare and Finned Tube Heat Exchanger

UNIT II **CONVECTION** **9+6**

Introduction to Convective Heat Transfer; Dimensional analysis for -forced convection, free convection; Heat transfer co-relations for - laminar and internal flows, turbulent and internal flows, Co-relation for turbulent and external flows, for flow across tube banks, Momentum.Heat transfer analogies; Boundary layer heat transfer- Equations, Approximate analysis in boundary layer, Theoretical concepts of natural / free convention heat transfer; Empirical relations for free convention heat transfer.

LIST OF EXPERIMENTS

1. Heat transfer studies by forced convection

UNIT III **HEAT EXCHANGER** **9+6**

Classification of heat exchangers; Co-current, Counter current& Cross-current; log-mean temperature difference; overall heat transfer coefficient; fouling factors. Various types of shell and tube heat exchangers; Effectiveness-NTU; method of heat exchanger analysis; Design of - double pipe heat exchanger, shell and tube heat exchanger & Plate and Spiral Heat exchangers.

LIST OF EXPERIMENTS

1. Heat transfer Studies in Shell and Tube heat exchanger
2. Heat transfer in Double pipe heat exchanger

UNIT IV HEAT TRANSFER WITH PHASE CHANGE 9+6

Boiling and Condensation-Types-Condensation heat transfer over vertical plate, Condensation heat transfer for various conditions & geometries, Fundamentals of boiling heat transfer, boiling heat transfer co-relations.

Evaporation: Types of evaporators, boiling point elevation and Duhring's rule, material and energy balances for single and multiple effect evaporators: forward, mixed and backward feeds, capacity and economy of evaporators.

LIST OF EXPERIMENTS

1. Heat transfer in Horizontal and vertical condenser
2. Heat transfer in Helical coil

UNIT V RADIATION & INDUSTRIAL APPLICATIONS 9+6

Introduction to radiation heat transfer, Thermal Radiation laws, Black and Gray bodies, Properties of a Blackbody, Kirchhoff's Law, Radiation intensity and radiation view factor, Radiation heat exchange, Radiation shield and gas radiation, emissivity, radiation between black surfaces and grey surfaces. Solar radiations, combined heat transfer coefficients by convection and radiation. Industrial applications -Heat transfer through packed and fluidized bed.

LIST OF EXPERIMENTS

1. Emissivity measurement
2. Heat transfer in packed column

TOTAL: 75 PERIODS

COURSE OUTCOMES

CO1: Understand the concepts of different modes of heat transfer.
CO2: Familiarize with correlations for convective heat transfer
CO3: Enhances the problem solving capability and design of heat exchangers.
CO4: Development of skills essential for good engineering practice in heat transfer with phase change.
CO5:Understand radiative heat transfer and application of heat transfer in industries.

TEXT BOOKS

1. Incropera, F. P. & Dewitt, D. P., (2011), Fundamental of Heat and Mass Transfer,John Wiley & Sons ISBN-10: 0-471-45728-0
2. Holman, J. P., 'Heat Transfer ', 8th Edn., McGraw Hill, 1997. **ISBN-10 :** 0078447852
3. Ozisik, M. N., Heat Transfer: A Basic Approach, McGraw-Hill, 1984 **ISBN-10 :** 0070479828
4. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999. **ISBN-10 :** 0070341907

REFERENCES

1. Cengel, Y.A. (2002) Heat Transfer: A Practical Approach. 2nd Edition, McGraw-Hill, New York.
2. Coulson, J.M. and Richardson, J.F., “Chemical Engineering “Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998.
3. McCabe, Warren L., Julian C. Smith, and Peter Harriott. Unit Operations of Chemical Engineering. 5th ed. New York; London: McGraw-Hill, 1993.

Course Articulation Matrix

CO	Program Outcomes														
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	2	2	-	-	-	-	-	-	-	2	3	3	3
CO2	3	3	2	3	2	-	-	-	-	-	-	2	3	3	3
CO3	3	3	3	3	3	-	2	2	3	3	-	2	3	3	3
CO4	3	3	3	2	2	-	3	3	3	3	-	2	3	3	3
CO5	2	3	2	1	-	-	3	-	-	-	1	2	3	3	3
Average	3	3	3	3	3	-	3	3	3	3	1	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23404 **PROCESS DATA ANALYTICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES

1. To make students learn about basics of data analytics and exploratory data analysis.
2. To make students learn about the sources of data in a process.
3. To make students apply the knowledge of data for modelling of prediction
4. To make students learn about data driven process control
5. To develop an understanding on achieving process optimization through available data.

UNIT I INTRODUCTION TO DATA ANALYTICS AND EXPLORATORY DATA ANALYSIS **9**

Data Analysis-Introduction; Data Analytics and Machine Learning; Introduction to Exploratory Data Analysis; Types of Exploratory Data Analysis; Summary Statistics; Simple Visualization; Outliers and Missing Values; Correlogram; Clustering and Dimensionality Reduction.

UNIT II PROCESS DATA SOURCE **9**

Plant Process Data; Data acquisition: Pilot Plant and Laboratory Data, Process Simulation Data, Synthetic Data; Data Cleaning; Data recording; Data management; Data analytics.

UNIT III DATA BASED MODELLING FOR PREDICTION **9**

Modelling for Prediction –Introduction; Simple Regression Models; Non-linear Regression Models; Non-linear Machine Learning Algorithms; Distribution Models; Model Performance and Validation; Correlation and Causality.

UNIT IV DATA BASED MODELLING FOR PROCESS CONTROL **9**

Process Control -Introduction; Data Based Control; PID Controllers; Model Predictive Control;

UNIT V PROCESS OPTIMIZATION **9**

Process Optimization- Introduction; Grid Search, Random Search and Gradient Search; Evolutionary Algorithms; Particle Swarm Optimization; Multi-objective Optimization; Bayesian Inference and Optimization

TOTAL:45 PERIODS

Course outcomes:

CO1: Studying about basics of data analytics and Exploratory Data Analysis

CO2: Learning various types and usage of process data

CO3: Applying data based modelling for prediction

CO4: Applying data based modelling for process control

CO5: Achieving process optimization

CO6: To learn about collection, valediction and application of data for the optimization of various process outputs in a chemical plant.

TEXT BOOKS:

1. Daniela Galatro, Stephen Dawe "Data Analytics for Process Engineers", 1st edition, Springer, 2024. ISBN: 9783031468681
2. Roger Peng "Exploratory Data Analysis with R", 1st edition, Packt, 2016. ISBN:978-1365060069
3. Beheshti, S., Benatallah, B., Sakr, S., Grigori, D., MotahariNezhad, H. R., Barukh, M. C., Gater, A., Ryu, S. H. "Process Analytics: Concepts and Techniques for Querying and Analyzing Process Data" 1st edition, Springer, 2016. ISBN: 9783319250373

REFERENCES:

1. T. Hastie, R. Tibshirani and J. Friedman, "Elements of Statistical Learning", Springer, 2009.
2. Araghinejad, Shahab. "Data-Driven Modeling: Using MATLAB® in Water Resources and Environmental Engineering" 1st edition, Springer, 2013. ISBN: 9789400775060.
3. María Ángeles Gil, Olgierd Hryniewicz, Przemyslaw Grzegorzewski, Sébastien Destercke, Thierry Denoeux "Uncertainty Modelling in Data Science" 1st edition, Springer, 2018. ISBN: 9783319975474
4. K. Murphy, "Machine Learning: A Probabilistic Perspective", Illustrated edition, MIT Press, 2012. ISBN: 9780262018029
5. Oakland, John., Oakland, Robert James. "Statistical Process Control" 7th edition,Taylor & Francis, 2018. ISBN: 9781351662680.

Course articulation matrix:

CO	Program Outcome														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3
CO2	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3
CO3	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3
CO4	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3
CO5	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3
CO6	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3
Average	3	3	3	3	3	1	3	1	1	1	3	3	3	3	3

CH23405 **MASS TRANSFER I** **L T P C**
3 0 2 4

COURSE OBJECTIVES

1. To impart knowledge on the mechanism of mass transfer under laminar and turbulent conditions.
2. To understand the principles of simultaneous heat and mass transfer and to apply these concepts in the design of cooling towers and drying
3. To learn the fundamentals of crystallization and its application in the design of crystallizers.
4. To impart knowledge on theoretical and practical insight on mass transfer operations
5. To enable the students to estimate the mass transfer parameters.

UNIT I MOLECULAR DIFFUSION 9+6

Introduction and overview of mass transfer operations; Molecular and eddy diffusion, Diffusion velocity and fluxes, Fick's first and second law, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion through variable cross sectional area, Diffusivity measurement and prediction; Multi-component diffusion, Diffusivity in solids.
Practical : Measurement of diffusivity

UNIT II CONVECTIVE MASS TRANSFER AND INTERPHASE MASS TRANSFER 9+12

Mass transfer coefficient concept and its types, Dimensionless groups and correlation for convective mass transfer coefficients, Mass transfer coefficient in laminar flow, Turbulent or Eddy diffusion, Theories of ass transfer; Momentum, Heat and Mass Transfer Analogies; Interphase mass transfer: Equilibrium and mass transfer between phases, the two resistance theory; Method of contacting the phases - Stage-wise and differential contractors.

Practical : 1. Solid Liquid mass transfer studies
2. Determination of mass transfer coefficient for surface evaporation

UNIT III HUMIDIFICATION AND COOLING TOWER 9+6

Vapour – liquid equilibrium and enthalpy for a pure substance, Terminologies and Definitions, Humidity chart and its use, Adiabatic Saturation Temperature, Wet bulb temperature; Cooling towers - Types, construction, operation and design calculations; Adiabatic humidification; Dehumidification.

Practical : Wetted wall column /
Estimation of mass and heat transfer coefficient for cooling tower

UNIT IV DRYING 9+6

Mechanism of drying and drying Equilibria, Classification of dryers, Drying Behaviour; Batch drying - Mechanism and calculation of drying rate and time, Through Circulation drying in

packed beds; Continuous dryers – material and energy balance, Estimation of drying time, Preliminary design of a rotary dryer, Advance drying techniques such as freeze drying, dielectric and microwave drying.

Practical : Drying characteristics of forced draft dryer

UNIT V CRYSTALLIZATION 9

Crystal geometry, Solid – liquid phase equilibrium, yield and purity of products; Heat effects in crystallization process; Theory of super saturation, nucleation and crystal growth; Crystal size distribution – The MSMPR crystallizer; Classification of crystallizers, Design consideration of batch and continuous crystallizers.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Describe the mechanism of mass transfer in fluids and solids and to determine the diffusivity practically and compare the results with the empirical correlations

CO2: Apply the theories of mass transfer and determine the mass transfer coefficient

CO3: Understand the principles of humidification process and apply the principles of heat and mass transfer phenomena

CO4: Understand the heat and mass transfer phenomena involved in drying processes and be able to perform related calculations.

CO5: Classify different crystallization processes and to analyze the kinetics of nucleation and crystal growth

TEXT BOOKS

1. Treybal, R. E., “Mass Transfer Operations”, 3rd Edition, McGraw-Hill, 2017, ISBN-13: 978-1259029158 ISBN-10: 1259029158.
2. McCabe, W.L., Smith, J.C., and Harriot, P., “Unit Operations in Chemical Engineering”, 7th Edition., McGraw-Hill, 2021, ISBN-13: 978-8184959635 ISBN-10: 9339213238.
3. Binay K. Dutta, ”Principles of Mass Transfer and Separation Processes”, PHI Learning Ltd, 2007, ISBN-13: 978-8120329904 ISBN-10: 812032990.

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1. Geankoplis, C.J., “Transport Processes and Unit Operations”, 4th Edition, Prentice Hall Inc., NewJersey, 2015, ISBN 8120326418.
2. Coulson, J.M. and Richardson, J.F., “Chemical Engineering” Vol. 1 : Fluid Flow, Heat Transfer and Mass Transfer, 6th Edition, Btterworth-Heinemann, 1999, ISBN-13: 978-0750644440 ISBN-10: 0750644443.
3. Coulson, J.M. and Richardson, J.F., “Chemical Engineering” Vol. 2 : Particle Technology and Separation Processes, 5th Edition, Btterworth-Heinemann, 2007, ISBN-13: 9780750644457, ISBN-10: 0750644451.

4. Welty, JR ,Wicks, C E and Wilson, R E., Fundamentals of Momentum, Heat and Mass Transfer, 5th Edition, John wiley and sons, 2008, ISBN-10: 0470128682, ISBN-13: 978-0470128688

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1. https://archive.nptel.ac.in/courses/103/103/103103145/
2. https://archive.nptel.ac.in/courses/103/103/103103035/
3. https://archive.nptel.ac.in/courses/103/103/103103034/
4. https://archive.nptel.ac.in/courses/103/103/103103154/

Course Articulation Matrix:

Course Out-comes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3
CO1	3	3	3	3	-	1	1	1	3	3	-	3	3	3	3
CO2	3	3	3	3	-	1	1	1	3	3	-	3	3	3	3
CO3	3	3	3	3	-	1	1	1	3	3	-	3	3	3	3
CO4	3	3	3	3	-	1	1	1	3	3	-	3	3	3	3
CO5	3	3	3	3	-	1	1	1	3	3	-	3	3	3	3
average CO	3	3	3	3	-	1	1	1	3	3	-	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23406	CHEMICAL REACTION ENGINEERING I	L	T	P	C
		3	0	2	4

OBJECTIVES

1. To enable the students to understand the kinetics of the homogeneous reaction
2. To enable the students to design different types of homogenous chemical reactors
3. To enable the students to understand the kinetics of multiple reaction
4. To enable the students to analyze the non-isothermal operation of different reactors.
5. To enable the students to estimate the residence time distribution function in different reactor.

UNIT I KINETICS OF HOMOGENOUS REACTION 9+8

Rate equation; elementary; non-elementary reactions; theories of reaction rate and Prediction. Design equation for constant and variable volume batch reactors, Concentration dependency of rate constant; Temperature dependency of rate constant. Analysis of batch experimental data using integral and differential analysis. Half-life calculation

Experiments

1.Kinetic studies in a Batch reactor, semi batch reactor

2. Determination of Activation Energy

UNIT II IDEAL REACTORS 9+8

Ideal reactor classification. Design of continuous reactors under steady state operation -stirred tank and tubular reactor; recycle reactors; combination of reactors and size comparison of reactors.

Experiments

3. Kinetic studies and conversion calculation in a Plug flow reactor

4. Kinetic studies and conversion calculation in a CSTR

5. Conversion calculation PFR followed by a CSTR

UNIT III MULTIPLE REACTIONS 9

Design of reactors for multiple reactions - consecutive, parallel and mixed reactions. Factors affecting choice, optimum yield and conversion in CSTR, PFR; selectivity and yield.

UNIT IV NON-ISOTHERMAL REACTORS 9+6

Non-isothermal homogeneous reactor systems, adiabatic reactors, rates of heat exchanges for different reactors, design for constant rate input and constant heat transfer coefficient, operation of batch and continuous reactors, optimum temperature progression.

Experiments

6. Kinetic studies of Adiabatic Reactor

UNIT V NON-IDEAL REACTORS 9+8

The residence time distribution for chemical reactors, residence time functions and relationship between them in reactor; Different models used in non-ideal reactors, conversion calculation using different models in non-ideal reactors.

Experiments

7. RTD studies in PFR ,

8. RTD studies in CSTR

TOTAL : 75 PERIODS

COURSE OUTCOME FOR THEORY

CO1: Apply the knowledge to evaluate the kinetics of homogenous reaction.
CO2: Develop the performance equation and determine the conversion of different reactors.
CO3: Design of reactor for multiple reactions and calculate yield and selectivity.
CO4: Analysis of non-isothermal operation of different reactors.
CO5: Demonstrate the residence time distribution function and analyze the non-ideality in the reactor.

TEXT BOOKS

1. Levenspiel. O., Chemical Reaction Engineering, Third Edition, John Wiley, 1999. ISBN: 9971512416
2. Fogler H.S., Elements of Chemical Reaction Engineering, Third Edition, Prentice Hall of India, 1999. ISBN: 8120322347
3. J.M.Smith Chemical Engineering Kinetics, Third Edition, Mc Graw Hill New York 1981 ISBN:0070587108

REFERENCES

1. Lanny D. Schmidth, The Engineering of Chemical Reactions, Second Edition, Oxford University Press, 2005. ISBN: 0195169255
2. Hayes, R.E., Mmbaga J.P., Introduction to chemical reactor analysis, second edition, CRC Publisher,2012. ISBN 9781439867006
3. Doraiswamy, L.K., DenizUner, Chemical Reaction Engineering Beyond the fundamentals, first edition, CRC Press , 2014. ISBN: 978-1439831229
4. Fronment, G.F.,.Bischoff K.B., Chemical Reactor Analysis and Design , Third Edition, John Wiley and Sons, 2011. ISBN: 978-0-470-56541-4

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	-	-	-	-	-	-	-	3	3	3
CO2	3	3	3	2	2	-	1	-	-	-	-	-	3	3	3
CO3	3	3	3	2	-	1	1	-	-	-	-	-	3	3	3
CO4	3	3	3	2	2	1	1	-	-	-	-	-	3	3	3
CO5	3	3	3	2	2	1	1	-	-	1	-	-	3	3	3
Overall	3	3	3	2	2	1	1	-	-	1	-	-	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23501	PROCESS DYNAMICS AND CONTROL	L	T	P	C
		3	0	2	4

COURSE OBJECTIVE

1. To present the basic principle of a control system and comprehend the dynamic nature of the process.
2. To impart the skills in developing mathematical models using transfer function approach and analyze their response.
3. To equip the students with the knowledge to design control systems and analyze their stability.
4. To impart the knowledge on sophisticated control techniques.
5. To introduce the basics of computer control in process industries.

UNIT I BASICS OF PROCESS CONTROL 9

Process Instrumentation - Need of measuring instruments, Performance characteristics - Static and Dynamic, Principal measuring instruments - Pressure, Temperature, Flow Rate, Liquid Level, pH and Concentration; Laplace Transforms - Properties of Laplace Transforms, Solution of ODE using Laplace Transforms, Forcing functions

UNIT II OPEN LOOP SYSTEM 9+12

Introduction to Chemical Process Control; Formulating Process Models using transfer function approach; Open-loop systems - first order systems and their transient response for standard inputs, first order systems in series, linearization and its application in process control; second order systems and their dynamics; transportation lag- first order and second order Pade approximation.

Practical:

1. Open loop response of first order system (Thermometer & Thermo well)
2. Open loop response of a single capacity tank system
3. Open loop response of second order system (U tube manometer)
4. Open loop response of non-interacting level System
5. Open loop response of Interacting level System

UNIT III CLOSED LOOP SYSTEM 9+10

Closed loop control systems - development of block diagram, servo and regulatory problems, transfer function for controllers and final control element- Types of control valve- sizing & characteristics, Modes of control action- ON/OFF, P, PI, PD, PID and their characteristics, transient response of closed-loop control systems, stability analysis using Routh's test

Practical:

1. Closed loop control and tuning of a pressure system
2. Closed loop control and tuning of a flow system
3. Closed loop control and tuning of a thermal system
4. Control valve characteristics

UNIT IV CONTROL SYSTEM DESIGN BY FREQUENCY RESPONSE 9+4

Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, bode diagram, stability criterion, tuning of controllers -Ziegler Nichols and Cohen-coon tuning method

Practical: Ziegler Nichols and Cohen-coon tuning method

UNIT V DIGITAL CONTROLSYSTEMS 9+4

Introduction to advanced control systems- cascade control, feed forward control, ratio control, multivariable control Introduction to digital control, Programmable Logic Controller, Distributed Control System, SCADA

Practical:

PLC based closed loop control and tuning of a level system

TOTAL: 75 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Recognize the different types of measuring devices and understand their working principles.
CO2: Derive the transfer function model and determine the open loop responses using various forcing functions practically.
CO3: Determine the necessary control modes for a closed loop control system and evaluate its stability in time-domain.
CO4: Analyze the response of control system in the frequency domain and implement the proper tuning method.
CO5: Compare various advanced control strategies and comprehend the implementation of computer control.

TEXT BOOKS

1. Stephanopoulos, G. (1984). *Chemical process control* (Vol. 2). New Jersey: Prentice Hall. **ISBN-10 :** 9789332549463
2. Ogunnaike, B. A., & Ray, W. H. (1994). *Process dynamics, modeling, and control* (Vol. 1). New York: Oxford University Press. ISBN: 9780195091199
3. Coughanowr, D. R., & Leblanc, S. E. (2008). Introductory concepts. *Process Systems Analysis and Control, 3rd Ed*, 1-6. ISBN 978–0–07–339789–4

REFERENCES

1. Bequette, B. W. (2003). *Process control: modeling, design, and simulation*. Prentice Hall Professional
2. Seborg, D. E., Mellichamp, D. A., Edgar, T. F., & Doyle III, F. J. (2010). *Process dynamics and control*. John Wiley & Sons.
3. Riggs, J. B., & Karim, M. N. (2006). *Chemical and Bio-process Control: James B. Riggs, M. Nazmul Karim*. Prentice Hall.

4. Luyben, W. L., Tyréus, B. D., & Luyben, M. L. (1998). *Plantwide process control* (Vol. 43). New York: McGraw-Hill.
5. Peter Harriott (1964). *Process Control*. New York: McGraw-Hill.

NPTEL LINK

https://archive.nptel.ac.in/courses/103/101/103101142/
https://nptel.ac.in/courses/103105064

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	2	2	2	-	-	-	2	2	3	3	2
CO2	3	3	3	2	2	2	2	-	-	-	2	2	3	3	2
CO3	3	3	3	2	2	2	2	-	-	-	2	2	3	3	2
CO4	3	3	3	2	2	2	2	-	-	-	2	2	3	3	2
CO5	3	3	3	2	2	2	2	-	-	-	2	2	3	3	2
Over all	3	3	3	2	2	2	2	-	-	-	2	2	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23502 **MASS TRANSFER II** **L T P C**
3 0 2 4

COURSE OBJECTIVES

1. To learn about the various operations of mass transfer
2. To execute the proper material balance of unit operations;
3. To solve the engineering problems related to mass transfer operations;
4. To understand the different process and mechanism involved in fluid-fluid and fluid-solid mass transfer operations.
5. To select the parameters for the designing of the mass transfer equipment

UNIT I ABSORPTION **9**

Mechanism of Absorption, Equilibrium solubility of gases, andoperating line concept in absorption calculations, Equipment for Gas Liquid contact: Design and Types, Kremser equation, concepts of NTU, HTU and overall volumetric mass transfer coefficients, plate efficiency, absorption factor, multicomponent absorption; mechanism and model of absorption with chemical reaction; thermal effects in absorption process

UNIT II DISTILLATION **9+15**

Concept of distillation, Vapour liquid equilibria - Raoult's law and deviations from ideality, vapor-liquid equilibrium diagrams, enthalpy concentration diagrams, relative volatility, Principle of distillation - flash distillation, differential distillation, steam distillation, multistage continuous rectification, Number of ideal stages by Mc.Cabe - Thiele method and Ponchan - Savarit method, Total reflux, minimum reflux ratio, optimum reflux ratio. Introduction to multi-component distillation, azeotropic, extractive distillation, and Pressure swing distillation

List of Experiments:

1. Separation of binary mixture using Simple distillation
2. Separation of binary mixture using Steam distillation
3. Separation of binary mixture using Packed column distillation

UNIT III LIQUID-LIQUID EXTRACTION **9+5**

Liquid - liquid extraction: Conceptand importance, Liquid equilibria -Ternary systems, triangular diagram, Effect of temperature and pressure, solvent characteristics and selection criterion, equilibrium stage wise contact calculations for batch and continuous extractors- differential contact equipment-spray, packed and mechanically agitated contactors and their design calculations-packed bed extraction with reflux. Pulsed extractors, Rotating disc contactors, centrifugal extractors-Supercritical extraction

List of Experiment:

1. Liquid-liquid extraction

UNIT IV LEACHING **9 + 5**

Solid-liquid equilibria- leaching equipment for batch and continuous operations, calculationof number of stages, Industrial application of Leaching, Factors affecting rate of leaching- Leaching

by percolation through stationary solid beds, moving bed leaching, counter current multiple contact (shank's system),Immersion type batch and continuous extractors, multi stage continuous cross current and countercurrent leaching, stage calculations, stage efficiency. Introduction to super-critical fluid extraction

List of Experiment:

1. Cross current leaching studies

UNIT V ADSORPTION, ION EXCHANGE AND MEMBRANE SEPARATION PROCESSES **9 + 5**

Adsorption - Types of adsorptions, nature of adsorbents and industrial applications of adsorption, adsorption equilibria: Freundlich, Langmuir and BET isotherms, effect of pressure and temperature on adsorption isotherms, Adsorption Hysteresis, Adsorption operations - stage wise operations, steady state moving bed and unsteady state fixed bed adsorbers, break through curves.

Principle of Ion exchange, techniques and applications. Introduction to membrane separation process; concept of osmosis, reverse osmosis, dialysis, electrodialysis.

List of Experiment:

1. Adsorption studies

TOTAL: 75 PERIODS

COURSE OUTCOMES:

Theory:

On the completion of the course students are expected to

CO1:Understand concept and determine the theoretical stages, number of transfer units and height requirements for a gas absorption process

CO2:Identify the suitable distillation techniques, determine the number of trays for stage wise contact and calculate the different parameters used in distillation processes.

CO3:Apply the ternary equilibrium diagram concepts to determine the number of stages required for separation of liquid-liquid extraction process and evaluate the performance of extraction process.

CO4:Describe core principles of leaching, setting up mass balances, use graphical methods to estimate the number of ideal stages in leaching operation and evaluate the performance of leaching process.

CO5:Understand the concept of adsorption techniques, various isotherms and ion exchange process

TEXT BOOKS

1. Treybal, R.E., "Mass Transfer Operations ", 3rd Edn., McGraw-Hill, 1981.ISBN-10 : 1259029158
2. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall Inc., New Jersey, 2003. ISBN-10 : 1292026022
3. Richardson J.F., and Harker J.H., "Coulson and Richardson's, Chemical Engineering – Volume 2", Butterworth-Heinemann, 2002 ISBN: 0750644451.

REFERENCES

1. McCabe, W.L., Smith, J.C., and Harriot, P., “Unit Operations in Chemical Engineering”, 7th Edition, McGraw-Hill, 2005.
2. Seader J.D. and Henley E.J., “Separation Process Principles”, 2nd Ed., John Wiley, 2006.
3. Wankat, P., “Equilibrium Stage Separations”, Prentice Hall, 1993.
4. Binay K. Dutta, ”Principles of Mass Transfer and Separation Processes”, PHI Learning Ltd, 2009.

NPTEL Link:

5. https://archive.nptel.ac.in/courses/103/103/103103154/
6. https://archive.nptel.ac.in/courses/103/103/103103035/
7. https://www.nptelvideos.com/course.php?id=169

Course Articulation Matrix

Course Out-comes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO2	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO3	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO4	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO5	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO6	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO7	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
CO8	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3
Overall	3	3	1	3	-	-	-	-	2	3	-	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23503 CHEMICAL REACTION ENGINEERING II L T P C
3 0 0 3

COURSE OBJECTIVES

1. To learn gas solid catalytic, gas solid non catalytic and fluid- fluid reaction
2. To increase of the knowledge of kinetics of chemical reactions
3. To apply kinetics to design and operation of the reactors.
4. To interpret results on the processes of chemical reaction.
5. To impart practical knowledge through study of different applications of the exposed concepts.

UNIT I GAS SOLID NON CATALYTIC REACTION 9

Gas solid non catalytic reaction. Reaction kinetics, Shrinking Core Model and Progressive conversion model, controlling resistances (diffusion through gas film, ash layer and chemical reaction controlling), rate controlling steps; time for Complete Conversion for Single and Mixed Sizes, design of fluid –particle reactors.

UNIT II CATALYSIS AND ADSORPTION 9

Catalysis and adsorption: physical properties of catalyst, surface area, void volume, solid density, volume determination, catalyst classification and preparation, catalyst promoters, catalyst inhibitors, catalyst poisons. Adsorption Isotherms Freundlich and Langmuir isotherms.

UNIT III GAS SOLID CATALYTIC REACTION 9

Gas solid catalytic reaction: steps in catalytic reaction, Single site, dual site mechanisms, Langmuir Hinshelwood, EleyRideal, Rate controlling steps. Experimental methods for determining rate, differential, integral reactor and reactor deign-.

UNIT IV DIFFUSION IN CATALYST 9

Diffusion Within Catalyst Particle, Mass and Heat Transfer Within Catalyst Pellets, Effectiveness Factor, Thiele Modulus, Effectiveness factor for non-isothermal condition.

UNIT V FLUID –FLUID REACTIONS 9

Fluid reaction. Kinetics and design of Fluid- Fluid Reactions. Rate equation, Kinetic regimes for absorption combined with chemical reaction. Various cases of mass transfer with chemical reaction, Factors to select the contactor, Tower Reactor Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the gas solid non catalytic reaction and different models for non-catalytic reaction.
CO2: Analyze methods for catalyst preparation and characterization.
CO3: Identify regions of mass transfer control and reaction rate control and calculate conversion.
CO4: Investigate the effect of temperature on reactor design and reaction parameters.

CO5: To evaluate the effectiveness factor, Thiele modulus.
CO6: Develop performance equations for different types of reactors using mass balances.

TEXT BOOKS

1. J.M.Smith Chemical Engineering Kinetics, Third Edition, Mc Graw Hill New York 1981 ISBN-10 : 0070665745
2. O. Levenspiel, Chemical Reaction Engineering , Third Edition, John Wiley 1999 ISBN: 978-0-471-25424-9
3. H.S. Fogler, Elements of Chemical Reaction Engineering, Third Edition, Prentice Hall of India, 1999 ISBN-10 : 0135317088

REFERENCES

1. Lanny D. SchmidthThe Engineering of Chemical Reactions, Second Edition, Oxford University Press, 2005.
2. L.K Doraiswamy, Deniz Uner, Chemical Reaction Engineering Beyond the fundamentals, CRC Press , 2014.
3. G.F Fronment, K.B.Bischoff Chemical Reactor Analysis and Design , John Wiley and Sons, 1979.
4. https://archive.nptel.ac.in/courses/103/102/103102012/
5. https://www.youtube.com/watch?v=F4MmOdWSgEg - Adv. Chemical Reaction Engineering Lectures. Topic 3 Diffusion & reaction in porous catalysts Part 2.
6. NPTEL- https://nptel.ac.in/ - Mod-01 Lec-21 GLR-2: Effect of chemical reaction on mass transfer: the slow reaction regime

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO3	PO 4	PO5	PO 6	PO 7	PO 8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	-	2	-	-	-	-	3	3	3	3
CO2	3	2	1	2	1	-	-	-	-	-	-	3	3	3	3
CO3	3	1	2	2	-	1	1	-	-	-	-	3	3	3	3
CO4	3	2	2	2	3	2	1	-	-	-	--	3	3	3	3
CO5	3	3	3	2	1	1	1	-	1	-	-	3	3	3	3
CO6	3	2	3	2	2	2	1		1			2	3	3	3
Overall	3	2	2.33	2	2.7	1	1		0.2			3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23U02	PERSPECTIVES OF SUSTAINABLE DEVELOPMENT	L T P C 2 0 2 3

MODULE I – INTRODUCTION **6**

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators.

