

Haldia Institute of Technology

ICARE Complex, Hatiberia, Haldia, Dist-Purba Medinipur, Pin-721657, WB.

(An Autonomous Institution under Maulana Abul Kalam Azad University of Technology)

NAAC Accredited Grade 'A' Institute,
NBA Accredited Department
Approved by: All India Council for Technical Education (AICTE)



Curriculum for B. Tech. in Chemical Engineering (006)

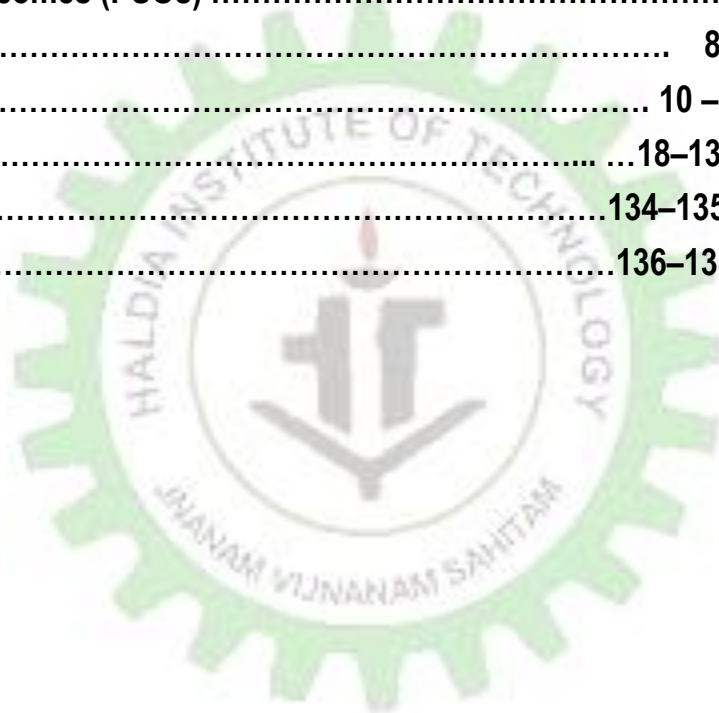
[NEP-2020 IMPLEMENTED]

(Applicable from the Student Batch of 2026-2030)

Haldia Institute of Technology, West Bengal
(An Autonomous Institution under Maulana Abul Kalam Azad University of Technology.)
Curriculum for B. Tech courses in Chemical Engineering
(Applicable from the Academic Session 2026-2030)

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Institutional Vision & Mission

VISION

To achieve Centre of Excellence in the field of Science, Technology and Management Education for creating dynamic human resources of global standards with capabilities of accepting new challenges.

MISSION

- To impart quality and value based education to raise satisfaction level of all stake-holders.
- To create competent, creative professionals, and great entrepreneurs who can work as individual or in group in multi-cultural global environments.
- To prepare citizens who would grow to be competent enough to contribute significantly with personal integrity and civic responsibility for the betterment of mankind throughout their careers and profession.

Department of Chemical Engineering

VISION

To become an internationally reputed department of higher learning for the growth and development of chemical and allied process industries to address the related problems.

MISSION

- To inculcate students with a strong fundamental knowledge to meet the needs of a rapidly changing technological environment in process development and equipment design.
- To carry out vibrant interdisciplinary research program that can creatively shape the undergraduates and graduates to address the needs of chemical engineering profession in particular and society in general.
- To develop leadership qualities to solve scientific and environmental challenges keeping in mind the safety and ethical concerns.

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Department of Chemical Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEO):

PEO1: To produce graduates with a strong foundation and understanding of the fundamental principles of science and engineering enabling graduates to pursue their careers as practicing chemical engineers in Chemical and Allied Engineering Industries.

PEO2: To produce graduates who are prepared to pursue their post-graduation and research in the emerging and allied areas of Chemical Engineering.

PEO3: To provide students with opportunities to integrate with multidisciplinary teams to develop skills with professional integrity and ethics to implement professional leadership.



Department of Chemical Engineering

PROGRAM OUTCOME (PO):

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in **WK1 to WK4** respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (**WK1 to WK4**)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (**WK5**)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (**WK8**).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (**WK2 and WK6**)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (**WK1, WK5, and WK7**).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (**WK9**)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (**WK8**)

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Department of Chemical Engineering

PROGRAM SPECIFIC OUTCOMES (PSO):

PSO1: Function professionally as an engineer to solve problems by applying acquired knowledge in chemical and allied field.

PSO2: Designing an environment friendly system for effective reaction, separation and purification and other operations in various processes with proper safety measures using modern engineering tools individually or in a team.

PSO3: Practicing engineering with professional ethics for the benefit of society with proper communication to the community.



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Credit Summary for B. Tech. Programme in CHE with effect from 2026-2030

Category/ Type of Course		Course Code	AICTE recommended Credit	Credit allocated at our Curriculum
Lecture		L		
Tutorial		T		
Practical		P		
Classroom Instruction		CI		
Laboratory Instruction		LI		
Term Work		TW		
Self Learning		SL		
BSC/ESC	Basic Science Courses	BSC	29*	27
	Engineering Courses	ESC	27*	27.5
Program Course	Program Core Course	PCC	58*	58
	Program Elective Course	PEC	9*	9
Multidisciplinary Course	Open or General Course(OE/GE)	OEC	9*	9
Skill Courses	Vocational and Skill Enhancement Course	VSEC	12*	15
Multidisciplinary Holistic development- humanities, Social Science and Management + Liberal Learning	Ability Enhancement course (AEC)	HSSM		
	Indian Knowledge System (IKS)			
	Value Education/value Addition/ Professional Ethics/Life skills Courses (VEC/EVLSC)/ Value Added Course (VAC)**			
	Entrepreneurship/ Economics			
	Co-curricular Activities			
Employment Enhancement Courses	Project	EEC	16*	16.5
	Summer Internship/ Internship			
	Seminar			
Mandatory Courses [Non-Credited]		AU	Non credit	
Total Credit (Semester/ Program)			160*	162
Honours Course			20	

- *Minor variation is allowed as per need of the respective disciplines.

Definition of Credit (as per National Credit Framework 2024): Total notional learning hours = 1200 Hours/ Year, 1 Credit = 30 notional learning hours

- A student will be eligible to get **B Tech degree with Honours** if he/she completes an additional 20 credit points/16 credit points (for lateral entry students). These could be acquired through MOOCs. For details kindly refer to APPENDIX – A
- A student will be eligible to get B.Tech. degree certificate, if he/she acquires 100 MAR points in 4 years of

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their study. Lateral entry students must acquire 75 MAR points in their 3 years of study.

For details kindly refer to APPENDIX – B.



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Curriculum for B. Tech courses in Chemical Engineering

(Applicable from the Academic Session 2026-2030)

Scheme of Instructions: First Year B.Tech. in **Branch CHE (GROUP A)**

Semester-I (w.e.f. 2026-27)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per semester)						EXAM SCHEME		
				CI		LI	TW+ SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	BS	BS-M101	Engineering Mathematics-I	42	14	0	64	120	4	30	70	100
2	BS	BS-PH102A	Engineering Physics	42	0	0	48	90	3	30	70	100
3	BS	BS-PH 192A	Engineering Physics Lab	0	0	42	03	45	1.5	40	60	100
4	ES	ES-BT 104	Biology for Engineers	28	0	0	32	60	2	30	70	100
5	ES	ES-ME 192	Engg. Drawing	0	0	42	03	45	1.5	40	60	100
6	HSSM	HM-AEC 105	English Language and Technical Communication	28	0	0	32	60	2	30	70	100
7	HSSM	HM-AEC 195	Language Lab	0	0	28	02	30	1	40	60	100
8	HSSM	HM-IKS 106	Values, Ethics and Indian Knowledge System	28	0	0	32	60	2	30	70	100
9	VSEC	VSEC-181	Soft Skills for Professional Development - I	0	0	28	02	30	1	-	-	100
10	HSSM	AU-181	NCC/NSS/CSP/Yoga	0	0	14	14	28	0	0	0	100
			Total hours	168	14	154	232	568	18			

	Program Course		Programme Course		Multidisciplinary Course	Skill Course	Multidisciplinary Holistic development- humanities, Social Science and Management + Liberal Learning					Employment Enhancement course			
Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge System	Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res. met	Mini Proj	Proj	Internship
Semester Credits	8.5	3.5				1.0	3.0	2.0							-
Cumulative Sum															

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SCHEME OF INSTRUCTION & SYLLABI

Branch **CHE (GROUP A)**

Scheme of Instructions: First Year B. Tech. in Chemical Engineering
Semester-II (w.e.f. 2026-27)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAMSCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	BS	BS-M 201B	Engineering Mathematics-II	42	14	0	64	120	4	30	70	100
2	BS	BS-CH 202 A	Engineering Chemistry	42	0	0	48	90	3	30	70	100
3	BS	BS-CH 292 A	Engineering Chemistry Lab	0	0	42	03	45	1.5	40	60	100
4	ES	ES-EE 203 A	Basic Electrical & Electronics Engg	42	0	0	48	90	3	30	70	100
5	ES	ES-CS 203	Programming for Problem Solving	42	14	0	64	120	4	30	70	100
6	ES	ES-CHE-201	Introduction to Chemical Engineering (Department Specific Subject)	42	0	0	48	90	3	30	70	100
7	ES	ES-EE 293 A	Basic Elec. & Electro. Engg. Lab	0	0	42	03	45	1.5	40	60	100
8	ES	ES-CS 293	Programming Lab	0	0	42	03	45	1.5	40	60	100
9.	ES	ES- ME 291	Workshop Practice	0	0	42	03	45	1.5	40	60	100
			Total	210	28	168	284	690	23			

	Program Course		Programme Course		Multidisciplinary Course	Skill Course	Multidisciplinary Holistic development- humanities, Social Science and Management + Liberal Learning						Employment Enhancement course		
Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge System	Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res.met	Mini Proj	Proj	Internship
Semester Credits	8.5	14.5											-		
Cumulative Sum	17	18				1.0	5.0								

Scheme of Instructions: Second Year B. Tech. in Chemical Engineering

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Curriculum for B. Tech courses in Chemical Engineering
(Applicable from the Academic Session 2026-2030)
Semester-III (w.e.f. 2027-28)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAM SCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	BS	BS-CHE 301	Numerical Methods for Chemical Engineering	42	0	0	48	90	3	30	70	100
2	BS	BS-CHE 302	Chemical Process Calculations	42	0	0	48	90	3	30	70	100
3	ES	ES-CHE 301	Chemical Engineering Thermodynamics	42	14	0	64	120	4	30	70	100
4	PC	PC-CHE 301	Fluid Mechanics	42	14	0	64	120	4	30	70	100
5	PC	PC-CHE 302	Solid and Fluid- Particle Processing	42	0	0	48	90	3	30	70	100
6	HSSM	HM-CHE 301	Economics for Engineers	28	0	0	32	60	2	30	70	100
7	PC	PC-CHE 391	Fluid Mechanics Laboratory	0	0	42	03	45	1.5	40	60	100
8	PC	PC-CHE 392	Solid and Fluid- Particle Processing Laboratory	0	0	42	03	45	1.5	40	60	100
9	BS	BS-CHE 391	Numerical Methods for Chemical Engineering Laboratory	0	0	28	02	30	1	40	60	100
Total				238	28	112	312	690	23			

Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res.meth	Mini Proj	Proj	Internship
Semester Credits	7.0	4.0	10.0							2.0				
Cumulative Sum	24.0	22.0	10.0			1.0	7.0							

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 Scheme of Instructions: Second Year B.Tech. in Chemical Engineering
 Semester-IV (w.e.f. 2027-28)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAMSCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	BS	BS-CHE 401	Materials Science	42	0	0	48	90	3	30	70	100
2	ES	ES-CHE 401	Energy Sources and Utilization	42	14	0	64	120	4	30	70	100
3	PC	PC-CHE 401	Heat Transfer	42	14	0	64	120	4	30	70	100
4	PC	PC-CHE 402	Separation Process I	42	14	0	64	120	4	30	70	100
5	PC	PC-CHE 403	Petroleum Engineering and Petrochemicals	42	14	0	64	120	4	30	70	100
6	HSSM	HM-CHE 401	Principles of Management	28	0	0	32	60	2	30	70	100
7	ES	ES-CHE 491	Energy Engineering Laboratory	0	0	42	03	45	1.5	40	60	100
8	PC	PC-CHE 491	Heat Transfer Laboratory	0	0	42	03	45	1.5	40	60	100
9	MC	AU- 481	Environmental Science (Non-Credited)	14	0	0	14	28	0			100
10	VSEC	VSEC-481	Soft Skills for Professional Development - II	0	0	28	32	60	1	-	-	100
Total				252	56	112	388	808	25			

Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge	Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res.meth	Mini Proj	Proj	Internship
Semester Credits	3.0	5.5	13.5			1.0	0	-	-	-	2.0		-		
Cumulative Sum	27	27.5	23.5			2.0	9.0								