MODULE II – ENVIRONMENTAL SUSTAINABILITY **6**

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis

MODULE III – SOCIAL & ECONOMIC SUSTAINABILITY **9**

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development.

Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization, Green accounting and sustainability reporting.

MODULE IV – SUSTAINABILITY IN CHEMICAL ENGINEERING **9**

Principles of green chemistry, designing safer chemicals and processes, use of renewable feedstocks, and energy-efficient synthesis. Sustainable process design, incorporating sustainability in process optimization. Waste minimization and resource recovery. Application of life cycle analysis (LCA) to chemical products and processes, tools and methodologies for LCA, and interpretation of results. Emerging technologies for sustainable chemical engineering, including innovations in sustainable chemical manufacturing, advances in bioprocessing, bio-based chemicals, and catalysis in sustainable production. Impact of environmental regulations on the chemical industry, strategies for compliance, and the role of international standards in promoting sustainability within chemical engineering practices.

MODULE V – SUSTAINABILITY PRACTICES **30**

Suggested Practices not limited to

- Energy efficiency – how to save energy (energy efficient equipment, energy saving behaviours).
- Chemical use and storage - the choice of chemicals being procured, the safe disposal of leftover chemicals, the impact of chemicals on the environment and long-term health impacts on humans.

- Green building, green building materials, green building certification and rating: green rating for integrated habitat assessment (GRIHA), leadership in energy and environmental design (LEED)
- Tools for Sustainability - Environmental Management System (EMS), ISO14000, life cycle assessment (LCA)
- Ecological footprint assessment using the Global Footprint Network spreadsheet calculator
- National/Sub national Status of Sustainable Development Goals

TOTAL: 60 PERIODS

REFERENCES:

1. Allen, D., & Shonnard, D. R. (2011). Sustainable engineering: Concepts, design and case studies. Prentice Hall.
2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
3. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge.
4. Clini, C., Musu, I., & Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.
5. Bennett, M., James, P., & Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.
6. Seliger, G. (2012). Sustainable manufacturing for global value creation (pp. 3-8). Springer Berlin Heidelberg.
7. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature.
8. Davim, J. P. (Ed.). (2013). Sustainable manufacturing. John Wiley & Sons.

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET **4L,8P**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES **4L,8P**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION **4L,8P**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING **4L,8P**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM **4L,8P**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

REFERENCES:

1 Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha (2020). Entrepreneurship, McGrawHill, 11th Edition

2. Bill Aulet (2024). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. John Wiley & Sons.

3. Bill Aulet (2017). Disciplined Entrepreneurship Workbook. John Wiley & Sons.

4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business

5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch

6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons
7. Marc Gruber & Sharon Tal (2019). Where to Play: 3 Steps for Discovering Your Most Valuable Market Opportunities. Pearson.

CH23701	TRANSPORT PHENOMENA	L	T	P	C
OBJECTIVES		3	0	0	3

1. To learn mass, momentum and energy transport at molecular, microscopic and macroscopic level to determine velocity, temperature and concentration profiles. Identify the transport processes involved in some simple situations.
2. To write down the equations of change for mass, momentum and energy for the system.
3. To understand the boundary conditions for each equation of change.
4. To make suitable assumptions and approximations at different steps for simplifying the problem with only one (or two) independent variable.
5. To solve the simplified problem analytically.

UNIT I MOMENTUM TRANSPORT 9

Importance of transport phenomena; analogous nature of transfer process; Viscosity, Newtonian& Non-Newtonian fluids, temperature and pressure effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport; shell momentum balance method, shear stress and velocity distributions- falling film, circular tube, annulus, slit. Adjacent flow of two Immiscible fluids

UNIT II EQUATIONS OF CHANGE FOR MOMENTUM 9

Momentum: Total derivative, partial derivative and substantial derivative, Equations of continuity, equation of motion- Navier's strokes equation and mechanical energy (Isothermal); Solutions of momentum transfer problems discussed under shell balance by applications of equation of change, dimensional analysis of equations of change.

UNIT III ENERGY TRANSPORT 9

Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport; thermal conductivity of liquids and solids; shell energy balance method, Energy flux and temperature distribution- solids and laminar flow with electrical, nuclear, viscous, chemical heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.

UNIT IV MASS TRANSPORT 9

Diffusivity; temperature and pressure effect on diffusivity, Fick's law, mechanism of mass transport; shell mass balance method, Mass flux and concentration distribution-solids and in laminar flow, stagnant gas film, heterogeneous and homogeneous chemical reaction systems, falling film, porous catalyst.

UNIT V EQUATIONS OF CHANGE FOR HEAT AND MASS 9

Energy: Equation of energy (non-isothermal) Equation of motion for free and forced convection.

Mass: Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component); Solutions of heat and mass transfer problems discussed under shell balance by applications of equation of change.

Analogies between momentum, heat and mass transfer

TOTAL: 45PERIODS

OUTCOMES:

CO1: Recognize the analogous nature of transport process, viscosity of gases and liquids and also the shell momentum balance to find momentum flux velocity distribution.

CO2: Apply the equation of change for different coordinate systems and solve momentum transport problems and scale factors for equation of change for different coordinate systems.

CO3: Illustrate the effect of temperature and pressure on thermal conductivity, theory of thermal conductivity of gases, liquids and solids and also the shell energy balance to find the heat flux, and temperature distribution

CO4: Calculate the effect of temperature and pressure on diffusivity, the diffusion of gases and liquids also the shell mass balance to find the flux and concentration distribution.

CO5: Apply the equation of change for different coordinate systems and solve mass and heat transport problems and scale factors for equation of change for different coordinate systems and to analyze the analogy between the transports

TEXT BOOKS

1. R.B. Bird, W.E. Stewart, and E.W. Lighfoot, “Transport Phenomena”, 2nd Edition., Newyork: John Wiley,2002 ISBN No: 9780470115398
2. J. R. Welty, R. W. Wilson, and C. W. Wicks, *“*Fundamentals of Momentum Heat and Mass Transfer*”*, 3rd Edition, USA: John Wiley,1984 ISBN No 9780470128688
3. R. S. Brodkey, and H. C.Hershey, “Transport Phenomena a Unified Approach”, USA: McGraw-Hill, 1987,ISBN No: 9780070079632

REFERENCES

1. J. Geankopolis, "Transport Processes in Chemical Operations", 3rd Edition., New Delhi, Prentice Hall of India, 1996.
2. William. M. Deen, “Analysis of Transport Phenomena”, USA: Oxford University Press,1998.
3. Richard. G. Griskey, " Transport Phenomena and Unit Operations: A Combined Approach",Newyork: John Wiley, 2002.
4. Amit Keshav and Bidyut Mazumdar, " Transport Phenomena", India: Wiley, 2020.
5. S.C.Roy and C. Guha, " Introduction To Transport Phenomena" India: Dhanpat Rai & Co, 2014.
6. https://archive.nptel.ac.in/courses/103/102/103102024/ (IIT Delhi)

Course Articulation Matrix:

Course Outcomes	ProgramOutcome														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	3	2	1	-	-	-	1	-	-	1	3	3	3
CO2	3	3	3	2	1	-	-	-	1	-	-	1	3	3	3
CO3	3	3	3	2	1	-	-	-	1	-	-	1	3	3	3
CO4	3	3	3	2	1	-	-	-	1	-	-	1	3	3	3
CO5	3	3	3	2	1	-	-	-	1	-	-	1	3	3	3
Average CO	3	2.8	3	2	1	-	-	-	1	-	-	1	3	3	3

1,2and3 are correlation levelswith weightings as Slight (Low), Moderate (Medium)and Substantial (High)respectively

CH23702 **PROCESS EQUIPMENT DESIGN** **L T P C**
3 0 0 3

OBJECTIVES

1. To impart knowledge on process and design of the equipment's that are used in process industries.
2. To enable the students to select appropriate equipment for the process and to adhere to standard specifications like BIS and ASTM.
3. To enable the students to understand the aspects of design, flow sheets and scale up in chemical plant design
4. To Point out the bottleneck parameters in the design
5. To Select the proper types of equipment for the duty asked.

UNIT I HEAT EXCHANGERS DESIGN –I **9**

Double Pipe Heat Exchangers, Shell and Tube Heat Exchangers and Condensers.

UNIT II HEAT EXCHANGERS DESIGN –II **9**

Cooling Towers, Dryers, Evaporators

UNIT III SEPARATION EQUIPMENTS **9**

Design of cyclone separators, Distillation column, Packed Bed, Absorption Column.

UNIT IV VESSELS AND SUPPORTS **9**

Basics of tanks, Vertical and Horizontal Pressure Vessels, Storage vessels, supports for vessels.

UNIT V ESSENTIAL ELEMENTS OF DESIGN **9**

Design of flow sheet, Plant Layout, P & ID, Pipe Line design and piping layout, Pumps and their performance curves and selection, Materials of construction and selection of process equipment's.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO 1: Design double pipe and shell and tube heat exchangers according to standards such as BIS, TEMA

CO 2: Design Cooling towers, evaporator and crystallizers

CO 3: Process and Equipment Design of separation equipment's such as absorbers, distillation column, extractors

CO 4: Calculate the design specifications of storage vessels and pressure vessels with the supports, flanges, nozzles, jackets, coils.

CO 5: Design the essential elements of a chemical engineering process (equipment sizes, material & energy balances, economics, environmental, safety)

TEXT BOOKS

1. Sinnott, R. K., & Towler, G. (2009). *Chemical engineering design: SI Edition*. Elsevier. ISBN 13: 978-0-7506-8423-1.
2. Sinnott, R. K. (2005). Coulson & Richardson's Chemical Engineering: Volume 6/Chemical Engineering Design 4TH edition. Elsevier Butterworth Heinemann. ISBN 0 7506 6538 6
3. M.V. Joshi's (2009) Process equipment design- Macmillan Publishing. ISBN 0230638104

REFERENCES

1. Kern, D. Q. (1950). *Process heat transfer*. Tata McGraw-Hill Education.
2. Hewitt, G. F., Shires, G. L., &Bott, T. R. (1994). *Process heat transfer* (Vol. 113). Boca Raton, FL: CRC press.
3. Treybal, R. E. (1980). Mass transfer operations. *New York*.
4. Moss, D. R. (2004). *Pressure vessel design manual*. Elsevier.
5. Crane, C. (1982). Flow of Fluids through Valves, Fittings, and Pipe. Technical Paper No. 410 M.
6. Couper, J. R., Penney, W. R., & Fair, J. R. (2009). Chemical Process Equipment-Selection and Design (Revised 2nd Edition). Gulf Professional Publishing.
7. https://msubbu.in/ln/design/index.html

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	3	-	-	2	2	2	2	3	3	3
CO2	3	3	3	2	2	3	-	-	-	-	2	2	3	3	3
CO3	3	3	3	2	2	2	-	-	-	-	2	2	3	3	3
CO4	3	3	3	2	2	-	-	-	-	-	2	2	3	3	3
CO5	3	3	3	2	2	1	-	-	-	-	2	2	3	3	3
Overall	3	3	3	2	2	1.8	-	-	2	2	2	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23703	SAFETY IN PROCESS INDUSTRIES	L T P C
		3 0 0 3

COURSE OBJECTIVES

1. To know types of hazards arising out of physical, chemical and biological agents
2. To enable the students to learn about various functions and activities of occupational health services.
3. To educate students about the implementation of safety procedures, risk analysis and assessment, hazard identification
4. To provide procedural knowledge on HAZOP.
5. Prepare onsite and offsite emergency plan.

UNIT I INTRODUCTION **9**

Need for safety in industries; Safety Programmes – components and realization; The Importance of Codes and Standards for Process Safety, Inherent safer design; Potential hazards – extreme operating conditions, toxic chemicals; safe handling.

UNIT II PROCESS SAFETY **9**

Implementation of safety procedures – periodic inspection and replacement; Accidents – identification and prevention; Runaway reactions; promotion of industrial safety, OSHA's Chemical NEP& regulatory approach to process safety management; MSDS

UNIT III FIRE AND EXPLOSION **9**

Fundamentals of fire and fire control, Emergency planning on-site & off-site emergency planning, risk management ISO 14000, Risk due to radiation, explosion due to overpressure, jet fire-fire ball, Dust explosion control, Nitrogen role in safety, Relief and relief Sizing,Layers of Protection Analysis.

UNIT IV HAZARD AND RISK **9**

Hazard identification safety audits, checklist, what-if analysis, Checklist, fishbone diagram, Hazard, HAZOP documentation, event tree analysis, fault tree analysis, bowtie analysis, Failure mode and effect analysis, EMS models case studies, Overall risk analysis Quantitative risk assessment - rapid and comprehensive risk analysis

UNIT V ACCIDENT ANALYSIS **9**

Incident investigations and root cause analysis; Hazan past accident analysis Fixborough-Mexico-Madras-Vizag, Bhopal analysis, elements of risk-based process safety, Reliability Engineering, Economics of loss prevention

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply the chemical process safety, safety codes
CO2: Compare safe handling of chemicals and plant inspection
CO3: Apply knowledge on safety management in different process industry
CO4: Analyse the hazard analysis in the process industry

CO5: Evaluate the different analyses to overcome the accidents in process industry

TEXT BOOKS

1. D. A. Crowl and J. F. Louvar, Chemical Process Safety: Fundamentals with Applications, 2nded. (NY: Prentice Hall), 2002. ISBN 0134857844, 9780134857848
2. Lees, Loss Prevention in the Process Industries, 2nd ed. (London: Butterworth Heinemann 1996) ISBN 978-0-7506-7555-0
3. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004, ISBN9781315220376

REFERENCES

1. T. A. Kletz, What Went Wrong? Case Histories of Process Plant Disasters (Houston, TX: Gulf Publishing Co., 1985).
2. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994
3. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., " Industrial Accident Prevention", McGraw Hill Book Co., 1980.
4. Handley, W., "Industrial Safety Hand Book ", 2nd Edn., McGraw-Hill Book Company, 1969.
5. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987, ISBN 0-85312969X
6. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965, ISBN 0470256788, 9780470256787

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	1	2	2	1	2	2	1	2	2	1	1	1	2	2	1
CO2	2	1	2	1	2	2	1	2	2	2	1	1	2	2	2
CO3	2	2	1	1	2	2	1	2	2	1	1	1	2	2	1
CO4	2	2	2	1	2	2	1	1	3	1	2	1	2	2	1
CO5	1	2	1	1	2	2	1	1	3	1	2	1	2	2	1
Overall CO	2	2	1	1	2	2	1	2	1	1	1	1	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23704	PROCESS MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the role and classification of models in chemical process systems.
2. To teach the applicability of dynamic behaviour of lumped parameter systems in chemical processes.
3. To expose the students to modelling principles involving complex phenomena.
4. To teach the applicability of distributed parameter models for processes involving spatial variations.
5. To equip the students with process modelling and simulation tools to tackle engineering problems.

UNIT I INTRODUCTION TO CHEMICAL PROCESS MODELING 9

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

UNIT II DYNAMIC MODELING OF LUMPED PARAMETER SYSTEMS 9

Dynamic models, Lumped parameter system, Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems – Solution of ODE using Eigen values – Jordan Canonical Form – Stiff equations– Gear's algorithm -Perturbation Methods

UNIT III MODELING COMPRESSIBLE FLOW AND SPECIALIZED EQUIPMENT 9

Analysis of compressible flow, heat exchanger, packed columns, Monolith Reactor Modeling Pseudo-homogeneous and Heterogeneous models for catalytic reactors – plug flow reactor, solution of ODE - boundary value problems

UNIT IV DISTRIBUTED PARAMETER SYSTEMS AND MODEL BUILDING TECHNIQUES 9

Development of Distributed Parameter System (DPS), Classification of DPS models, Analysis laminar flow in pipe, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, classification and solution of partial differential equations, Empirical model building, Estimation of parameters, population balance, stochastic modelling - Principal Component Analysis.

UNIT V PROCESS FLOW SHEETING AND SIMULATION 9

Degree of freedom analysis, single and network of process units, systems yielding linear and nonlinear algebraic equations, flow sheeting – sequential modular and equation-oriented approach, tearing, partitioning and precedence ordering, solution techniques for linear and non-linear algebraic equations

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Evaluate the need for modeling in chemical process design and operation.

CO2: Demonstrate proficiency in applying the principles of lumped parameters models to formulate process models.

CO3: Analyze the dynamic behaviour of distributed parameter systems using analytical and numerical techniques.

CO4: Develop and utilize models for specialized equipment and complex phenomena in chemical engineering.

CO5: Apply process modeling and simulation software to solve real-world chemical engineering problems.

TEXT BOOKS

1. Bequette, B.W., "Process Dynamics: Modelling, Analysis and Simulation," Prentice Hall (1998) 0132068893
2. Himmelblau D.M. and Bischoff K.B., Process Analysis and Simulation, Wiley, 1988, 0471399906
3. Varma A. and Morbidelli M., Mathematical Methods in Chemical Engineering, Oxford University Press, 1997 ISBN 0195098218

REFERENCES

1. Golub G.H. and van Loan C.F., Matrix Computations, Johns Hopkins University Press, 3rd Edition, 1996
2. Ogunnaike B. and W. Harmon Ray. Process Dynamics, Modeling, and Control, Oxford University Press, 1995
3. Chapra S.C. and Canale R.P. Numerical Methods for Engineers, McGraw Hill, 2001
4. Press W.H., Teukolsky S.A., Vetterling W.T. and Flannery B.P., Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007
5. Luyben, W.L., "Process Modelling Simulation and Control ",2nd Edn, McGraw-Hill Book Co., 1990
6. NPTEL LINK

https://archive.nptel.ac.in/courses/103/105/103105215/

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	3	3	-	-	-	1	1	1	1	2	3	2
CO2	3	3	3	3	3	-	-	-	1	1	1	1	2	3	2
CO3	3	3	3	3	3	-	-	-	1	1	1	1	2	3	2
CO4	3	3	3	3	3	-	-	-	1	1	1	1	2	3	2
CO5	3	3	3	3	3	-	-	-	1	1	1	1	2	3	2
Over all	3	3	3	3	3	-	-	-	1	1	1	1	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23705 **INTERNSHIP/ INDUSTRIAL TRAINING** **L T P C**
0 0 0 2

OBJECTIVE:

The course is aimed to

1. Provide students with hands-on experience in a real-world industrial environment.
2. Enable students to apply theoretical knowledge gained during their degree program to practical situations in the industry.
3. Facilitate the development of professional skills and competencies, including communication, teamwork, and problem-solving.
4. Allow students to explore their career interests and gain insights into potential career paths in their field of study.
5. Enhance students' understanding of industry standards, practices, and expectations through direct interaction and feedback from industry professionals

The students shall be evaluated on the following,

1. Internship report
2. Presentation
3. Endorsement letter from industry
4. Attendance with feedback

OUTCOMES:

On the completion of the course students are expected to

CO1: Provides real work experience.
CO2: Opportunity to explore students' interest.
CO3: Students will be able to integrate classroom knowledge and theory with practical application.
CO4: Provides a nice learning curve for students with little experience.
CO5: Develops professional skills and competencies.

REFERENCES:

1. Internship | NITI Aayog
2. AICTE Internship Policy.pdf (aicte-india.org)

Course Articulation Matrix:

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	1	1	1	2	2	2	2	1	3	2	1
CO2	3	2	2	2	2	-	-	1	2	2	1	2	2	2	1
CO3	3	2	2	2	2	1	1	-	-	-	1	1	1	1	1
CO4	3	1	1	2	2	1	1	1	2	2	1	2	2	2	1
CO5	3	1	1	2	2	1	1	-	1	2	1	1	3	3	1
Overall CO	3	2	2	2	2	1	1	1	2	2	1	2	3	3	1

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

UC23U01	STANDARDS - CHEMICAL ENGINEERING	L	T	P	C
		1	0	0	1

COURSE OBJECTIVES

1. To familiarize the students with the basic codes and symbols used in process industries.
2. To equip students with the knowledge on selection and sizing of process equipment.
3. To develop students' skill in selection and sizing of valves and controls.

MODULE I – OVERVIEW OF STANDARDS **6**

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation. Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards.

MODULE II – SYMBOLS **3**

Recommendation for letter symbols, signs and abbreviations used in chemical engineering, Color code for identification of pipelines, Recommendations on Graphical Symbols for Process Flow Diagrams, Piping and Instrumentation Diagrams, Graphical symbols for pipelines and instrumentation diagrams.

MODULE III – PROCESS EQUIPMENT **3**

Recommendation on nominal capacities for process equipment, Recommendation on nominal diameter for process equipment, Crushing and grinding equipment - Classification and methods for measuring capacity, Sizes of process vessels and leading dimensions, Shell and Tube Type Heat Exchangers, Shell Flanges for Vessels and Equipment, Data sheet for shell and tube type heat exchangers.

MODULE IV – VALVES AND CONTROLS **3**

Nominal sizes for valves, Marking system for valves, Dimensions for ferrous valves - face to face and end to end, General Purpose Ball Valves, Cast or Forged Steel Check Valves (Flanged or Butt Welding Ends) for Petroleum, Petrochemicals, Chemicals and Allied Industries, Fire test for valves (including soft seated quarter turn valves) - Method of test.

Process measurement control functions and instrumentation - Symbolic representation, Part 1 to 4.

TOTAL: 15 PERIODS

COURSE OUTCOMES:

CO3: Determine the codes and symbols used in process industries.
CO4: Appreciate the standards used in designing the process equipment.
CO5: Apply the appropriate choice of valves and controls in chemical process industries.

REFERENCES

Publication of Bureau of Indian Standards:

1. IS 3030 : 1965, IS 2379 : 1990, IS 3232 : 1999, IS 9446 : 1980.
2. IS 2843 : 1964, IS 2844 : 1964, IS 3612 : 1994, IS 4179 : 1967, IS 4503 : 1967, IS 4864 to 4870 : 1968, IS 10123 : 1982.
3. IS 9520 : 2008, IS 9866 : 1981, IS 9884 : 1981, IS 9890 : 1981, IS 10989 : 1984, IS 11611 : 1992, IS 12754, 1 to 4 : 1989 (ISO 3511, 1 to 4).

Note: For all standards verify with the latest amendments.

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1															
CO2															
CO3	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO4	3	3	3	3	2	3	2	2	2	2	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	3	2	2	3	3	3	3
Avg															

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23801 **PROJECT WORK**

	L	T	P	C
OBJECTIVES	**0**	**0**	**16**	**8**

1. Provide students with the opportunity to apply theoretical knowledge to real-world industrial or research problems.
2. Develop students' ability to independently plan and execute a comprehensive research or design project.
3. Enhance students' skills in critical thinking, problem-solving, and project management.
4. Foster collaboration and communication skills through interactions with faculty, industry professionals, and peers.
5. Prepare students for professional practice or further research by exposing them to industry standards, methodologies, and tools.

Project work based on research or design aspects

SYLLABUS: Students are required to individually work on a specific project or topic that has been approved by the faculty. The students can select any project or topic relevant to their specialization within the program and of interest to the faculty in the department, research institution or any industry. The mode of the work can be experimental, theoretical, or industrial. At the end of the semester, students must submit a detailed report on their project work. This report should contain a clear definition of the identified problem, a comprehensive literature review related to the area of work, and a detailed methodology of the work was carried out.

COURSE OUTCOMES

The students will be able to

CO1: Apply the fundamental concept learnt during the course to solve industrial problems

CO2: Review the current status based on the information available in the literature or data obtained in the laboratory/industry

CO3: Carry out material and energy balance for entire plant

CO4: Design equipment’s based on process industries

CO5: Evaluate the economics of a process through cost estimation

TOTAL: 240 PERIODS

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	3	3	3	3	3	2	2	2	2	2
CO2	2	2	3	3	3	2	3	2	3	3	3	3	2	2	3
CO3	3	3	3	2	3	3	2	3	3	2	3	3	3	3	3
CO4	3	3	3	3	3	2	2	3	3	3	2	2	3	3	3
CO5	3	3	3	3	3	3	3	3	2	2	3	3	2	3	3
Over all	2.8	2.8	2.8	2.6	3	2.6	2.6	2.8	2.8	2.6	2.6	2.6	2.4	2.6	2.8

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23001 **CHEMICAL PROCESS DESIGN**

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

1. To understand the concept of chemical processes and development.
2. To gain knowledge on selecting the type of reaction and reactors to enhance the product development.
3. To understand the concepts separation system.
4. To understand and implement the concept on heat integration on a chemical process.
5. To gain knowledge on process optimization.

UNIT I GENERAL PROCESS CONSIDERATION **9**

Process design development, general design consideration, formulation of design problem-the hierarchy and approaches of chemical process design and integration.

UNIT II CHOICE OF REACTORS **9**

Reactions and reactor systems, design of idealized reactors, reactor performance, reactor conditions and configurations, Reactor networks in process flow sheets.

UNIT III CHOICE OF SEPARATORS **9**

Separation systems introduction - choice of separator for homogeneous fluid mixtures, choice of separator for heterogeneous fluid mixtures, multicomponent distillation, distillation sequencing, separation systems in process flowsheets.

UNIT IV ENERGY INTEGRATION AND HEAT EXCHANGER NETWORK SYNTHESIS **9**

Heat exchangers, Heat exchange networking, HEN design, heat exchanger integration in reactor and distillation column, energy target – pinch technology, composite curves, problem table algorithm.

UNIT V RECYCLE SYSTEMS AND OPTIMIZATION **9**

Functions of process Recycles in continuous and batch processes, optimization of recycle loop in continuous and batch process, o optimization approaches to optimal design, role of simulations in process design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understand the concepts of chemical process's design and development.
CO2: Evaluate the choice of reactors and configure reactor design.
CO3: Execute the concept of separation processes.
CO4: Apply the skill in thermal design of heat transfer equipment and assessing thermal efficiency.
CO5: Apply the concepts of process recycling and optimize engineering problems in any chemical processes.

TEXT BOOKS

1. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, West Sussex, UK, 2005. ISBN: 978-1-119-99014-7
2. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers, 5th Edition, McGraw-Hill International Editions (Chemical Engineering Series), NewYork, 2003. ISBN 0072392665,
3. Douglas, J. M., Conceptual design of chemical processes, Vol. 1110, New York: McGraw-Hill, 1988. **ISBN-10 :** 0070177627

REFERENCES

1. Robert E. Treybal, Mass Transfer Operations, 3rd Edition. McGraw-Hill International Editions, Singapore, 1981.
2. Sinnott, R. K., Coulson & Richardson's Chemical Enginering: Volume 6, Chemical Engineering Design, Elsevier Butterworth Heinemann, 1999.
3. Xian Wen Ng, Concise Guide to Heat Exchanger Network Design, Springer Nature Switzerland, 2021.
4. Xing Luo, Wilfried Roetzel, Dezhen Chen, Design and Operation of Heat Exchangers and their Networks, 1st Edition, Academic Press, 2019.
5. Seider, W. D., Seader, J. D., & Lewin, D. R. Product & Process Design Principles: Synthesis, Analysis and Evaluation, John Wiley & Sons, 2009.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O 1	PS O 2	PS O 3
CO1	3	3	3	3	2	-	-	-	3	2	3	2	2	3	-
CO2	3	3	3	3	3	-	1	-	3	3	3	3	3	3	-
CO3	3	3	3	3	3	-	1	-	3	3	3	2	3	-	-
CO4	3	3	3	3	3	-	-	-	3	3			1	1	-
CO5	3	3	3	3	3	3	3	-	3	3	3	3	3	3	2
Overall	3	3	3	3	3	1	1	-	3	3	2	2	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23C02 **OPTIMIZATION OF CHEMICAL PROCESSES** **L T P C**
3 0 0 3

COURSE OBJECTIVES

1. To impart knowledge on optimization techniques in chemical engineering processes
2. To enable students to understand the concepts of optimization
3. To obtain a mathematical representation of the optimization problem
4. To describes different solution techniques that can be used to actually solve
5. To emphasis on problems arising in Chemical Engineering applications

UNIT I PROBLEM FORMULATION & CLASSIFCATION 9

Introduction; formulation of objective functions; fitting models to data; classification of functions; necessary and sufficient conditions for optimum; unimodal, multimodal functions; analytical methods

UNIT II LINEAR PROGRAMMING 9

Review on basic concepts of LP formulations; Simplex methods; Big-M method, two phase method and Duality in linear programming.

UNIT III NON-LINEAR PROGRAMMING 9

The Lagrange multiplier method, Integer, quadratic, geometric and dynamic programming

UNIT IV NUMERICAL METHODS 9

Unimodal functions; Newton, quasi Newton, secant methods; region elimination methods, polynomial approximation; quadratic and cubic interpolation techniques for optimum. Multimodal functions; direct methods; Powell's technique; indirect methods; gradient and conjugate gradient methods; secant method

UNIT V APPLICATIONS 9

Heat transfer and energy conservation; separation processes; fluid flow systems; reactor design and operation; large scale systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Be familiar on the basic problem formulation and optimization.

CO2: Evaluate mathematical characteristics of Linear programming

CO3: Demonstrate computational solution techniques for nonlinear unconstrained optimization.

CO4: access various techniques used in constrained optimization

CO5: Apply the optimal and dynamic optimization.

TEXT BOOKS

1. Edgar T.F., Himmelblau D.M., Lasdon,L.S., Optimization of Chemical Processes, Second Edition, McGraw-Hill, New York, 2001. ISBN 0070393591
2. Rao, S. S., Engineering Optimization: Theory and Practice, Fifth Edition, Wiley, New York, 2019. ISBN: 978-1-119-45471-7
3. Ramirez, W.; " Computational Methods in Process Simulation ", 2nd Edn., Butterworths Publishers, New York, 2000. ISBN: 075063541X

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1. Reklaitis G.V., Ravindran A., Ragsdell, K.M., Engineering Optimization, Wiley, New York, 1980.
2. Chaves, I.D.G., López, J.R.G., Zapata, J.L.G., Robayo, A.L., Niño, G.R., process optimization in chemical engineering in :process analysis and simulation in chemical engineering, springer, cham., 2016.
3. MATLAB Documentation (https://www.mathworks.com)
4. Engineering Optimization: Methods and Applications - A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, 2nd Edition, Wiley India, 2006.

Course Articulation Matrix:

Course	Program Outcomes														
Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	2	2	2	1	1	-	1	1	1	2	2	2	2
CO2	1	2	2	2	2	1	1	-	1	2	2	2	2	2	2
CO3	1	2	2	2	2	1	1	-	1	2	2	2	2	2	2
CO4	2	2	2	2	2	1	1	-	1	2	2	2	2	2	2
CO5	2	2	2	2	2	1	1	-	1	2	2	2	2	2	2
overall	1	2	2	2	2	1	1	-	1	2	2	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23002	FINITE ELEMENT METHOD	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To enable the students to develop mathematical models for Boundary Value Problems and their numerical solution.
2. To enable the students to apply concepts of Finite Element Analysis to solve one dimensional problem.
3. To enable the students to determine field variables for two dimensional scalar variable problems.
4. To enable the students to determine field variables for two dimensional vector variable problems.
5. To enable the students to understand and apply the need for Isoparametric transformation and the use of numerical integration.

UNIT I INTRODUCTION **9**

Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems –Basic concepts of the Finite Element Method.

UNIT II ONE-DIMENSIONAL PROBLEMS **9**

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors. Solution of problems from solid mechanics and heat transfer. Longitudinal vibration frequencies and mode shapes.

UNIT III TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS **9**

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements – Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Quadrilateral elements – Higher Order Elements.

UNIT IV TWO DIMENSIONAL VECTOR VARIABLE PROBLEMS **9**

Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects – Stress calculations - Plate and shell elements.

UNIT V ISOPARAMETRIC FORMULATION **9**

Natural co-ordinate systems – Isoparametric elements – Shape functions for iso parametric elements – One and two dimensions – Serendipity elements – Numerical integration and application to plane stress problems - Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Develop mathematical models for Boundary Value Problems and their numerical solution.
CO2: Formulate the Finite Element methodology to solve the one dimensional problem(s).
CO3: Estimate field variables for two dimensional scalar variable problems.
CO4: Determine field variables for two-dimensional vector variable problems.
CO5: Apply the Isoparametric transformation and the use of numerical integration to engineering problems

TEXT BOOKS

1. Rao, S.S., "The Finite Element Method in Engineering", 6th Edition, Butterworth Heinemann, 2018. ISBN 0128143649, 9780128143643
2. Reddy, J.N. "Introduction to the Finite Element Method", 4thEdition, Tata McGrawHill,2018. ISBN 1259861910, 9781259861918
3. Seshu.P, "Text Book of Finite Element Analysis", PHI Learning Pvt. Ltd., New Delhi, 2012. ISBN 8120323157, 9788120323155

REFERENCES

1. David Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw Hill, 2005
2. Dhanaraj. R and Prabhakaran Nair. K, "Finite Element Analysis", Oxford Publications, 2015.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Student Edition, 2004.
4. TirupathiR. Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.

Course Articulation Matrix:

PO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2			1			2	2	3		1
CO2	3	2	2	2	2			1			2	3	3		1
CO3	3	3	3	2	2			2			2	2	3		1
CO4	3	3	2	2	2			1			2	2	3		1
CO5	3	3	2	2	2			1			2	2	3		1
Avg	3	2.8	2.2	2	2			1.2			2	2.2	3		1

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

CH23003 MACHINE LEARNING IN CHEMICAL ENGINEERING LT P C
3 0 0 3

COURSE OBJECTIVES

1. To introduce the fundamental concepts and principles of machine learning and its relevance in chemical engineering.
2. To enable students to apply machine learning techniques for data analysis, process modeling, and optimization in chemical engineering.
3. To educate students on supervised, unsupervised, and time series analysis methodologies with practical applications.
4. To provide hands-on experience with popular machine learning tools and libraries.
5. To foster critical thinking and problem-solving skills through the application of machine learning to real-world chemical engineering challenges.

UNIT I INTRODUCTION TO MACHINE LEARNING 9

Definition and principles, Historical perspective, Importance and need for machine learning in chemical engineering, Overview of machine learning types: supervised, unsupervised, and reinforcement learning, Introduction to data preprocessing, Feature selection and engineering, Overview of popular machine learning tools and libraries.

UNIT II SUPERVISED LEARNING 9

Regression techniques: Linear regression, Polynomial regression, Support vector regression, Classification techniques: K-nearest neighbors, Decision trees, Random forests, Support vector machines, Neural networks, Evaluation metrics: MSE, RMSE, MAE, R-squared, Confusion matrix, ROC curve, Precision, Recall, F1 score, Case studies in chemical process modeling and optimization

UNIT III UNSUPERVISED LEARNING 9

Clustering techniques: K-means, Hierarchical clustering, DBSCAN, Dimensionality reduction techniques: PCA, t-SNE, Autoencoders, Anomaly detection, Association rule learning, Applications in process monitoring, fault detection, and quality control in chemical engineering.

UNIT IV TIME SERIES ANALYSIS 9

Introduction to time series data, Time series decomposition, Smoothing techniques, ARIMA models, Seasonal decomposition of time series (STL), Autocorrelation and Partial Autocorrelation functions, Forecasting methods, Applications in predictive maintenance, energy optimization, and process control in chemical engineering.

UNIT V APPLICATIONS AND CASE STUDIES 9

Integration of machine learning with chemical engineering software, Case studies of successful applications in chemical engineering: predictive maintenance, energy optimization, reaction yield

prediction, Hands-on projects using real-world datasets, Future trends and ethical considerations in machine learning for chemical engineering.

TOTAL: 60 PERIODS

COURSE OUTCOMES

CO1: Explain the fundamental concepts and principles of machine learning and their relevance to chemical engineering.
CO2: Apply supervised learning techniques for data analysis and process modeling in chemical engineering.
CO3: Utilize unsupervised learning methods for clustering, anomaly detection, and dimensionality reduction in chemical processes.
CO4: Implement time series analysis for predictive maintenance, energy optimization, and process control in chemical engineering.
CO5: Design and execute machine learning projects to solve complex engineering challenges, integrating machine learning with chemical engineering software and tools for real-world applications.

TEXT BOOKS

1. Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer. **ISBN-10 :** 0241973376
2. Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective. MIT Press. ISBN-10 : 0262018020
3. Montgomery, D. C., & Runger, G. C. (2018). Applied Statistics and Probability for Engineers. Wiley **ISBN-10 :** 9788126562947

REFERENCES

1. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
2. Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer.
3. Alpaydin, E. (2014). Introduction to Machine Learning. MIT Press.
4. Barto, A. G., & Sutton, R. S. (2018). Reinforcement Learning: An Introduction. MIT Press.
5. Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: Principles and Practice. OTexts.
6. Chollet, F. (2018). Deep Learning with Python. Manning Publications.
7. Arockia, L., Rik, D. (2023). Fun with Machine Learning: Simplify the Data Science process by automating repetitive and complex tasks using AutoML. BPB Publications.

Course Outcome	Program Outcome														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	2	2	2	2	2	2	2	2	3	2	2
CO2	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
CO3	3	3	3	2	3	2	2	2	2	2	2	2	3	2	2
CO4	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
CO5	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
Average	3	**3**	**3**	**2.6**	**2.8**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	3	2	2

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

CH23004 CHEMICAL PROCESS FLOW SHEETING L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To enable students to understand the basic concept of preparation of flow sheet.
2. To impart knowledge on flow sheet preparation by equation solving methods.
3. To understand how to invent chemical process flowsheets,
4. To generate and develop process alternatives.
5. To simulate the steady state behavior of process flowsheets using a suitable simulation software.

UNIT I FLOWSHEET 9

Introduction, symbols, flowsheet presentation with examples, manual flowsheet calculation, flowsheeting approaches

UNIT II DECOMPOSITION OF NETWORKS 9

Partitioning and tearing a flowsheet, tearing algorithms based on signal flow graph, algorithms based on reduced graph, comparing various tearing algorithms

UNIT III SEQUENTIAL MODULAR APPROACH TO FLOWSHEETING 9

Principle of method, convergence of flowsheet using different methods - Newton's method, direct substitution, Wegstein's method, dominant Eigenvalue method, quasi Newton method, criteria for acceleration

UNIT IV FLOWSHEETING BY EQUATION SOLVING METHODS 9

Precedence ordering, disjoining, tearing a system of equations, SWS algorithm, maintaining sparsity, solution of system of equations using Newton's method

UNIT V CASE STUDIES 9

Simulation of process flowsheets involving mass recycle, energy recycle, tear stream and design specification, demonstration of open source flowsheeting software

COURSE OUTCOME:

CO1 Apply the basic concept in preparation of flowsheet

CO2 Demonstrate the knowledge on preparing networks

CO3 Evaluate different approach in flow sheeting

CO4 Demonstrate the flow sheet preparation by equation solving methods

CO5 Evaluate the case studies using flow sheeting software

TEXT BOOKS

1. Babu, B V., Process Plant Simulation, Oxford University Press, 2004 **ISBN-10 :** 9780195668056

2. A.W.Westerberg.,H PHutchison ., process flowsheeting., Cambridge university press.,2011 **ISBN- 10 :** 0521279151
3. Douglas, J. M., Conceptual Design of Chemical Process, McGraw Hill, 1988. **ISBN-10 :** 0070177627

REFERENCE BOOKS

1. Bequette, B.W., “Process Dynamics: Modelling, Analysis and Simulation,” Prentice Hall (1998)
2. Luyben, W.L., “ Process Modelling Simulation and Control “,2nd Edn, McGraw-Hill Book

COURSE ARTICULATION MATRIX:

Course							**Program Outcomes**								
Outcomes	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO 3**
CO1	2	-	-	-	1	-	1	1	1	2	1	2	2	2	2
CO2	2	-	-	-	2	1	1	1	1	2	1	2	2	2	2
CO3	2	1	2	1	2	1	1	1	1	2	2	2	2	2	2
CO4	2	2	2	1	2	1	1	1	1	2	2	2	2	2	2
CO5	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2
Over all	2	1	1	1	2	1	1	1	1	2	2	2	2	2	2

CH23005 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

COURSE OBJECTIVES

1. To enable the students to learn basics CFD
2. To enable the students to learn laminar and turbulent flow models
3. To impart knowledge on computational solution techniques
4. To enable the students to use finite volume methods for computational studies
5. To enable the students to evaluate flow field computation techniques for steady and unsteady flows

UNIT I GOVERNING EQUATIONS 9

Governing equations of fluid flow and heat transfer - Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations.

UNIT II TURBULENCE AND ITS MODELLING 9

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, free turbulent flows, flat plate boundary layer and pipe flow, Turbulence models, mixing length model, The k-omega model, Reynolds stress equation model, algebraic stress equation model.

UNIT III FINITE VOLUME METHOD FOR DIFFUSION PROBLEMS 9

Introduction to finite volume method, one-dimensional steady state diffusion, two-dimensional diffusion, discretised equations for diffusion problems

UNIT IV FINITE VOLUME METHOD FOR CONVECTION-DIFFUSION PROBLEMS 9

Steady one-dimensional convection and diffusion, the central differencing scheme, properties of discretisation schemes - conservativeness, boundedness, transportiveness, Assessment of the central differencing scheme for convection-diffusion problems, The upwind differencing scheme, hybrid differencing scheme, power-law scheme, higher order differencing schemes, quadratic upwind differencing scheme.

UNIT V FINITE VOLUME METHOD FOR UNSTEADY FLOWS 9

One-dimensional unsteady heat conduction, transient convection-diffusion equation, solution procedure for unsteady flow calculations. Implementation of inlet, outlet and wall boundary conditions, constant pressure boundary condition.

TOTAL:45 PERIODS

COURSE OUTCOME:

CO1 Apply the basics of CFD and governing equations for conservation of mass momentum and energy

CO2 Analyze mathematical characteristics of partial differential equations

CO3 Compare computational solution techniques for time integration of ordinary differential equations

CO4 demonstrate various discretization techniques used in CFD

CO5 Evaluate flow field computation techniques for steady and unsteady flows

TEXT BOOKS

1. Versteeg H. K. and Malalasekera, W., An introduction to computational fluid dynamics: the finite volume method, Second edition, Pearson, 2008. ISBN13 978-0131274983.
2. Anderson, J. D. Computational fluid dynamics: The Basics with Applications, McGraw-Hill, 1995. ISBN13 978-1259025969
3. Chung T.J Computational Fluid Dynamics Cambridge University Press 2003. ISBN13 978-0521769693
4. Fletcher, C. A. J., "Computational Techniques for Fluid Dynamics", Springer Verlag, 1997. ISBN 978-3-540-53058-9

REFERENCE BOOKS

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", NarosaPublishing House, New Delhi, 2001.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw – Hill Publishing Company Ltd. 1998.
3. Subas, V. Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier Stock Equation", Pineridge Press Limited, U.K., 1981.
5. Ranade, V. V., Computational flow modeling for Chemical Reactor Engineering, Academic Press, 2002.

COURSE ARTICULATION MATRIX:

Course Outcome	Program Outcome														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	2	2	2	1	1	2	2	1	2	2	2	1
CO2	2	2	2	2	2	2	1	1	2	2	1	2	2	2	1
CO3	2	2	2	2	2	2	1	1	2	2	1	2	2	2	1
CO4	2	2	2	2	2	2	1	1	2	2	1	2	2	2	1
CO5	2	2	2	2	2	2	1	1	2	2	1	2	2	2	1
Average	2	2	2	2	2	2	1	1	2	2	1	2	2	2	1

CH23006 **CHEMICAL PLANT DESIGN** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1.To understand the intricacies in equipment sizing and selection
2. To enable students with the design of various process condition in static equipment
3. To familiarize with ancillaries design in static equipment.
4. To understand the design and importance of pressure valves in process plant design
5. To develop knowledge in designing chemical process unit with safety as paramount

UNIT I ROTARY EQUIPMENT **9**

Pumps: Various types: Centrifugal, Reciprocating& Other Positive displacement types – Plunger, Piston, Diaphragm, Gear, Screw, Lobe, Vane, etc.; Compressors: Various types: Axial, Centrifugal, Reciprocating, and other positive displacement type such as Rotary Screw, Scroll, etc. Further, compressors are classified into two namely Oil free and Oil flooded lubricated; Fans: Various types: Axial fans (including Propeller, Tube-axial, and Vane-axial) and Centrifugal fans. Further fans are classified as Induced draft and Forced draft types; Steam Turbines: : Various types: Back Pressure and Condensing Types with and without extraction, Impulse & Reaction types; Gas Turbines : Various types: Turbojet, Turboprop, Turbofan and Turboshaft Engines; Motor :Various types: AC motors (Synchronous & Asynchronous motors), DC motors (brushed and brushless), Variable Frequency and Variable Speed motors and Special purpose motors, Generator: Various types: AC and DC generator; Other Special Equipment: Various types: Power Recovery Turbines, Heat Pumps, Ejector pump, NASH vacuum pump Case Studies – From Industries on operations and maintenance aspects viz. Trouble shooting, Energy improvement, Capacity augmentation, Design tips, Equipment safety, Catastrophic incidents, etc.

UNIT II STATIC EQUIPMENT - HEAT TRANSFER EQUIPMENT **9**

Heat Exchangers– Shell and Tube, Double Pipe, Plate &Frame type, Tube in tube Scraped surface, and Fin tube, Coolers, Condensers, Fin Fan Coolers; Fired Heaters& Boilers– With or without air preheaters, Balanced draft or simply natural draft or even only forced draft, With and without waste heat generation, Refrigeration& Air Conditioning– HVAC (Heating, Ventilation, and Air Conditioning); Miscellaneous – Chilled water system with vapour compression refrigeration, Ejector refrigeration system, direct contact heat exchanger (such as cooling towers, Jet condensers, direct contact feed), Incinerator. Case Studies – From Industries on operations and maintenance aspects viz. Fouling control, Pinch study for energy recovery, Capacity creep, Design tips, Equipment safety, Catastrophic incidents, etc

UNIT III STATIC EQUIPMENT - MASS TRANSFER

9

Mass Transfer Operations: Multi Component Distillation columns, Extractive distillation, Reactive Distillation, Azeotropic distillation, Divided wall columns, Dryers, Adsorption Isotherm, Pressure Swing Adsorption, Importance of recycles and Optimization needs, Absorption processes & operating variables, Liquid – Liquid Solvent Extraction ; Humidification & dehumidification,

Evaporation, Precipitation, Crystallizers, Membrane filtration; Reactors– CSTR, Slurry phase reactor, Tubular, Trickle Bed Reactor, etc., thermodynamically controlled reaction and kinetically controlled reaction, Reaction Kinetics, Importance of Reactor internals. Case Studies – From industries across life cycle such as Trouble shooting, enhance conversion & selectivity, IoT use, Debottlenecking, Design tips, Safety Incidents "Fit - For Purpose" Assessment, etc.

UNIT IV EQUIPMENT ANCILLARIES 9

Special equipment– Static Mixer, Agitators, Jet Mixing, Ejectors, Eductors, Structured Packing, Grid Packing and Random Packing, Demisters, Vortex Breaker, Calming Baffles, Schoepentoeter, Vapour horn device, Cyclone separators; Package units – Inert gas generators, Feed stream filters (Mechanical, Chemical), Scrubbers, Spray Nozzles, Guard beds, Flare stack, Ground Flare, Flame arrestors, Strainers, Spring supports, Expansion joints, Electrostatic Precipitators; Steam Traps – Thermodynamic, Inverted Bucket type, Thermostatic – Float, Bimetallic type, etc., Case Studies – From Industries on operations & maintenance aspects viz. Trouble shooting, Efficiency / Effectiveness tracking, Debottlenecking, Design tips, Safety & Environmental Incidents, etc

UNIT V STATIC EQUIPMENT - PRESSURE VESSELS, INTERNALS &SAFETY VALVES 9

Pressure Vessels – Vertical / Horizontal, Knock Out Drums, Steam and Blow down drum, Cold & Hot Separators, Surge drum, Deaerators, Water Seal Pot, Molecular seals, Shock Absorbers, Pressure snubber, Silencer, Slug Catcher, Desalter, Coke drum; Vessel & Columns - associated structural accessories such as Platforms, Ladders, Staircase etc. Internals –Column internals such as Trays (Sieve, Valve, Bubble Cap, Baffle, Dual flow, Multi down comer, Chimney tray etc.), Packings (structured, grid, random, etc.), Packed tower internals – Bed support plates, Liquid distributors, Bed limiters etc.; Mist eliminators, Demisters, Coalescing pads, Vortex breakers etc. Safety Valves: Normal, balanced bellows, pilot operated, etc., Rupture Discs, and Design codes governing Safety valve design, Case Studies– From industrial operations & maintenance activities– ASME codes, Trouble shooting, Efficiency tracking, Use of IoT, Debottlenecking, and Design tips, Safety & Environmental Incidents, etc.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply the basic on designing chemical process unit for rotary equipment

CO2: Demonstrate the operations of boilers, heat exchangers, refrigeration and air conditioners.

CO3: Evaluate Knowledge on operations of reactors, humidifiers and mass transfer operations

CO4: compare the different types of equipment in process industries

CO5: Apply the knowledge on usage of different valves such as pressure, safety and internal

TEXT BOOKS

1. Chemical Engineering Handbook - Robert H. Perry; Don W. Green and James O. Maloney, McGraw Hill Professional,2007, ISBN 0071593136,
2. Heat Transfer – D.Q. Kern, Second Edition , 2019, ISBN 1119363640

3. Mass Transfer Operations, Robert E. Treybal, McGraw Hill Education, 3RD EDITION,ISBN-10 : 1259029158
4. Principles of Mass Transfer and separation Processes , BK Dutta, PHI Learning Pvt. Ltd., 21 Jan 2007 - Technology & Engineering, ISBN 8120329902

REFERENCES

1. Applied Process Design for Chemical and Petrochemical Plants – Ernest E. Ludwig
2. Fluid Mechanics, Heat Transfer, and Mass Transfer (Chemical Engineering Practice) – KSN Raju

Course Outcome	Program Outcome														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	2	2	-		1	-	2	1	2	2	2	2
CO2	2	2	2	2	2	-		1	-	2	1	2	2	2	2
CO3	2	2	2	2	2	-		1	-	2	1	2	2	2	2
CO4	2	2	2	2	2	-		1	-	2	1	2	2	2	2
CO5	2	2	2	2	2	-		1	-	2	2	2	2	2	2
Average	2	2	2	2	2	-		1	-	2	1	2	2	2	2

CH23007 **PLANT LAYOUT**

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

- To understand the importance of plant layout in mitigating risk on people, plant, planet
- To apply knowledge in placing equipment for ease of operability & maintainability

UNIT I STANDARDS FOR AREA CLASSIFICATION 9

Standards for area classification–Electrical Area classifications, OSHA (Occupational Safety and Health Administration) regulations, National Fire Protection Association (NFPA), Petroleum Hazards Classification, IP15 Petroleum classification based on flash point, OISD standards (Oil Industry Safety Directorate), API Codes (American Petroleum Institute), PESO (Petroleum and Explosives Safety Organization) guidelines, Investigations Reports & Best practices data Chemical Safety Board, USA

Case Studies – From Industries on Lessons from Incidents from Environmental Protection Agency (EPA), Safety & Environmental Incidents, etc.

UNIT II INTER UNIT DISTANCES 9

Distance between plants, substation, centralized control room, utilities sections / captive power plants; Inter-distance between adjacent Columns, Storage tanks, Tank dykes; Flare stack location (based on Prevailing up-wind direction), Design to keep it smokeless, Sterile zone/area – Governing API /OISD Standards, Field cabins. Access to firefighting facilities, Fire tank capacity, Foam need assessment, Design to tackle simultaneous fire incidents, Protection of fire network and ensuring availability on demand, Risk evaluation(arising from inventory of inflammable liquid, potential formation of explosive mixture, operation above auto-ignition temperature, toxic release, etc.) based on credible scenario;3D models used in equipment & piping isometric, Maintenance accessibility, Safe work place specially at elevated platform, Ease of emergency evacuation; Bow Tie Analysis to mitigate risk right at design stage, Blast proof design of control room, Minimize employee occupancy at a given time in risk zone.**Case Studies** – From Industries on operations &maintenance aspects viz. Trouble shooting, Efficiency / Effectiveness tracking, Debottlenecking, Design tips, Safety & Environmental Incidents, etc.

UNIT III STORAGE TANKS 9

Storage Tanks – Fixed or Floating roof, Mounded Bullet tanks, Cryogenic storage tanks & their special design requirements, Special designs along with breather systems, Lightening arrestors, Earth pits, other appurtenances –Manways for roofs or tank sidewalls, Catwalks, Roof vents, Roof hatches, Nozzles, Roofs (flat-style, knuckle-style, or pitched), Aluminium geodesic domes, Ladders, etc. Comfort factors Vs Inventory carrying cost, Safe operation of floating roof travel, breather sizing, steam coils design, rainwater drains, dyke capacity, inter tank distance based on product hazard classification, tank inspection schedule, ease of cleaning, confined place entry, water spray and other firefighting feature, fugitive emission control, etc.

Case Studies – From Industries on operations & maintenance aspects viz. Trouble shooting, Water traps and roof collapse, safe filling height, Design tips, Safety & Environmental Incidents, etc.

UNIT IV AT RISK SYSTEMS AND EQUIPMENT 9

At-risk systems and equipment: Fuel gas systems, Fuel oil network, Hydrogen gas for generator cooling in power plants; Plant battery systems, Ammonia systems, Solid handling of coal and coke dust, Sulphur yard, Toxic gas loss of containment, etc, MSDS of every stream being handled / processed, Spent catalyst safe disposal ;Safe at Risk Assessment: Overall risk assessment using credible scenario along with preventive measures &systems to be in place to eliminate / minimize loss of containment. **Case Studies** – From Industries on operations & maintenance aspects viz. Trouble shooting, Process Control, Early event detection, Debottlenecking, Design tips, Safety & Environmental Incidents, etc.

UNIT V BASIC ENGINEERING DESIGN PACKAGE 9

Basic Engineering Design Package (BEDP): First document to be prepared and approved between Process Engineering Team and Owner's representative. It shall cover not limited to – Site Conditions (weather, wind rose, seismic activity, water table, etc.); System of measurement (in FPS or MKS for flow of gas / liquid / steam, temperature, pressure, heat duty, inferential properties, etc.), Design considerations and margins, Design philosophies such as Operating & Control philosophy, Vent & Drain philosophy, Isolation philosophy, sparing philosophy etc. Raw material details (Capacity, conditions, logistics including receipt modes & storage criteria) Product offtake plans and modes of distribution, environmental norms, Levels of power & utilities that would be available for safe and hassle free operations ; Green belt cover, use of renewables, zero liquid discharge, maximum air cooling / condensing, storm water channel considerations, rain water harvesting ; Flare gas recovery, flight path and tall structures in industry premises, MIQA (mechanical integrity and quality assurance) considerations, equipment designed life ; Feed definition / variability / flexibility, product mix& swings, product quality, custody transfer design basis, turnaround plans ; Energy & loss targets and best in class design considerations, criteria for smooth and faster start-up, onstream factor, spinning margin, applicable codes, built in features for continual improvement, advanced process control and other s/w deployment for SCM (Supply Chain Mgt) and O&M (Operation and Maintenance) excellence. **Case Studies** – Lessons learnt from Industries viz. examples of regret investment, deviations from original design & impact thereof, market forces & design adaptability, challenges in product quality, etc.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: understand the importance of plant layout in mitigating risk on people, plant, planet

CO2: understand the knowledge in placing equipment for ease of operability & maintainability

CO3: understand the storage tanks operation and usage at safety level

CO4: knowledge on usage of equipment at safety levels and their risk assessment

CO5: understand the basic engineering design package

TEXT BOOKS

- GAVIN TOWLER and RAY SINNOTT Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design

M.JOSHI, PROCESS EQUIPMENT DEISGN

REFERENCE BOOKS

OISD Guideline on Plant Layout - OISD-STD-118
OSHA Guidelines on Plant Layout
API Guidelines on Plant layout

Course Articulation Matrix:

Course Outcomes	Program Outcomes															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1	2	1	1	1	1	1	2	2	2	2	2
CO2	2	1	2	2	2	1	1	1	1	1	2	2	2	2	1
CO3	2	1	2	2	2	1	1	1	1	1	1	2	2	2	2
CO4	2	1	1	2	2	1	1	1	1	1	2	2	2	2	1
CO5	2	1	2	2	2	1	1	1	1	1	1	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23008 **DESIGN SAFETY** **LT P C**
3 0 0 3

1. To acquire knowledge on Controlling of safety systems and Relief systems and to acquire knowledge on design activities of safety and relief systems.
2. To provide about the various risks and hazards involved in petroleum industries and its control measures.
3. To provide deep insight into the electrical systems in petroleum industries
4. To impart knowledge on risk analysis, toxic effect and planning for onsite and offsite emergency planning in petroleum industries.
5. To inculcate the students in hazardous identification techniques, reliability analysis of the processing system, event trees & fault trees analysis, hazards and operability analysis (HAZOP).

UNIT I SAFETY SYSTEMS 9

Safety systems: Deployment of sensors (Toxic, HC and Thermal) at critical locations, Fire network including elevated fire monitors, Egress system, Escape route and Assembly point, Water curtain, eye wash requirement, Clean and cooler water supply ;Dovetail Early Event Detections system to forecast and forewarn on 'unsafe' conditions emerging in process units, Cause & Effect diagram, Alarm rationalization, Partial or Total Plant Trips review; Setting up IOW (Integrity Operating Window), Utility stations at strategic locations in process units (for supply of LP steam, Nitrogen, Industrial Air, Service water), Fire Proofing of structures, ROVs (Remote Operated Valves), EIVs (Emergency Isolation Valves), Redundancy in trips (1 oo 1; 2 oo 3) and avoidance of spurious trips ;SIL (Safety Integrity Level) in process safety, HIPS (High Integrity Protection System),Shutdown system reset – Field or Controlled room, Centralized Vs Decentralized Control centre, Need of Chemical filter in Control Room Air conditioning, Cyber-attack prevention, Mutual aid plan. Case Studies – From Peer Industries on Performance Benchmark, Process safety Management, Safety Culture, Asset Integrity, Litigations, Safety & Environmental Incidents, etc

UNIT II ELECTRICAL SYSTEMS 9

Power systems – KV level, 3 phase and single phase, LT, HT generation and distribution network systems, MCC / PCC (motor control centre and power control centre) substations, Electrical Energy Audits, Exergy analysis, Cogen design aspects ; Emergency Power needs based on process criticalities (including power back up for fire water and plant safe shut down), Load shedding, Essential and Non- essential power load ;Uninterrupted Power System (UPS), Load assessment for UPS, Battery bank ;Earth pit design and maintenance aspects, Earth – Neutral Differential & impacts of stray voltage, Fault Level and its relevance in industry, Start-up load, Power from two independent Sources, Relay / Fuse Coordination. Electrical load distribution and its influence on safety relief / flare load in an industrial complex, Interphase with DCS (Distributed Control System), PLCs (programmable logic controls), I/P (Current to Pneumatic transmission) convertor failures ;An overview on electrical failures viz. cable fault, over load, over voltage due to surges, lightning strokes, aging of conductor, internal & external stresses on the conductors, spike in power banks, etc., Case Studies – Industries experiences on Steam – Power balance for efficiency enhancement,

smart debottlenecking to minimize cable routing & MCC / PCC use, Safety & Environmental Incidents, etc.

UNIT III FLARE SYSTEM 9

LP, HP, LLP and H2S flares, Types – Single Point Flares (Sonic & Subsonic), Multi Point Flares, Coanda Flares, Vent Tips, Enclosed Flares and Air Assisted Gas Flares ;Pilot gas system, Electronic ignition, Flare tip design, Flare noise reduction, Fire Ball prevention, Smokeless flare at worst weather conditions, Radiation impact zone, Flare release scenarios (fire, blocked mode, partial and total power failure), Nitrogen purge, flare header network design; Safety margins in design, Assessing flare loss in a multi units complex where metering individual headers is near impossible ;Flare gas recovery and Zero Flare release, Flare gas quality tracking and hydrogen management in refineries & petrochemicals. Case Studies – Industries experiences viz. Flare tips header maintenance, Trouble shooting, Smart debottlenecking of units to limit flare load within capacity, Safety & Environmental Incidents, etc

UNIT IV RISK MITIGATION MEASURES 9

HAZOP (Hazard and Operability Study), HAZID (Hazard identification), HAZAN (Hazard Analysis), EERA (Emergency escape route analysis), SIL (Safety Integrity levels) study, QRA (Quantitative Risk Assessment)and Dispersion studies ;Trip reset (Field and Control Room) and MSDS (Material Safety Data Sheet) for all streams being handled, Bow Tie Analysis, Risk Evaluation using 8 x 8 Matrix, FMEA (Failure Modes And Effects Analysis),Insurance premium assessment and measures to minimize ;Best practices – Updated documentation, SOPs (Standard Operating Procedures), SMPs (Standard Maintenance Procedures), PSM audits, Competency mapping and enhancement, employee loyalty programme, etc. Business risk – Risk in transportation of feed and products especially in sea routes (marine pollution); HSE norms non-compliance; Act of force majeure; etc. Case Studies – Industries experiences such as Trouble shooting, Efficiency / Effectiveness tracking, Debottlenecking, Design tips, Safety & Environmental Incidents, etc.