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Scheme of Instructions: Third Year B.Tech. in Chemical Engineering

Semester-V (w.e.f. 2028-29)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAMSCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	PC	PC-CHE 501	Separation Process II	42	14	0	64	120	4	30	70	100
2	PC	PC-CHE 502	Chemical Reaction Engineering	42	14	0	64	120	4	30	70	100
3	PC	PC-CHE 503	Chemical Process Technology	42	14	0	64	120	4	30	70	100
4	PE	PE-CHE 501	Core Elective I	42	0	0	48	90	3	30	70	100
5	OE	OE-CHE 501	Open Elective I	42	0	0	48	90	3	30	70	100
6	PC	PC-CHE 591	Separation Process Laboratory	0	0	42	03	45	1.5	40	60	100
7	PC	PC-CHE 592	Process Equipment Design and Drawing	0	0	56	04	60	2	40	60	100
8	EE	SEM-CHE 591	Technical Seminar	0	0	42	03	45	1.5			100
9	VSEC	VSEC-581	MATLAB based Process Simulation & Optimization	0	0	56	04	60	2	-	-	100
Total				210	42	196	302	750	25			

Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res.meth	Mini Proj	Proj	Internship
Semester Credits			15.5	3.0	3.0	2.0							1.5	
Cumulative Sum	27	27.5	39.0	3.0	3.0	4.0	9.0						1.5	

Core Elective I	PE-CHE 501A	PE-CHE 501B	PE-CHE 501C
Name of the Subject	Polymer Science and Engineering	Advanced Separation Process	Biochemical Engineering

Open Elective I	OE-CHE 501A	OE-CHE 501B	OE-CHE 501C
Name of the Subject	Introduction to AI Driven Chemical Processes	Fuel Cell and Battery Technology	Cryogenic Engineering

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Scheme of Instructions: Third Year B.Tech. in Chemical Engineering

Semester–VI (w.e.f. 2028-29)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAMSCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	PC	PC-CHE 601	Transport Phenomena	42	14	0	64	120	4	30	70	100
2	PC	PC-CHE 602	Instrumentation and Process Control	42	14	0	64	120	4	30	70	100
3	PC	PC-CHE 603	Project Engineering	42	0	0	48	90	3	30	70	100
4	PC	PC-CHE 604	Industrial Process Safety	42	0	0	48	90	3	30	70	100
5	PE	PE-CHE 601	Core Elective II	42	0	0	48	90	3	30	70	100
6	OE	OE-CHE 601	Open Elective II	42	0	0	48	90	3	30	70	100
7	MC	AU-681	Constitution of India	14	0	0	14	28	0			100
8	PC	PC-CHE 691	Chemical Reaction Engineering Laboratory	0	0	42	03	45	1.5	40	60	100
9	PC	PC-CHE 692	Instrumentation and Process Control Lab	0	0	42	03	45	1.5	40	60	100
10	VSEC	VSEC-681	Introduction to ESG and ZLD	0	0	28	02	30	1			100
Total				266	28	112	342	748	24			

Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge	Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res.meth	Mini Proj	Proj	Internship
Semester Credits			17.0	3.0	3.0	1.0							1.5		
Cumulative Sum	27	27.5	56.0	6.0	6.0	5.0	9.0						1.5		

Core Elective I	PE-CHE 601A	PE-CHE 601B	PE-CHE 601C
Name of the Subject	Fertilizer Technology	Nanoscience and nanotechnology	Industrial Pollution Control

Open Elective I	OE-CHE 601A	OE-CHE 601B	OE-CHE 601C
Name of the Subject	Waste to Energy	Waste Management and Recycling	Food Processing Technology

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Scheme of Instructions: Fourth Year B.Tech. in Chemical Engineering

Semester–VII (w.e.f. 2029-30)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAMSCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	PE	PE-CHE 701	Core Elective III	42	0	0	48	90	3	30	70	100
2	EE	EE- CHE 791	Project Work I	0	0	168	168	336	6			100
3	EE	EE-CHE 792	Industrial Internship	0	0	160	200	360	3			100
10	VSEC	VSEC-781	Industrial IoT & Arduino Programming	0	0	28	02	30	1	-	-	100
Total				42	0	356	418	816	13			

Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res. meth	Mini Proj	Proj	Internship
Semester Credits				3.0		1.0	-	-	-	-			9.0	
Cumulative Sum	27	27.5	56.0	9.0	6.0	6.0	9.0						10.5	

Core Elective I	PE-CHE 701A	PE-CHE 701B	PE-CHE 701C
Name of the Subject	Chemical Process Intensification	Computational Fluid Dynamics	Computer aided Process Design

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Scheme of Instructions: Fourth Year B.Tech. in Chemical Engineering
Semester–VIII (w.e.f. 2029-30)

Sr. No.	Course Category	Course Code	Course Title	Teaching & Learning Scheme (in hrs per Semester)						EXAMSCHEME		
				CI		LI	TW + SL	Total	Total Credits	CA	ESE	TOTAL
				L	T	P						
1	OE	OE-CHE 801	Open Elective III	42	0	0	48	90	3	30	70	100
2	EE	EE-CHE 891	Project Work II	0	0	168	168	336	6			100
3	PC	PC-CHE 891	Grand Viva	0	0	0			2			100
Total				42	0	168	216	426	11			

Course Category	Basic Science (BS)	Engineering Science (ES)	Programme Core (PC)	Programme Elective (PE)	Open Elective (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Ability enhance Course	Indian Knowledge	Value Education	Co-curricular	Entrepreneurship/Economics/Management	Res. meth	Mini Proj	Proj	Internship
Semester Credits			2		3.0		-	-	-	-	-		6.0		
Cumulative Sum	27	27.5	58.0	9.0	9.0	6.0	9.0						16.5		

Open Elective I	OE-CHE 801A	OE-CHE 801B	OE-CHE 801C
Name of the Subject	Statistical Quality control	Additive Manufacturing	Operation Research

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SEMESTER-I

Course Code: BS-M101	Category: Basic Science Course
Course Title: Engineering Mathematics-I	Semester: 1 st
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: 10+2 Level Mathematics.	Branch: All Engineering Branch Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Apply elementary row operations, rank methods, and the Cayley–Hamilton theorem to determine the consistency of systems of linear equations, and compute eigenvalues and eigenvectors for matrix diagonalization in engineering applications.	
CO2: Apply mean value theorems and Leibnitz's theorems for successive differentiation, and determine the convergence of improper integrals using Beta and Gamma functions.	
CO3: Compute partial derivatives, Jacobians, and total differentials for functions of several variables, and employ the Lagrange Multiplier method to find extrema and saddle points in constrained optimization problems.	
CO4: Calculate the gradient, divergence, and curl of vector fields and apply fundamental theorems—namely Green's, Gauss Divergence, and Stokes' theorems—to evaluate line, surface, and volume integrals.	
Module 1: Introduction to Linear Algebra (14 hours) Introduction to Matrix Algebra, Elementary row and column operations over a matrix; Rank of a matrix; Rank and nullity; System of linear equations and its consistency; Cayley-Hamilton theorem; Eigenvalues and Eigenvectors; Diagonalization of matrices.	
Module 2: Differential & Integral Calculus of Single Variable (14 hours) Leibnitz's Theorem on Successive Derivatives; Mean value theorem (Rolle's, Lagrange's, Cauchy's, Taylor's and Maclaurin's theorems with remainders); Improper integrals; Beta and Gamma functions and their properties; Convergence of improper integrals.	
Module 3: Calculus of functions with several variables (15 hours) Introduction to functions of several variables; Limit and continuity, Partial derivatives, Homogeneous functions and Euler's theorem, Chain rules, Differentiation of implicit functions, Total differentials and their applications, Jacobians. Maxima, Minima and Saddle points of functions; Lagrange Multiplier method and their applications; Concept of line integrals, Double and triple integrals.	
Module 4: Vector Calculus (13 hours) Introduction to Vector Algebra, Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar point function, divergence and curl of a vector point function, Directional derivative. Green's theorem, Gauss Divergence Theorem and Stoke's theorem (Applications Only).	

* Applications of Module 1 to 4 for relevant disciplines.

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CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1	2	-	-	-	-	-	1
CO 2	3	2	1	1	1	-	-	-	-	-	1
CO 3	3	3	2	1	2	-	-	-	-	-	1
CO 4	3	3	1	2	2	-	-	-	-	-	1

Text Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India.
2. B.S. Grewal, Higher Engineering Mathematics. S. Chand & Co.
3. John Bird, Higher Engineering Mathematics. Elsevier.
4. S. S. Sastry, Engineering Mathematics (PHI, 4PthP Edition, 2008).
5. H.K. Dass, Advanced Engineering Mathematics, S. Chand & Co.

Reference Books:

1. Seymour Lipschutz, Marc Lars Lipson, Linear Algebra, McGraw-Hill Companies, Inc.
2. Robert Wrede, Murray R. Spiegel, Advanced Calculus, McGraw-Hill Companies, Inc.
3. Murray R. Spiegel, Vector Analysis, McGraw-Hill Companies, Inc.
- 4.

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Paper Code: BS PH 102 A	Category: Basic Science
Paper Name: Engineering Physics	Semester: 1st
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: 10+2 Physics	Branch: CHE Total Lecture: 42L
Course Outcomes:	
CO1: Student will represent, solve and formulate the phenomena of Simple Harmonic Motion, Damped & Forced oscillations and realize the problem of simple mechanical systems and their electrical analogy to model complex physical sensors and control circuits used in bio-processing and food plant automation.	
CO2: Students will be able to calculate fluid behavior using Reynolds number, Poiseuille's law, and Bernoulli's theorem, distinguishing between Newtonian and non-Newtonian fluids. They will apply the Laws of Thermodynamics and heat transfer mechanisms to design efficient cooling, heating, and sterilization systems.	
CO3: Students will understand and correlate interference, diffraction, polarization of light and analyze the mechanism of LASER along with their applications like high-precision measurement, sterilization, and material processing.	

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CO4: Students will formulate principles of quantum mechanics to analyze radiation and to solve problems of particle in infinite potential well with the concept of wave function.
Module- 1 Waves and Vibrations [8L] Harmonic Oscillation, Simple Harmonic Motion, Damped Oscillation, Relaxation time & log decrement. Forced oscillation, Electromechanical Analogy between Mechanical Oscillator with Electrical circuit, Mechanical Impedance, Transient and Steady state oscillations, Resonance, Bandwidth, Quality factor, Sharpness of Resonance.
Module- 2 Fluid Mechanics and Thermal Physics [10L] Fluid properties- Fluid flow nature, Streamline motion, Vortex motion, Newton's law of viscosity, Newtonian vs non-Newtonian fluids, Temperature & pressure effects, Reynolds number, Pipe flow (Poiseuille law): Surface tension, Bernoulli's theorem and applications. Thermal properties- Thermal Expansions, Specific heats, Conduction, Convection, Radiation, Laws of Thermodynamics, Entropy.
Module-3 Physical Optics and Light Devices [14L] Interference- Superposition of waves, Division of wave front and division of amplitude, Interference in parallel and wedge-shaped film-Thin film Interference, Newton's rings- determination of wave length and thickness. Diffraction- Fresnel and Fraunhofer diffraction, Single Slit, Double Slit, Optical grating (Qualitative discussion only) Polarization- Introduction, States of Polarization, Brewster's law, Malus Law, Phase Retardation Plate. Lasers- Characteristics of Laser, Spontaneous and Stimulated Emission, Population Inversion, Classification of Laser, construction and working, Einstein's coefficients, Example of Gas Laser (He-Ne), Solid state laser (Ruby) and LED and p-n junction semiconductor lasers, Quantum well Lasers (concept only), Applications of Laser
Module-4 Modern Physics [10L] Blackbody Radiation, Planck's Radiation law, photoelectric effect, X-ray production and diffraction, Bragg's law, Compton Effect, Dual Nature of Matter, De' Broglie hypothesis, Heisenberg's Uncertainty Principle, Group velocity and Phase velocity, Wave function, Postulates of Quantum Mechanics, Quantum Mechanical operator, Eigen function and Eigen value, Schrödinger's time dependent and time independent wave equation-Particle in 1D box, Particle in 3D box, Concept of degeneracy

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1	0	1	1	1	1	1	1
CO 2	3	3	1	1	0	1	1	1	1	1	1
CO 3	3	3	1	1	0	1	1	1	1	1	1
CO 4	3	3	1	1	0	1	1	1	1	1	1

Text Books:

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1. Vector Analysis – M.R.Spiegel
2. Waves and Oscillation – N.k.Bajaj, Chattopadhyay and Rakshit
3. Principles of Physics, 10ed, David Halliday, Robert Resnick Jearl Walker , Wiley
4. Optics –A.K.Ghatak McGraw Hill Education India Private Limited
5. Modern Physics for Scientists and Engineers, J. R. Taylor, C.D. Zafiratos and M. A.Dubson, 2nd Ed., Pearson (2007)
6. Modern Quantum Mechanics, J. J. Sakurai, Cambridge University Press
7. Classical Theory of Electricity and Magnetism, A. K. Roychowdhury
8. Statistical Mechanics, Reif, Pathria
9. General Properties of matter, D.S. Mathur

Paper Name: Engineering Physics Laboratory	Category: Basic Science Course
Paper Code: BS-PH-192 A	Semester: First
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic knowledge in higher secondary chemistry.	Branch: CHE Total Lecture: 42 P

Course Outcomes (COs)

- CO 1:** Describe and understand the working formulas, uses of instruments, and apparatus used in diverse experiments.
- CO 2:** Apply theoretical concepts to effectively execute experiments and record experimental data.
- CO 3:** Analyze experimentally collected data, validate it through calculations, graphical representation, and error estimation, while adhering to necessary precautions.
- CO 4:** Integrate acquired knowledge and apply it across various engineering disciplines.