UNIT V PROCESS CONTROL & INSTRUMENTATION 9

Pneumatic (analogue controls) to DCS journey, Single loop Vs Multi loop controls, I/O cards, Graphic design & grouping to minimize user latency in process control ;Designed for safety through redundancy right from dedicated impulse lines to card level, PLC (Programmable Logic Controls), Cascaded Control, Process Historian, Online reporting by exception, Inferential predictions ;Use of AI / ML in controlling plant within best operating zone, QMIs (Quality Measuring Instruments), Alarm rationalization, Operator Fatigue ;Functional designs in delayed (by a few seconds) trip, Machine monitoring viz. signature analysis (vibration and axial displacement), surge control with differing mol wt of process gas, tribology analysis ;Emphasis on lab instrumentation to get “tell-tale” indications on existence of unsafe conditions, hand held instrumentations to work in confined space, communication system (field & control room, etc.) etc. CCTV at select places to monitor and alert well in advance. Centralized fire control panel for the whole premises by way of wired network of safety sensors. Case Studies – From Industries on operations & maintenance aspects viz. Trouble shooting, Efficiency / Effectiveness tracking, Debottlenecking, Design tips, Safety & Environmental Incidents, etc.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Determine the safety systems both to prevent incident & to minimize loss

CO2: Evaluate the safety in electrical systems

CO3: Apply knowledge on flare systems and their safety

CO4: Apply knowledge on risk analysis and mitigation

CO5: Evaluate on the control systems and their safety usage in different process industries

TEXT BOOKS

1. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl, J.F. Louvar, Prantice Hall, NJ, 1990, ISBN 0134857844, 9780134857848
2. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965, ISBN 0470256788, 9780470256787
3. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987, ISBN 0-85312969X

REFERENCES

1. Handley, W., "Industrial Safety Hand Book ", 2nd Edn., McGraw-Hill Book Company, 1969.
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., "Industrial Accident Prevention", McGraw-Hill Book Co., 1980.
3. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994
4. Dan Petersen, "Techniques of Safety Management", McGraw-Hill Company, Tokyo, 1981
5. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004, ISBN9781315220376

COURSE ARTICULATION MATRIX:

CO	Program Outcomes														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	3	3	2	1	1	1	1	2	1	1	2	2	2
CO2	2	2	3	3	2	1	1	1	1	2	2	2	2	2	2
CO3	2	2	3	3	3	1	1	1	1	2	1	1	2	2	2
CO4	2	2	3	3	3	1	1	1	1	1	2	2	2	2	2
CO5	2	2	3	2	2	1	1	1	1	2	1	2	2	2	2
Over all	2	2	3	3	2	1	1	1	1	2	1	2	2	2	2

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

CH23009 **MATERIALS OF CONSTRUCTION** **L T P C**
3 0 0 3

COURSE OBJECTIVES

1. To make the students understand materials selection, based on their properties and processing.
2. To enable the students, select the suitable materials based on their mechanical behavior.
3. To familiarize the students with the phase diagrams and phase transformation of materials.
4. To equip students with the knowledge on types and manufacturing of metals.
5. To develop students' skill in selection of materials required for processing in chemical industries.

UNIT I INTRODUCTION **9**

Structure – Property relationship - Selection criteria and processes: General criteria of selection of materials in process industries. Properties: Mechanical, Thermal, Physical, Chemical, Electrical, Magnetic and Technological properties. Processing of Metals and Alloys- Casting, Hot and cold rolling, Forging, Extrusion, Deep drawing.

UNIT II MECHANICAL BEHAVIOUR **9**

Elastic, Anelastic and Viscoelastic Behaviour – Introduction to Slip, Slip planes, Plastic Deformation by Slip: Critical resolved shear stress, Mechanism of Creep, Creep Resistant Materials – Fracture: Ductile and Brittle, Fatigue fracture, Griffith's theory, S-N curves, Fracture toughness.

UNIT III PHASE DIAGRAMS AND PHASE TRANSFORMATIONS **9**

Gibb's Phase rule : Unary and Binary phase diagrams , Al CO - Cr O , Pb-Sn, Ag-Pt and Iron- Iron Carbide Phase Diagram – Lever rule – Invariant reactions- TTT diagrams – Micro structural changes – Nucleation and growth – Martensitic transformations – Solidification and Crystallization – Glass transition – Recrystallization and Grain growth.

UNIT IV FERROUS, NON-FERROUS METALS AND COMPOSITES **9**

Pig iron, Cast iron, Mild Steel-Manufacturing process, properties &, Applications Stainless steels, Special Alloy steels-properties and uses; Heat treatment of plain-carbon steels. Manufacturing methods of Lead, Tin and Magnesium. Properties and applications in process industries. FRP-Fiber Reinforced Plastics (FRP), manufacturing methods; Asphalt and Asphalt mixtures; Wood.

UNIT V NANOMATERIALS **9**

Introduction to Nanotechnology- Zero Dimensional Nano Structures – Nano particles – One Dimensional Nano Structures- Nano wires and Nano rods – Two Dimensional Nano Structures, Films – Special Nano Materials - Nano Structures fabricated by Physical Techniques – Characterisation and Properties of Nano Materials – Applications of Nano Structures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Consider the basic material knowledge such as internal structure, properties and processing of metals.

CO2: Appreciate the mechanical behavior of the metals.

CO3: Demonstrate phase diagrams and phase transformations of metals.

CO4: Familiarize the manufacturing process of ferrous, non-ferrous metals and composites and nanomaterials.

CO5: Apply knowledge of various materials properties and processing methods in chemical industry.

TEXT BOOKS

1. William D. Callister, “Materials Science and Engineering”,7th edn, John Wiley & Sons, Inc. 0470054883
2. V. Raghavan, Materials Science and Engineering, Prentice Hall 2015 **ISBN-10 :** 9788120350922
3. Brenner D, “Hand book of Nanoscience and technology” (2002) CRC Press, 0849312000

REFERENCES

1. Henry R Clauster, “Industrial and Engineering Materials” McGraw Hill Book Co. (1975)
2. Kingery W D and Bowen H K and Unimann D R, “Introduction to Ceramics” John Wiley and Sons, Second edition (1991)
3. Fahrner W R, “Nanotechnology and Nanoeletronics” Springer International edition(2005)
4. Budinsky K G and Budinsky K M “ Engineering Materials- Properties and Selection” Prentice Hall of India (2002)

S. K. Hajra Choudhury, "Material Science and processes", 1stEdn. , 1977. Indian Book Distribution Co., Calcutta.

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO2	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO4	3	3	3	3	2	3	2	2	2	2	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	3	2	2	3	3	3	3
Avg	3	3	3	3	2.8	2.8	2	2	2.2	2	2.2	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23010 STATUTORY REQUIREMENTS AND CUSTOMER CARE LT P C
3 0 0 3

COURSE OBJECTIVE

1. To understand the purpose of competitive edge within the regulatory systems set.
2. To learn about the importance of environmental regulations
3. To understand the concepts of Net Zero Concept
4. To leverage learning to become SMART manufacturer
5. To learn about the importance and norms of responsive care.

UNIT I PEOPLE AND PROCESS SAFETY 9

Factory Act, IBR (Indian Boiler Regulations), Weights & Measures, Power Connection from State Electricity Board, Labour Legislation, Compensation, Fines, Litigations, Image, etc. and other commercial approvals like company registration, GST Registration, IT act, Excise Regulations etc. For operations under EOU (Export oriented units) or SEZ (Special Economic Zones), take additional approval from Export Processing Zone (EPZ) and SEBI. Case Studies – Assess the number of days taken for all such approval and apply LEAN to crunch time.

UNIT II ENVIRONMENTAL REGULATIONS 9

Water act, Air act, for highly polluting industry category EIA (Environment Impact Assessment) is mandatory, Environmental Protection Act, Licence needed for 'Drugs & Pharmaceuticals' from State Drug Controller, Hazardous substance management, Waste Management rules, Pollution Control Boards / Consent to operate (State and Union Government) specially for Industries Requiring Water and Affecting Effluent Disposal. Case Studies – Assess the number of days taken for all such approval and apply LEAN to crunch time. Additionally, benchmark on HSE norms to compare with peer industries for improvement options.

UNIT III CUSTOMER CARE 9

Customer definition, Kano Model, CRM, PFABFS model (Property, Feature, Advantage, Benefit and Savings both monetary and emotional value); Product Supply Specification based on end use applications with competitive edge over peer industries; Quality Cost, Custody transfer precision, Wing to Wing co-operation with customers / suppliers to enhance value chain returns; Development of new products and services – Ideation, proof of concept, pilot run & commercialization. Case Studies – Products & Services that made difference, Companies that disappeared when changes were not picked up in time, Point of Sale tips for lasting impression, Cycle time to launch new product.

UNIT IV INTERNSHIP PREPARATION AND DO'S & DON'TS 9

Safety Contact, Mandatory use of PPE, Assembly points, Alarm station, Mock drills, Firefighting apparatus use on demand, know the escape routes; Shadow the trainer, learning objective – pick any one viz. Catalysis – past say three to five catalyst change, the conversion variation, generation of low value side reactions, sintering & loss of margin, H2 loss, any tell-tale indications from apple core tests of spent catalyst, Deep dive into design of say, heat exchangers network with a view to achieve O&M

excellence, Asset reliability – O&M efforts to continuously track PSM critical equipment, Energy benchmarking, Overall processing margins against best in class peer industries, Inventory management and assessment of revenue by blocked investment, Water management, etc. Case studies – In nearby cluster of industries at Tamil Nadu, assess O&M gaps and work to bridge the gap, learn about competencies gaps, past LFIs with RCA initiated, etc

UNIT V SUSTAINABILITY REPORTING 9

Understanding aspects like 'Net Zero Concept', Green House Gases release reduction, ZLD (zero Liquid discharge), Benefits to the society, Concepts of linear economy and circular economy, Life Cycle Analysis, Think Global and Act Local, learn on 17 Sustainable Development Goals as per UN charter, Use Global Reporting Initiative (GRI) formats for Sustainability reporting, Project assignment – Work on Sustainability reporting for nearby cluster of industries in Tamil Nadu

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Apply the basis on different acts and their regulations
CO2: Demonstrate knowledge in different ACT on water, air and environmental protection
CO3: Evaluate knowledge on the preparation of Kano model, CRM, PFABFS
CO4: discuss on Do's and Don'ts in an internship program
CO5: Apply the concepts of ZLD, GHG release and circular economy

TEXT BOOKS

1. Todd Zenger, Beyond Competitive Advantage**:** How to Solve the Puzzle of Sustaining Growth While Creating Value., 2016. ISBN:9781633690011
2. Michael E. Porter., Competitive Advantage: Creating and Sustaining Superior performance
3. A handbook on special Economic zones, ISBN: 81-87080-84-1

REFERENCES

1. Paul B. Thompson, Patricia E. Norris., Sustainability What Everyone Needs to Know
2. DOs and DON'Ts to Make the Most of Your Internship (twc.edu)
3. Turaga, Rama Mohana & Sugathan, Anish. (2020). Environmental Regulations in India. 10.1093/acrefore/9780199389414.013.417.
4. How to use FAB selling. (Features, Advantages and Benefits). – Scotty Schindler – Street Smart Entrepreneur.
5. National Environment Policy, 2006 – Environmental law and policies (inflibnet.ac.in)

Course Articulation Matrix

course outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	-	-	-	2	1	1	1	2	2	2	2	2	2
CO2	2	-	-	-	2	1	1	1	1	2	2	2	2	2	2
CO3	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2
CO4	2	-	-	-	2	1	1	1	2	2	1	2	2	2	2
CO5	2	-	1	2	2	1	1	1	1	2	1	2	2	2	2
Overall	2	2	1.5	2	2	1.2	1	1	1.4	2	1.6	2	2	2	2

CH23011 **PROCESS PLANT UTILITIES** **LT P C**
3 0 0 3

COURSE OBJECTIVES:

1. Provide a comprehensive understanding of industrial water requirements and treatment methods to ensure the efficient use and management of water in industrial processes.
2. Equip students with knowledge about steam generation, types of steam generators, and techniques to address common issues such as scaling and corrosion in boilers.
3. Introduce the principles of refrigeration and ventilation systems, including different refrigeration cycles and the production of cryogenic temperatures, to enhance the understanding of temperature control in industrial applications.
4. Familiarize students with the performance characteristics and applications of compressors and vacuum pumps, as well as the associated piping systems, lubrication, and moisture removal techniques.
5. Highlight the importance of insulation in various industrial processes, covering insulation materials and techniques for different temperature ranges to optimize energy efficiency and process effectiveness.

UNIT I INDUSTRIAL WATER **9**

Hard and Soft water, Requisites of Industrial Water and its uses. Methods of Water Treatment such as Chemical Softening and Demineralization, Resins used for Water Softening, Reverse Osmosis, Effects of impure Boiler Feed Water.

UNIT II STEAM GENERATION **9**

Properties of Steam, Types of Steam Generator such as Solid Fuel Fired Boiler, Waste Gas Fired Boiler and Fluidized Bed Boiler. Scaling and Corrosion in boiler and Trouble Shooting. Steam Traps and Accessories

UNIT III REFRIGERATION AND VENTILATION **9**

Principles of refrigeration, refrigeration systems like vapor compression and vapor absorption cycles, types of Refrigeration Cycles and their importance. Production of cryogenic temperature. Exhaust

UNIT IV COMPRESSORS AND VACUUM PUMPS **9**

Compressors and Vacuum pumps- Performance characteristics of Compressor and Vacuum pumps. Piping systems. Air leaks. Lubrication. Oil and moisture removal.

UNIT V INSULATION **9**

Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and subzero temperatures, including cryogenic insulation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO 1:determine the importance of process utility and recognize importance of treatment and conservation of water.

CO 2: Outline the basic properties of steam along with their generation and utilization of steam in process plants.
CO 3: Identify the role of refrigerant for different refrigeration systems and their importations, ventilation systems.
CO 4: Explain the various types of compressors and vacuum pumps, piping systems used in industries.
CO 5: Examine the suitable insulation for different materials piping, fittings and valves.

TEXT BOOKS

1. Ballaney, P.L., Thermal Engineering, Khanna Publisher New Delhi, 1981 ISBN-10 : 8174090312
2. Goodall,P.M., " The efficient use of steam", IPC Science and Technology(1980) ISBN 0861030184, 9780861030187
3. P. N. Ananthanarayan, “Basic Refrigeration & Air conditioning”, Tata McGraw Hill, New Delhi, 2007. ISBN 1259062708

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1. Perry, R.H., and Green, D.W,: Perry's Chemical Engineers Handbook, Eighth Edition, McGraw Hill (ISE), 2008.
2. W.L McCabe J.C.Smith, and Harriot. P.: Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill, Publication,2008.
3. Ludwig, E.E.: Applied Process Design for Chemical and Petrochemical Plants, Gulf Publishing Company, Texas, Vol.1, 4th Edition 2007, Vol.2, 4th Edition 2010, Vol.3, 3rd Edition 2011.
4. Ashutosh Pande, "Plant Utilities", Vipul Prakashan, Mumbai.1999.
5. Nordell,Eskel, "Water treatment for industrial and other uses", Reinhold publishing corporation, Newyork.(1961)

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	1	1	-	1	3	3	2	-	-	3	2	3	2	1
CO2	3	3	1	1	2	-	1	1	-	-	2	2	3	1	1
CO3	3	2	1	1	2	-	1	-	-	-	1	2	3	3	1
CO4	3	2	1	1	2	-	-	-	-	-	1	2	3	3	1
CO5	3	2	1	1	2	-	-	-	-	-	1	1	3	3	1
Over all	3	2	1	1	2	1	2	1	-	-	2	3	3	3	1

Course Articulation Matrix:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23012 **BIOCHEMISTRY** **LT P C**
3 0 0 3

COURSE OBJECTIVES

1. To enable students, learn the fundamentals of biomolecules
2. To learn the molecular architecture of eukaryotic cells and organelles, including membrane structure and dynamics;
3. To understand the principles of bioenergetics and enzyme catalysis;
4. to acquire knowledge and understanding of current concepts in the course
5. To develop critical thinking skills on metabolic pathways and their key steps.

UNIT I INTRODUCTION TO BIOMOLECULES - CARBOHYDRATES 9

Basic principles of organic chemistry, role of carbon, types of functional groups, chemical, nature of water, pH and biological buffers, bio molecules structure and properties of Carbohydrates (mono, di, oligo & polysaccharides) Proteoglycans, glucosaminoglycans. mutarotation, glycosidic bond, reactions of monosaccharides, reducing sugars. Starch, glycogen, cellulose and chitin. Proteoglycans, glycosaminoglycans. hyaluronic acid, chondroitin sulfate

UNIT II STRUCTURE AND PROPERTIES OF OTHER BIOMOLECULES 9

Lipids: fatty acids, glycerol, saponification, iodination, hydrogenation, phospholipids, glycolipids, sphingolipids, cholesterol, steroids, prostaglandins.Protein: Amino Acids, Peptides, Proteins, measurement, structures, hierarchy of organization primary, secondary, tertiary and quaternary structures, glycoproteins, lipoproteins. Determine of primary structure.Nucleic acids: purines, pyrimidines, nucleoside, nucleotide, RNA, DNA-Watson-Crick structure of DNA, reactions, properties, measurement, nucleoprotein complexes.

UNIT III METABOLISM CONCEPTS AND CARBOHYDRATE METABOLISM 9

Functions of Proteins, Enzymes, introduction to biocatalysts, metabolic pathways, primary and secondary metabolites. Interconnection of pathways and metabolic regulation. Glycolysis, TCA cycle, gluconeogenesis, pentose phosphate shunt &glyoxalate shunt.

UNIT IV INTERMEDIARY METABOLISM AND REGULATION 9

Fatty acid synthesis and oxidation, reactions of amino acids, deamination, transamination and decarboxylation, urea cycle, Bioenergetics - High energy compounds, electronegative potential of compounds, respiratory chain, ATP cycle, calculation of ATP yield during oxidation of glucose and fatty acids.

UNIT V PROTEIN TRANSPORT AND DEGRADATION 9

Protein targeting, signal sequence, secretion; Folding, Chaperone and targeting of organelle proteins, Protein degradation, receptor-mediated endocytosis, turnover.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Sketch the structure of biomolecules

CO2: Analyse biomolecules based on its properties.

CO3: Distinguish metabolism for carbohydrates and lipids

CO4: Formulate the bioenergetics for compounds

CO5: Assess intermediary metabolism and their pathways

TEXT BOOKS

1. Lehninger Principles of Biochemistry 6th Edition by David L. Nelson, Michael M. Cox W.H. Freeman and Company 2017 : ISBN-13: 978-1-4641-0962-1
2. Satyanarayana, U. and U. Chakerapani, "Biochemistry" 3rd Rev. Edition, Books & Allied Ltd., 2006. ISBN : 9788131264973
3. Rastogi, S.C. "Biochemistry" 2nd Edition, Tata McGraw-Hill, 2003. ISBN-10 : 0070681759
4. 4· Conn, E.E., et al., "Outlines of Biochemistry" 5th Edition, John Wiley & Sons, 1987. ISBN-10 : 8126509309.

REFERENCES

1. Berg, Jeremy M. et al. "Biochemsitry", 6th Edition, W.H. Freeman & Co., 2006. ISBN-10 : 0716787245
2. Murray, R.K., et al "Harper's Illustrated Biochemistry", 31st Edition, McGraw-Hill, 2018. ISBN-101259837939:
3. Voet, D. and Voet, J.G., "Biochemistry", 4th Edition, John Wiley & Sons Inc.,2010. ISBN: 978-0-470-57095-1
4. https://www.youtube.com/watch?v=JxK5rZxbyQY- Biochemistry of Carbohydrates
5. https://www.youtube.com/watch?v=hok2hyED9go- Protein Structure and Folding
6. http://rguir.inflibnet.ac.in/bitstream/123456789/16743/1/9781984665836.pdf

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	Sketch the structure of biomolecules	2	-	-	-	-	1	2	1	2	2	1	1	2	2	2
CO2	Analyse biomolecules based on its properties	2	-	-	-	-	1	2	1	2	2	1	1	2	2	2
CO3	metabolism for carbohydrates and lipids	2	-	-	1	1	1	2	1	2	2	1	1	2	2	2
CO4	Formulate the bioenergetics for compounds	2	-	-	1	1	1	2	1	2	2	1	1	2	2	2
CO5	Assess intermediary metabolism and their pathways	2	1	1	1	2	1	2	1	2	2	2	2	2	2	2
Overall CO		**2**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**1**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23013 **BIO PROCESS TECHNOLOGY** **LT P C**
3 0 0 3

COURSE OBJECTIVES

1. To understand the fundamentals of bioprocesses
2. To study the stoichiometry and energetics of cell growth and product formation
3. To evaluate the kinetics and mechanism of microbial growth
4. To evaluate the kinetics and thermodynamics of enzymatic process
5. To learn the ethics and safety norms of bioprocesses

UNIT I INTRODUCTION TO BIOPROCESS **9**

Biologists and Engineers, comparison of chemical and biochemical processing overview of biological basics, About cells and its growth, the stoichiometry of microbial growth and product Bioprocesses: Regulatory Constraints

UNIT II MEDIA FORMULATION AND DEVELOPMENT **9**

Media formulation, Media Sterilization: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization. Air Sterilization: Methods of air sterilization, mechanism of air sterilization, solid and liquid handling. Industrially fermented broth

UNIT III UNDERSTANDING BIOREACTORS **9**

Purpose and importance of bioreactors, Classification of bioreactors, bioreactors for animal cells, bioreactors for plant cells, bioreactors for immobilized cells, operations of bioreactors, stirred tank reactor, plug flow reactor (PFR), fluidized bed reactor, bubble column, airlift reactor, Agitation, and Aeration: Mechanical agitation, power consumption in agitation, bubble aeration, bioreactors for waste management

UNIT IV TRANSPORT PROCESSES **9**

Diffusivity and mechanism of mass transfer - derivation of the equations of mass transport by diffusion-stationary and unsteady mass transport by diffusion, mass transfer coefficient, macroscopic balances for mass transport. Mechanisms and applications of heat transfer-mode of heat transfer-conduction, convection and radiation, Application of Heat and Mass transfer in biochemical processes.

UNIT V BIOETHICS AND BIOSAFETY **9**

Introduction to Bioethics. Social and ethical issues, the process of biotechnology involved in generating new forms of life for informed decision making, Definition of Biosafety. Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release into the environment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: understand the fundamentals of bioprocesses

CO2: Formulate and demonstrate various operating units in bioprocess.

CO3: Design a bioreactor with process mechanisms and waste management

CO4: Analyse transportation processes in reactors and their behaviours

CO5: Judge on biosafety and bioethics.

TEXT BOOKS

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986. ISBN-10 : 9780070701236
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996. ISBN 10: 0824700996
3. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995 ISBN-10 : 0122208560

REFERENCES

1. Transport Phenomena, by Bird R.B., Steward W.E., and Lightfoot E.N., John Wiley & sons, Inc., New York, 2002
2. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition, New Jersey, PHI Publishers, 2010
3. Voet, D. and Voet, J.G., “Biochemistry”, 4th Edition, John Wiley & Sons Inc.,2010.
4. https://bioprocessing.weebly.com/bioprocess-technology.html
5. https://nptel.ac.in/courses/102106083- Transport Phenomena in Biological Systems

Course Articulation Matrix:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	understand the fundamentals of bioprocesses	2	1	1	2	1	1	2	2	1	1	1	2	2	2	2
CO2	Formulate and demonstrate various operating units in bioprocess	2	2	2	2	1	1	2	2	2	1	1	2	2	2	2
CO3	Design a bioreactor with process mechanisms and waste management	2	3	3	2	2	1	2	2	2	1	1	2	2	2	2
CO4	Analyse transportation processes in reactors and their behaviours	2	3	3	2	2	1	2	2	2	1	2	2	2	2	2
CO5	Judge on biosafety and bioethics	2	1	1	2	2	1	2	3	3	2	2	2	2	2	2
Overall CO		2	2	2	2	2	1	2	2	2	2	2	2	2	2	2

CH23014	FERMENTATION AND BIO PROCESSING	L T P C 3 0 0 3

COURSE OBJECTIVE

1. To recognize the fundamentals of fermentation technology
2. To distinguish bioreactor operations
3. To understand fermentation and its kinetics
4. To understand instrumentation and process control in fermenters.
5. To design fermenter with auxiliaries

UNIT I FERMENTATION PROCESSES 9

Importance of fermentation, Fermentation and redox potential, solid-liquid fermentation, solid state fermentation, Kinetics of fermentations, Biosensors for fermentations, Production processes in fermentation

UNIT II MICROBIAL GROWTH KINETICS 9

Diversity of patterns of microbial growth in situ and ex situ, Microbial growth under homogeneous conditions, Heterogeneous microbial growth, Growth kinetics, Derivation of mathematical models, and identification

UNIT III DESIGN OF FERMENTERS 9

fermentation processes, Fermentation processes and microorganisms, Kinetics and stoichiometry, Mass balances and design for batch, continuous and fed-batch reactors, Comparison of batch, continuous and fed-batch reactors, Heat generation and heat balances, examples of industrial fermentation processes

UNIT IV INSTRUMENTATION AND CONTROL 9

Common Instruments for Process Automation – Temperature, Gas Flowrate, Liquid Flowrate, Off-Gas Analysis, pH, Dissolved Oxygen, Pressure, Foam Level, Stirring , Redox Potential, Advanced Instrumentation for Bioprocess Control and Automation - Flow Injection Analysis, Sequential Injection Analysis Fluorescence, Mass Spectrometry, Near Infrared Spectroscopy, Soft sensors, Biomass, Bioreactor automation

UNIT V FERMENTATION AND COMMODITY PRODUCTS 9

Engineering of Secretory Pathways, production of heterologous proteins, fungal, yeast fermentation of industrial products.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Analyse different modes of fermentation and identify its limitations.

CO2: Characterise the kinetics of cell growth and apply to different cell systems

CO3: Set and control fermenter for producing maximal products under optimal conditions

CO4: Gather knowledge on the operation of control systems in fermentation and bioprocess industry

CO5: Acquire knowledge on the commodity, fermentation production and their production pathways

TEXT BOOKS

1. Aydin Berenjian Essentials in Fermentation Technology, Springer ,2019. 978-3-030-16229-0
2. Peter F. Stanbury, Allan Whitaker and Stephen J. Hall , Principles of Fermentation Technology (Second Edition), , Pergamon, 1995 ISBN-10 : 0080999530
3. Michael L. Shuler, Bioprocess Engineering: Basic Concepts, Pearson Education India; 2nd edition (1 January 2015), ISBN-10 : 9332549370

REFERENCES

1. Fermentation and Biochemical Engineering Handbook; Editors-in-Chief: Henry C. Vogel and Celeste M. Todaro, Third Edition, Elsevier, 2014.
2. Fermentation Biotechnology: Principles, Processes, and Products (Prentice Hall advanced references series), Owen P. Ward, Prentice Hall, 1989
3. Computer Applications in Fermentation Technology: Modelling and Control of Biotechnological Processes, N. M. Fish, Springer, 2011.
4. https://onlinecourses.nptel.ac.in/noc22_bt19- Bioreactor design and analysis
5. https://unacademy.com/content/study-material/fermentation-technology/instrumentation-of-bioreactors-and-on-line-and-off-line-controls

COURSE ARTICULATION MATRIX:

CO	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	2	2	2	2	1	1	2	1	-	-
CO2	1	2	1	2	2	2	2	2	2	1	1	2	1	2	1
CO3	1	2	3	3	3	2	2	2	2	1	2	2	1	2	1
CO4	1	2	3	3	3	2	2	2	2	2	2	2	1	2	1
CO5	1	2	2	2	3	2	2	2	2	2	2	2	1	2	1
Overall CO	1	2	2	2	2	2	2	2	2	1	2	2	1	2	1

CH23015 BIO SEPERATION AND DOWNSTREAM PROCESSING L T P C
3 0 0 3

COURSE OBJECTIVE

1. To learn the fundamentals of bio separations
2. Develop an understanding of a broad range of bio separation methods.
3. Gain advanced knowledge of the basic principles of bio separation processes
4. Design and scale up of operations involved in bio separation
5. Demonstrate an ability to utilize a process flow diagram

UNIT I BASICS OF BIOSEPARATION 9

Introduction to By-products and Bioseparation: Range and characteristics of bio products, Characteristics of Fermentation Broth, Selection of unit operation with due consideration of the physical, chemical and biochemical aspects of biomolecules. Stages of Downstream Processing.

UNIT II CENTRIFUGATION AND FILTRATION 9

Primary Separation: Removal of insoluble and Biomass (and particulate debris) separation techniques, Flocculation and sedimentation, Centrifugation-Ultracentrifugation, Gradient centrifugation, Filtration: Theory of Filtration, Pre-treatment of Fermentation Broth, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes.

UNIT III ABSORPTION 9

Gas Absorption: Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor, stripping factor, minimum gas liquid ratio, Single stage gas absorption Cross Current, Co- current, Countercurrent, Multistage Counter current Operation, Absorption with Chemical Reactions, Related problems.

UNIT IV EXTRACTION 9

Liquid-Liquid Separation Process: Single Stage Operation, Equipments for liquid-liquid extraction. Types of extraction processes: Reactive extraction, Aqueous two-phase systems, Reverse micellar extraction, solid-liquid extraction, Supercritical fluid Extraction. Different types of extractors and designing of extractors. Distillation: Simple, Steam and Equilibrium distillation, Fractionation, Mccabe Thiele method, azotropes.