List of Experiments

1. Determination of coefficient of viscosity by Poiseuille's capillary flow method
2. Determination of Planck constant using photocell.
3. Determination of wavelength of the given laser source by diffraction method
4. Determination of wavelength of a monochromatic light by Newton's ring
5. Determination of Band gap of semiconductor. (2 probe, 4 probe Method)
6. Determination of rigidity modulus of the material of a wire by dynamic method
7. Determination of conductivity of a Bad Conductor by Lee's and Charlton Method
8. Determination of specific charge (e/m) of electron by J.J. Thompson's method.
9. Determination of resistance of ballistic galvanometer by half deflection method and study of variation of logarithmic decrement with series resistance.
10. Determination of unknown resistance using Carey Foster's bridge

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11. To study current voltage characteristics, load response, areal characteristic and spectral response of a photovoltaic solar cell.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	1	2	1	2	3	3	1	3
CO 2	3	3	2	1	3	1	2	3	3	1	3
CO 3	3	3	2	1	3	2	2	3	3	3	3
CO 4	3	3	1	1	2	2	2	3	3	3	3

Learning Resources

1. C.L. Arora, B.Sc. Practical Physics.
2. Harnam Singh and Dr. P.S.Hemne, B.Sc. Practical Physics

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Paper Name: Biology for Engineers	Category: Engineering Science
Paper Code: ES-BT104	Semester: First
L-T-P : 2 -0-0	Credit: 2.0
	Branch: CHE
	Total Lecture: 28 L

COURSE CONTENTS

Introduction to Biological Sciences (6 L)

Introduction to Biology: Science and comparison with other disciplines. Differences between Science & Engineering and Biologist & Biological Engineer.

The concept of biomimicry and its modern-day applications. The interdisciplinary nature of biological sciences.

Diversity of the living world, Taxonomy, Nomenclature, Taxonomic hierarchy, Biological classification.

Cell: Basic unit of life - Prokaryotes and Eukaryotes, Cell theory.

Biomolecules (8 L)

Introduction to Biomolecules: Sources, Structure, Characteristics and functions of the biomolecules (Carbohydrates, Proteins, Lipids and Nucleic acids).

Enzymology: Properties of enzymes, Enzyme structure, Classification and functions, Mechanism of enzyme reaction, Enzyme activity, Factors affecting enzyme activity.

Introduction to Metabolism in biological systems

Molecular aspects of life (8 L)

Molecular basis of Information Transfer: Central dogma, Replication, Transcription, Genetic code, Translation.

Immunity to Infection - Innate and Acquired immunity, Organs and cells of the immune system, Classification of antibodies.

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Microbes as Infectious Agents: Examples from human diseases

Biology and its Industrial Applications (6 L)

Applications of Biology: Agriculture, Medicine, Industry, Environment, Bio-robotics, 3D bio-printing, Biosensors, Bioinformatics etc. New generation bio-fabricated products and future challenges

Course Outcomes (COs):

CO1: Remember and understand the biological concepts from an engineering perspective

CO2: Understand the classification, structure and functions of various Biomolecules

CO3: Perception of the various biomolecular aspects of life

CO4: Apply and implement biological principles for the development of next generation technologies

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	1	-	-	-	1	-	-	-	-	-
CO 2	2	1	1	1	-	2	-	-	-	-	-
CO 3	3	2	2	2	-	2	-	-	-	-	-
CO 4	3	3	3	2	3	3	3	3	-	-	2

Learning Resources:

1. Gabi Nindl Waite, Lee Waite, Applied Cell and Molecular Biology for Engineers, McGraw-Hill Education, 2007.
2. Arthur T. Johnson, Biology for Engineers, Second Edition, CRC Press, 2019.
3. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, —Biology: A global approach, Pearson Education Ltd, 2014.
4. G. S. Stent and R. Calendar, —Molecular Genetics, Freeman and company, 1978.

Web Reference:

NPTEL: https://onlinecourses.nptel.ac.in/noc19_ge31/preview

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Course Code: ES-ME192	Category: Engineering Science Course
Course Title: Engineering Drawing	Semester: 1st
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic understanding of elementary geometry, Mathematical concepts related to lines and angles, and visualization of simple three-dimensional objects.	Branch: A CHE Total Lecture: 42L
Course Outcomes:	

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CO1: Understand and apply different types of engineering scales including plain, diagonal, and vernier scales for accurate graphical representation.
CO2: Construct geometrical curves and conic sections such as parabola, hyperbola, and ellipse using standard engineering drawing methods.
CO3: Apply principles of orthographic projection and draw projections of points, lines, and plane surfaces in first-angle and third-angle projection systems.
CO4: Draw and interpret projections of solids including cube, prism, pyramid, cylinder, cone, and frustums in different orientations.
CO5: Develop isometric views and isometric projections of simple engineering solids and objects.
CO6: Prepare sectional views, determine true shape of sections, and develop surfaces of engineering solids for practical engineering applications.
Module 1: Scales [3 Hours] Plain scales, Diagonal scales, Vernier scales
Module 2: Geometrical Construction and Curves [3 Hours] Conic Section: Parabola, Hyperbola, Ellipse
Module 3: Projection of Points, Lines, Surfaces [9 Hours] Orthographic Projection – First angle and third angle projection More no. of problems should be practiced in first angle projection. Projection of lines inclined to the planes Projection of surfaces Pentagon, Hexagon
Module 4: Projection of Solids [12 Hours] Cube, Pyramid, Prism, Cylinder, Cone, Frustums
Module 5: Isometric View and Isometric Projection [6 Hours] Prism, Pyramid, Cylinder, Cone and examples of simple solid objects / models.
Module 6: Sectional Views of Solids, True Shape of a Section [6 Hours]
Module 7: Development of Surfaces [3 Hours] Cube, Prism, Cylinder, Truncated Cone

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	-	2	-	-	1	-	2	-
CO 2	3	3	2	1	2	-	-	1	-	2	-
CO 3	3	3	2	2	2	1	-	1	1	3	-
CO 4	3	3	3	2	2	1	-	1	1	3	1
CO 5	2	2	3	2	3	1	-	1	1	3	1
CO 6	3	3	3	2	2	1	1	1	1	3	1

Learning Resources:

1. Pradeep Jain, AnkitaMaheswari, A.P. Gautam, Engineering Graphics & Design, Khanna Publishing House.
2. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House.

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3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication.
4. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
6. Corresponding set of CAD Software Theory and User Manuals.

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Paper Code: HM-AEC 105	Category: Humanities and Social Sciences, including Management (HSSM)
Paper Title: English Language & Technical Communication	Semester: 1 st
L-T-P: 2-0-0	Credit: 2
Pre-Requisites: Basic English grammar, vocabulary, reading, writing, and communication skills.	Total Lectures: 28
Course Outcomes: Upon the completion of the course, the student will be able to	
CO1: Apply the principles, types, and flow of communication in diverse contexts.	
CO2: Construct grammatically accurate sentences and transform sentence structures effectively.	
CO3: Analyse texts and develop comprehension, vocabulary, and précis writing skills.	
CO4: Draft professional letters and official correspondence using appropriate format and tone.	
Module 1: Fundamentals of Communication (8 L) Definition of Communication, Process, Model (Brief Overview of Linear, Interactive & Transactional Model of Communication), 7 C's of Effective Communication; Types of Communication: Verbal and Non-verbal Communication (KOPPACT, Chromatics, Olfactics); Levels of Communication: Interpersonal, Intrapersonal, Mass Communication, Organisational Communication, External Communication, Extrapersonal Communication; Flow of Communication: Upward, Downward, Horizontal, Diagonal, Spiral, Grapevine and its Types; Barriers to Communication (Physical, Psychological, Physiological, Semantic, Organisational, Cultural Barriers) and methods to overcome them.	
Module 2: Functional Grammar (6 L) Parts of Speech (functional approach); Tense and its uses; Common Grammatical Errors and Corrections (Subject-verb agreement, articles, prepositions); Transformation of Sentences: Active and Passive Voice, Direct and Indirect Speech, Degrees of Comparison; Phrases & Clauses; Simple, Compound and Complex Sentences (Transformation & Synthesis)	
Module 3: Comprehension and Vocabulary Skill (6 L) Reading Comprehension (scientific, descriptive, analytical, report/data-based, narrative, case-study based); Synonym and Antonym; Phrasal verbs; One-word substitution (includes technical words); Precise Writing	
Module 4: Professional Writing Skills (8 L)	

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Business Letters (Inquiry Letter, Order Letter, Complaint Letter, Adjustment Letter, Sales Letter); Cover letter & CV; Office Correspondence: Notice, Agenda, Minutes, Circular/Memo, Email; Essay Writing (analytical, descriptive, argumentative, expository)

CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	1	1	1	1	2	3	2	3	1	2
CO 2	1	1	1	1	1	1	3	1	2	1	2
CO 3	1	2	1	1	1	2	3	2	2	1	3
CO 4	1	1	1	1	1	2	3	3	3	2	2

Learning Resources

1. Debashis Bandyopadhyay and Malathy Krishnan, *Connect: A Course in Communicative English*, Cambridge University Press, 2018.
2. Sanjay Kumar and Pushp Lata, *Communication Skills*, Oxford University Press, 2015.
3. Nira Konar, *Communication Skills for Professionals*, Prentice Hall of India, 2nd edition, 2011.
4. Wren and Martin, *Modern English Grammar & Composition*, S Chand Publishing, 2025.
5. S. Prasad & K.P. Thakur, *Common Errors in English*, Bharati Bhawan Publishers, 2021.
6. R.C. Sharma and Krishna Mohon, *Business Correspondence and Report Writing*, Tata McGraw-Hill Publishing Company Ltd., 2017.
7. McCarthy, *English Vocabulary in Use*, Cambridge University Press, 2017.
8. E. Sureshkumar and P. Sreehari, *Communicative English*, Orient Blackswan, 2007.
9. Jeremy Comfort, *Speaking Effectively, Developing Speaking Skills for Business English*, Cambridge University Press, 1994.
10. Michael Swan, *Practical English Usage*, OUP, 1995.
11. F.T. Wood, *Remedial English Grammar*, Macmillan, 2007.
12. Arora, V. N and Lakshmi Chandra. *Improve your Writing*. OUP, 2013.

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Paper Code: HM-AEC 195	Category: Humanities and Social Sciences, including Management (HSSM)
Paper Title: Language Laboratory	Semester: 1 st
L-T-P: 0-0-2	Credit: 1
Pre-Requisites: Basic English proficiency and readiness to participate in practical communication activities.	Total Classes: 28
Course Outcomes: Upon the completion of the course, the student will be able to	
CO1: Demonstrate effective listening and speaking skills in academic and social contexts.	
CO2: Interpret texts and short stories for meaningful comprehension.	
CO3: Apply basic writing skills in English communication.	
CO4: Evaluate individual communication skills through group discussion and debate activities.	
Module 1: Listening and Speaking Skills (8 P) Listening to conversations, short passages, news, and speeches, Listening for general and specific information, Basic speaking activities: self-introduction, daily conversation, Simple presentations, extempore, and conversational practice (face-to-face/telephonic), Introduction to pronunciation: sounds, stress, and intonation, Practice for clarity and neutral accent	
Module 2: Reading Skills (6 P) Reading comprehension of technical and non-technical passages, identifying main ideas and supporting details, Reading two short literary texts.	
Module 3: Writing Skills (6 P) Technical Report Writing: Types and formats (Project Report, Progress Report, Lab Report, Survey Report, Incident/Accident Report), Essay writing, Dialogue/Creative writing, Statement of Purpose	
Module 4: Communication Practice and Soft Skills (8 P) Group Discussion: Strategies and Practice (structured/unstructured), Debates, Interpersonal Communication Skills, SWOT analysis (Self-assessment of Communication Skills)	

CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	1	-	-	-	1	1	2	3	1	2
CO 2	1	2	1	1	-	2	2	-	2	-	2
CO 3	1	1	1	-	1	1	1	2	3	1	2
CO 4	1	2	1	1	-	2	2	3	3	1	2

Learning Resources:

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1. Balasubramanian, T. *A Textbook of English Phonetics for Indian Students*. Macmillan India, 1981.
2. Board of Editors. *Contemporary Communicative English for Technical Communication*. Pearson Longman, 2010.
3. Comfort, Jeremy. *Speaking Effectively: Developing Speaking Skills for Business English*. Cambridge University Press, 1994.
4. Hacker, Diane. *A Pocket Style Manual*. Bedford/St. Martin's, 2003.
5. Konar, Nira. *English Language Laboratories: A Comprehensive Manual*. PHI Learning, n.d.
6. Sudharani, D. *Manual for English Language Laboratory*. WB ed., Pearson Education, 2010.
7. Suresh Kumar, E., and P. Sreehari. *Communicative English*. Orient Blackswan, 2007.
8. Language Software: *Orell Talk MAX Version*
9. Wilson, Anil. *Figments of Imagination*. Inter University Press Private Limited, 2022.
10. Singh, Khuswant. *Best Indian Short Stories*. Harper Collins, 2024.
11. Thomas, J. A. *100 Indian Stories*. Aleph Books, 2025.