UNIT V CHROMATOGRAPHY AND MEMBRANE SEPARATION 9

Theory of chromatography, Shape and yield of a chromatographic peak, Binary chromatography, Hydrodynamic chromatography. Membrane-based bioseparation - Classification of membrane processes, Ultrafiltration, Microfiltration, Dialysis, Liquid membrane processes, Membrane chromatography, Electrophoresis, Affinity ultrafiltration, Field-flow fractionation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Identify bio separation processes

CO2: Acquire knowledge on theory, design, and application of centrifugation and filtration

CO3: To analyse absorption and their difficulties in bioprocessing

CO4: Gather knowledge on extraction of bio products

CO5: Assess on bio separation techniques

TEXT BOOKS

1.Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980. ISBN-10 : 1259029158

2.Roger G. Harrison, Paul Todd, ScottR. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press ISBN: 9780195391817

3.B.Shivshankar, Bioseparations: Principles and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012 ISBN: 978-8120326491

4. Bioseparation& bioprocessing (2nd Ed) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, (09-2007) ISBN-10 : 3527315853

REFERENCES

1. P.A. Belter, E.L. Cussler and Wei-ShouHu.,Bioseparations-Downstream Processing for Biotechnology, Wiley Interscience Publication, 1988.
2. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982. Scopes Ak, Protein Purification, IRL Press, 1993
3. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
   Separation and purification techniques in biotechnology, FredreichDechow, 1989
4. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag
5. https://www.aiche.org/sites/default/files/cep/20141036a.pdf

Course Outcomes	Statements	Program Outcome														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Identify bio separation processes	2	1	1	1	1	1	2	2	2	2	2	2	2	1	2
CO2	Acquire knowledge on theory, design, and application of centrifugation and filtration	2	2	2	2	3	1	2	2	2	2	2	2	2	2	2
CO3	To analyse absorption and their difficulties in bioprocessing	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2
CO4	Gather knowledge on extraction of bio products	2	2	2	2	3	2	2	2	2	1	2	2	2	2	2
CO5	Assess on bio separation techniques	2	3	2	3	3	2	2	2	2	1	2	2	2	2	2
Overall CO		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

CH23016 ENZYME IMMOBILISATION TECHNOLOGY LT P C
3 0 0 3

COURSE OBJECTIVES

1. To understand Enzymes, homogeneity, and heterogeneity
2. To know the catalytic activity of enzyme and its regulation
3. To acquire knowledge on enzyme immobilization methods enzymes kinetics
4. To study mass transfer in enzyme and immobilized enzyme reactors
5. To design immobilized enzyme reactors.

UNIT I INTRODUCTION 9

Catalysis and biocatalysis, Enzyme classification and nomenclature, enzyme structure, functionality and relationship, enzyme activity, enzyme sources, synthesis, recovery and purification, enzymes as process catalysts.

UNIT II HOMOGENEOUS ENZYME KINETICS 9

Hypothesis of enzyme kinetics, rapid equilibrium and steady-state hypothesis, determination of kinetic parameters, various types of kinetic inhibition, reactions with more than one substrate, effect of environmental variables- pH, temperature, and ionic strength.

UNIT III BASICS OF IMMOBILISATION 9

Immobilisation – Functional properties, Classification of Immobilisation techniques – Adsorption, matrix entrapment, crosslinking, covalent binding- advantages & disadvantages of each method, selection and characterisation of matrices for immobilisation, effect of physico chemical parameters on immobilised enzymes.

UNIT IV HETEROGENEOUS ENZYME KINETICS 9

Mass transfer effects in heterogeneous biocatalysis, partition effects, Immobilised enzyme kinetics, external (film) diffusion, internal (pore) diffusional kinetics, Thiele modulus and Effectiveness factor. Effects of electrostatic potential of the micro environment.

UNIT V ENZYME REACTORS & APPLICATION OF IMMOBILISED ENZYMES 9

Design of reactors with immobilised enzymes, Design of advanced immobilized enzyme systems, Application of immobilised enzymes in food industry, textile industry, Pharmaceutical industry & in medicine, in the production of biofuels, detergent industry, production of various bio-products, as biosensors.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the basic knowledge on classification of enzymes and their nomenclature

CO2: Understand Enzymes, homogeneity, and heterogenicity

CO3: Understand structural, functional properties, and metabolic pathways of enzymes

CO4: Learn immobilization procedures, and their different types

CO5: Knowledge on designing enzyme reactors

TEXT BOOKS

1. “Enzyme Technology” by M.F.Chaplin and C.Bucke, Cambridge University press, 1990. ISBN 0521344298
   (Website for the book, www:lsbu.ac.uk/biology/enztech/)
2. “Biocatalysts and Enzyme Technology” by K. Buchholz,V. Kasche and U.T. Bornscheur, Wiley,2005 ISBN: 978-3-527-32989-2
3. Prasad N.K, Enzyme Technology: Pacemaker Of Biotechnology, Prentice Hall India Learning Private Limited (1 January 2011) ISBN-10 : 8120342399

REFERENCES

1.“Enzyme Technology”, by Shanmugam,S. and Satish Kumar,T.,IK International Pvt. Ltd, New Delhi, 2008.
2. Enzyme Biocatalysis: Principles and Applications’ by A.Illanes, Springer,2008
3. Murray Moo-Young , Bioreactor Immobilized Enzymes and Cells: Fundamentals and Applications, Springer, 1988
4. https://www.pace.edu.in/img/course/enzy_MODULE_3.pdf

COURSE ARTICULATION MATRIX:

Course Outcomes	Statements	Program Outcome														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand The basic knowledge on classification of enzymes and their nomenclature	2	-	-	1	-	1	1	2	1	1	-	1	2	1	1
CO2	understand Enzymes, homogeneity, and heterogenicity	2	-	1	1	1	1	1	2	1	1	-	1	2	1	1
CO3	understand structural, functional properties, and metabolic pathways of enzymes	2	-	1	1	1	1	1	2	1	1	-	1	2	1	1
CO4	learn immobilization procedures, and their different types.	2	2	2	1	2	1	1	2	1	1	-	1	2	1	1
CO5	knowledge on designing enzyme reactors.	2	2	3	2	2	2	1	2	2	1	2	1	2	1	1
Overall CO		2	1	2	1	1	1	1	2	1	1	1	1	2	1	1

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

CH23017	BIO REACTOR DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE

1. To understand the fundamentals of bioreactor design
2. To design single and multiple bioreactors
3. Interpretation of different types of reactors and their non-ideal behaviour.
4. To illustrate control and instrumentation of various process parameters.
5. To design a bioprocess system.

UNIT I BIOREACTOR DESIGN & MEDIA REQUIREMENTS 9

Microbial growth and product formation kinetics, Bioreactor Selection, Reactor operational mode and selection.

UNIT II DESIGN EQUATIONS FOR BIOREACTORS 9

Basic Design Equations/ Mole Balances: Batch, Fed-Batch and Repetitive Batch Reactors, Continuous: Stirred tank and tubular flow reactors, Microbial death kinetics, Design criterion for sterilization, Batch and continuous sterilization of medium, Multiple reactions-series, parallel and mixed-mode, Air sterilization.

UNIT III BIOREACTOR REQUIREMENTS 9

Process-General requirements; Basic design and construction of bioreactors and their ancillaries; Material of construction, Vessel geometry, Bearing Assemblies, Motor drives, Aseptic seals; Flow measuring devices, Valves, Agitator and Sparger Design, Sensors, Non-isothermal homogeneous reactor systems. Adiabatic reactors, batch and continuous reactors, optimum temperature progression.

UNIT IV DESIGN OF BIOREACTORS 9

Process and mechanical design of Bioreactors, volume, sparger, agitator-type, size and motor power, heat transfer calculations for coil and jacket, sterilization system, scale-up, scale down, bioinstrumentation and control.

UNIT V NOVEL BIOREACTORS DESIGN 9

Design of Immobilized enzyme packed bed Reactor. Fluidized bed reactors, Slurry Reactors, Airlift Loop reactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes; SSF bioreactors. bioreactor design considerations for plant and animal cell cultures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Differentiate bioreactor design based on operational mode and type of substrate.

CO2: Select the bioreactor based on open or closed circuit operation

CO3: Structuring bioreactors with accessories for different type of operations.

CO4: Classify necessities for process and mechanical design of bioreactors.

CO5: Planning and designing new bioreactors for specific applications.

TEXT BOOKS

1. Binoy Ranjan Maiti ,Principles of Bioreactor Design, Viva Books Originals Publication 2018 ISBN: 9789387925076
2. Kalidas C ,Chemical Kinetic Methods: Principles of relaxation techniques New Age International 1996. ISBN-10 : 8122415679
3. Forment G F and Bischoff , Chemical Reactor Analysis and Design K B John Wiley 1990. ISBN: 978-0-470-56541-4

REFERENCES

1. Shijie Liu Bioprocess Engineering -Kinetics, Biosystems, sustainability and reactor Design, , Elsevier Publication 2013.
2. Binoy Ranjan Maiti, Principles of Bioreactor Design, VIVA BOOKS – ORIGINALS, 2018
3. Joaquim M.S. Cabral, Manuel Mota, Multiphase Bioreactor Design, CRC Press, 2001
4. https://onlinecourses.nptel.ac.in/noc22_bt19- Bioreactor Design and Analysis.
5. https://virtualbioreactor.wordpress.ncsu.edu/virtual-bio-reactor/

COURSE ARTICULATION MATRIX:

Course Outcomes	Statements	Program Outcomes														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Differentiate bioreactor design based on operational mode and type of substrate.	1	2	2	3	3	2	2	2	2	2	2	2	2	2	2
CO2	Select the bioreactor based on open or closed circuit operation	2	2	2	3	3	2	2	2	2	2	2	2	2	3	2
CO3	Structuring bioreactors with accessories for different type of operations.	2	2	2	3	3	2	2	2	2	2	2	2	2	3	2
CO4	Classify necessities for process and mechanical design of bioreactors.	2	2	3	3	3	2	2	2	3	2	2	2	2	3	2

CO5	Planning and designing new bioreactors for specific applications.	2	2	3	3	3	2	2	2	3	2	2	3	2	3	2
Overall CO		2	2	2	3	3	2	2	2	3	2	2	2	2	3	2

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

CH23018	BIOENERGY	LT P C 3 0 0 3

COURSE OBJECTIVES:

1. To know the classification, characterization, and sources of biomass
2. To understand the process in gasification of biomass
3. To learn the types of combustion of biomass.
4. able to learn the gasification types and applications
5. to understand the different combustion and cogeneration of biomass.

UNIT I INTRODUCTION TO BIOMASS CONCEPT 9

Biomass sources and classification; Biomass characteristics & preparation; Chemical composition and properties of biomass; Size reduction, Briquetting of loose biomass, Drying, Storage and handling of biomass.

UNIT II BIOGAS CONVERSION TECHNOLOGIES 9

Biogas technology: Feedstock for producing biogas; Microbial and biochemical aspects and operating parameters for biogas production, Kinetics and mechanism. Dry and wet fermentation, Digestors for rural application-High rate digesters for industrial waste water treatment.

UNIT III THERMOCHEMICAL CONVERSION METHODS 9

Pyrolysis and thermo-chemical conversion: Thermo-chemical conversion of lignocellulosic biomass. Incineration for safe disposal of hazardous waste, Biomass processing for liquid fuel production, Pyrolysis of biomass-pyrolysis regime, effect of particle size, temperature, and products obtained.

UNIT IV GASIFICATION OF BIOMASS 9

Gasification of biomass: Thermochemical principles: Effect of pressure, temperature and introducing steam and oxygen. Design and operation of Fixed and Fluidised Bed Gasifiers, Safety aspects.

UNIT V COMBUSTION TECHNIQUES 9

Combustion of biomass and cogeneration systems: Combustion of woody biomass-theory, calculations and design of equipment, Cogeneration in biomass processing industries. Case studies: Combustion of rice husk, Use of bagasse for cogeneration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Compare the fundamental knowledge on classification, characterization and sources of biomass

CO2: Apply the production of biogas

CO3: Apply knowledge on the operations of incineration, pyrolysis.

CO4: Evaluate the process in gasification of biomass

CO5: Compare knowledge on the types of combustion of biomass.

TEXT BOOKS

1. Anju Dahiya, Bioenergy: Biomass to biofuels First Edition, Academic Press, 2014.ISBN: 9780124079090
2. Li, Yebo, and Samir Kumar Khanal. Bioenergy: principles and applications. John Wiley & Sons, 2016. ISBN: 978-1-118-56831-6
3. M.S.Swaminathan, Bioenergy resources-planning production and utilization,Concept Publishing, 1995, ISBN 8170225493

REFERENCES

1. Vaughn C Nelson, Kenneth L. Starcher. Introduction to bioenergy. CRC Press, 2017.
2. Wall, Judy D., Caroline S. Harwood, and Arnold Demain. "Bioenergy." Bioenergy.. ASM Press, 2008.

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	2	1	2	1	2	1	2	2	1	1	1	1	2	1	2
CO2		-	2	1	2	1	2	2	1	1	1	2	2	2	2
CO3	2	1	2	1	2	1	2	2	2	1	1	2	2	1	2
CO4	2	1	2	1	2	1	2	2	1	1	1	2	2	2	2
CO5	2	2	2	2	2	1	2	2	1	1	1	2	2	1	2
Avg	2	1	2	1	2	1	2	2	1	1	1	1	2	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23019 **RENEWABLE ENERGY** **L T P C**
3 0 0 3

COURSE OBJECTIVES

1. Equip students with a comprehensive understanding of various renewable energy sources and their potential to address global energy demands.
2. Empower students to analyze and evaluate the scientific principles, applications, and environmental implications of renewable energy technologies.
3. Evaluate the potential for renewable energy resource assessment and integration into existing energy grids.
4. Analyse the social, economic, and environmental implications of large-scale renewable energy deployment.
5. Introduce students to the latest advancements and research trends in renewable energy technologies.

UNIT I INTRODUCTION TO ENERGY CONCEPT **9**

Introduction: Energy: Past, Today, and Future. A brief history of energy consumption. Energy & Environment. Renewable Energy – Quality, quantity, availability, advantageous and limitations.

UNIT II PHOTOVOLTAIC ENERGY **9**

Solar energy: Sun and its Energy: Basics of Solar Energy. Solar Energy in the Past. Solar Thermal Energy Solar Photovoltaic.

UNIT III BIO-GEOTHERMAL TECHNIQUES **9**

Bio energy &Geothermal energy: Conversion. Bio degradation. Biogas generation. Fuel properties. Biomass gasifier. Geothermal Resources, Geothermal Technologies.

UNIT IV WIND ENERGY **9**

Wind energy: Wind Resources. Wind Turbines. Environmental Impact. Data and energy estimation. Conversion. Wind mill Performance and applications.

UNIT V TIDAL, WAVES AND OCEAN ENERGY **9**

Tidal energy; Ocean Energy Potential against Wind and Solar. Wave Characteristics and Statistics. Wave Energy Devices. Tide Energy Technologies. Ocean Thermal Energy. Osmotic Power.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Demonstrate a comprehensive understanding of the major renewable energy sources (solar, wind, hydro, geothermal, biomass) and their potential to contribute to global energy security

CO2: Describe the technology behind solar energy conversion and analyze factors affecting the efficiency of photovoltaic systems.

CO3: Evaluate the potential of bio-energy and geothermal resources as sustainable energy sources.

CO4: Analyze the scientific principles of wind energy conversion and assess the suitability of wind power for different locations

CO5: Explore the potential of tidal, wave, and ocean energy sources. Explain the challenges and advancements in harnessing their power.

TEXT BOOKS

1. V. V. N. Kishore , Renewable Energy Engineering and Technology: Principles and Practice, The Energy and Resources Institute, TERI, 2010 ISBN 1138866989
2. Jenkins, Nicholas, and Janaka Ekanayake. Renewable energy engineering. Cambridge University Press, 2017. ISBN 1009295780
3. Vaughn Nelson, Introduction to Renewable Energy (Energy and the Environment), CRC Press, 2015, ISBN: 978-1498701938

REFERENCES

1. Martin A. Green, Solar Energy, (3rd Edition, 2018, ISBN: 978-0128071549)
2. Burton, Jenkins, et al. Wind Energy Handbook (2nd Edition, 2011, ISBN: 978-0857091547), Wiley
3. Tiwari, Gopal Nath, and Rajeev Kumar Mishra. Advanced renewable energy sources. Royal Society of Chemistry, 2012.
4. Clive Jones Jr. Biomass Energy: Theory and Practice (3rd Edition, 2017, ISBN: 978-1498707582)
5. Kothari, D. P., Ranjan, Rakesh, Singal, K. C., Renewable Energy Sources And Emerging Technologies, 3rd edition, PHI Learning,
6. Mehmet Kanoğlu, Yunus A. Çengel, John M. Cimbala, Fundamentals and Applications of Renewable Energy (1st Edition, 2020, ISBN: 978-1260455304)
7. Nptel course Renewable energy sources https://archive.nptel.ac.in/courses/103/103/103103206
8. NPTEL (Energy from Biomass and Wastes) https://archive.nptel.ac.in/courses/103/103/103103207

Course Articulation Matrix:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course	**Program Outcomes**														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO 3**
CO1	1	1	1	1	1	2	1	2	1	1	1	2	2	2	2
CO2	1	1	2	2	2	2	1	2	1	1	1	2	2	2	2
CO3	1	2	2	2	2	2	1	1	1	1	1	2	2	2	2
CO4	1	2	2	2	2	2	1	1	1	1	1	2	2	1	1
CO5	1	2	2	2	2	2	1	1	1	1	1	2	2	2	1
Overall CO	1	1	2	2	2	2	1	1	1	1	1	2	2	2	2

CH23020	ENERGY TECHNOLOGY	L T P C
		3 0 0 3

COURSE OBJECTIVES:

1. Provide an overview of global and Indian energy scenarios, including energy units and conversion factors.
2. To enable the students understand the principles, efficiency, and merits/demerits of conventional energy resources and power plants.
3. To impart knowledge to students on various non-conventional energy sources and their applications.
4. To enable the student to understand the origin, resources, and conversion methods of biomass energy.
5. To educate students on energy conservation techniques, management, and audit methodologies.

UNIT I ENERGY 9

Introduction to energy – Global energy scene – Indian energy scene - Units of energy, conversion factors, general classification of energy, energy crisis, energy alternatives.

UNIT II CONVENTIONAL ENERGY 9

Conventional energy resources, Thermal, hydel and nuclear reactors, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.

UNIT III NON CONVENTIONAL ENERGY 9

Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, energy plantations. Wind energy, types of windmills, types of wind rotors, Darrieus rotor and Gravian rotor, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.

UNIT IV BIOMASS ENERGY 9

Biomass origin - Resources – Biomass estimation. Thermochemical conversion – Biological conversion, Chemical conversion – Hydrolysis & hydrogenation, solvolysis, biocrude, biodiesel power generation gasifier, biogas, integrated gasification.

UNIT V ENERGY CONSERVATION 9

Energy conservation - Act; Energy management importance, duties and responsibilities; Energy audit – Types methodology, reports, instruments. Benchmalcing and energy performance, material and energy balance, thermal energy management.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
The students will be able to

CO1: Gain an understanding of global and Indian energy scenes, energy units, and the concept of energy alternatives.
CO2: Learn about the different types of conventional energy resources and power plants, along with their efficiencies and combustion processes.
CO3: Acquire knowledge of various non-conventional energy sources, including solar, wind, ocean, tidal, and geothermal energy.
CO4: Understand the origin and resources of biomass energy and the different methods of biomass energy conversion.
CO5: Develop skills in energy conservation, management, and auditing, including performance benchmarking and material/energy balance

TEXT BOOKS

1. Rao, S. and Parulekar, B.B., Energy Technology, Khanna Publishers, 2005 ISBN 8174090401
2. Rai, G.D., Non-conventional Energy Sources, Khanna Publishers, New Delhi, 1984.ISBN 8174090738, 9788174090737
3. Nagpal, G.R., Power Plant Engineering, Khanna Publishers, 2008. ISBN 8174091556

REFERENCES

1. Energy Management, Paul W.O'Callaghan McGraw – Hill, 1993Handley, W., "Industrial Safety Hand Book ", 2nd Edition. McGraw-Hill Book Company, 1969.
2. El. Wakil, Power Plant Technology, Tata McGraw Hill, New York, 2002.
3. Sukhatme. S.P., Solar Enery - Thermal Collection and Storage, Tata McGraw hill, New Delhi, 1981.
4. Handbook of Energy Audit by 7th edition Albert Thumann, P.E., C.E.M & William J Younger C.E.M, Faiment Press 2008
5. Nejat Vezirog, Alternate Energy Sources, IT, McGraw Hill, New York.

Course	**Program Outcomes**														
Out comes	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1	1	1	1	2	1	1	1	1	1	2	2	1
CO2	3	2	3	2	2	2	2	1	2	2	2	1	3	2	1
CO3	3	2	3	1	2	2	2	1	2	1	1	1	3	2	1
CO4	3	2	3	2	2	1	2	1	1	1	1	1	3	2	1
CO5	3	2	3	2	3	2	2	1	1	1	2	2	3	2	1
Overall	2.8	1.8	2.6	1.6	2	1.6	2	1	1.4	1.2	1.4	1.2	2.8	2	1

CH23021 ELECTROCHEMICAL ENGINEERING L T P C
3 0 0 3

COURSE OBJECTIVES

1. To understand the basic concept of electrochemistry and electrochemical engineering concepts.
2. To design different type of electro chemical reactor for the conversion
3. To know the properties and application energy storage materials
4. To analyze the electrochemical electrode potential and energy storage capacitance of the material
5. To understand the principles of battery and fuel cell.

UNIT I INTRODUCTION TO BASIC PRINCIPLES 9

Introduction and Basic Principles, Electrochemical Cells, Characteristics of electrochemical reactions, Importance of Electrochemical systems, Faraday law, Faraday efficiency, current density, Electrochemical Reactions, cell potential, standard potential, reference electrode, Concepts of equilibrium potential, Nernst equation, over potential and its different types, equilibrium exchange current density-derivation of Butler-Volmer equation and Tafel.

UNIT II ELECTROCHEMICAL REACTORS AND DEIGN 12

Electrochemical Kinetics. Batch reactor, continuous reactors. Plug flow electrochemical reactor, parallel plate reactor, Continuous stirred tank electrochemical reactor. General view of simple CSTER systems; CSTER in cascades; CSTER analysis of batch electrochemical reactors, CSTER analysis of semi-continuous electrochemical reactors; CSTER analysis of electrolyte recycling; Batch reactor combined with electrolyte recycling.

UNIT III MATERIALS FOR ENERGY STORAGE APPLICATION 9

Electrochemical Energy storage system. Capacitor, electrical double layer capacitor, Materials for electrode preparation, super capacitor application. Semiconducting materials. Electrochemical Properties of materials. Photo electrochemical Reactor. Application of Photo electrochemical reactor.

UNIT IV ELECTRO ANALYTICAL TECHNIQUES AND CORROSION MEASUREMENT 9

Electrochemical cells, cyclic voltammetry, electrochemical impedance, corrosion fundamentals, corrosion types, corrosion estimation using electrochemical techniques.

UNIT V BATTERY AND FUEL CELL 9

Classification of batteries and cell chemistry, cell voltage, cell construction, charging of batteries, Fuel cell, Fuel cell classification, PEM fuel cell, solid oxide fuel cell, application. Flow battery, Other type of batteries.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Thomas F.Fuller, JohnN.Harb Electrochemical Engineering, 2018, wiley publisher, 111900425X
2. K.Scott, Electrochemical Reaction Engineering, Academic Press Inc 1991, ISBN 0126333300,
3. B.Viswanathan, M.Aulice Scibioh, Fuel Cells:Principles And Applications, Universities Press; First Edition,2006, ISBN 1420060287

REFERENCES

1. T.Z.Fahidy, “Principles of Electrochemical Reactor Analysis”, Elsevier, 1985.
2. A.J.Bard & L.R. Faulkner, ”Electrochemical Methods Fundamentals and Applications”, John Wiley & Sons. 3nd Edition, 2001.
3. Zaki Ahmad, “Principles of Corrosion Engineering & Corrosion Control”, Butterworth Heinemann, London, 2006
4. B. E. Conway, “Electrochemical Supercapacitors : Scientific Fundamentals and Technological Applications”, Kluwer Academic / Plenum publishers, New York, 1999.

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	1	3	2	2	1	1	-	-	-	-	-	3.	3	3	-
	3	3	2	2	1	1	-	-	2	-	-	3	3	3	-
	3	3	2	2	-	-	-	-	-	-	-	3	3	3	-
	2	2	2	-	-	1	-	3	2	1	1	-	3	3	-
	3	-	-	-	1	-	2	-	-	-	1	3	3	3	-
	2.4	3	2	-	1	1	2	1	2	1	1	3	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23022	POWER PLANT ENGINEERING	L T P C
		3 0 0 3

COURSE OBJECTIVES

1. Understand the components, layouts, and economics of various power plants.
2. Learn about different boiler classifications, types, and their specific applications.
3. Explore the features, working principles, and performance aspects of steam turbines.
4. Examine the classification, components, and future prospects of gas turbine power plants.
5. Study refuse-derived fuel-based power plants and advanced technologies like IGCC, IFCC, MHD, fuel cells, and micro turbines.

UNIT I INTRODUCTION TO POWER PLANTS 9

Power Plants - Features, Components and Layouts - Working of Power Plants, Power Plant Economics.

UNIT II BOILER 9

Boiler Classification - Boiler Types - Fire Tube & Water Tube Boilers - Fluidized Bed Boilers - Positive Circulation Boilers - Thermal Liquid Heaters & Vaporizers

UNIT III STEAM TURBINE 9

Steam Turbines: Classification - Features - Working – Performance; Losses in Steam Turbines - Trouble Shooting

UNIT IV GAS TURBINE 9

Gas Turbines: Classification and Comparison of Different Types Gas Turbine Power Plants Components - Economics & Future of Combined Cycles

UNIT V REFUSE DERIVED FUEL BASED POWER PLANTS 9

Integrated Gasification Combined Cycle (IGCC) – Indirect Fired Combined Cycle (IFCC) – Magneto Hydrodynamics (MHD) – Fuel Cells – Micro turbines– RDF based power plants.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply fundamental knowledge on components, layouts and working of power plants

CO2: Differentiate the types, classification and usage of boilers

CO3: Apply knowledge on classification and usage of steam turbines

CO4: Compare the types of gas turbines

CO5: Apply knowledge on the application of integration of various process in power plants

TEXT BOOKS

1. Thomas C. Elliott ,"Standard Hand Book of Power Plant Engineering" McGraw Hill Professional, 2012 - Technology & Engineering, 0071811087
2. R.K.Rajput, a textbook on powerplant engineering, Laxmi Publications; Fifth edition, 2016, ISBN 8131802558
3. P.K.Nag, power plant engineering, McGraw Hill Education; Fourth edition, 2017, 9339204042

REFERENCES

1. E L Wakil, "Power Plant Engineering", McGraw-hill Book Co, N.Y. 2001.
2. Arora and Domkundwar, A course in Power Plant Engineering, Dhanpat Ra, N.Delhi.2003
3. Nag, P.K., "Power Plant Engineering", 2 nd Edition, TMH, 2001

Course Articulation Matrix:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course	Program Outcomes														
Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	2	2	2	2	1	1	1	1	1	2	2	2
CO2	2	2	2	2	2	2	2	2	1	1	2	1	2	2	2
CO3	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2
CO4	2	2	2	2	2	2	2	2	2	1	-	1	2	2	2
CO5	2	2	2	2	2	2	2	3	2	1	1	1	2	2	2
Overall CO	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2

CH23023 NON-RENEWABLE ENERGY SOURCES L T P C
3 0 0 3

COURSE OBJECTIVES

1. To understand the fundamental knowledge on petroleum and its products.
2. To learn the usage of coal and its environmental issues.
3. To understand natural gas and its environmental issues.
4. To understand the fundamentals of nuclear engineering.
5. To gain knowledge about nuclear reactors and nuclear waste management

UNIT I PETROLEUM RESOURCES 9

Origin of Petroleum, Composition, Extraction of Petroleum. Products of Petroleum refining: Diesel; Gasoline; LPG; Fuel oil; Tar; and Bitumen. Environmental Issues associated with petroleum resources.

UNIT II COAL 9

Types of coal; Composition of coal; Oxygen content, Proximate and Ultimate Analysis of coal; Carbonization, Coal for generation of electricity, coal liquefaction, coal blending. Environmental Issues associated with usage of coal.

UNIT III NATURAL GAS 9

Resources of Natural Gas, Properties and classification of natural gas, transportation of natural gas, products from natural gas, liquefied natural gas, chemicals from natural gas, shale gas; Environmental Issues associated with usage of coal.

UNIT IV FUNDAMENTALS OF NUCLEAR ENGINEERING 9

Nuclear models, binding energy, Radio activity, half-life, mechanism of nuclear fission and fusion, decay chains, neutron reactions. Nuclear Fuels; Nuclear fuel reserves of Uranium and Thorium, Nuclear fuel cycles, characteristics, production and purification, other fuels Zirconium, Beryllium.

UNIT V NUCLEAR REACTORS 9

Nuclear reactors and classification, boiling water reactors (BWR), pressurized heavy water reactor (PHWR), fast breeder reactor (FBR), basics of nuclear fusion reactor. Nuclear Power Plant -Waste Management and Safety

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Apply the fundamental knowledge on petroleum and its products

CO2: Analyse the usage of coal, types and its composition

CO3: Apply knowledge on the properties, classification and products of natural gas

CO4: Determine the fundamentals of nuclear engineering

CO5: Evaluate knowledge on the usage of nuclear reactors, nuclear waste management and safety usage.

TEXT BOOKS

1. Roy L.Nersesian " Energy for the 21st Century" ISBN:9780765628206, 0765628201, Taylor and Francis Group Second edition 2015.
2. J.Kenneth Shultis and Richard E.Faw "Fundamentals of Nuclear Science and Engineering" ISBN:9781439894088, 1439894086, CRC Press, Second edition 2007.
3. Rao, S., and B. B. Parulekar. "Energy Technology: Non-conventional, Renewable and Conventional. " Khanna Publication, 3rd (2012). ISBN 8174090401

REFERENCES

1. Andrew L.Simon " Energy Resources" ISBN: 9781483187501, 1483187500, Elsevier Science 2013.
2. Arun K.Nayak, Parimal Pramod Kulkarni " Severe Accidents in Nuclear Reactors Corium Retention Technologies and Insights" ISBN:9780128223055, 0128223057, Elsevier Science 2021.
3. Rahul Tondia, Anuraag Sehgal and Puneet Kamboj "Future of coal in India smooth transition or bumpy roads ahead?" ISBN:9781648288463, 1648288464, Notion Press, 2020.
4. Charles D.Ferguson, "Nuclear energy what everyone needs to know" ISBN:9780199759453, 0199759456, Oxford University Press, 2011
5. Rafiq islam, "New Developments in Sustainable Petroleum Engineering and Technology" Nova Press, 2012.