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Paper Code: HM-IKS 106	Category: Humanities and Social Sciences, including Management (HSSM)
Paper Title: Values, Ethics & Indian Knowledge System	Semester: 1st
L-T-P: 2-0-0	Credit: 2
Pre-Requisites: Basic awareness of social, ethical, and cultural issues.	Total Lectures: 28
Course Outcomes: Upon the completion of the course, the student will be able to	
CO1: Explain the fundamental concepts of values, ethics, and moral reasoning.	
CO2: Apply ethical principles and professional values in workplace and organizational settings.	
CO3: Analyze ethical issues arising in engineering practice, research, and sustainable development.	
CO4: Evaluate the relevance of the Indian Knowledge System to holistic well-being and society.	
Module 1: Understanding Values & Ethics (8 L) Ethics, Ethical values, Moral values, Virtue theory, Civic virtue, Empathy, Trustworthiness, Harmony, Maslow's need hierarchy theory, Societal values, Aesthetic values, Value spectrum of a good life, Value education, Value system in contemporary society and gender inclusivity.	
Module 2: Professional Ethics (6 L) Ethical principles in Workplace, Ethical Leadership, Good corporate governance, Corporate social responsibility, Role of CSR in enhancing brand reputation	

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Module 3: Engineering Ethics and Global Issues (6 L)

Ethical duties and responsibilities of an engineer, Conflict between business deal and professional ideal, Whistle blowing, Environmental and Sustainability Ethics, Research Ethics, Bio-Ethics.

Module 4: Indian Knowledge System (8 L)

Introduction and Importance of Indian Knowledge System, Indian Knowledge System – Contribution to the world- Zero and Decimal System, Ayurveda medicine, Philosophical concepts of the four Vedas, Yoga, etc. Psychological aspects of health and wellness, Knowledge Triangle.

CO & PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	1	-	-	-	2	3	2	2	-	1
CO 2	-	2	1	-	-	3	3	3	3	2	2
CO 3	-	3	1	1	1	3	3	2	2	1	2
CO 4	-	1	-	-	-	3	2	1	1	-	3

Learning Resources

1. Mahadevan, B, et al. *Introduction to Indian Knowledge System*. 30 May 2022.
2. *Bharat BoudhIKS*. 21 vols., VBUSS Publications, 2025.
3. Mishra, A., W. Biswas, and A. Giri. *Ethics, Values and Indian Ethos*. New Age Publishers, 2022.
4. Kapur, K., and A. K. Singh, editors. *Indian Knowledge Systems*. Vol. 1, Indian Institute of Advanced Study, 2005.
5. Shankaracharya, Sri Adi. *Tatvabodh*. Commentary by Swami Tejomayananda, Central Chinmaya Mission Trust, 1995.
6. Ramdhoni, Reshmi. *Ancient Indian Culture and Civilisation*. Star Publication, 2018.

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Paper Code: VSEC-181	Category: Vocational & Skill Enhancement Course (VSEC)
Paper Title: Soft Skills for Professional Development - I	Semester: 1 st
L-T-P: 0-0-2	Credit: 1
Pre-Requisites: Basic knowledge in English fundamentals, computer skills, current awareness, and participation skills.	Total Classes: 28 AGE
Course Outcomes: Upon completion of the course, the student will be able to	
CO1: Apply English language skills for competitive and professional communication.	
CO2: Demonstrate teamwork, group discussion skills, and design thinking techniques.	

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CO3: Analyze arguments and present ideas through debates and PowerPoint presentations
CO4: Develop career readiness through resume writing, interviews, and wellness practices.
Module 1: Communication & Competitive English Foundations (6 P) Diagnostic test (grammar, vocabulary, comprehension); Vocabulary drills (synonyms, antonyms, idioms); Error detection exercises; Reading Comprehension Practice; General Awareness.
Module 2: Design Thinking, Group Discussion & Team Communication (8 P) Introduction to Design Thinking; Empathy Mapping & Problem Identification; Creative Problem-Solving Activities; GD simulations (fishbowl method); Initiation, entry, and summarization drills; Themed GDs (current, abstract, case-based); Role-based discussions.
Module 3: Debate & PowerPoint Presentation (6 P) Types of Debates: Argument building (claim–evidence–reasoning), Structured debates (for/against); Rapid rebuttal rounds; PowerPoint Presentation.
Module 4: Professional Writing & Career Readiness (8 P) Job Application Letter; Resume review and improvement; Voice Assessment; HR question practice; Mock interviews; Stress interview simulation; Mental Wellness.

Assessment Scheme: English Language Proficiency: 20 | Design Thinking: 20 | GD: 20 | Debate/PowerPoint Presentation: 20 | Interview: 20 | Total: 100

CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	1	-	-	-	-	-	-	3	-	2
CO 2	1	2	2	1	-	1	1	3	3	1	2
CO 3	1	3	1	1	1	1	1	2	3	-	2
CO 4	1	1	-	-	-	1	2	2	3	2	3

Learning Resources

1. Debashis Bandyopadhyay and Malathy Krishnan, *Connect: A Course in Communicative English*, Cambridge University Press, 2018.
2. Sanjay Kumar and Pushp Lata, *Communication Skills*, Oxford University Press, 2015.
3. Nira Konar, *Communication Skills for Professionals*, Prentice Hall of India, 2nd edition, 2011.
4. Wren and Martin, *Modern English Grammar & Composition*, S Chand Publishing, 2025.
5. S. Prasad & K.P. Thakur, *Common Errors in English*, Bharati Bhawan Publishers, 2021.
6. Susmit Maity & Arpita Mazumdar, *Crack Campus Placements*, SelfyPage Developers Pvt. Ltd., 2024.

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SEMESTER-II

Course Code: BS-M201B	Category: Basic Science Courses
Course Title: Engineering Mathematics-II	Semester: 2 nd
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: 10+2 Level Mathematics.	Branch: CHE Total Lecture: 56L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Apply analytical methods to solve and analyze first-order and higher-order ordinary differential equations, including nonlinear, Bernoulli, second-order linear, variation of parameters, and Cauchy–Euler equations for modeling physical systems.	
CO2: Demonstrate understanding of complex variables by verifying Cauchy–Riemann equations, identifying analytic functions, expanding functions using Taylor and Laurent series, classifying singularities, and applying Cauchy’s Residue Theorem to evaluate contour integrals.	
CO3: Apply Laplace and inverse Laplace transforms, including the Convolution Theorem, to convert differential equations into algebraic forms and solve initial value problems in physical systems.	
CO4: Determine the convergence or divergence of numerical sequences and series using various mathematical tests (Ratio, Root, Raabe’s, etc.) to ensure the stability and validity of power series expansions.	
Module 1: Ordinary Differential Equations (ODE) (14 hours) Linear and non-linear differential equations, Bernoulli’s equation. General solution of ODE of first order and higher degree (Solvable for x, solvable for y, solvable for p and Clairaut’s equation). Solutions of Second order Linear ODE with constant Coefficients, Method of variation of parameters, Cauchy–Euler equations. Simultaneous linear differential equations.	
Module 2: Calculus of Complex Variables (16 hours) Complex functions, Analytic functions, Cauchy–Riemann Equations (statement only). Sufficient conditions for a function to be analytic. Harmonic and Conjugate Harmonic functions, Milne Thomson method. Concept of simple curve, closed curve, smooth curve & contour. Cauchy’s theorem (statement only). Cauchy’s integral formula, Zeroes and Singularities, Taylor’s series and Laurent’s series. Residue, Cauchy’s Residue theorem (statement only) and its applications.	
Module 3: Laplace Transform (13 hours) Definition and Properties of Laplace Transform (LT), LT of elementary functions, Evaluation of sine, cosine, exponential integrals using LT. LT of periodic and step functions. Inverse LT, Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of ODEs.	
Module 4: Sequence and Series (13 hours) Convergence of sequence and series; Tests for convergence: Comparison test, Cauchy’s Root test, D’ Alembert’s Ratio test, Raabe’s test, Leibnitz’s Test (statement only); Absolute convergence and Conditional convergence.	

* Applications of Module 1 to 4 for relevant disciplines.

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CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	2	-	-	-	-	-	1
CO 2	3	3	1	2	2	-	-	-	-	-	1
CO 3	3	3	2	2	3	-	-	-	-	-	1
CO 4	3	3	1	2	1	-	-	-	-	-	1

Text Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India.
2. B.S. Grewal, Higher Engineering Mathematics. S. Chand & Co.
3. John Bird, Higher Engineering Mathematics. Elsevier.
4. S. S. Sastry, Engineering Mathematics (PHI, 4PthP Edition, 2008).
5. H.K. Dass, Advanced Engineering Mathematics, S. Chand & Co.

Reference Books:

1. S. Ponnusamy, Herb Silverman, Complex Variables with Applications, Birkhäuser Boston.
2. Daniel A. Murray, Introductory Course in Differential Equations, Longmans & Green.
3. Robert Wrede, Murray R. Spiegel, Advanced Calculus, McGraw-Hill Companies, Inc.
4. Murray R. Spiegel, Schaum's Outlines: Laplace Transforms.

Course Code: BS-CH 202A	Category: Professional Core Courses
Course Title: Engineering Chemistry	Semester: Second
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic knowledge in higher secondary chemistry.	Branch: CHE
	Total Lecture: 42L
Course Outcomes: Upon successful completion of this course, students will be able to	
CO1: Remember and apply quantum mechanical principles, spectroscopic techniques, thermodynamic laws, and polymer synthesis concepts to explain the fundamental physicochemical behavior of inorganic, organic, and polymeric systems.	
CO2: Understand and analyze the electronic structure of coordination complexes, interpret spectral data, evaluate reaction spontaneity, and distinguish functional properties of soft materials using appropriate experimental tools.	
CO3: Demonstrate molecular bonding and orbital interactions, vibrational modes, reaction kinetics, and stereochemical features to predict the structural and functional properties of chemical systems.	
CO4: Employ crystal field theory, spectroscopic characterization, kinetic models, and analytical	

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techniques such as TGA, and chromatography to evaluate the properties and performance of coordination compounds, drug molecules and advanced materials.
Module 1: Electronic Foundations to Molecular Architecture (10 L) Wavefunction, Eigenvalues & Eigenfunctions; LCAO (O_2 , CO, NO, C_2H_4); CFT: Ions of Fe, Cr, Mn and their colour, Electrical conductivity and Magnetic (spin-only) properties; Anomalous Bonding in Zeise's salt.
Module 2: Spectroscopic Techniques and Applications (8 L) Classifications of Spectroscopy; UV-Vis, Emission spectroscopy; IR; 1H NMR and chemical shift (numerical problem) in the context of $C_2H_5OH/C_2H_5O^-$ C_2H_5
Module 3: Entropy, Spontaneity and Reaction Dynamics (12 L) 2nd Law & Clausius-Clapeyron, Phase rule & diagram of water; Gibbs-Helmholtz & Equilibrium (Haber process / NH_3); Kinetic vs Thermodynamic Control (Butadiene + HBr); Collision Theory & Transition State Theory; Heterogeneous catalysis (chemisorption vs physisorption, example-contact process); Kinetics of Enzyme Catalysis
Module 4: Soft Materials & Analysis (12 L) Stereochemistry (R/S, E/Z), Drug molecules [use and synthesis (Aspirin, Paracetamol, Codeine, Morphine, Heroin)], Polymer [Synthesis (PE, PS, PVC, PET, Bakelite) & Tacticity]; Conducting (PANI) and Biodegradable (PLA) Polymers; Thermal Analysis (TGA/DSC); Principles of Chromatography (TLC/GC/HPLC).

CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	2	1	1	1	-	-	-	2
CO 2	3	3	2	3	1	2	1	-	-	-	2
CO 3	3	3	2	2	2	1	1	-	-	-	2
CO 4	3	3	3	3	2	2	1	1	1	1	2

Learning Resources

1. P. C. Rakshit, Physical Chemistry Sarat Book House.
2. S. Pahari, Physical Chemistry New Central Book Agency.
3. P. W. Atkins, & Paula, J. de Atkins', Physical Chemistry, Oxford University Press.
4. J. D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley India Pvt. Ltd.
5. F.A. Cotton, G. Wilkinson, and P.L. Gaus, Basic Inorganic Chemistry 3rd Ed.; Wiley India.
6. J. E. Huheey, E. A. Keiter, & R. L. Keiter, Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
7. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, Second edition, Oxford University Press.
8. S. Sen Gupta, Reaction Mechanisms in Organic Chemistry, Oxford University Press.
9. L. Finar, Organic Chemistry (Volume 1) Pearson Education.
10. R. N. Morrison, & R. N. Boyd, Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. D. Nasipuri, Stereochemistry of Organic Compounds, Wiley Eastern Limited.
12. E. L. Eliel, & S. H. Wilen, Stereochemistry of Organic Compounds, Wiley: London, 1994.
13. Sharma, Industrial Chemistry (including Chemical Engineering), GOEL Publishing House.

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14.D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan Introduction to Spectroscopy, Brooks/Cole Cengage Learning, 2009.

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Paper Name: Engineering Chemistry Laboratory	Category: Basic Science Course
Paper Code: BS-CH 292A	Semester: Second
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic knowledge in higher secondary chemistry.	Branch: CHE Total Lecture: 42L

Name of the Experiments: (Any eight experiments will be performed based on theory syllabus of the respective branches)

1. Standardization of NaOH solution with standard Oxalic acid solution.
2. Standardization of KMnO_4 solution by standard Oxalic acid solution
3. Conductometric and pH- metric titration for determination of strength of a given HCl solution against a standard NaOH solution.
4. Determination of the partition coefficient of a substance between two immiscible liquids.
5. Determination of chloride ion in a given water sample by Argentometric method (using chromate indicator solution)
6. Determination of dissolved oxygen present in a given water sample.
7. Complexometric titration for determination of calcium and magnesium hardness of water.
8. Determination of concentration of Organic molecules using UV-Vis. spectroscopy.
9. Study of conformational analysis and reactivity using Molecular Optimization technique.
10. Principle of Thin Layer Chromatography using ortho nitrophenol and para nitrophenol; paracetamol, aspirin, ibuprofen; benzoic acid, benzaldehyde, aniline; glycine, alanine, leucine etc.
11. Preparation of materials- phthalimide, aspirin, soap, phenyl, melamine formaldehyde etc.
12. Estimation of Fe^{2+} in Mohr salt using permanganometry.
13. Determination of Biochemical Oxygen Demand (BOD) of Water Sample by Dilution Method
14. Determination of Chemical Oxygen Demand (COD) of Water Sample by Dichromate Reflux Method

Course Outcomes: Upon successful completion of this course, students will be able to

CO1: Explain the underlying principles, theoretical concepts, and safety protocols of various laboratory techniques, including volumetric titrations, instrumental methods, preparation of materials and computational molecular optimization.

CO2: Illustrate standard laboratory procedures, calibration and handling of analytical instruments, precise preparation of standard solutions, execution of analytical titrations and the synthesis/separation of organic compounds.

CO3: Articulate experimental data quantitatively and qualitatively, performing accurate chemical calculations, interpreting graphical plots and utilizing computational data to evaluate molecular properties.

CO4: Analyse structured laboratory reports that document experimental observations, errors and calculations systematically, while upholding professional ethics, safety consciousness, and environmental responsibility in chemical waste management

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CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	2	3	3	2	2	3	1	3
CO 2	2	2	3	3	2	3	3	3	3	-	3
CO 3	2	2	2	2	3	3	2	3	2	-	3
CO 4	3	2	3	2	3	3	3	3	3	2	3

Learning Resources

1. A. I. Vogel, Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
2. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Course in Practical Chemistry, New Central Book Agency; 3rd edition.
3. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
5. H. T. Clarke, A Handbook of Organic Analysis (Qualitative and Quantitative), Fourth Edition, CBS Publishers and Distributors (2007).
6. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

Paper Name: Basic Electrical and Electronics Engineering	Category: Engineering Science
Paper Code: ES-EE 203 A	Semester: First / Second
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic knowledge of Physics mainly Electric charge and current, Voltage and resistance, Magnetism and electromagnetic induction, Energy and power etc	Branch: CHE Total Lecture: 42 L

Course Outcomes:

CO 1: Remember the concepts of different network theorems for electrical and electronic circuits.
CO 2: Understand the concepts of basic laws of electricity, magnetic circuits, electronics circuit and its applications.
CO 3. Apply relevant theorems and electromagnetic concepts to provide efficient solutions of electrical and electronics related problems.
CO4: Analyze electrical and electronic circuits for effective problem-solving.

COURSE CONTENTS:

Module 1:

Unit 1: DC Circuits (9L)

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Independent and dependent voltage and current sources. Kirchhoff's Current Law (KCL), Kirchhoff's Voltage Law (KVL). Analysis of electrical circuits using Mesh and Nodal analysis. Source transformations between voltage and current sources. Network theorems: Superposition Theorem, Thevenin's Theorem, and Norton's Theorem.

Unit 2: AC Fundamentals (6L)

Generation of alternating voltage. RMS and average values for various wave shapes. Analysis of AC series circuits (R, RL, RC, RLC) using phasor techniques. Concept of real, reactive, and apparent power; power factor and power triangle. Resonance in RLC series circuits: conditions and characteristics.

Module 2: Three-Phase Systems (3L)

Unit 1: Fundamentals of balanced three-phase systems, Star (Y) and Delta (Δ) configurations: line and phase voltage/current relationships. Three phase power measurement by two wattmeter method.

Unit 2: Basics of three phase Induction Motor (4L)

Construction of three phase Induction Motor, Generation of rotating magnetic field, Operating principle, slip.

Module 3: Single Phase Transformers (10L)

Magnetic Materials and B-H curve, Single-Phase Transformers: principle of operation, constructional features, EMF equation. Equivalent circuit of transformer, Phasor diagram at no load and loaded conditions, Calculation of equivalent circuit parameters by open and short circuit test, power losses and efficiency calculations.

Module 4: Electronics

Unit 1: Basics of Diode (2L)

Basics of p type and n type semiconductor, V-I characteristics of p-n junction diode, Zener diode.

Unit 2: Basics of Bipolar Junction Transistor (3L)

BJT construction, BJT Configurations: Common Emitter (CE), Common Base (CB), and Common Collector (CC).

Unit 3: Operational Amplifiers (Op-Amps) (5L)

Op-Amp Fundamentals: Ideal vs. Practical Characteristics, Applications of Op-Amps: Inverting and Non-Inverting Amplifiers, Summing Amplifier, Integrator and Differentiator Circuits.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3	3	-	-	-	-	-	3
CO 2	3	3	3	3	3	2	2	-	-	-	3
CO 3	3	3	3	3	3	2	2	-	-	-	3
CO 4	3	3	3	3	3	2	2	-	-	-	3

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Paper Name: Programming for Problem Solving	Category: Engineering Science Course
Paper Code: ES-CS- 203	Semester: Second
L-T-P: 3-1-0	Credit: 4
	Branch: CHE Total Lecture: 56 L

COURSE CONTENTS

Module 1 [14L]

Unit 1:Introduction to Programming (6 L)

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) Overview of Number system and its conversion: Binary, Octal & HEX

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.

From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code

Unit 2:Arithmetic expressions and precedence (2 L)

Unit 3:Conditional Branching and Loops (6 L)

Writing and evaluation of conditionals and consequent branching; Iteration and loops

Module 2 [14L]

Unit 1:Arrays (6 L)

Arrays (1-D, 2-D), Character arrays and Strings

Unit 2:Basic Algorithms (8 L)

Searching algorithm (Linear & Binary search), Basic Sorting Algorithms (Bubble, Selection), notion of order of complexity through example programs (no formal definition required)

Module 3 [14L]

Unit 1: Function (7 L)

Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Unit 2: Recursion (7 L)

Recursion, as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Tower of Hanoi problem.

Module 4 [14 L]

Unit 1:Structure & Union (4 L)

Basic concepts of Structures & Union; Array of Structures, Structure-Union comparison with implementation.

Unit 2: Pointers (6 L)

Concept of pointers, Pointer arithmetic, array of pointers, passing pointer to function, function returning pointer, Array-

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pointer relationship-basic idea.

Course Code: ES-CHE 201	Category: Engineering Science Courses
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**Unit
3:File
hand
ling
(4
L)
Basic
idea
about
read,
write,**

append in file operation. Sample file creating and reading a file.

Course Outcomes (COs)

- CO1:** Understand and remember the basic concepts of C programming.
CO2: Apply control structures such as loops and conditionals to develop and solve problems.
CO3: Apply concept of array, strings, pointers for efficient data storage and manipulation.
CO4: Design complex data structures and manage file operations.

Learning Resources

1. R. S. Salaria, Computer Concepts and Programming in C, Khanna Publishers .
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.
3. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	2	2	-	-	-	2	-	2
CO 2	2	2	1	3	3	-	1	-	-	-	-
CO 3	2	2	2	2	2	1	2	3	3	2	3
CO 4	3	2	2	3	3	-	-	-	-	1	-

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Course Title: Introduction to Chemical Engineering.	Semester: 2 nd
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Foundational high school or early university-level knowledge.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understanding the relation among chemical science, engineering, and technology.	
CO2: Remembering the different features of chemical operations in industries.	
CO3: Applying the knowledge during interaction with industry experts.	
CO4: Analyzing the gathered knowledge during exposure to different components to industries.	
Module 1: Overview of Chemical Process Industries. (10 hrs) Interrelationship between Chemistry / Engineering Chemistry and Chemical Engineering. Unit Operations and unit processes involved in Chemical Engineering - an overview. Chemical Industries - scope of a chemical engineer, different features & characteristics of chemical Industries. Physical separation /transformation and chemical transformation during raw material to product formation.	
Module 2: Fundamental concept of Chemical Process (12 hrs) Batch and continuous processes, Role of thermodynamics and kinetics in chemical transformation. Process flow sheet presentation. Different dimensionless groups and their use in chemical engineering. Conversion of units. Sources of information and data for calculating different physical properties of components, Group contribution method in estimating different physical properties like density, heat capacity etc.	
Module 3: Concept of Unit operations (12 hrs) Basic ideas / features of some useful equipments /units involved in the chemical process like, pump, blowers, compressors, ejector, economizer, boiler, knockout drum, barometric condenser, stripper etc. pump selection, pipe size selection, tubes, fittings, and valves. Outlines of unit operations involved in separating multiphase systems - distillation, filtration, crystallization, absorption, adsorption, extraction, leaching, evaporation, drying etc.	
Module 4: Environmental Impact of Industries (8 hrs) Plant layout. Pollution consideration and occupational safety aspects. Plant Utilities. Process Data Representation and Analysis - interpolation and extrapolation, curve-fitting and least squares method, fitting a line to scattered data.	

Course Articulation Matrix:

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

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CO–PSO Mapping Matrix

COs \ PSOs	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	2	1
CO3	2	1	3
CO4	3	2	2

Learning Resources:

1. Coulson & Richardson's chemical engineering, vol VI, by R. K. Sinnott
2. Introduction to Chemical Engineering by S.K. Ghosal, S.K. Sanyal and S. Dutta, Tata Mc Graw Hill Publishing Company Limited, New Delhi

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Paper Name: Basic Electrical and Electronics Engineering Laboratory	Category: Engineering Science
Paper Code: ES-EE 293 A	Semester: First / Second
L-T-P: 0-0-3	Credit: 1.5
	Branch: CHE Total Lecture: 42 P

Course Outcomes:

CO1: Remember fundamental laws and theorems to solve DC and AC electrical networks problems.
CO2: Understand the principles and characteristics of core electrical and electronic components in practical circuit.
CO3: Evaluate the performance of electrical machines, electrical and electronic circuits using appropriate theoretical models and test procedures.
CO4: Design basic electrical and electronic circuits involving RLC circuits, rectifiers, amplifiers.

Experiments:

1. Verification of Superposition Theorem.
2. Verification of Thevenin's and Norton's Theorems.
3. Measurement of three phase power by two wattmeter method.
4. Study of Series Resonance in RLC Circuit.
5. Open-Circuit and Short-Circuit Tests on a Single-Phase Transformer.
6. Load test of three phase induction motor.
7. Study of i-v characteristic of p-n junction diode.
8. Study of i-v characteristic of Zener diode.
9. Study of input and output voltage, ripple factor of half wave and full wave rectifier.
10. Study of Inverting and Non-Inverting Amplifiers.