Course Articulation Matrix:

Course	**Program Outcomes**														
Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	1	1	1	2	1	2	3	1	2	2	2
CO2	2	2	2	1	1	1	1	2	1	2	3	1	2	2	2
CO3	2	2	2	1	1	1	1	2	1	2	3	2	2	2	2
CO4	2	2	2	1	1	1	1	2	1	2	3	2	2	2	2
CO5	2	2	2	1	1	1	1	2	1	2	3	3	2	2	2
Overall CO	2	2	2	1	1	1	1	2	1	2	3	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23024	AIR POLLUTION ENGINEERING	L T P C
		3 0 0 3

COURSE OBJECTIVES:

1. Understand the regulatory framework and standards for air quality and pollution control.
2. Learn principles and design of equipment for controlling gaseous pollutants through absorption, adsorption, and incineration.
3. Explore mechanisms and technologies for particulate air pollution control.
4. Examine methods for controlling various air pollutants, including VOCs, HCs, sulfur oxides, nitrogen oxides, and mobile source pollutants.
5. Analyze air pollution dispersion models and meteorological factors affecting air quality.

UNIT I INTRODUCTION 9

Introduction to Air Quality; An Overview of the Clean Air Act Amendments; Air Pollution Regulatory Framework - Regulatory System – Laws and Regulations – Clean air Act – Provisions for Recent Developments. Ambient Air Quality Standards in India; Properties of Air Pollutants; Sources and effects of air pollution, emission standards, Air Quality Index

UNIT II GASEOUS POLLUTANTS 9

Absorption- Principles, Description of equipment-Packed and Plate columns -Design and Performance equations; .Adsorption- Principle Adsorbents, Equipment descriptions - PSA - Adsorption cycle - Solvent recovery system-Continuous Rotary bed, Fluidized bed, Design and Performance equations ; Incinerators, Hydrocarbon incineration kinetics- Equipment description- Design and Performance equations.

UNIT III PARTICULATE AIR POLLUTION 9

Particle Collection mechanisms– Fluid particle Dynamics – Particle size Distribution – Efficiency – Gravity Settling chambers Cyclones- Electrostatic precipitators and Bag houses

UNIT IV AIR POLLUTION CONTROL 9

Principles of Pollution Prevention- Characteristics and control of VOCs and HCs, Characteristics and control of sulphur oxides and nitrogen oxides, Control of mobile source pollutants - Control of particulate matters – Techniques of air pollution control – equipments.

UNIT V AIR POLLUTION MODELLING 9

Meteorology and winds- Stability of the atmosphere, lapse rates & inversions- Air pollution dispersion models, Gaussian equation and variation, Industrial Air Pollution Sources and Prevention

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1:compare the nature and characteristics of air pollutants, and basic concepts of air quality management.

CO2: Identify, formulate and solve air pollution problems using air pollution control devices to meet applicable standards

CO3: Apply the knowledge about particulate air pollutants and control devices.

CO4: Evaluate the air quality behaviour and its measurement

CO5: Determine the air pollution Control in industries using various models

TEXT BOOKS

1.Richardw.Boubeletal.,"FundamentalsofAirPollution",AcademicPress,NewYork,1994. ISBN 0080507077

2. NoelDeNevers,"AirPollutionControlEngg.",McGrawHill,NewYork,1995. **ISBN-10 :** 0070393672

3. M.N.Raoetal.,"AirPollution"TataMcGrawHill,1989 **ISBN-10 :** 9780074518717

REFERENCES

1. David, H.F., Liu, Bela G., Liptak Air Pollution, Lweis Publishers, 2000.
2. Stern, A.C., Air Pollution (Vol.I – Vol.VIII), Academic Press, 2006.
3. Davis, W.T., Air Pollution Engineering Manual, John Wiley & Sons,Inc.,2000.
4. Heck, R.M., and Farrauto, R.J., Catalytic Air Pollution Control: Commercial Technology, 2nd Edition John Wiley Sons, 2012
5. Pierce, J.J., Environmental pollution and control, Butterworth-Heinemann, 4th edn, 1997.

COURSE ARTICULATION MATRIX:

Course	Program Outcomes														
Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	1	1	2	1	2	2	2	2	2	2	2	2	1	2
CO2	2	3	2	2	3	2	2	2	2	2	2	1	2	2	2
CO3	2	3	2	2	3	2	2	2	2	2	2	1	2	2	2
CO4	2	3	2	2	3	2	2	2	2	2	2	1	2	2	2
CO5	2	3	3	2	3	2	2	2	2	2	2	1	2	2	2
Overall CO	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2

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

CH23025	WASTE WATER TREATMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To gain knowledge on the waste water generation and the waste characteristic.
2. To understand the concepts of physio-chemical treatment methodologies.
3. To understand the concepts of biological treatment methodologies.
4. To impart knowledge on the theoretical knowledge and technology development of various wastewater treatment process.
5. To gain knowledge on advanced technologies for treating wastewater.

UNIT I WASTE WATER TREATMENT AN OVERVIEW 9

Overall introduction about technologies adopted for water treatment, source and characteristics of waste water; regulations – health and environment concerns in waste water management.

UNIT II PHYSICAL TREATMENT METHODS 9

Activated sludge process and variations, sequencing batch reactors, membrane reactors- trickling filters- fluidized bed reactors, aerated lagoons, waste stabilization ponds- design of units – UASB, up flow filters.

UNIT III CHEMICAL TREATMENT METHODS 9

Role of unit processes in waste water treatment, principles of chemical treatment – coagulation, flocculation, precipitation, flotation, solidification and stabilization, disinfection

UNIT IV BIOLOGICAL TREATMENT METHODS 9

Objectives of biological treatment, principles of aerobic and anaerobic treatment, kinetics of biological growth, factors affecting growth – attached and suspended growth, determination of kinetic coefficients for organics removal, biodegradability assessment, selection of bio reactors.

UNIT V ADVANCED WASTE WATER TREATMENT 9

Technologies used in advanced treatment- removal of colloids and suspended particles– TOC and heavy metal removal, membrane filtration – ion exchange – advanced oxidation process – zero liquid discharge.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Compare the Physical and chemical Characteristics of wastewater and their measurement.
CO2: Evaluate the effluent treatment techniques through physical treatment methods.
CO3: Analyze the chemical reactions involved for effluent treatment.
CO4: Apply the concepts of biological treatment methods.
CO5: Determine the suitable advanced techniques to completely eliminate the traces of toxicity.

TEXT BOOKS

1. Wastewater Engineering Treatment and Reuse: McGraw Hill, G. Tchobanoglous, FI Biston, 2002. ISBN 0077441214
2. Industrial Waste Water Management Treatment and Disposal by WasteWater McGraw Hill III Edition 2008. ISBN 0071592393

3. S.P. Mahajan, Pollution control in process industries, 27th Ed. Tata McGraw Hill Publishing Company Ltd., 2012. ISBN 0074517724

REFERENCES

1. Casey, T.J., Unit Treatment Processes in Water and Wastewater Engineering, John Wiley & Sons, 2006.
2. Metcalf & E ddy, Inc. Wastewater Engineering - Treatment, Disposal, and Reuse, Fourth Edition, Tata McGraw-Hill, 1995.
3. Cheremisinoff, P.N., Handbook of water and wastewater technologies, BH Publications, 2002.
4. Sincero, P.A., and Sincero, A.G., Physical Chemical treatment of water and wastewater, IWA Publications, 2002.
5. Spellman, R.F., Handbook of water and wastewater treatment plant operations, CRC Press/Taylor & Francis Publications, 2009

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	-	1	2	2	2	2	2	2	2	2	2	2	1	1
CO2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	1
CO3	2	2	1	2	2	2	2	2	2	2	2	2	2	2	1
CO4	2	2	2	2	3	2	2	2	2	2	2	2	2	2	1
CO5	2	3	2	2	3	2	2	2	2	2	2	2	2	2	1
Overall	2	2	2	2	3	2	2	2	2	2	2	2	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23026 **SOLID WASTE MANAGEMENT** **LT P C**
3 0 0 3

COURSE OBJECTIVES:

1. Understand the sources, types, and characteristics of municipal solid wastes and their impacts.
2. Learn methods for waste reduction, on-site storage, and recycling of various materials.
3. Explore techniques for the collection and transfer of residential and commercial wastes.
4. Examine physical and thermal processing techniques for waste treatment and resource recovery.
5. Analyze methods for the safe disposal of waste, including the design and management of sanitary landfills.

UNIT I SOURCES AND CHARACTERISTICS 9

Sources and types of municipal solid wastes- Public health and environmental impacts of improper disposal of solid wastes- sampling and characterization of wastes - factors affecting waste generation rate and characteristics - Elements of integrated solid waste management – Requirements and salient features of Solid waste management rules (2016) –- Role of public and NGO"s- Public Private participation – Elements of Municipal Solid Waste Management Plan.

UNIT II SOURCE REDUCTION, WASTE STORAGE AND RECYCLING 9

Waste Management Hierarchy - Reduction, Reuse and Recycling - source reduction of waste – On-site storage methods – Effect of storage, materials used for containers – segregation of solid wastes – Public health and economic aspects of open storage – case studies under Indian conditions – Recycling of Plastics and Construction/Demolition wastes.

UNIT III COLLECTION AND TRANSFER OF WASTES 9

Methods of Residential and commercial waste collection – Collection vehicles – Manpower – Collection routes – Analysis of waste collection systems; Transfer stations –location, operation and maintenance; options under Indian conditions – Field problems- solving.

UNIT IV PROCESSING OF WASTES 9

Objectives of waste processing – Physical Processing techniques and Equipment; Resource recovery from solid waste composting and bio meth nation; Thermal processing options – case studies under Indian conditions.

UNIT V WASTE DISPOSAL 9

Land disposal of solid waste- Sanitary landfills – site selection, design and operation of sanitary landfills – Landfill liners – Management of leachate and landfill gas- Landfill bioreactor – Dumpsite Rehabilitation

TOTAL: 45 PERIODS

COURSE OUTCOMES: The students will be able to

CO1: state solid waste characteristics and its sources.
CO2: Identify and analyze different methods of treatment of solid waste.
CO3: Illustrate Industrial practices in solid waste management.
CO4: Discuss the significance of recycling reuse and reclamation of solid wastes.
CO5: Assess the relationships between environmental guidelines, human activities and quality of impacted soil, water and air

TEXT BOOKS

1. William A. Worrell, P. AarneVesilind (2012) Solid Waste Engineering, Cengage Learning, 2012. ISBN 1305888359
2. John Pitchel (2014), Waste Management Practices-Municipal, Hazardous and industrial CRC Press, Taylor and Francis, New York. ISBN 1466585188
3. Tchobanoglous, G., Theisen, H. M., and Eliassen, R. “Solid. Wastes: Engineering Principles and Management Issues”. McGraw Hill, New York, 1993. ISBN 0070632375

REFERENCES

1. Government of India, “Manual on Municipal Solid Waste Management”, CPHEEO, Ministry of UrbanDevelopment, New Delhi, 2000.
2. Manser A.G.R. and Keeling A.A “Practical handbook of processing and recycling municipal waste”, Lewis Publishers, CRC Press, 1996
3. Dhungel Rajan, “Model of Solid Waste Management in urbanizing areas”, LAP Lambert Academic Publishing 2014
4. Vesilind, P.A. and Rimer, A.E., “Unit Operations in Resource Recovery Engineering”, Prentice Hall, Inc., 1981

COURSE ARTICULATION MATRIX:

Course	**Program Outcomes**														
Outcomes	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	-	-	-	-	1	2	2	2	2	1	2	2	1	2
CO2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2
CO3	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2
CO5	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2
Overall CO	2	1	2	2	2	2	2	2	2	2	2	2	1	1	2

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

CH23027 ENVIRONMENTAL IMPACT ASSESSMENT L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To impart the knowledge on EIA procedure in India
2. To impart the knowledge on identification and assessment of environmental impacts of a project
3. To enable the students to develop knowledge on mitigation and management of impacts caused
4. To enable the students to develop an understanding on the importance and methods of performing social impacts of developmental projects
5. To enable the students to learn monitoring methods and to develop knowledge of learning from EIA case studie

UNIT I INTRODUCTION 9

Impacts of Development on Environment – Rio Principles of Sustainable Development-Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle –EIA Notification and Legal Framework.

UNIT II ENVIRONMENTAL ASSESSMENT 9

Screening and Scoping in EIA – Drafting of Terms of Reference, Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna - Matrices – Networks – Checklist Methods - Mathematical models for Impact prediction.

UNIT III ENVIRONMENTAL MANAGEMENT PLAN 9

Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna – Environmental Monitoring Plan – EIA Report Preparation – Public Hearing-Environmental Clearance

UNIT IV SOCIO ECONOMIC ASSESSMENT 9

Baseline monitoring of Socio economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost benefit Analysis

UNIT V MONITORING STUDIES AND APPLICATION 9

Environmental monitoring – guidelines, policies- planning of monitoring programmes, Environmental management Post project audit, case studies of EIA developmental projects in food, fertilizer and pharmaceuticals.

TOTAL: 45 PERIODS

COURSE OUTCOMES: The students will be able to

CO1: Apply the concept of environmental Impact assessment
CO2: Compare various components and assessment techniques of EIA.
CO3: Evaluate Environmental management plan
CO4: Analyze the socio economic impacts caused by the project
CO5: Develop knowledge through case studies and to study EIA monitoring
CO6: Analyze the quality of given EIA report an to develop parts of EIA without shortcomings

TEXT BOOKS

1. Canter, L. W., Environmental Impact Assessment, 2nd Edition, McGraw Hill, New York, 1996. ISBN: 9780070097674
2. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, 2nd edition, Wiley, 2013. ISBN: 9781118678404
3. Anjaneyulu, Y., and Manickam, V., Environmental Impact Assessment, Methodologies, 2nd Edition, CRC Press, 2011. ISBN:9780415665568

REFERENCES

1. Becker H. A., Frank Vanclay, "The International handbook of social impact assessment" conceptual and methodological advances, Edward Elgar Publishing,2003. ISBN: 9781847201058
2. Barry Sadler and Mary McCabe, "Environmental Impact Assessment Training Resource Manual", 2nd edition, United Nations Environment Programme,2002. ISBN: 9280722301
3. Judith Petts, "Handbook of Environmental Impact Assessment Vol. I", Wiley-Blackwell Science, 1999. ISBN: 9780632047727
4. Judith Petts, "Handbook of Environmental Impact Assessment Vol. II", Wiley-Blackwell Science, 2009. ISBN: 9781444311495
5. Ministry of Environment and Forests EIA Notification and Sectoral Guides, Government of India, Gazette of India, 2006.

COURSE ARTICULATION MATRIX:

Course Outcomes	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	1	1	2	1	2	2	2	2	2	2	2	2	2	2
CO2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2
CO3	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2
CO4	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2
CO5	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2
CO6	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2
Overall CO	2	1	1	2	1	2	2	2	2	2	2	2	2	2	2

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

CH23028 PROCESS SAFETY MANAGEMENT L T P C
3 0 0 3

COURSE OBJECTIVES:

1. The course could provide basic knowledge of Occupational Health and Safety Management Systems and Environmental Management System standards
2. To inculcate the knowledge of various terms and terminologies which are used in the Occupational Health, Safety and Environmental Management systems
3. To understand and learn the different outcomes and safety analysis in process industries.
4. Effectively employ the hazard analysis techniques in Industry and help in preventing the accidents in Industry
5. To achieve an understanding of the principles of safety management. Evaluate the safety performance of an organization from accident records.

UNIT I PROCESS SAFETY INFORMATION 9

Personal Safety vs Process Safety, Importance of Process Safety, Organisational learning Elements of Process Safety - Overview; Process Safety Information (PSI) – Importance of Process Safety Information, Types of PSI, Collection of PSI, familiarization of formats for capturing PSI, Challenges.

UNIT II SAFETY PROGRAMMES AND PROCEDURES 9

Need for safety in industries; Safety Programmes – components and realization; Potential hazards– extreme operating conditions, toxic chemicals; Safe handling-Implementation of safety procedures – periodic inspection and replacement; Standard Operating Procedure – Overview and its importance, how to write effective operating procedure, Types of Procedures, Standard operating conditions and consequence of deviation; Emergency planning and response, Layers of protection analysis.

UNIT III ACCIDENT ANALYSIS 9

Accidents – identification and prevention, promotion of industrial safety. permit-to-work system, Safe shift handover, Process Safety Incident reporting and Investigation – Element overview, reporting and its importance; Process safety incident classification, Root cause analysis, making recommendations; Past accident analysis-Fixborough-Mexico- Chernobyl nuclear disaster-Bhopal gas analysis, Ennore Oil Spill- Fire and explosion protection.

UNIT IV PROCESS HAZARD ANALYSIS 9

Hazard identification- safety audits, checklist, what if analysis, vulnerability models- event tree analysis- fault tree analysis. Asset Integrity Process Hazard Analysis - Introduction to PHA, Overview of PHA Techniques, Selection of PHA Techniques Implementation of recommendation – Key Aspects. Cyclic PHA /Revalidation; Review of PHA methodology (Prerequisites, Team Composition and their attributes), Process safety hazard control

UNIT V SAFETY MANAGEMENT 9

OSHA, Employee Participation – Overview, Benefits of Employee participation, Various modes of engaging workforce in PSM, Challenges; Management of Change – Types of Changes, Managing Changes in PSM Perspective, Framework, evaluating changes- Institutionalizing and integrating safety into the PSM fabric, 5 tier approach, selection, training,

Performance monitoring; Case studies – Process safety management in industry – present and futuristic approach.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1:Apply the chemical process safety, safety codes

CO2: Compare safe handling of chemicals and plant inspection

CO3: Evaluate the different analysis to overcome the accidents in process industry

CO4: Analyse the hazard analysis in process industry

CO5: Apply knowledge on safety management in different process industry

TEXT BOOKS

1. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl, J.F. Louvar, Prantice Hall, NJ, 1990, ISBN 0134857844, 9780134857848
2. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation",
   Wiley Interscience, 1965, ISBN 0470256788, 9780470256787
3. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987, ISBN 0-85312969X
4. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004, ISBN9781315220376

REFERENCES

1. Handley, W., "Industrial Safety Hand Book ", 2nd Edn., McGraw-Hill Book Company, 1969.
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., "Industrial Accident Prevention", McGrawHill Book Co., 1980.
3. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994
4. Dan Petersen, "Techniques of Safety Management", McGraw-Hill Company, Tokyo, 1981.
5. John Ridley, "Safety at Work", Butterworth and Co., London, 1983
6. Relevant Indian Standards and Specifications, BIS, New Delhi.
7. "Safety and Good House Keeping", N.P.C., New Delhi, 1985John Ridley, "Safety at Work", Butterworth and Co., London, 1983
8. Relevant Indian Standards and Specifications, BIS, New Delhi.
9. "Safety and Good House Keeping", N.P.C., New Delhi, 1985

COURSE ARTICULATION MATRIX:

Course Outcomes	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	-	2	1	2	2	2	2	2	2	2	2
CO2	2	1	2	2	-	1	2	1	2	1	1	2	2	3	2
CO3	2	1	1	2	2	2	2	2	2	2	2	3	2	2	2
CO4	2	2	1	2	3	2	2	2	2	2	2	2	3	2	2
CO5	2	1	3	2	3	1	2	2	2	2	2	2	2	2	3
Overall CO	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2

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

CH23029 **RISK AND HAZOP ANALYSIS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To provide knowledge on risk, hazard and their assessment techniques in Industry
2. To educate the students about the root cause analysis
3. Identify hazards in process and categorize zone level
4. Evaluate risk assessment and eliminate hazard by engineering control.
5. Understand the importance of HAZOP in process industries
6. Conduct HAZOP for the real time scenario

UNIT I RISK ANALYSIS **9**

Risk analysis introduction, rapid risk analysis –comprehensive risk analysis – identification, evaluation and control of risk, Quantitative risk analysis, 5 why analysis, fish bone diagram, event tree, fault tree, consequence analysis and layer of protection analysis, Bow tie analysis

UNIT II RISK ASSESSMENT **9**

Risk assessment – introduction and available methodologies, quantitative risk assessment Risk assessment steps.

UNIT III EMERGENCY PLANNING AND RESPONSE **9**

Overall risk analysis-emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies- marketing terminal, gas processing complex ; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.

UNIT IV HAZARDS **9**

Hazard -Types of Hazard, Hazard identification – methods: Process Hazard Analysis - Introduction to PHA, Overview of PHA Techniques, Selection of PHA techniques Implementation of recommendation – Key Aspects. Cyclic PHA /Revalidation; Review of PHA methodology (Prerequisites, Team Composition and their attributes)

UNIT V HAZOP **9**

Introduction to HAZOP-Significance of HAZOP -HAZOP procedure –HAZOP Analysis - Computer usage in HAZOP- softwares employed - Limitations of HAZOP – case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply the knowledge of types of risks arising in working environment
CO2: Evaluate Risk Assurance and Assessment
CO3: Design Risk management systems and planning
CO4: Analyze the effect of process hazard
CO5: Compare Hazop and its consequences and to create hazard free working premises

TEXT BOOKS

1. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl, J.F. Louvar, Prantice Hall, NJ, 1990. ISBN 0134857844, 9780134857848
2. Fawatt, H.H. and Wood, W.S., “Safety and Accident Prevention in Chemical Operation“, Wiley Interscience, 1965, ISBN 0470256788, 9780470256787

3. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987 ISBN 10085312969X

REFERENCES

1. Handley, W., “Industrial Safety Hand Book “, 2nd Edition. McGraw-Hill Book Company, 1969.
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., “Industrial Accident Prevention“, McGraw-Hill Book Co., 1980.
3. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994
4. Dan Petersen, “Techniques of Safety Management”, McGraw-Hill Company, Tokyo, 1981.
5. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004 , ISBN9781315220376

Course	**Program Outcomes**														
Out comes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	2	2	2	2	1	1	1	2	-	1
CO2	2	1	2	2	2	2	2	2	2	1	2	1	2	-	1
CO3	2	2	3	3	2	2	2	2	2	1	2	2	2	2	1
CO4	2	2	3	3	2	2	2	2	2	1	2	2	2	2	1
CO5	2	2	3	3	2	2	2	2	2	1	2	2	2	2	1

CH23030 CRUDE UPSTREAM PROCESSING

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

1. The course aims to help students develop a complete understanding of the characteristics of petroleum reservoirs.
2. Students will also learn about the reservoir drive mechanisms and their influence on oil reservoir performances, together with an introduction to reserves classification and the different reserve estimation methods
3. Students will also learn about the enhanced oil recovery methods.
4. The unit provides an overview of petroleum production technologies and crude oil field handling methods at processing plants.
5. Learn the Importance of Unconventional Gas Reservoirs such as Gas Hydrates and Shale Gas.

UNIT I PETROLEUM EXPLORATION & DRILLING 9

Classification and description of clastic and nonclastic reservoir rocks. Origin, migration and accumulation of Petroleum. Petroleum exploration methods, Drilling method, Drilling fluids function and properties, Drilling problems, their control & remedies

UNIT II RESERVOIR ENGINEERING 9

Petrophysical properties of reservoir rocks. Coring and core analysis. Reservoir fluid properties. Phase behaviour of hydrocarbon system. Flow of fluids through porous media. Water and gas coning. Reservoir pressure measurements. Reservoir drives, drive mechanics and recovery factors. Reserve estimation & techniques,

UNIT III ENHANCED OIL RECOVERY TECHNIQUES 9

Basic principles and mechanism of EOR, Screening of EOR process. Concept of pattern flooding, recovery efficiency, permeability heterogeneity. Macroscopic and microscopic displacement efficiency. EOR methods: Chemical flooding, Miscible flooding, Thermal recoveries

UNIT IV PETROLEUM PRODUCTION OPERATIONS 9

Well equipment. Well-completion techniques, Well production problems and mitigation. Well servicing & Workover operations. Workover & completion fluids. Formation damage. Well stimulation techniques. Artificial lift techniques. Field processing of oil & gas.

UNIT V LATEST TRENDS IN PETROLEUM ENGINEERING 9

Coal bed methane, shale gas, oil shale, gas hydrate, and heavy oil, Storage and transportation of petroleum and petroleum products

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: To learn the basics of crude exploration and drilling techniques

CO2: To study the basics of the reservoir and its mechanism

CO3: Analyse and understand the microscopic and macroscopic displacement of oil.

CO4: To understand the well-completion techniques and simulation methods

CO5: To understand the latest trends in petroleum engineering and gain knowledge on different energy source apart from petroleum.

TEXTBOOKS

1. Petroleum Exploration Handbook: A Practical Manual Summarizing the Application of the Earth Sciences to Petroleum Exploration, Moody, Graham B. (editor), Published by McGraw Hill Book Company, New York, 1961, ISBN 10: 0070428670 / ISBN 13: 9780070428676.
2. Hydrocarbon Exploration and Production, 2nd edition, Frank Jahn, Mark Cook, Mark Graham, Elsevier Science, 2008, ISBN 0080568831, 9780080568836.
3. Developments in Petroleum Science, L.P. Dake (Eds.) Fundamentals of Reservoir Engineering Elsevier Science (1978), ISBN: 978-0-444-41667-4

REFERENCES

1. Petroleum Reservoir Simulation: The Engineering Approach, M. Rafiqul Islam, J.H. Abou-Kassem, S.M. Farouq-Ali, Gulf Professional Publishing, 2020
2. Oil and gas production handbook, An introduction to oil and gas production, transport, refining and petrochemical industry, Havard Devold, 2013
3. B. Guo, W.C. Lyons and A. Ghalambor, Petroleum Production Engineering: A Computer Assisted Approach, Elsevier, 2007.
4. T. Ahmed and P. D. McKinney, Advanced Reservoir Engineering, Elsevier, 2005.
5. Petroleum Reservoir Engineering, 1960 – J.W.Amyx, D.M.Bass, and R.L.Whiting
6. Phase Behavior of Petroleum Reservoir Fluids, 2007 – K.S.Pedersen and P.L.Christensen

Course Articulation Matrix:

Course	Program Outcomes														
Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	1	2	2	1	2	2	1	2	2	1	1	1	2	2	1
CO2	2	1	2	1	2	2	1	2	2	2	1	1	2	2	2
CO3	2	2	1	1	2	2	1	2	2	1	1	1	2	2	1
CO4	2	2	2	1	2	2	1	1	3	1	2	1	2	2	1
CO5	1	2	1	1	2	2	1	1	3	1	2	1	2	2	1
Overall CO	2	2	1	1	2	2	1	2	1	1	1	1	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23031 **PETROLEUM REFINING I**

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

1. To enable the students to learn the methodologies in the primary petroleum refining processes like crude preparation, atmospheric and vacuum distillation, Lube, asphalt and wax processing.
2. To enable students to examine how each refinery process works
3. To allow students to learn each operating variables are applied to achieve the objectives of each refinery process
4. The students learn the different heavy crude oil processing techniques
5. To understand the asphalt and wax processing techniques

UNIT I INTRODUCTION 9

Crude Oil origin & composition, supply and demand, connate water, Classification of hydrocarbons, Non-Hydrocarbons or Hetero-Atomic Compounds, Thermophysical Properties of Petroleum Fractions and Crude Oils, Refinery feedstocks and products, characterisation factor, Quality testing methods, storage tanks and transportation.

UNIT II DISTILLATION 9

Types of salt in crude, Dehydration and desalting methods, - preheating train and design- furnace and its operation. ASTM, TBP apparatus, cut points, flash zone, types of refluxes, steam properties, atmospheric distillation, steam jet ejectors, vacuum distillation – wet and dry, packed columns.

UNIT III LIGHT DISTILLATES 9

Sources of sulfur in refinery-types of sulfur compounds in crude-sweetening processes- various sulfur treatment processes in products - H_2S properties and removal by physical and chemical process, Merox treatment, Steam reforming Distillate hydrotreater unit, Refinery off gases, LPG Processing, Naptha desulphurisation process, Naptha reforming process, applications, Lobs Base Stocks, BS standards.

UNIT IV HEAVY DISTILLATES 9

Viscosity index calculation and pour point - LOBS processing by solvent treatment and hydro treatment- solvent selection -solvent extraction by NMP, furfural, - MEK solvent dewaxing/-refrigerating and filtration -hydro finishing- types of LOBS based on VI- types or groups of lube processing-spindle/LN/IN/HN/BN processing and blending, applications.

UNIT V ASPHALT AND WAX TECHNOLOGY 9

Vacuum residue properties- propane deasphalting-asphalt processing and types-chemical structure-air blowing of bitumen- slack wax processing- wax and types/properties- wax deoiling-unit operations in wax plants- refrigerating and filtration/ hydro treating of wax- molding and storage.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand crude oil supply and demand, different refinery feedstocks and products, and study quality testing methods.

CO2: In-depth knowledge of crude distillation unit operating atmospheric and vacuum conditions.

CO3: Understand the light distillate processing and desulphurisation process including Bharat standards

CO4: Study the heavy crude distillate processing, and blending techniques.

CO5: To study asphalt and wax processing technology

TEXTBOOKS

1. Modern Petroleum Refining Processes, BK BhaskaraRao, Oxford & IBH Publishinng Co. Pvt. Ltd. ISBN 8120417151, 9788120417151.

2. Prasad, R., “Petroleum Refining Technology”, Khanna Publishers, New Delhi, 2000, ISBN1683921062, 9781683921066
3. Fundamentals of Petroleum Refining, M.A. Fahim, T.A. Al-sahhaf, A.S. Elkilani; Elsevier Science and Technology, 2010, ISBN 978-0-444-52785.

REFERENCES

1. J.G. Speight and B. Ozum, “Petroleum Refining Processes”, Marcel Dekker Inc, New York,2002
2. G.D. Hobson, “Modern Petroleum Technology”, Vol I & II, John Wiley & Sons, New York,5th edition, 1984
3. David.S.J.” STAN”Jones and Peter R.Pujado “Handbook of Petroleum Processing,Springer,2006.
4. Smalheer, C.V and R.Kennedy Smith Lubricant Additives. The Lezius – Hill Company, Cleveland, Ohio. USA, 1987
5. James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, Petroleum Refining : Technology and Economics, CRC Press, 2007

Course Articulation Matrix:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	2	1	1	2	2	1	-	1	1	1	2
CO2	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1
CO3	2	2	2	1	1	1	1	2	2	1	1	1	2	2	2
CO4	2	1	2	2	1	1	2	1	2	1	1	1	1	1	2
CO5	2	1	2	2	2	2	2	1	2	1	1	1	2	1	1
Overall CO	2	2	2	1	1	1	1	1	2	1	1	1	1	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23032 **PETROLEUM REFINING II**

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

1. To enable the students to learn the methodologies in the secondary petroleum refining or upgrading processes like thermal cracking, coking,
2. To enable the students to learn catalytic cracking, hydrocracking, hydrotreating, reforming, isomerisation, alkylation and sulfur finishing processes
3. To enable students to learn refinery operations on FCC, Vis breaker, DCU, Reformer, etc.
4. To understand reforming, isomerisation and alkylation process
5. To understand the operation on utilities like steam, cooling water, instrument air, H_2, and N_2.