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Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3	3	-	-	-	-	-	3
CO 2	3	3	3	3	3	2	2	-	-	-	3
CO 3	3	3	3	3	3	2	2	2	3	2	3
CO 4	3	3	3	3	3	2	2	2	3	2	3

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Paper Name: Programming for Problem Solving	Category: Engineering Science Course
Paper Code: ES-CS- 293	Semester: Second
L-T-P: 0-0-3	Credit:1.5
	Branch: CHE
	Total Lecture: 42 L

The laboratory should be preceded or followed by a tutorial to explain the approach or algorithm to be implemented for the problem given

Tutorial 1: Problem solving using computers, Variable types and type conversions

Lab1: Familiarization with programming environment; Simple computational problems using arithmetic expressions

Tutorial 2: Branching and logical expressions:

Lab 2: Problems involving if-then-else structures

Tutorial 3: Loops, while and for loops:

Lab 3: Iterative problems e.g., sum of series

Tutorial 4: 1D Arrays: searching, sorting:

Lab 4: 1D Array manipulation

Tutorial 5: 2D arrays and Strings

Lab 5: Matrix problems, String operations

Tutorial 6: Functions, call by value:

Lab 6: Simple functions

Tutorial 7: Recursion, structure of recursive calls

Lab 7: Recursive functions

Tutorial 8: Numerical methods (Root finding, numerical differentiation, numerical integration):

Lab 8: Programming for solving Numerical methods problems

Tutorial 9: Pointers, structures and dynamic memory allocation

Lab 9: Pointers and structures

Tutorial 10: File handling:

Lab 10: File operations

Course Outcomes (COs)

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CO1: Demonstrate the ability to write. Compile and execute basic C program.

CO2: Develop algorithms and solve problems using control structures.

CO3: Implement programs that utilize array, string, pointers for storage, memory access and manipulation.

CO4: Use structures and unions to create, manipulate complex data type and perform file operational for reading and writing data.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	3	2	2	-	-	-	2	-	2
CO 2	3	3	3	-	3	3	3	-	1	2	-
CO 3	2	3	2	2	-	2	1	3		2	3
CO 4	1	2	2	3	3	-	-	-	-	1	-

Paper Name: Workshop Practice	Category: Engineering Science Course
Paper Code: ES-ME 291	Semester: Second
L-T-P: 0-0-3	Credit: 1.5
	Branch: CHE Total Lecture: 42L

Theory (6P)

1. Carpentry (Wood Working): Timber, Seasoning and Preservation, Plywood and Plyboards, Carpentry Tools, Engineering applications. Different Joints

2. Metal Joining: Definitions of welding, brazing and soldering processes, and their applications. Oxy-acetylene gas welding process, equipment and techniques. Types of flames and their applications. Manual metal arc welding technique and equipment. AC and DC welding, electrodes, constituents and functions of electrodes. Welding positions. Types of weld joint. Common welding defects such as cracks, slag inclusion and porosity.

3. Bench work and Fitting: Tools for laying out, chisels, files, hammers, hand hacksaw, their specifications and uses.

4. Metal Cutting: Introduction to machining and common machining operations. Cutting tool materials, geometry of cutting tool, cutting fluid. Definition of machine tools, specification and block diagram of lathe, shaper, milling, drilling machine and grinder. Common lathe operations such as turning, facing and chamfering and parting. Difference between drilling and boring. Use of measuring instruments like micrometer / verniercaliper.

5. Tin Smithy: Sheet metal introduction, tools and operations, Shearing and Bending of sheets, types of joints

Jobs to be made in the Workshop

Group A(6 P)

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Carpentry Shop: T-Lap joints and Dovetail joints

Group B (6 P)

- a. Gas Welding practice on mild steel flat/sheet (up to 3mm thick)
- b. Lap joint by Gas Welding (up to 3mm thick)
- c. Manual Metal Arc Welding practice (up to 5mm thick)
- d. square butt joint by MMA Welding
- e. Lap joint by MMA Welding

Group C

Fittings work: Sawing and Finishing by Filing. (6 P)

Group D

- a. Jobs on lathe with turning, facing, chamfering and parting operations (6 P)
- b. Job on shaper and milling machine for finishing two sides of a job (6 P)
- c. Drilling of holes of size 5- and 12-mm diameters on the jobs / External threads making by dies, Tap size drill hole/ hand tapping operations

Group E

Smithy - making simple products on sheet metal (6 P)

Learning Resources

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. and Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu, "Manufacturing Technology – I" Pearson Education, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Course Outcomes (COs)

CO1: Train the students in metal joining process like welding, soldering, etc

CO2: Impart skill in fabricating simple components using sheet metal

CO3: Cultivate safety aspects in handling of tools and equipment.

CO4: Define, describe and determine the types and nature of the physical parameters like cutting speed, feed, depth of cut etc applied on mechanical manufacturing systems.

CO5: Classify and explain the effects of the above physical parameters as applied on mechanical manufacturing systems for proper comprehension.

CO6: Develop the collective skill and potentiality and leadership quality to work in a group or team.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	2	1	3	3	2	2	2	2
CO 2	3	3	3	3	3	3	3	3	3	3	3
CO 3	3	3	3	3	2	2	3	3	3	3	2

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CO 4	3	2	3	3	2	3	2	2	2	2	2
CO 5	3	2	3	3	2	3	2	2	2	2	2
CO 6	3	3	3	3	3	3	3	3	3	3	3

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SEMESTER-III

Course Code: BS- CHE 301	Category: Basic Science Courses
Course Title: Numerical Methods for Chemical Engineering.	Semester: 3 rd
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Foundational high school or early university-level knowledge	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the consequences of finite precision and the inherent limits of the numerical methods considered.	
CO2: Implement the various types of numerical methods for solving different types of engineering problems in consideration of the mathematical operations involved, accuracy requirements, and available computational resources.	
CO3: Evaluate the modern scientific problems using different numerical techniques.	
CO4: Compile the numerical techniques for the solution of integration, linear equations, ordinary differential equations, interpolations, etc.	
Module 1: Numerical Methods and Error Analysis for Chemical Engineering (10 hours) Introduction, Approximation and Concept of Error & Error Analysis. Inherent, rounding of errors, absolute errors, relative errors. Linear Algebraic Equations: Direct Method: Gauss elimination, Gauss Jordan, LU decomposition, and matrix inversion, Iterative Method: Gauss Jacobi, Gauss-Siedel method. Chemical engineering problems involving the solution of linear algebraic equations.	
Module 2: Nonlinear Equations, Interpolation and Regression (12 hours) Root finding methods for solution on non-linear algebraic equations: Bisection, Newton-Raphson and Secant methods, Error criterion. Chemical engineering problems involving the solution of nonlinear equations. Interpolation and Approximation: Newton's forward and backward interpolation, Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression, Newton's divided difference.	
Module 3: Integration and Ordinary Differential Equations (12 hours) Numerical integration: Trapezoidal rule, Simpson's rule, Integration with unequal segments, Chemical engineering problems involving numerical differentiation and integration Ordinary Differential Equations: Euler method, Modified Euler method, Huen's method, Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs.	
Module 4: Partial Differential Equations (8 hours) Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.	

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Course Articulation Matrix:

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

CO-PSO Mapping Matrix

	PSO1	PSO2	PSO3
CO 1	3	1	-
CO 2	3	3	-
CO 3	3	3	1
CO 4	3	2	-

Learning Resources:

1. S. K. Gupta, Numerical Methods for Engineers, New Academic Science, 2012.
2. R. S. Salaria, Numerical Methods, Khanna Publishing House, 2018
3. S. C. Chapra & R. P. Canale, Numerical Methods for Engineers with Personal Computer Applications, McGraw-Hill Book Company, 1985.
4. R. L. Burden & J. D. Faires, Numerical Analysis, 7th Ed., Brooks Coles, 2000.
5. P. Ahuja, Introduction to Numerical Methods in Chemical Engineering, PHI, 2010
6. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1978.
7. W. H. Press et al., Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

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Course Code: BS-CHE 302	Category: Basic Science Courses
Course Title: Chemical Process Calculations	Semester: 3 rd
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic knowledge of unit, dimensions, mole concept, principle of steady state and unsteady-state unit operation, thermophysics, and thermochemistry	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Remember & understand the process parameters/ variables involved in any processing unit of Chemical processing industries or its allied sectors, to list and relate the process variables and then label them on block diagram/ simple flow diagram of the processing unit.	

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CO2: Apply the knowledge and concepts of mass balance or energy balance computation to select the basis of solution of the specific problem and then to identify the important key components for solving chemical process engineering problems under certain processing conditions.
CO3: Analyze to compare and simplify the appropriate techniques, then evaluate the exact solutions of complex chemical engineering problems with an understanding of the limitations, laws, and regulations related to economic, environmental, ethical, and health issues.
CO4: Create in aspects of ability to invent, and adapt the modified techniques with an understanding of engineering and management principles, and also to engage as an individual or as a team member independently in the profession for life-long learning in the broad context of technological changes.
Module 1: Introduction to Units, Dimensions, and useful terminologies (10 hours) Dimensions and units, physical quantities in chemical engineering, Dimensionless groups, Dimensional homogeneity, Dimensional analysis, Buckingham's pi theorem and its application, Data fittings in semi-log and log-log graph. Concept of mole, mole fraction, weight fraction, average molecular weight, Compositions of mixtures of solids, liquids, and gases. Specific gravity scales.
Module 2: Material Balance without Chemical Reaction (10 hours) Basis of calculations, material balance problems on mixing, crystallization, absorption, extraction, distillation, drying, etc. Humidity and Saturation, various humidity terms like molar, absolute, relative & percentage saturation, humid heat, humid volume, dry bulb temperature, dew point, humidity chart, and its use.
Module 3: Material Balance with chemical reaction (10 hours) Concept of stoichiometry, limiting reactant, excess reactants and inert, fractional and percentage conversion, fractional yield and percentage yield, selectivity, combustion, and related problems. Material Balances with recycling, bypass, and purging.
Module 4: Energy Balance (12 hours) The fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine Equation, Cox chart, Duhring's plot, Raoult's law, Henry's law and related numerical problems, Watson equation, Trouton's rule, Kistyakowsky equation. Energy balance: Heat capacities, estimation of heat capacities, calculation of enthalpy changes, Kopp's rule. Energy balances with chemical reaction: Heat of reaction, the heat of combustion, heat of formation, Calorific values, Hess's Law, and related problems of various chemical processes.

Course Articulation Matrix:

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

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CO-PSO Mapping Matrix

	PSO1	PSO2	PSO3
CO 1	3	3	3
CO 2	3	2	3
CO 3	3	2	3
CO 4	2	3	2

Learning Resources:

1. Bhatt, B.I., Vora, S.M., "Stoichiometry", Fourth Edition, Tata McGraw-Hill Publishing Company Ltd, 2004.
2. Hougen, O.A., Watson, K.M., Ragatz, R.A., Chemical Process Principles, Part-I material & Energy Balances, Second Edition, CBS Publishers & Distributors, 2004
3. Venkataramani, V., Anantharaman, N., Begum, K.M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
4. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.
5. Narayanan K.V., Lakshmikutty B., "Stoichiometry and Process Calculations", 2nd edition, Prentice Hall of India.

Course Code: ES-CHE 301	Category: Engineering Science Courses
Course Title: Chemical Engineering Thermodynamics	Semester: 3rd
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: A strong foundational knowledge of mathematics, chemistry and physics.	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understanding the basic concepts and related laws of thermodynamics, its application in closed and open system.	
CO2: Applying the concepts of heat engine and heat pump / refrigerator, refrigeration and other cycles and also the properties of non-ideal gases and liquids in open and closed system.	
CO3: Analyzing the concept of fugacity, activity, the Raoult's law, the bubble point, dew point and flash calculation and Chemical Reaction Equilibria.	
CO4: Evaluating the application of solution thermodynamics, Chemical Reaction Equilibria, and solve different thermodynamic problems involving equilibria of different phases.	
Module 1: Introduction & Basic Concepts of thermodynamics: (14 hours) Scope of thermodynamics, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Reversible process; Constant P, V, T processes; Mass and energy balances for open systems. Heat effects.	

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PVT behavior; – Equation of State-Ideal gas law, vander Waals, virial and cubic equations of state, etc.; Reduced conditions & corresponding states theories

Module 2: Second Law of Thermodynamics: (14 hours)

Entropy; Entropy changes of an ideal gas; Thermodynamic property of fluids, Maxwell relations, The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. Concept of free energy.

Thermodynamic analysis of steam power plants; Rankine cycle; internal combustion engine, Otto engine; Diesel engine; Jet engine.

Module 3: Solution Thermodynamics: (14 hours)

Fundamental property relationships, free energy and chemical potential, partial properties. Vapor-liquid equilibrium (VLE): phase rule, simple models for VLE –Raoult's law; Bubble point, dew point, Flash calculations, etc.

Non ideal solutions: The non-ideal solution and the residual and excess properties. Definition of fugacity and fugacity coefficient of pure species and species in solution, Activity and activity coefficient. Gibbs Duhem equation.