UNIT I THERMAL CRACKING AND COKING 9

Resid upgradation technologies- cracking-thermal cracking-mechanism/principle/reactions-process variables- Visbreaking- soaker process- coil visbreaker-Disadvantages-Coking-thermodynamics and mechanism of coking-delayed coking-operation-fluid coking- flexi coking-types of coke and properties- yield pattern of cracking and coking, coke applications.

UNIT II CATALYTIC CRACKING 9

Principles of catalytic cracking-mechanisms- FCC- main reaction of FCC- role of FCC in refinery-Fluidization- feedstocks/products/yield pattern- Kinetics and thermodynamics of FCC reactions-FCC catalyst and licensor technologies- reaction/regeneration/fractionation sections-slide valves and its importance- riser/cyclone separator/reactor internals.

UNIT III HYDROGEN AND HYDROCONVERSION 9

H_2 requirements - steam reforming and shift conversion-operation and NI catalyst-Hydro treatment processes- catalyst and reaction chemistry-Naphtha/Diesel/lube/wax/gasoline hydro treatment - Hydrocracking process- Typical hydrocracker in refinery- catalyst/severity/conversion/Temperature profile for yield pattern-reaction kinetics of hydrocracker- Operation and variables

UNIT IV REFORMING/ISOMERISATION/ALKYLATION 9

Reforming feed index-RON-various reforming technologies - platforming reactions - kinetics and thermodynamics of Pt catalyst reactions - Operation in Straight Run and Continuous Run mode-yield calculation- Isomerization techniques- reactions and kinetics- various technologies in isomerisation-importance of catalyst-hexane production-Alkylation process-reactions – various alkylation processes- process variables in reforming/ isomerisation /alkylation

UNIT V FINISHING PROCESSES AND UTILITIES 9

Electricity and steam generation by Gas turbine/boiler-Cooling tower operation-Fuel oil-Cryogenic distillation of air to N_2 and O_2 production, Sour water stripper, API separators, dissolved air flotation, product blending facilities, Road and rail loading facilities, Jetty and dock facilities, Waste disposal facilities

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: To learn the different thermal cracking techniques and its applications

CO2: To understand the reactions and mechanism involved in FCC

CO3: Analyse the Hydrogen requirements in refineries and learn the methods of hydrogen production.

CO4: Study the technologies involved in Reforming/Isomerisation/Alkylation processes.

CO5: To learn the various utilities used in the refineries.

TEXTBOOKS

1. David.S.J." STAN"Jones and Peter R.Pujado "Handbook of Petroleum Processing, Springer,2006, ISBN 978-1-4020-2820-5.
2. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2020, ISBN 1683921062, 9781683921066.
3. W. L. Nelson, Petroleum Refinery Engineering, McGraw-Hill Book Co, 1969

REFERENCES

1. J.G. Speight and B. Ozum, "Petroleum Refining Processes", Marcel Dekker Inc, New York, 2002
2. G.D. Hobson, "Modern Petroleum Technology", Vol I & II, John Wiley & Sons, New York, 5th edition, 1984
3. Modern Petroleum Refining Processes, BK BhaskaraRao, Oxford & IBH Publishinng Co. Pvt. Ltd. ISBN 8120417151, 9788120417151.
4. Fundamentals of Petroleum Refining, M.A. Fahim, T.A. Al-sahhaf, A.S. Elkilani; Elsevier Science and Technology, 2010, ISBN 978-0-444-52785.

Course Articulation Matrix:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11		PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	2	2	2	2	2	1	2		1	1	2	1
CO2	1	2	1	2	2	2	2	1	1	2	2		2	1	1	1
CO3	2	1	1	2	2	2	1	2	2	2	2		1	1	2	2
CO4	1	2	1	1	2	1	1	2	1	2	2		1	1	1	2
CO5	1	1	1	1	2	2	1	1	2	1	1		2	1	1	2
Overall CO	1	1	1	1	2	2	1	1	1	1	1		1	1	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23033 **PETROCHEMICAL TECHNOLOGY**

L T P C

OBJECTIVES **3 0 0 3**

1. To study the process and production of different chemicals from crude oil.
2. To enable the students to learn the operation and methodologies in petrochemical industries
3. To enable students to learn the application of petrochemicals in all process fields
4. To enable students to learn each product of petrochemical industries
5. To understand application with production techniques in detail

UNIT I PETROCHEMICALS EVOLUTION **9**

Petrochemical Industries and their feedstock selection, History, Economics, Growth of petrochemical industry.-structure of Petrochemical complexes- Classification of petrochemicals- Basic building processes- Integration with the refinery-flow scheme.

UNIT II INTERMEDIATES FOR PETROCHEMICAL INDUSTRIES **9**

Production Methods - Reforming and cracking of feedstocks; Sources: Chemicals from synthesis gas, olefins and aromatics-Ethylene, Propylene, C_4hydrocarbons, higher olefins, Benzene, Toluene, Xylene, cyclohexane, Para Diethylbenzene (PDEB), Linear Alkyl Benzene (LAB) and Paraffin (NP/HNP/LNP).

UNIT III COMPLEX PETROCHEMICAL PRODUCTS **9**

Purified Terephthalic Acid (PTA), Acrylonitrile, Acrylic acid, dimethyl terephthalate, ethanol, ethylene glycol, Ethylene Oxidemethyl tertiary butyl ether, vinyl acetate, vinyl chloride, Maleic and phthalic anhydride, ethyl benzene, Phenol, Cumene, Styrene, Bisphenol, Aniline – Process flow scheme- various technology- advantages-yield pattern-process variables, applications.

UNIT IV POLYMERS **9**

Supply and demand of polymers, Polymers production: Fibers, Rubbers and Plastics. Acrylonitrile butadiene styrene (ABS), Polybutadiene Rubber, Butyl Rubber, polyethylene-LDPE, HDPE, Polypropylene, PVC, PS, PAN, Nylon and Polycarbonates, circular polymers, Fibre Reinforced Polymers – FRP.

UNIT V GLOBAL CHEMICALS **9**

Petrochemicals-Lubricants, additives, adhesives, agrochemicals, cosmetics raw materials, electronic chemicals, detergents, paint, healthcare and pharmaceuticals, Fertilizers-Ammonia, Urea, NPK, decarbonisation, net zero carbon.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply the basic knowledge of the petrochemical industry and its growth, history

CO2: To study different intermediates for petrochemical industries

CO3: To learn different complex petrochemicals along with their applications.

CO4: To analyse the supply and demand of polymers and to study different polymer production technologies.

CO5: To understand the global petrochemical market.

TEXT BOOKS

1. Bhaskara Rao, B.K.“A Text on Petrochemicals”, 2nd Edition, Khanna Publishers, New Delhi,2004, ISBN 8174090444
2. Wiseman .P., "Petrochemicals", UMIST Series in Science and Technology, John Wiley &Sons,1986, ISBN 13: 9780853127413
3. A. Chawvel and G. Lefebvre, “Petrochemical Process”, Vol. I & II, Gulf Publishing Co., Houston, London,1989, ISBN 0872017729, 9780872017726

REFERENCES

1. Brownstein A.M.'Trends in Petrochemical Technology', Petroleum Publishing Company,1976.
2. G.Margaret Wells, 'Handbook of Petrochemicals and Processes' 2nd Revised Edition, Gower Publishing Company, 2018.
3. Robert A. Meyers, “Handbook of Petrochemicals Production Processes”, McGraw-Hill Education: New York, 2 nd edition, 2019 (ISBN: 9781259643132)
4. L.F. Hatc and MatarSarri, “From Hydrocarbons to Petrochemicals”, Gulf Publishing Co.,Houston, London
5. A.L. Waddams, “Chemicals from Petroleum”, Gulf Publishing Company, London, 4th edition, 1980

Course Articulation Matrix:

Course	Program Outcomes														
Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO3
CO1	1	1	2	1	2	2	1	2	2	1	1	1	2	2	1
CO2	1	2	2	1	2	2	1	2	2	2	1	1	2	2	2
CO3	2	2	1	1	1	2	1	2	2	1	1	1	2	2	1
CO4	2	2	2	1	2	2	1	1	3	1	2	1	2	2	1
CO5	1	2	1	1	1	2	1	1	3	1	2	1	2	2	1
Overall CO	2	2	1	1	2	2	1	1	2	1	1	1	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23034 **NATURAL GAS ENGINEERING**

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

1. To understand the natural gas reservoirs and their production.
2. This gives insight about the natural gas properties, utilization of natural gas
3. It covers Gas processing methods at the surface, Gas flow measurement and fundamentals, Gas Reservoir Performance, Volumetric measurement and Transportation.
4. It covers Natural gas production methods.
5. Importance of Unconventional Gas Reservoirs such as Gas Hydrates and Shale Gas

UNIT I INTRODUCTION **9**

Composition of Natural Gas, Supply and Demand, Utilization of Natural Gas, Natural Gas Industry, Natural Gas Reserves, Types of Natural Gas Resources, Future of the Natural Gas Industry, Physical properties of natural gas and hydrocarbon liquids associated with natural gas, Phase behaviour, Reservoir aspects of natural gas. The calorific value of gas and measurement

UNIT II WELL PERFORMANCE **9**

Well inflow performance relationship (IPR), Skin factor, Productivity Index, Gas well testing, Wellbore Performance: TPR Curve, Single Phase & multi-phase flow, Choke Performance: CPR Curve, Sonic and Subsonic Flow, Well Deliverability: Nodal Analysis

UNIT III NATURAL GAS PRODUCTION **9**

Natural Gas Production: Downstream, Surface Facilities, Principle of Separator, Design of Separator: Vertical, Horizontal; Two-Phase Separation, Three Phase Separation, Use of Mollier Diagrams.

UNIT IV NATURAL GAS PROCESSING **9**

Field separation and oil absorption process, Refrigeration and low-temperature processing, Liquefaction Process, Dehydration of Natural Gas, Sweetening of Natural gas and sulphur recovery. Processing for LPG, CNG, system, Conversion of gas to liquid, Gas Gathering System, Steady Flow in Simple Pipeline System, Steady State and non-Steady State Flow in Pipelines, Solution for Transient Flow.

UNIT V ISSUES AND CHALLENGES **9**

Underground Storage and Conservation of Natural Gas. LPG, NGL & LNG storage, Flow through pipeline, issues and solutions, Unconventional Production of Natural Gas: Shale Gas, Gas Hydrates, Coal bed Methane, Oil Shale, Pyrolysis of Carbonaceous Materials.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: This will help students to learn about the formation, composition, utilization and properties of natural gas.

CO2: Helps the students to understand the well performance

CO3: Learn the Natural gas production methods and separation techniques.

CO4: This unit will help students to understand different natural gas processing processes & flow in pipelines

CO5: This unit focuses on the issues and challenges during processing and production

TEXTBOOKS

1. B. Guo and A. Ghalambor, Natural Gas Engineering Handbook, Gulf Publishing Company, 2005, ISBN 0127999957, 9780127999951
2. D.L. Katz and R.L. Lee, Natural Gas Engineering, McGraw-Hill, 1990, ISBN 0070333521, 9780070333529
3. Boyan Guo Ali Ghalambor, “Natural Gas Engineering Handbook”, Gulf publishing company. 2012.

REFERENCES

1. B. Guo, W.C. Lyons and A. Ghalambor, Petroleum Production Engineering: A Computer Assisted Approach, Elseveir, 2007.
2. T. Ahmed and P. D. McKinney, Advanced Reservoir Engineering, Elsevier, 2005.
3. Petroleum Exploration Handbook: A Practical Manual Summarizing the Application of the Earth Sciences to Petroleum Exploration, Moody, Graham B. (editor), Published by McGraw Hill Book Company, New York, 1961, ISBN 10: 0070428670 / ISBN 13: 9780070428676.
4. Hydrocarbon Exploration and Production, 2nd edition, Frank Jahn, Mark Cook, Mark Graham, Elsevier Science, 2008, ISBN 0080568831, 9780080568836.
5. Developments in Petroleum Science, L.P. Dake (Eds.) Fundamentals of Reservoir Engineering Elsevier Science (1978), ISBN: 978-0-444-41667-4.
6. Oilfield Processing, Vol. II: Crude Oil, 1995, Francis S. Manning, Ph.D. P.E & Richard E.Thompson Ph.D. P.E

Course Articulation Matrix:

Course	Program Outcomes														
Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO3
CO1	2	2	2	1	2	2	1	2	2	1	1	1	2	2	1
CO2	1	2	1	1	2	2	1	2	2	2	1	1	2	2	2
CO3	2	1	2	1	2	2	1	2	2	1	1	1	2	2	1
CO4	1	1	2	2	2	2	1	1	3	1	2	1	2	2	1
CO5	1	2	1	1	2	2	1	1	3	1	2	1	2	2	1
Overall CO	2	1	2	1	2	2	1	1	2	2	1	1	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23035 ENVIRONMENTAL REGULATIONS, HEALTH & SAFETY IN PETROLEUM INDUSTRIES

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

1. To enable the students to learn the advanced techniques, automation, unit integration and instrumentation techniques in the refinery.
2. To enable students to understand the environmental regulations, safety and government policies on refinery
3. To provide wide exposure to the students about various legislations applicable to an industrial unit.
4. To provide exposure to the students about safety and health provisions related to hazardous processes as laid out in Factories Act 1948.
5. To enable students to learn the energy saving techniques and refinery economics

UNIT I ENVIRONMENTAL REGULATION AND GOVERNMENT POLICIES 9

Classes of petroleum-based on flash point- storage tank design- GAS/LIQUID/SOLID wastes from refinery units-environmental standards on air and water pollution and control - Solid waste management- Sludge conditioning and treatment and disposal- Effluent treatment plant-TTP-greenhouse gases-Bharat stages and its regulations- Recent modification for BS-6- Policies on biofuel-EBP-Biodiesel

UNIT II CORROSION & PROCESS CONTROL 9

Corrosion- reaction and types- refinery corrosion tests- controlling parameters- corrosion control in equipment and pipelines Instrumentation- Flow/pressure/temperature/level transmitter-Control systems and logics – controller types- mode of controllers- cascade, split range, ratio etc. - P/PI/PID controllers and control tuning

UNIT III REFINERY UNIT INTEGRATION AND RECENT TRENDS 9

Overall modern refinery flow sheet- products routing- naphtha utilization route up and integration-Diesel/gasoline/ATF/kerosene route up to blending header- Blending processes-line blending-Blending of diesel and MS calculation- LP model for blending operation- Recent trends in ADU with pre-flash- RFCC-OHCU-Prime G+-catalytic dewaxing- PSA technology-DWC technology- Blue H2 process-Pre-reforming- moving bed in CRU and isom-Advanced lube processing

UNIT IV HEALTH AND SAFETY IN THE PETROLEUM INDUSTRY 9

Health hazards in the Petroleum Industry: Toxicity, Physiological, Asphyxiation, respiratory and skin effects of petroleum hydrocarbons, sour gases. Safety System: Manual & automatic shutdown system, blow down systems. Gas detection system. Fire detection and suppression systems. Factories act 1948, Personal protection system & measures. HSE Policies. Disaster & crisis management in the Petroleum Industry, Environmental transport of petroleum wastes, Offshore oil spill and oil spill control.

UNIT V ENERGY SAVING AND REFINERY ECONOMICS 9

Furnace efficiency calculation-steam utilization- plume length- insulation of pipelines- heat tracing-steam traps-Standard Refinery Fuel Tonnage- Fuel and loss- operational cost- margin cost- refining capacity-complexity factor- crude oil evaluation and procurement-monthly production planning-cracks-Gross Refinery Margin-operation optimization by Linear Programming model-shutdown planning- Refinery Transfer Price-taxation-pricing

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Apply the regulations and government policies in refining industries.

CO2: Demonstrate knowledge of advanced techniques, automation and instrumentation techniques and corrosion in petroleum industries

CO3: Apply knowledge of unit integrations in refineries.

CO4: Study the health and safety aspects in refineries

CO5: Evaluate the basis on energy saving techniques and refinery economics

TEXTBOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press , 5th Edition, 2007, ISBN9780429207730
2. Coughanowr, D. R., & Leblanc, S. E. (2008). Introductory concepts. Process Systems Analysis and Control, 3rd Ed, 1-6, ISBN 978–0–07–339789–4—ISBN 0–07–339789–X
3. Smith,R.(2005).Chemical process:design and integration. JohnWiley&Sons, ISBN 0470011912, 9780470011911
4. Corrosion Control in the Oil and Gas Industry 1 st Edition, SankaraPapavinasam, 2013 ISBN: 9780123970220
5. Gilbert, M. Masters., “Introduction to Environmental Engineering and Science”, 3rd edition 2008, ISBN 1292038179, 9781292038179

REFERENCES

1. Luyben, W. L., Tyréus, B. D., &Luyben, M. L. (1998). Plant wide process control (Vol. 43). New York: McGraw-Hill.
2. Stephanopoulos, G. (1984). Chemical process control (Vol. 2). New Jersey: Prentice hall.
3. Gilbert M. Masters, Introduction to Environmental Engineering and Science, Prentice -Hall India , 2000
4. Cheremisinoff N.P. and Graffia M.L., “Environmental Health and Safety Management. A Guide to Compliance”, Pressure safety de-sign practices for refinery and chemical operations”, JaicoPublica-tion. 2003
5. Handley, W., “Industrial Safety Hand Book “, 2nd Edn., McGraw-Hill Book Company, 1969.
6. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., “Industrial Accident Prevention“, McGrawHill Book Co., 1980.
7. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994

Course Articulation Matrix:

Course	Program Outcomes												

Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	2	2	1	2	1	2	2	2	2	1
CO2	1	2	1	1	1	2	2	1	2	2	2	3	1	2	1
CO3	1	2	1	2	1	2	2	1	1	2	2	2	1	2	1
CO4	2	2	1	2	2	2	2	1	2	1	1	2	1	2	1
CO5	2	2	1	2	2	2	2	2	2	1	1	2	1	2	1
Overall CO	1	1	1	1	1	2	2	1	2	1	1	1	1	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23303 **CHEMICAL PROCESS CALCULATIONS** **LT P C**
3 0 0 3

COURSE OBJECTIVES:

1. To teach basic concepts of chemical engineering calculations that lays the foundation for subsequent courses in thermodynamics, unit operations, kinetics, and process dynamics and control.
2. To impart knowledge on process flow sheet, writing mass and energy balance to establish the relations between known and unknown process variables.
3. To formulate the material and energy balances on chemical processes and to obtain solutions using appropriate methods.
4. To utilize stoichiometry and thermodynamics in the analysis and design of chemical processes
5. Apply problem-solving skills to real-world chemical engineering scenarios, ensuring safety, efficiency, and sustainability in process operations.

UNIT I INTRODUCTION TO CHEMICAL CALCULATIONS AND FUNDAMENTALS OF STOICHIOMETRY **9**

Systems of Units and Dimensions, Conversion of Units, Dimensional Homogeneity and Data Analysis, Numerical Calculation and Estimation Computational Techniques, Processes and Process Variables; Use of Molal Quantities, Densities and Specific gravity, Composition of solids, liquids and gases, other expression for concentration

UNIT II MATERIAL BALANCES **9**

Flow-sheet - degrees of freedom and its importance in flow-sheet, Material Balance Calculations for unit operations; Balances on Multiple Unit Processes, Recycle, bypass, and purge calculations; Chemical Reaction Stoichiometry, Balances on Reactive Processes, Combustion Reactions; computer-based calculations.

UNIT III SINGLE AND MULTIPHASE SYSTEMS **9**

Single-Phase Systems - Liquid and Solid Densities, Ideal Gases, Equations of State for Non-ideal Gases, The Compressibility Factor Equation of State; Multiphase Systems - Single-Component Phase Equilibrium, The Gibbs Phase Rule; Gas-Liquid Systems - One Condensable Component, Multicomponent Gas-Liquid Systems; Solutions of Solids in Liquids; Equilibrium Between Two Liquid Phases

UNIT IV ENERGY AND ENERGY BALANCES **9**

Forms of Energy - The First Law of Thermodynamics, Kinetic and Potential Energy; Energy Balances on Closed Systems, Energy Balances on Open Systems at Steady State; Tables of Thermodynamic Data; Energy Balance Procedures; Balances on Nonreactive Processes - Elements of Energy Balance Calculations, Changes in Pressure at Constant Temperature, Changes in Temperature, Phase Change Operations, Mixing and Solution

UNIT V BALANCES ON REACTIVE AND TRANSIENT PROCESSES **9**

Heats of Reaction - Measurement and Calculation of Heats of Reaction, Hess's Law, Formation Reactions and Heats of Formation, Heats of Combustion, Energy Balances on Reactive Processes, Fuels and Combustion; Transient Processes - The General Balance Equation, Material Balances, Energy Balances on Single-Phase Nonreactive Processes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Perform the basic chemical calculations, systems of units and measurement scales and methods of analysis.

CO2: Describe process flow diagrams and perform steady-state mass balance calculations for batch and continuous processes.

CO3: Analyze the single and multiphase systems, determine the physical and chemical properties of flows and stream component.

CO4: Assess energy balance procedures, Develop and solve energy balance calculations for nonreactive processes.

CO5: Formulate and Solve material and energy balance for reactive and unsteady state processes.

TEXT BOOKS

1. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", 3rd Edition, John Wiley & Sons, New York, 2005.
2. David M. Himmelblau and James B. Riggs, "Basic Principles and Calculations in Chemical Engineering", Eighth Edition, Prentice Hall Inc., 2014

REFERENCES

1. Bhatt, B.I and Vora, S.M., "Stoichiometry ", 4th Edition, Tata McGraw-Hill, 2004.
2. Hougen O A, Watson K M and Ragatz R A, "Chemical process principles" Part 1: Material and Energy Balances, 2nd Ed., John Wiley & Sons, 2004.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	1	1	2	1	2	1	3	2	1	3	3	3	1
CO2	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
CO3	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
CO4	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
CO5	3	3	3	3	2	1	2	1	3	2	1	3	3	3	1
Overall	3	3	2.6	2.6	2	1	2	1	3	2	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23009 **MATERIALS OF CONSTRUCTION** **LT P C**
3 0 0 3

COURSE OBJECTIVES:

1. To make the students understand materials selection, based on their properties and processing.
2. To enable the students, select the suitable materials based on their mechanical behavior.
3. To familiarize the students with the phase diagrams and phase transformation of materials.
4. To equip students with the knowledge on types and manufacturing of metals.
5. To develop students' skill in selection of materials required for processing in chemical industries.

UNIT I INTRODUCTION **9**

Structure – Property relationship - Selection criteria and processes: General criteria of selection of materials in process industries. Properties: Mechanical, Thermal, Physical, Chemical, Electrical, Magnetic and Technological properties. Processing of Metals and Alloys- Casting, Hot and cold rolling, Forging, Extrusion, Deep drawing.

UNIT II MECHANICAL BEHAVIOUR **9**

Elastic, Anelastic and Viscoelastic Behaviour – Introduction to Slip, Slip planes, Plastic Deformation by Slip: Critical resolved shear stress, Mechanism of Creep, Creep Resistant Materials – Fracture: Ductile and Brittle, Fatigue fracture, Griffith's theory, S-N curves, Fracture toughness.

UNIT III PHASE DIAGRAMS AND PHASE TRANSFORMATIONS **9**

Gibb's Phase rule : Unary and Binary phase diagrams , Al CO - Cr O , Pb-Sn, Ag-Pt and Iron-Iron Carbide Phase Diagram – Lever rule – Invariant reactions- TTT diagrams – Micro structural changes – Nucleation and growth – Martensitic transformations – Solidification and Crystallization – Glass transition – Recrystallization and Grain growth.

UNIT IV FERROUS, NON-FERROUS METALS AND COMPOSITES **9**

Pig iron, Cast iron, Mild Steel-Manufacturing process, properties &, Applications Stainless steels, Special Alloy steels-properties and uses; Heat treatment of plain-carbon steels. Manufacturing methods of Lead, Tin and Magnesium. Properties and applications in process industries. FRP-Fiber Reinforced Plastics (FRP), manufacturing methods; Asphalt and Asphalt mixtures; Wood.

UNIT V NANOMATERIALS **9**

Introduction to Nanotechnology- Zero Dimensional Nano Structures – Nano particles – One Dimensional Nano Structures- Nano wires and Nano rods – Two Dimensional Nano Structures, Films – Special Nano Materials - Nano Structures fabricated by Physical Techniques – Characterisation and Properties of Nano Materials – Applications of Nano Structures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Consider the basic material knowledge such as internal structure, properties and processing of metals.

CO2: Appreciate the mechanical behavior of the metals.

CO3: Demonstrate phase diagrams and phase transformations of metals.
CO4: Familiarize the manufacturing process of ferrous, non-ferrous metals and composites and nanomaterials.
CO5: Apply knowledge of various materials properties and processing methods in chemical industry.

TEXT BOOKS

1. William D. Callister, “Materials Science and Engineering”,7th edn, John Wiley & Sons, Inc.
2. V. Raghavan, Materials Science and Engineering, Prentice Hall
3. S. K. Hajra Choudhury, "Material Science and processes", 1stEdn. , 1977. Indian Book Distribution Co., Calcutta.
4. Brenner D, “Hand book of Nanoscience and technology” (2002)

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1. Henry R Clauster, “Industrial and Engineering Materials” McGraw Hill Book Co. (1975)
2. Kingery W D and Bowen H K and Unimann D R, “Introduction to Ceramics” John Wiley and Sons, Second edition (1991)
3. Fahrner W R, “Nanotechnology and Nanoeletronics” Springer International edition(2005)
4. Budinsky K G and Budinsky K M “ Engineering Materials- Properties and Selection” Prentice Hall of India (2002)

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO2	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO4	3	3	3	3	2	3	2	2	2	2	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	3	2	2	3	3	3	3
Avg	3	3	3	3	2.8	2.8	2	2	2.2	2	2.2	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23C02 OPTIMIZATION OF CHEMICAL PROCESSES LT P C
3 0 0 3

COURSE OBJECTIVES:

1. To impart knowledge on optimization techniques in chemical engineering processes
2. To enable students to understand the concepts of optimization
3. To obtain a mathematical representation of the optimization problem
4. To describes different solution techniques that can be used to actually solve
5. To emphasis on problems arising in Chemical Engineering applications

UNIT I PROBLEM FORMULATION & CLASSIFCATION 9

Introduction; formulation of objective functions; fitting models to data; classification of functions; necessary and sufficient conditions for optimum; unimodal, multimodal functions; analytical methods

UNIT II LINEAR PROGRAMMING 9

Review on basic concepts of LP formulations; Simplex methods; Big-M method, two phase method and Duality in linear programming.

UNIT III NON-LINEAR PROGRAMMING 9

The Lagrange multiplier method, Integer, quadratic, geometric and dynamic programming

UNIT IV NUMERICAL METHODS 9

Unimodal functions; Newton, quasi Newton, secant methods; region elimination methods, polynomial approximation; quadratic and cubic interpolation techniques for optimum. Multimodal functions; direct methods; Powell's technique; indirect methods; gradient and conjugate gradient methods; secant method

UNIT V APPLICATIONS 9

Heat transfer and energy conservation; separation processes; fluid flow systems; reactor design and operation; large scale systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Be familiar on the basic problem formulation and optimization.

CO2: Evaluate mathematical characteristics of Linear programming

CO3: Demonstrate computational solution techniques for nonlinear unconstrained optimization.

CO4: access various techniques used in constrained optimization

CO5: Apply the optimal and dynamic optimization.

TEXT BOOKS

1. Edgar T.F., Himmelblau D.M., Lasdon,L.S., Optimization of Chemical Processes, Second Edition, McGraw-Hill, New York, 2001.
2. Rao, S. S., Engineering Optimization: Theory and Practice, Fifth Edition, Wiley, New York, 2019.
3. Ramirez, W.; " Computational Methods in Process Simulation ", 2nd Edn., Butterworths Publishers, New York, 2000.

REFERENCES

1. Reklaitis G.V., Ravindran A., Ragsdell, K.M., Engineering Optimization, Wiley, New York, 1980.
2. Chaves, I.D.G., López, J.R.G., Zapata, J.L.G., Robayo, A.L., Niño, G.R., process optimization in chemical engineering in :process analysis and simulation in chemical engineering, springer, cham., 2016.
3. MATLAB Documentation (https://www.mathworks.com)
4. Engineering Optimization: Methods and Applications - A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, 2nd Edition, Wiley India, 2006 ,

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	2	2	2	1	1	-	1	1	1	2	2	2	2
CO2	1	2	2	2	2	1	1	-	1	2	2	2	2	2	2
CO3	1	2	2	2	2	1	1	-	1	2	2	2	2	2	2
CO4	2	2	2	2	2	1	1	-	1	2	2	2	2	2	2
CO5	2	2	2	2	2	1	1	-	1	2	2	2	2	2	2
overall	1	2	2	2	2	1	1	-	1	2	2	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23011	PROCESS PLANT UTILITIES	LT P C 3 0 0 3

OBJECTIVES

1. Provide a comprehensive understanding of industrial water requirements and treatment methods to ensure the efficient use and management of water in industrial processes.
2. Equip students with knowledge about steam generation, types of steam generators, and techniques to address common issues such as scaling and corrosion in boilers.
3. Introduce the principles of refrigeration and ventilation systems, including different refrigeration cycles and the production of cryogenic temperatures, to enhance the understanding of temperature control in industrial applications.
4. Familiarize students with the performance characteristics and applications of compressors and vacuum pumps, as well as the associated piping systems, lubrication, and moisture removal techniques.
5. Highlight the importance of insulation in various industrial processes, covering insulation materials and techniques for different temperature ranges to optimize energy efficiency and process effectiveness.

UNIT I INDUSTRIAL WATER 9

Hard and Soft water, Requisites of Industrial Water and its uses. Methods of Water Treatment such as Chemical Softening and Demineralization, Resins used for Water Softening, Reverse Osmosis, Effects of impure Boiler Feed Water.

UNIT II STEAM GENERATION 9

Properties of Steam, Types of Steam Generator such as Solid Fuel Fired Boiler, Waste Gas Fired Boiler and Fluidized Bed Boiler. Scaling and Corrosion in boiler and Trouble Shooting. Steam Traps and Accessories

UNIT III REFRIGERATION AND VENTILATION 9

Principles of refrigeration, refrigeration systems like vapor compression and vapor absorption cycles, types of Refrigeration Cycles and their importance. Production of cryogenic temperature. Exhaust

UNIT IV COMPRESSORS AND VACUUM PUMPS 9

Compressors and Vacuum pumps- Performance characteristics of Compressor and Vacuum pumps. Piping systems. Air leaks. Lubrication. Oil and moisture removal.

UNIT V INSULATION 9

Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and subzero temperatures, including cryogenic insulation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO 1:determine the importance of process utility and recognize importance of treatment and conservation of water.

CO 2: Outline the basic properties of steam along with their generation and utilization of steam in process plants.

CO 3: Identify the role of refrigerant for different refrigeration systems and their importations, ventilation systems.