Module 4: VLE and Chemical Reaction Equilibria (14 hours)

Liquid phase properties from VLE, Models for excess Gibbs free energy, heat effects and property change on mixing. VLE by modified Raoult's law; VLE from K-value correlations; Bubble point, dew point, Flash calculations.

Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multi reaction equilibria. Phase rule for reacting system.

Course Articulation Matrix:

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

CO–PSO Mapping Matrix

	PSO1	PSO2	PSO3
CO 1	2	1	3
CO 2	2	3	1
CO 3	1	3	2
CO 4	3	2	1

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Learning Resources:

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, "Introduction to Chemical Engineering Thermodynamics," 8th edition, McGraw-Hill International Edition, 2005.
2. K. V. Narayanan, "A textbook of Chemical Engineering Thermodynamics," 2nd edition, PHI, 2013.
3. Y.V.C. Rao, "Chemical Engineering Thermodynamics", University Press, Hyderabad, 1997.

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Course Code: PC-CHE 301	Category: Professional Core Courses
Course Title: Fluid Mechanics	Semester: 3 rd
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Basics of fluid mechanics, basic equations of fluid flow, and transportation.	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the fundamental properties of fluid and their characteristics, laws of fluid Mechanics, and their applications. Concepts of Boundary Layer Theory, fluid kinetics, and fluid dynamics.	
CO2: Establish the Euler's Equation and Bernoulli's equation in fluid mechanics. Concept and applicability of the Navier-Stokes equation	
CO3: Analyze the flow over immersed bodies, the concept of drag and lift. Principle of the packed column, the importance of fluidization bed; minimum fluidization velocity; pneumatic conveying and their industrial applications.	
CO4: Understand and develop the concept of flow-measuring devices and their industrial applications. fluid moving machinery, pumps, their working principles and industrial applications.	
Module I: Concept of fluid and its characteristics (15 hours) Introduction to fluids, Types of fluid, Newtonian and non-Newtonian fluid, Continuum hypothesis, Terminologies of fluid flow, velocity–local, average, maximum, flowrate–mass, volumetric, velocity field; dimensionality of flow; flow visualization –streamline, path line, streak line, stress field; viscosity; Newton's law of viscosity, Reynold's number—its significance, laminar, transition and turbulent flows: Boundary layer concept, Prandtl boundary layer, compressible and incompressible flows. Blasius solution, Boundary layer separation. Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition, Spectral nature of turbulence, Fluid statics - pressure distribution, Manometry, Forces on submerged bodies (planar and curved), Buoyancy, Rigid body motion (translation and rotation) Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices –manometer, U-tube, inclined-tube, inverted U-tube manometer. Kinematics of fluid, Basic laws for a system; relation of system derivatives to the control volume formulation.	

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Module II: Basic equation of fluid flow and its application (15 hours)

System and control volume approaches, Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Turbulent flow. The flow of incompressible fluid in a circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseuille equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, the relation between average and maximum velocity, Bernoulli's equation-kinetic energy correction factor; head loss; friction factor-Fanning and Darcy, Moody diagram. Major and minor losses; Pipe fittings and valves, schedule no, equivalent diameter, conservation of mass; continuity equation, momentum balance equation-Introduction to Navier Stokes and Euler equations. momentum correction factor. Flow-Eulerian and Lagrangian descriptions. Kinematic decomposition of flow motion.

Flow measurement, Transportation of fluids - Introduction; hydraulic coefficient, the general equation for internal flow meters; Orifice meter; Venturimeter; Weirs, the concept of area meters: Rotameter; Local velocity measurement: Pitot tube. Mass flow meter, Notches and weirs – Rectangular, Triangular, trapezoidal.

Module III: Flow past immersed bodies (15 hours)

Differential analysis: mass and momentum balances, Navier-Stokes equation, unidirectional flow, viscous flow, Stokes law, Skin drag, and pressure drag, Introduction: the concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body; packed bed; the concept of Sphericity; Ergun equation, modified friction factor Potential flow, Potential function, Introduction; different types of fluidization; minimum fluidization velocity; governing equation; industrial uses.

Module IV: Transportation and metering of fluid (11 hours)

Fluid moving machines: Introduction; Basic classification of pumps: Non-Mechanical Pumps—acid egg, steam jet, ejector, air lift pump, Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification, efficiency, Characteristic curves for centrifugal pumps, Compressible flows, fan, blower, and compressor.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	2	1	2	3	1	2
CO 2	2	2	2	2	2	-	1	-	2	1	2
CO 3	3	2	2	2	2	-	1	2	-	1	2
CO 4	3	3	2	2	2	3	2	3	3	2	2

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CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	-	1	1
CO 2	1	-	1
CO 3	2	1	-
CO 4	1	2	2

Learning Resources:

1. Unit operations of Chemical Engineering: McCabe, Smith and Harriot, TMH, 6th Edn.
2. S.S. Rattan, Fluid Mechanics, Khanna Publishing House, New Delhi, 2018
3. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005
4. Introduction to Fluid Mechanics. R.W. Fox, P.J. Pritchard, and A.T. McDonald, John Wiley
5. Fluid Mechanics, A.K. Mohanty, PHI
6. M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
7. V. Gupta and S.K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International, 2011
8. Transport Process and Unit Operations: Geankoplis, 3rd Edn. PHI
9. Principles of Unit Operations: Foust and Wenzel, Wiley, 1980

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Course Code: PC-CHE 302	Category: Professional Core Courses
Course Title: Solid and Fluid– Particle Processing	Semester: 3 rd
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic knowledge of Engineering Mathematics, Engineering Physics, and Engineering Chemistry.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: After completion of the course, students will be able to:	
CO1: Describe the basic concept of Mechanical Operations used in chemical process industries.	
CO2: Classify and explain solid-solid and solid-fluid related operations, identifying methods for measuring the performance of equipment.	
CO3: Examine the factors affecting solid handling-related operations with respect to the sustainable development of process industries.	
CO4: Design and troubleshooting of Industrial equipment related to Mechanical Operations.	
Module 1: Solid particle characterization and screening (11 hours) Introduction to solid particles, Characteristics of solid particles: Particle size, shape, and their distribution, Relationship among shape factors and particle dimensions, Concept of Sphericity, Measurement of surface area. Properties of solid mixture. Screening, various screen series and	

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Differential and cumulative method of screen analysis. Industrial screens- grizzly, gyratory and vibratory screens, revolving screens, trammels, capacity and effectiveness of screens, magnetic separation, electrostatic separation.

Module 2: Methods of size-reduction and enlargement (11 hours)

Principle of comminution, Types of crushers, grinders & disintegrators for coarse and intermediate & fine grinding. Energy & power requirement for size reduction, laws of crushers & work index, close & open circuit grinding, feed control, mill discharge and removal & supply of heat in wet grinding. Size enlargement– objectives, methods and equipment used in industries. Storage of solids, Types of flow in solid discharge, and various problems.

Module 3: Motion of particles through fluids and solids (10 hours)

Concept of sedimentation, terminal settling velocity, batch settling test, free & hindered settling, Flocculation, types of thickeners & thickener area calculation, batch & continuous settling chambers, and sorting of classifiers. Centrifugal settling process, cyclone, & principle of centrifugal sedimentation.

Module 4: Filtration and centrifugal separation (10 hours)

Types of filtration, requirements of filter media, and filter aids. Principle of cake filtration, constant pressure & constant rate filtration, Batch & continuous filtration equipment – filter press, leaf filter, cartridge filter & rotary drum filter. Centrifugal filtration, design of cyclones and hydro-cyclones.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	1	-	-	2	-	2	-	-	2
CO 2	2	1	1	1	1	2	-	1	-	2	3
CO 3	3	2	1	2	2	2	-	2	-	-	2
CO 4	3	2	3	2	1	3	2	3	2	-	2

CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	1
CO 2	1	2	1
CO 3	2	2	-
CO 4	2	3	2

Learning Resources:

- McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.
- Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.
- Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester; New York, 2008.
- Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.
- Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.
- Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties, and Applications, 2nd Ed., Wiley, 2013.

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Course Code: HM-CHE 301	Category: Humanities and Social Sciences, including Management
Course Title: Economics for Engineers	Semester: 3 rd
L-T-P: 2-0-0	Credit: 2
Pre-Requisites: Fundamentals of Mathematics	Branch: Chemical Engineering Total Lecture: 28 L
Course Outcomes: After completion of the course, students will be able to:	
CO1: Recall and explain fundamental concepts of engineering economics.	
CO2: Apply economic principles and techniques to analyze engineering projects and make informed decisions based on economic criteria.	
CO3: Analyze project cost structures, estimate costs using appropriate methods, and evaluate the cost-effectiveness of the engineering projects using NPV, IRR, BCR, etc.	
CO4: Integrate economic sustainability considerations into engineering design and decision-making processes by assessing project risk through sensitivity analysis.	
Module 1: Introduction to Engineering Economy (4 hours) Origin of Engineering Economy, Principles of Engineering Economy, Role of Engineers in Decision Making.	
Module 2: Time Value of Money (12 hours) Introduction to Time Value of Money, Simple Interest, Compound Interest, Nominal Interest rate, Effective Interest rate, Continuous Compounding, Economic Equivalence, Development of Interest Formulas, The Five Types of Cash flows, Single Cash flow Formulas, Uneven Payment Series, Equal Payment Series. Methods of comparison of alternatives: NPV, Profitability Index or Benefit Cost Ratio, Payback Period Method, Equivalent Worth Methods, Present Worth Method, Future Worth Method, Annual Worth Method, Rate of Return Methods (IRR and ARR)	
Module 3: Engineering Costs & Estimation (6 hours) Elements of cost (Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring and Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs) and cost estimation models (Per-Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve), Concept of Revenue, Break even analysis, Cost sheet.	
Module 4: Inflation And Price Change (6 hours) Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In Engineering Economic Analysis, Cash Flows that inflate at different Rates.	

Course Articulation Matrix:

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

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CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	2	1	1
CO2	3	2	1
CO3	3	2	1
CO4	2	3	2

Learning Resources:

1. Donald Newnan, Ted Eschembach, Jerome Lavelle: Engineering Economics Analysis, OUP
2. R. Paneer Seelvan: Engineering Economics, PHI
3. Sullivan and Wicks: Engineering Economy, Pearson
4. John A. White, Kenneth E. Case, David B. Pratt: Principle of Engineering Economic Analysis, John Wiley
5. James L. Riggs, David D. Bedworth, Sabah U. Randhawa: Economics for Engineers 4e, Tata McGraw-Hill

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Paper Name: Fluid Mechanics Laboratory	Category: Professional Core Courses
Paper Code: PC-CHE 391	Semester: 3 rd
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic knowledge of Fluid Mechanics.	Branch: Chemical Engineering Total Lecture: 42 L

Name of the Experiments

1. Pipeline assembling and a layout drawing.
2. Experiments on Reynolds Apparatus for visualization and determination of flow regimes.
3. Verification of Bernoulli's Principle experimentally
 - i. Calibration of an Orifice meter
 - ii. Calibration of a Venturimeter
 - iii. Calibration of a Rotameter
4. Determination of co-efficient of Pitot tube and construction of velocity profile across the cross section of pipe.
5. Determination of co-efficient of Discharge for different types of weirs.
6. Determination of pressure drop for flow through packed bed and verification of Ergun equation.
7. Experiment on fluidization techniques and determination of
 - i. Minimum fluidization velocity
 - ii. Pressure drop profile

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8. Determination of the efficiency of a centrifugal pump.

Course Outcomes (COs):

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

CO1: Recalling the basics of fluid mechanics to relate with relevant engineering instruments/equipment.

CO2: Applying the fundamental knowledge of fluid mechanics through experimental.

CO3: Analyzing the working of various fluid mechanics instruments/ equipment.

CO4: Evaluating the performance of the instruments/ equipment by comparing the results with established values and developing the skill of presenting the results in form of written reports.

Course Articulation Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	-	-	-	2	2	1	2
CO 2	3	3	1	3	3	1	-	3	2	1	2
CO 3	3	3	1	3	3	2	-	3	2	1	2
CO 4	3	3	1	3	2	1	1	3	3	2	3

CO-PSO Mapping Matrix:

COs \ PSOs	PSO1	PSO2	PSO3
CO 1	3	2	1
CO 2	3	3	1
CO 3	3	3	1
CO 4	3	3	2

Learning Resources

1. P. Pritchard, P.J. Fox and McDonald's Introduction to Fluid Mechanics, John Wiley & Sons Inc., 8th edition, 2011.
2. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
3. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical Engineering (Volume 2), Butterworth-Heinemann, 5th edition, 2002.
4. Jain A.K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, 1998.
5. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition, 2010.