CO 4: Explain the various types of compressors and vacuum pumps, piping systems used in industries.

CO 5: Examine the suitable insulation for different materials piping, fittings and valves.

TEXT BOOKS

1. Ballaney, P.L., Thermal Engineering, Khanna Publisher New Delhi, 1981 ISBN-10 : 8174090312
2. Goodall,P.M., " The efficient use of steam", IPC Science and Technology(1980) ISBN 0861030184, 9780861030187
3. P. N. Ananthanarayan, “Basic Refrigeration & Air conditioning”, Tata McGraw Hill, New Delhi, 2007. ISBN 1259062708

REFERENCES

1. Perry, R.H., and Green, D.W,: Perry's Chemical Engineers Handbook, Eighth Edition, McGraw Hill (ISE), 2008.
2. W.L McCabe J.C.Smith, and Harriot. P.: Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill, Publication,2008.
3. Ludwig, E.E.: Applied Process Design for Chemical and Petrochemical Plants, Gulf Publishing Company, Texas, Vol.1, 4th Edition 2007, Vol.2, 4th Edition 2010, Vol.3, 3rd Edition 2011.
4. Ashutosh Pande, "Plant Utilities", Vipul Prakashan, Mumbai.1999.
5. Nordell,Eskel, "Water treatment for industrial and other uses", Reinhold publishing corporation, Newyork.(1961)

Course Articulation Matrix:

Course Outcomes	Program Outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	1	3	3	2	-	-	3	2	3	2	1
CO2	3	3	1	1	2	-	1	1	-	-	2	2	3	1	1
CO3	3	2	1	1	2	-	1	-	-	-	1	2	3	3	1
CO4	3	2	1	1	2	-	-	-	-	-	1	2	3	3	1
CO5	3	2	1	1	2	-	-	-	-	-	1	1	3	3	1
Over all	3	2	1	1	2	1	2	1	-	-	2	3	3	3	1

CH23001	CHEMICAL PROCESS DESIGN	LT P C 3 0 0 3

COURSE OBJECTIVES:

1. To understand the concept of chemical processes and development.
2. To gain knowledge on selecting the type of reaction and reactors to enhance the product development.
3. To understand the concepts separation system.
4. To understand and implement the concept on heat integration on a chemical process.
5. To gain knowledge on process optimization.

UNIT I GENERAL PROCESS CONSIDERATION 9

Process design development, general design consideration, formulation of design problem-the hierarchy and approaches of chemical process design and integration.

UNIT II CHOICE OF REACTORS 9

Reactions and reactor systems, design of idealized reactors, reactor performance, reactor conditions and configurations, Reactor networks in process flow sheets.

UNIT III CHOICE OF SEPARATORS 9

Separation systems introduction - choice of separator for homogeneous fluid mixtures, choice of separator for heterogeneous fluid mixtures, multicomponent distillation, distillation sequencing, separation systems in process flowsheets.

UNIT IV ENERGY INTEGRATION AND HEAT EXCHANGER NETWORK SYNTHESIS 9

Heat exchangers, Heat exchange networking, HEN design, heat exchanger integration in reactor and distillation column, energy target – pinch technology, composite curves, problem table algorithm.

UNIT V RECYCLE SYSTEMS AND OPTIMIZATION 9

Functions of process Recycles in continuous and batch processes, optimization of recycle loop in continuous and batch process, o optimization approaches to optimal design, role of simulations in process design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understand the concepts of chemical process's design and development.
CO2: Evaluate the choice of reactors and configure reactor design.
CO3: Execute the concept of separation processes.
CO4: Apply the skill in thermal design of heat transfer equipment and assessing thermal efficiency.
CO5: Apply the concepts of process recycling and optimize engineering problems in any chemical processes.

TEXT BOOKS

1. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, West Sussex, UK, 2005.

2. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers, 5th Edition, McGraw-Hill International Editions (Chemical Engineering Series), NewYork, 2003.
3. Douglas, J. M., Conceptual design of chemical processes, Vol. 1110, New York: McGraw-Hill, 1988.

REFERENCES

1. Robert E. Treybal, Mass Transfer Operations, 3rd Edition. McGraw-Hill International Editions, Singapore, 1981.
2. Sinnott, R. K., Coulson & Richardson's Chemical Enginering: Volume 6, Chemical Engineering Design, Elsevier Butterworth Heinemann, 1999.
3. Xian Wen Ng, Concise Guide to Heat Exchanger Network Design, Springer Nature Switzerland, 2021.
4. Xing Luo, Wilfried Roetzel, Dezhen Chen, Design and Operation of Heat Exchangers and their Networks, 1st Edition, Academic Press, 2019.
5. Seider, W. D., Seader, J. D., & Lewin, D. R. Product & Process Design Principles: Synthesis, Analysis and Evaluation, John Wiley & Sons, 2009.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O 1	PS O 2	PS O 3
CO1	3	3	3	3	2	-	-	-	3	2	3	2	2	3	-
CO2	3	3	3	3	3	-	1	-	3	3	3	3	3	3	-
CO3	3	3	3	3	3	-	1	-	3	3	3	2	3	-	-
CO4	3	3	3	3	3	-	-	-	3	3			1	1	-
CO5	3	3	3	3	3	3	3	-	3	3	3	3	3	3	2
Overall	3	3	3	3	3	1	1	-	3	3	2	2	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23036	MODERN SEPARATION TECHNIQUES	LT P C 3 0 0 3

COURSE OBJECTIVES:

The objective of this course is

1. To impart knowledge on the fundamentals and the basic concepts of conventional and advanced separation process.
2. To provide exposure on new, emerging and non-traditional separation techniques and their potential applications
3. To analyze and evaluate the performance of different separation processes, considering factors such as efficiency, selectivity, and energy consumption.
4. To explore emerging and novel separation technologies, including hybrid processes
5. To address practical challenges encountered in industrial separation processes, such as scaling up from laboratory to industrial scale

UNIT I BASICS OF SEPARATION PROCESS 9

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

UNIT II MEMBRANE SEPARATIONS 9

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

UNIT III SEPARATION BY ADSORPTION AND ION EXCHANGE 9

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

UNIT IV CHROMATOGRAPHY AND ELECTROPHORESIS 9

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

UNIT V OTHER TECHNIQUES 9

Separation involving Lyophilization, Reactive and catalytic distillation, Advantage & disadvantages, zone melting, Adductive Crystallization, melt Crystallization, Supercritical fluid Extraction, Oil spill Management, Hybrid Systems, Industrial Effluent Treatment by Modern Techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of this course, students will be able to

CO1: Apply the key concepts of conventional and advanced separation processes.
CO2: Differentiate the principle of membrane separation for various systems and develop design equations.
CO3: Evaluate the principles of adsorption and Ion exchange techniques
CO4: Conceptualize the separation system for multi-component mixtures using chromatographic techniques and electrophoresis.
CO5: Get familiarize with new, emerging and non-traditional separation techniques and their potential applications in chemical and allied process industries.

TEXT BOOK

1. Ronald W.Roussel - " Handbook of Separation Process Technology ", John Wiley,New York, 1987 ISBN 8126519037
2. Seader J.D. and Henley E.J., “Separation Process Principles”, 2nd Ed., John Wiley, 2006. ISBN 1118139623
3. Schoew, H.M. - " New Chemical Engineering Separation Techniques ", Interscience Publishers, 1972. B000E4JOC2

REFERENCES

1. Lacey, R.E. and S.Loeb - "Industrial Processing with Membranes", Wiley – InterScience, New York, 1972.
2. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd.,1982.
3. Osadar, Varid Nakagawa I - " Membrance Science and Technology ", MarcelDekkar (1992).
4. Wankat, P., “Equilibrium Stage Separations”, Prentice Hall, 1993. 5. Wankat, P., “Rate Controlled Separations”, Prentice Hall, 1993.
5. Philip C. Wankat, “Separation Process Engineering”, Prentice-Hall, 4th Edition, 2016.
6. Christie J Geankoplis, “Transport Processes and Separation Process principles”, Prentice-Hall of India Private Ltd, New Delhi, 4th Edition 2006.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	1	2	-	1	1	-	-	-	1	3	3	3	2
CO2	3	1	1	2	1	1	1	-	-	-	1	3	3	3	2
CO3	3	1	1	2	1	1	1	-	-	-	1	3	3	3	2
CO4	3	1	1	2	1	1	1	-	-	-	1	3	3	3	2
CO5	3	1	1	2	1	1	1	-	-	-	1	3	3	3	2
Over all	3	1	1	2	1	1	1	-	-	-	1	3	3	3	2

LIST OF OPEN ELECTIVES

CH23901	POLYMER TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To impart knowledge of types of polymers, elastomers and resins.
2. To provide knowledge on different polymerization reactions and polymerization techniques.
3. To provide knowledge about polymer processing.
4. To instruct knowledge on important properties of polymers, elastomers and application oriented polymers.
5. To know the importance of polymer composites.

UNIT I GENERAL ASPECTS OF POLYMERS 9

Classification of polymers- natural and synthetic, thermoplastic and thermosetting. Types and mechanism of polymerization: addition (free radical, cationic, anionic and living); condensation and copolymerization, Functionality-degree of polymerization. Techniques of polymerization: Bulk, emulsion, solution and suspension.

UNIT II POLYMER PROCESSING 9

Additives and mixing process, types of additives. Types of moulds – ejector system – ejection techniques – mould cooling – CAD / CAM, extrusion moulding, injection moulding, special moulding techniques.

UNIT III ELASTOMERS AND APPLICATION ORIENTED POLYMERS 9

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

UNIT IV PROPERTIES OF POLYMER MATERIALS 9

Molecular weight – number average and weight average, polydispersity, glass transition temperature, mechanical properties, thermal properties, electrical properties, rheological properties, and optical properties.

UNIT V POLYMER COMPOSITES 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Understand the fundamentals of polymers and mechanism of polymerization techniques.
CO2: Apply the mechanism and effectiveness of polymerization in making finished materials.
CO3: Understand the knowledge of elastomers and its processing.
CO4: Understand the knowledge of molecular weight, glass transition temperature and othe important properties of polymer.
CO5: Understand the generals aspects of polymer composite materials.

TEXT BOOKS

1. Birley, Haworth, Batchelor, Physics of Plastics – Processing Properties and Materials Engineering, Hamer Publication, 1992. ISBN: 3446150986.
2. F.W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2007. ISBN: 9788126511105.
3. R. Griskey, Polymer Process Engineering, Springer Netherlands, 2012. ISBN:9789401105811

REFERENCE

1. Vishu Shah, Hand book of Plastics Testing and Failure Analysis, 3rd Edition, John-Willey &Sons, New York, 2007. ISBN:9780470100417.
2. Sabu Thomas, Kuruvilla Josep, “Polymer Composites: Volume 1” First Edition, Wiley, 2012. ISBN:9783527645237.
3. Zehev Tadmor, Costas G. Gogos, Principles of Polymer Processing, 2nd Edition, Willey, 2013. ISBN:9780470355923.
4. Morton-Jones, John W. Ellis, Polymer Products: Design, Materials and Processing, First Edition, Springer Netherlands, 2012. ISBN:9789400941014.
5. George Odian, Principles of polymerization, 4th Edition, Willey, 2004. ISBN:9780471274001.

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	-	-	-	2	-	1	-	1	-	-	-	2	2	-	-
CO2	-	-	-	-	-	-	-	1	-	-	-	3	2	1	-
CO3	-	-	-	2	-	-	2	1	-	2	-	1	-	-	2
CO4	-	-	2	3	-	1	2	1	-	-	- -	-	-	-	1
CO5	-	-	3	3	-	-	3	-	-	3	-	1	3	-	1
Overall	-	-	3	2	-	1	2	1	-	2	-	1	2	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23902	FRONTIERS OF CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To gain knowledge on the latest trends to be followed in the process industries
2. To understand the difference between process design and product design
3. To know the ways of harnessing the renewable energy
4. To learn about the properties of various materials.
5. To understand the concept of bioengineering

UNIT I PROCESS INTENSIFICATION 9

Novel reactor configurations; combination of reaction and separation; use of different energy fields, lab on a chip.

UNIT II CHEMICAL PRODUCT DESIGN 9

Scope and importance; identification of needs and specifications; sources of ideas and screening ideas; selection of product idea; process development for product manufacture; specialty chemical manufacture; economic aspects.

UNIT III RENEWABLE ENERGY 9

Hydrogen production, Hydrogen economy, Fuel Cell Technology, biofuel cells and bio hydrogen,

solar energy

UNIT IV MATERIALS ENGINEERING 9

Polymers and composites, ceramics and glasses, colloidal dispersions and nanoparticles, thin films and electronic materials

UNIT V BIOENGINEERING 9

Bioengineer, Biomechanical concepts, bio transport and biomaterials, blood rheology & heart mechanics, biomolecular and cellular engineering, drug discovery and development.

TOTAL: 45 PERIODS

TEXT BOOK

1. Keil, F. J., Modeling of Process Intensification Wiley-VCH Verlag GmbH & Co. KGaA2007 ISBN 3527610596
2. Cussler, E.l. and Moggridge, G.D., “Chemical product design” Cambridge University Press, Cambridge, 2001 ISBN 113949791X,
3. Hoffmann,P, Tomorrow’s energy: hydrogen, fuel cells, and the prospects for a cleaner planet, MIT Press, Sabon, 2002 ISBN 026258221X, 9780262582216

REFERENCE BOOKS

1. Mitchell, B.S., An introduction to materials engineering and science for chemical and materials engineers, John Wiley and Sons Inc., New Jersey, 2004

COURSE OUTCOMES

CO1: Apply the chemical Engineering concepts,
CO2: Determine the product design and process design.
CO3: Apply knowledge on renewable energy, energy economy
CO4: Differentiate the Polymers and composites, ceramics and glasses, colloidal dispersions

CO5: Evaluate nanoparticles, thin films and electronic materials

Course Articulation Matrix:

Course Outcomes	Program Outcomes														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	2	2	1		1	1	-	1	-	3	3	3	2
CO2	3	3	2	2	1	1	1	1	-	1	-	3	3	3	2
CO3	3	3	2	2	1	1	1	1	-	1	-	3	3	3	2
CO4	3	3	2	2	1	2	1	1	-	1	-	3	3	3	2
CO5	3	3	2	2	1	2	1	1	-	1	-	3	3	3	2
CO6	3	3	2	2	1	2	1	1	-	1	-	3	3	3	2
Overall	3	3	2	2	1	2	1	1	-	1	-	3	3	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EMERGING TECHNOLOGY COURSES

CH23E03	SUSTAINABLE MATERIAL AND ELECTRONIC WASTES RECYCLING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Understand the principles and methods of materials recycling and waste management.
2. Learn waste characterization techniques and their applications in waste processing and resource recovery.
3. Analyze metal waste recycling processes for aluminum, copper, and zinc industrial waste.
4. Explore electronic waste recycling, including printed circuit boards and spent batteries.
5. Investigate emerging technologies in waste recycling and material separation.

UNIT I INTRODUCTION TO MATERIALS RECYCLING AND WASTE MANAGEMENT

Introduction to Materials Recycling and waste management, Categories of metallurgical and electronic waste. Key unit operations involved in pre-treatment of metallurgical and electronic waste, Application of pyrometallurgy, hydrometallurgy and electrometallurgy and refining for Material separation and enrichment of raw materials.

UNIT II WASTE CHARACTERIZATION TECHNIQUES

Waste Characterization- Introduction- Principle of Spectroscopic Techniques- Infrared Spectroscopy, Scanning Electron Microscopy, Electron Microprobe (MP), Proton Induced X-ray Emission (PIXE), X-Ray Diffraction, On-line Identification for Recyclable Materials, Using Waste Characterization in Waste Processing and Resource Recovery, Environmental Testing

UNIT III METAL WASTE RECYCLING

Metal waste recycling: Aluminium industrial waste, dross, scrap, red mud, spent pot lining, salt slag.: Metallurgical waste recycling: Copper industrial waste, smelter slags, raffinates, spent electrolytes, Zinc industrial waste, zinc ash, zinc dross, flue dust and scraps

UNIT IV ELECTRONIC WASTE RECYCLING

Electronic waste recycling: Waste Printed Circuit Board, delamination and metal recovery, Spent batteries and recovery of valuable materials from waste electrodes, Environmental impacts of materials recycling

UNIT V EMERGING TECHNOLOGIES IN WASTE RECYCLING AND SEPARATION

Emerging New Technologies: Magnetic Carrier Technology. Separation by Silica-Polyamine Complexes, Molecular Recognition Technology, Separation in Magnetic Fluids, Mesoporous Adsorbents, Liquid Membrane Processes, Nanofiltration, Double Membrane Electrolytic Cell (DMEC), Air Assisted Solvent Extraction

COURSE OUTCOMES

CO1: An introduction to metal and electronic waste, including the opportunities presented by zero-waste technologies and solutions

CO2: Explorations of waste management and characterization

CO3: Practical discussions of approaches for estimating waste generation and the materials used in metal and electronic equipment and manufacturing perspectives

CO4: In-depth treatments of various recycling technologies, including physical separation, pyrometallurgy, hydrometallurgy, and biohydrometallurgy

CO5: emerging new technologies in waste separations and treatment methodologies.

TEXT BOOKS:

1. Resource Recovery and Recycling from Metallurgical Wastes, Ed:S. Ramachandra Rao, waste Management Series, 7, Elsevier, 1st Edition, 2006. ISBN 0080451314, 9780080451312
2. Resource Recovery and Recycling from Waste Metal Dust, Daniel Ogochukwu Okanigbe, Abimbola Patricia Popoola, Springer Cham, 978-3-031-22491-1,Edition 1, 2023 ISBN-10 : 3031224949
3. Electronic Waste: Recycling and Reprocessing for a Sustainable Future,Maria E. Holuszko, Amit Kumar, Denise C.R. Espinosa, Print ISBN:9783527344901 , Wiley-VCH GmbH,2022 ISBN: 978-3-527-81640-8

REFERENCES:

1. Electronic Waste Recycling Techniques, Hugo Marcelo Veit and Andrea Moura Bernardes, Topics in Mining, Metallurgy and MaterialsEngineering, Springer International Publishing Switzerland,2020
2. Electronic Waste Management, R. E. Heister and R. M. Harrison, Issues in Environmental Science and Technology, 27, RSC Publishing, Cambridge.

Course Outcomes	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	1	2	1	2	2	1	1	3	2	2
CO2	3	3	2	2	2	2	2	2	2	2	2	1	3	3	2
CO3	2	3	3	2	2	2	2	1	2	2	2	2	3	2	2
CO4	3	3	3	3	3	2	2	2	2	2	2	2	3	2	3
CO5	2	2	2	3	3	3	2	1	2	2	2	2	3	3	2
Overall	2.6	2.6	2.4	2.4	2.4	2	2	1.4	2	2	1.8	1.6	3	2.4	2.2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23E02 PROCESS INTENSIFICATION IN CHEMICAL INDUSTRIES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. Understand the principles and strategies of process intensification.
2. Analyze the role of process intensification in sustainable development.
3. Explore cavitation-based process intensification and monolith reactor applications.
4. Examine intensified distillation, extraction, ion exchange, and membrane processes.
   Learn about microprocess technology and its application in process intensification.

UNIT I INTRODUCTION AND MECHANISM PROCESS INTENSIFICATION 9

History, Philosophy and Concept, Principle Features, Strategies and domain based techniques; Intensification by fluid flow process, Mechanism of Intensification by mixing, Intensification in Reactive system;

UNIT II ROLE AND DESIGN TECHNIQUE ROLE OF PROCESS INTENSIFICATION IN SUSTAINABLE DEVELOPMENT 9

Problems leading to sustainable development, Concept, Issues and Challenges, Strategies in process design; Scales and stages of process intensification, Methods and Tools for Achieving sustainable design, Multi-level Computer aided tools

UNIT III PROCESS INTENSIFICATION BY CAVITATION, MONOLITH REACTOR 9

Introduction and Mechanism of Cavitation-based PI, Cavitation Reactor Configurations and activity, Parametric effects on cavitation. Introduction of monolith reactor, Preparation of monolithic catalyst, Application of monolithic catalyst, Hydrodynamics, transport of monolithic reactor

UNIT IV PROCESS INTENSIFICATION IN DISTILLATION, EXTRACTION, ION EXCHANGE, MEMBRANE 9

Introduction and Principles, Types of Intensified Distillation Units, Design of membrane-assisted distillation; Introduction and Principles, Supercritical extraction for process intensification, Introduction to membrane and its principles, Membrane engineering in process intensification

UNIT V MICRO PROCESS TECHNOLOGY IN PROCESS INTENSIFICATION 9

Introduction to microprocess technology, Process Intensification by Microreactors, Hydrodynamics and transport in microchannel based microreactor

COURSE OUTCOMES:

CO1: Analyze and apply the principles and techniques of process intensification in fluid flow processes and reactive systems.

CO2: Evaluate sustainable development issues and strategies in process design, including the use of multi-level computer-aided tools for sustainable design.

CO3: Explain and implement cavitation-based process intensification techniques and the design and application of monolithic catalysts in reactors.

CO4: Design and optimize intensified distillation units, including membrane-assisted distillation and supercritical extraction processes.

CO5: Apply microprocess technology principles to develop and optimize microreactors, focusing on hydrodynamics and transport within microchannel-based systems.

TEXT BOOKS:

1. Kamelia Boodhoo and Adam Harvey. Process Intensification for Green Chemistry Engineering Solutions for Sustainable Chemical Processing, Edited by Kamelia Boodhoo and Adam Harvey , School of Chemical Engineering & Advanced Materials Newcastle University, UK. Willey, 2013. ISBN 9781118498521
2. Juan¬Gabriel¬Segovia-Hernández¬ Adrián¬Bonilla-Petriciolet Editors, Process Intensi cation in Chemical Engineering Design Optimization and Control, Springer, 2016 ISBN 3319283928,
3. David Reay, Colin Ramshaw, and Adam Harvey, Process Intensification: Engineering for efficiency, sustainability and flexibility, IchemE, 2nd edition, 2013, Elsevier. ISBN 0080983057

REFERENCES:

1. S. K. Majumder, Hydrodynamics and Transport Processes of Inverse Bubbly Flow, 1st ed. Elsevier, Amsterdam (2016)

Course Outcomes	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	2	2	2	2	2	2	3	2	2
CO2	3	3	2	2	2	3	3	1	2	2	2	2	3	3	2
CO3	3	3	3	3	3	2	2	2	2	2	2	2	3	2	3
CO4	3	3	3	3	3	3	2	2	2	2	2	2	3	2	3
CO5	3	2	2	3	3	3	2	1	2	2	2	2	3	3	2
Overall	3	2.8	2.6	2.6	2.8	2.6	2.2	1.6	2	2	2	2	3	2.4	2.4

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23E01 ARTIFICIAL INTELLIGENCE FOR CHEMICAL ENGINEERS LT P C
3 0 0 3

COURSE OBJECTIVES:

1. Understand the fundamentals and applications of AI in chemical engineering.
2. Learn the principles and operations of Deep Artificial Neural Networks (DNN).
3. Explore Convolutional Neural Networks (CNN) and their role in pattern recognition.
4. Study notable deep networks and the concept of Transfer Learning.
   Examine sequence modeling using Recurrent Neural Networks (RNN) and their variants.

UNIT I : Introduction **9**

Introduction to Artificial Intelligence; Applications of AI in chemical engineering areas like Process control, Process design, Planning and operations, Modelling and simulation and Product design, development and selection like Separation Design, Heat-Exchanger Network Synthesis, Thermodynamic Model Selection and Physical Property Estimation,

UNIT II Deep Artificial neural networks (DNN) **9**

Activation functions and their importance in incorporating nonlinearities into the predictive models. The feedforward process in ANN layers with dense fully connected layers. The error(loss) functions as a measure of the ANN performance. Backpropagation algorithm for neuron learning. Various optimization algorithms for neuron learning like Adams, Stochastic Gradient, Descent and their variations.

UNIT III Convolution neural networks (CNN). **9**

The drawbacks of Deep ANN. How CNN take into account the spatial patterns. The working of the CNN in pattern recognition. The role of kernels, pooling, padding and stride in CNN learning. How the kernels help in reducing the learning parameters (weight sharing). One-, two- and three-dimensional convolutions. The problems of vanishing/exploding gradients in deep networks.

UNIT IV Advanced Deep Networks and Transfer Learning **9**

Some outstanding deep networks proposed like AlexNet, VGGNet, Inception, GoogleNet and ResNets. The problems they faced and how they resolved the problems. The concept of Transfer Learning and how one can use these proposed networks to solve other relevant problems. Autoencoders for dimensionality reduction.

UNIT V Sequence modeling using the Recurrent neural networks (RNN). **9**

The application of this architecture in predictions based on sequential data. Various RNN

architectures proposed like many to one, One to many and Many to many. The variants of RNN like Gated Recurrent Units (GRU) and the Long Short-Term Memory (LSTM) architectures. Object Detection with the R-CNN, Fast and Faster R-CNN algorithms.

Course outcomes:

CO1: Understand and apply Artificial Intelligence (AI) techniques in chemical engineering for process control, design, planning, operations, and product development.

CO2: Develop and evaluate deep artificial neural networks (DNN) by implementing activation functions, error functions, backpropagation, and optimization algorithms.

CO3: Design and implement convolutional neural networks (CNN) to recognize spatial patterns, handle kernels, pooling, and address vanishing/exploding gradient issues.

CO4: Analyze and utilize advanced deep networks such as AlexNet, VGGNet, Inception, and ResNets, and apply transfer learning and autoencoders for solving related problems.

CO5: Apply recurrent neural networks (RNN), including their variants like GRU and LSTM, for sequence modeling and predictions based on sequential data, and perform object detection using R-CNN algorithms.

Text Books:

1. Raff, Edward. Inside Deep Learning: Math, Algorithms and Models. Manning Publications,2022. ISBN 1617298638,
2) Quantrile, Thomas, Liu, Y. A, Artificial Intelligence in Chemical Engineering, Academic Press, 1991 ISBN 0125695500
3) Ian Goodfellow, Yoshua Bengio, Aaron Courville. Deep Learning. (Adaptive Computation and Machine Learning series). 2015. ISBN13 978-0262035613

References:

1. Christopher M. Bishop. Pattern Recognition and Machine Learning (Information Science and Statistics). Springer. 2006. ISBN13 978-0387310732

Course Outcomes	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	3	2	1	2	2	2	2	3	2	2
CO2	3	3	2	2	3	3	2	1	2	2	2	2	3	2	2
CO3	3	3	2	2	3	3	2	1	2	2	2	2	3	2	2
CO4	3	3	3	2	3	3	2	1	2	2	2	2	3	2	2
CO5	3	3	2	2	3	3	2	1	2	2	2	2	3	2	2
Overall	3	2.8	2.2	2	3	3	2	1	2	2	2	2	3	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CH23E04 HYDROGEN STORAGE AND FUEL CELL TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To enable students to understand and explain the principles and mechanisms of hydrogen production and storage technologies.
2. To equip students with the skills to analyze and interpret the kinetics of fuel cell reactions and identify factors that influence their performance.
3. To train students in applying advanced characterization techniques to evaluate hydrogen storage materials and fuel cell performance.
4. To prepare students to critically assess the economic, safety, and environmental aspects of hydrogen and fuel cell technologies.
5. To familiarize students with real-world applications and challenges of hydrogen and fuel cells in various sectors such as power generation, transportation, and portable devices.

UNIT I INTRODUCTION TO HYDROGEN AND FUEL CELLS 9

Overview of hydrogen as an energy carrier, Types of fuel cells: Low and high-temperature fuel cells, Fuel cell thermodynamics: Heat, work potentials, prediction of reversible voltage, fuel cell efficiency, Types and applications of fuel cells.

UNIT II HYDROGEN PRODUCTION AND STORAGE 9

Hydrogen production methods: Electrolysis, steam methane reforming, thermochemical methods, biological methods. Hydrogen storage technologies: Compressed gas, liquid hydrogen, metal hydrides, chemical storage. Safety issues, cost expectations, and life cycle analysis of hydrogen storage.

UNIT III FUEL CELL KINETICS 9

Fuel cell reaction kinetics: Electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, Electro catalysis: Design and activation kinetics, mass transport in fuel cell: Flow field design, transport in electrode and electrolyte.

UNIT IV CHARACTERIZATION AND MODELING 9

characterization: In-situ and ex-situ techniques, i-V curve, frequency response analysis. Hydrogen storage characterization: Pressure-composition-isotherm (PCI) analysis, gravimetric and volumetric measurements.Fuel cell modeling and system integration: 1D model – analytical solution, and CFD models.

UNIT V HYDROGEN FUEL CELL SYSTEM AND ITS APPLICATIONS 9

Fuel cell balance of system, Fuel processor, fuel cell power section (fuel cell stack), power conditioner, Automotive applications: Hydrogen fuel cell vehicles, infrastructure challenges. Portable and stationary applications: Portable electronic devices, backup power systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understand the history and development of chemical industry since origin.
CO2: Understand basic calculations and transfer operations in chemical engineering.
CO3: Understand various unit processes and thermodynamic principles.

CO4: Understand flow sheeting to represent a chemical industry in terms of process flow diagram.

CO5: Understand the usage of softwares and applications of chemical engineering in diversified fields

TEXT BOOKS

1. Badger W.L. and Banchero J.T., “Introduction to Chemical Engineering”, 6th Edition, Tata
   McGraw Hill, 1997. ISBN 10: 0070850275 / ISBN 13: 9780070850279
2. Ghosal, S.K, Sanyal S.K. and Dutta.S, “Introduction to Chemical Engineering” TMH Publications, New Delhi, 1998. ISBN 10: 0074601407 / ISBN 13: 978-0074601402
3. Sittig M. and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010.

REFERENCES

1. McCabe, W.L., Smith, J. C. and Harriot, P. “Unit operations in Chemical Engineering”, McGraw Hill, 7th Edition, 2001.
2. Finlayson, B. A., “Introduction to Chemical Engineering Computing”, John Wiley & Sons, New Jersey, 2006.
3. Randolph Norris Shreve, George T. Austin, “Shreve’s Chemical Process Industries”, 5th edition, McGraw Hill, 1984.
4. Pushpavanam, S, “Introduction to Chemical Engineering”, PHI Learning Private Ltd, New Delhi, 2012.
5. Bhatt B. I. and Vora, S. M, “Stoichiometry”, 4th edition, McGraw Hill, 2004.

COURSE ARTICULATION MATRIX:

Course Outcome	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	2	2	2	2	2	2	2	2	3	2	2
CO2	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
CO4	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
CO5	3	3	3	3	3	2	2	2	2	2	2	2	3	2	2
Average	3	3	2.8	2.8	2.8	2	2	2	2	2	2	2	3	2	2

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