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Paper Name: Solid and Fluid–Particle Processing Laboratory	Category: Professional Core Courses
Paper Code: PC-CHE 392	Semester: 3 rd
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic knowledge of Solid and Fluid–Particle Processing	Branch: Chemical Engineering Total Lecture: 42 L

List of Experiments:

1. Verification of Rittinger 's Law and determination of grind ability index of a drop weight crusher for a given granular solid sample.
2. Determination of reduction ratio and capacity of a laboratory scale Ball Mill.
3. Estimation of capacity and reduction ratio of a batch Hamme Mill.
4. Determination of average particle size of a given solid sample using a sieve shaker by
(i) Random Sampling (ii) Coning and quartering.
5. Determination of overall effectiveness of a sieve shaker for a given solid sample of unknown size.
6. Estimation of Mixing Index at different times and power consumption for fluid mixing for different rotational speeds of the impeller.
7. Determination of rate of sedimentation for given slurry by plotting interface height vs. Time.
8. Design of a continuous thickener by conducting a batch sedimentation test for a given sedimentation duty.
9. Determination of specific cake resistance ' α ' and filter medium resistance ' R_m ' by filtering a slurry using plate and frame filter press.
10. Estimation of ' α ' (specific cake resistance) and ' R_m ' by filtering slurry using a batch centrifugal filter.
11. Determination of the recovery percentage of coal in froth from coal-sand mixture by using Froth Floatation Technique.

Course Outcomes (COs)

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

CO1: Memorize and understand the fundamentals of particle and fluid particle processing by doing the experiment in hand through teamwork.

CO2: Understand the importance of various equipment of particle and fluid particle processing used in process industries by applying its working principle through experiment.

CO3: Analyze the principles of particle and fluid particle processing for designing various size reduction equipment, size separation, filtration, mixing and conveying types of equipment.

CO4: Justify between the professional ethics and responsibility in aspects of safety and environmental protection during experimental work.

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Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	3	3	3
CO2	3	3	3
CO3	3	2	2
CO4	3	2	2

Learning Resources:

1. Laboratory Manuals.
2. Mc.Cabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

Paper Name: Numerical Methods for Chemical Engineering Laboratory	Category: Basic Science Courses
Paper Code: BS-CHE 391	Semester: 3 rd
L-T-P: 0-0-2	Credit: 1
Pre-Requisites: Basic Understanding on C, C++ and Python.	Branch: Chemical Engineering Total Lecture: 28 L

Name of the Experiments

1. Introduction to use of computers for numerical calculations
2. Matrix Multiplication using C language.
3. Matrix Multiplication using MATLAB.
4. Solution of linear algebraic equations using direct method (Gauss elimination, etc.)
5. Solution of linear algebraic equations using indirect method (Gauss-Seidel, etc.)
6. Solution of a non-linear equation using bracketing and open-end methods (Newton-Raphson and

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Secant) method.

7. Newton's Forward and Backward Interpolation, Lagrange Interpolation.
8. Numerical integration: Trapezoidal Rule, Simpson's 1/3 rule and 3/8 rule.
9. Solving of ODEs by using Euler's method.
10. Solving of ODEs by using Runge-Kutta method.
11. Solution of simple PDEs

Course Outcomes (COs)

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

CO1: Define the methodologies to handle engineering problems numerically.

CO2: Understand the pertinent parameters of different engineering problems using suitable methods.

CO3: Apply a preferable method to handle the different engineering problems.

CO4: Differentiate the engineering problem critically.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3	3	-	3	3	3	2	3
CO 2	3	3	3	3	3	-	2	3	3	2	3
CO 3	3	3	3	3	3	-	3	3	3	2	3
CO 4	3	3	3	3	3	-	3	3	3	3	3

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	-	2
CO 2	3	-	2
CO 3	3	-	2
CO 4	3	-	2

Learning Resources:

1. S.K. Gupta, Numerical Methods for Engineers, New Academic Science, 2012.
2. R.S. Salaria, Numerical Methods, Khanna Publishing House, 2018.
3. S.C. Chapra & R.P. Canale, Numerical Methods for Engineers with Personal Computer Applications, Mc Graw Hill Book Company, 1985.
4. R.L. Burden & J.D. Faires, Numerical Analysis, 7th Ed., Brooks Coles, 2000.
5. K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1978.
6. W.H. Press et al., Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

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SEMESTER-IV

Course Code: BS-CHE 401	Category: Basic Science Courses
Course Title: Materials Science	Semester: 4 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basics of Chemistry.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be capable of:	
CO1: Understanding the basics of atomic structure, crystal geometry, and various mechanical properties of materials.	
CO2: Analyzing the classification of hard and soft materials, including polymers, glass, ceramics, and composites, their characterization, properties, and engineering applications.	
CO3: Applying phase diagram basics to interpret equilibrium phase diagrams, solidification, and phase transformations in alloys.	
CO4: Analyzing corrosion principles, types, and control strategies, along with principles of solid solutions, allotropes, and semi-crystalline materials to understand engineering material structures.	
Module 1: Introduction to materials (12 hours) Atomic structure of materials; bonding between atoms like metallic bonding, ionic bonding, covalent bonding, Vander Waals bond; role of materials selection in design, structure-property-processing-performance relationships; crystal geometry: crystal co-ordinate system, classification of crystals and lattices; Miller indices of directions and planes, inter-planar spacing, Bragg's law, introduction to experimental techniques of XRD for material characterization.	
Module 2: Metals and alloys (10 hours) Packing of atoms inside solids, close-packed structures, 3-D close packing of equal hard spheres, HCP and CCP structure, c/a ratio of an ideal HCP crystal, strength and properties of materials: plastic deformation, Corrosion: basic concepts and forms of corrosion, corrosion mechanism and prevention, protective materials and coating.	
Module 3: Solid solutions (10 hours) Interstitial and substitutional solid solutions; structure of allotropes (carbon-based), ionic solids, semi-crystalline materials: classification, structure and configuration of glass, ceramics, polymers and copolymers; imperfections/defects in solids: vacancies, interstitials, dislocations: types and characteristics of dislocations, free surface, grain boundary, stacking faults, equilibrium concentration of vacancy.	
Module 4: Basics of phase diagrams (10 hours) Phases and components, uses of phase diagrams, solidification and structure of metals, equilibrium phase diagrams of binary alloys; composition of phases in the 2-D phase region: tie line rule, relative amount of two phases region; eutectic systems: Pb-Sn phase diagram; Gibbs phase rule, Iron-Carbon phase diagram; phase transformation, T-T-T diagram.	

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Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

COs \ PSOs	PSO1	PSO2	PSO3
CO1	3	3	3
CO2	3	3	3
CO3	3	2	2
CO4	3	2	3

Learning Resources:

1. William F. Smith, Javad Hashemi and Francisco Presuel-Moreno, Foundations of Materials Science and Engineering (7th edition, 2022).
2. Lawrence H. Van Vlack, Elements of Material Science and Engineering, Pearson Education. (6th edition, 2002).
3. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited, (6th Edition, 2015).
4. Lakhtin, Engineering Physical metallurgy; MIR publishers. (1st edition, 2005).
5. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
6. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley Publisher.
7. B. S., Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.
8. Ray, Sridhar & Abraham. Extraction of non-ferrous metal, EWP
9. L. Von Bogdandy and H.J. Engell, The Reduction of Iron Ores, Springer-Verlag, NY.
10. Callister R Subramaniam., Material Science and Engineering, Wiley, 2nd Edition, 2014.

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Course Code: ES-CHE 401	Category: Engineering Science Courses
Course Title: Energy Sources and Utilization	Semester: 4 th
L-T-P: 4-0-0	Credit: 4
Pre-Requisites: Basics of Chemistry and chemical process calculations	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Students will be capable of	
CO1: Understanding the basic concepts of conventional and alternative energy, energy consumption pattern in both India and worldwide.	
CO2: Applying the properties, exploration, processing and utilization of solid, liquid, and gaseous energy sources.	
CO3: Analyzing the engineering aspects in the field of coal and crude oil's exploration and processing in a refinery.	
CO4: Analyzing the importance of renewable and their utilization such as solar, wind, hydro, geothermal, ocean thermal, fuel cell, nuclear energy, etc.	
Module 1: Solid Fuels (15 hours) Introduction: Conventional (fossil energy) and non-conventional (alternative energy) resources & reserves. Solid Fuels: Coal origin, Chemical composition, Calorific value, Types & Different measuring equipment, problems, Classification of Indian Coal, Biomass, Wood, and Charcoal. Formation of Coal, Classification & Rank of Coal, Peat, Lignite, Sub-Bituminous coal, Bituminous coal, Anthracite coal, Cannel & Bog head coal. Properties and beneficiation: Physical Properties of Coal, Proximate & Ultimate Analysis of Coal, Cleaning, Washing & Storage of Coal. Utilization of Coal. Carbonization, Combustion, excess air calculation, etc.	
Module 2: Liquid Fuels- composition, synthesis, and properties (15 hours) Liquid Fuels: Origin and composition of crude oil, Classification of Crude Oils, Crude oil processing, Desalting process, Constitution of petroleum, theory of the formation of crude petroleum oil. Characterization of crude oil & petroleum fuels. Operation and flow sheet of crude distillation plant. Atmospheric Distillation, Vacuum Distillation, Cracking— Thermal & catalytic cracking, reforming processes, coking, vis-breaking, Process of a typical Indian refinery. Parameters and testing logistics of petroleum products—Octane no.; Cetane no.; Aviation fuel, Power no.; Pour point; Smoke point; Char point; Cloud point; Flash point; Fire point; Aniline point and Diesel index. Derivation of Liquid fuel from coal: Bergius and Fischer-Tropsch process. Introduction to other Synthetic Liquid Fuels.	
Module 3: Gaseous Fuels- composition, synthesis, and properties (13 hours) Gaseous Fuels: Classification of gaseous fuel; Physico-chemical principles, Calorific Value, Wobbes index, and flame speed. Flow sheet & operation of Producer gas, Water gas, Carburetted water gas, oil gas, and coke-oven gas, blast furnace gas, Natural Gas, and LPG. Compressed Natural Gas, Coal Gas, Coal Bed Methane. Aerobic & Anaerobic Digestion Principles and Operation of Aerobic & Anaerobic Digestors, Bio gas: generation and management & flow sheet with special reference to waste utilization. Synthetic fuels: Hydrogenation of coal.	
Module 4: Non-conventional energy (13 hours) Non-conventional energy: Solar Energy: Devices for measurement of solar flux. Different types of Solar collectors (Flat plate, parabolic, concentric & heliostat), Utilization of Solar Energy- For room heating, water heating other industrial uses -solar Pond, Photovoltaic cells, Chemical storage, etc. Geothermal Energy & Wind Energy: Utilization of Geothermal Energy; Biogas from plant wastes, communities bio-gas plants, Fermentation, Operating principles of different types of Wind Energy Mills,	

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Energy from Ocean, Tydal, Biomass, Fuel Cell, Hydrogen, etc.
Nuclear energy: Sources of Nuclear fuels, Indian scenario; Introduction to Nuclear reactions and power generation by nuclear reactors.

Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	2	1	1
CO2	1	2	-
CO3	2	1	-
CO4	2	3	2

Learning Resources:

1. Fuels & Combustion: Dr. Samir Sarkar, Orient Longmans
2. Elements of Fuels. Furnace and Refractories: O. P. Gupta
3. Non-conventional energy sources, G. D. Rai Khanna Publishers
4. Non-Conventional Energy Resources, D.S. Chauhan and S. K. Srivastava, New Age International Publishers.
5. Fundamentals of Renewable Energy Systems, D. Mukherjee and S. Chakrabarti, New Age International Publishers.
6. Fuel and Combustion: Sharma S. P. and Chandra Mohan

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Course Code: PC-CHE 401	Category: Professional Core Course
Course Title: Heat Transfer	Semester: 4 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Basic Engineering Science, Chemical Process Calculations.	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the fundamentals of conductive, convective, and radiative heat transfer for their engineering applications.	
CO2: Apply the concept of heat transfer coefficient and its calculation for natural and forced convection using various empirical correlations.	
CO3: Perform heat transfer calculations involving phase changes and radiative heat transfer between bodies of different sizes and shapes.	
CO4: Utilize the overall concept of heat transfer for the design of different types of heat exchange equipment, such as heat exchangers, evaporators, etc., for industrial applications.	
Module 1: Conductive Heat Transfer (14 hours) Heat Transfer Fundamentals: Modes of heat transfer, thermal conductivity, thermal diffusivity, and heat transfer coefficient; Differential equations of heat transfer, Conductive heat transfer – Fourier's law, compound resistance in series, General heat conduction equation, Insulation, Critical insulation thickness; Unsteady state heat conduction- Lumped system analysis, Significance of Biot and Fourier number, Use of transient temperature chart, Application of one and two-dimensional steady-state heat transfer problems; Concept of heat transfer from extended surfaces.	
Module 2: Convective Heat Transfer and Heat Exchanger (14 hours) Convective heat transfer - natural and forced convection; Dimensional analysis- forced convection in system of simple geometries (plate, cylinder etc.), Dittus - Boelter Equation, Thermal boundary layer, Physical Interpretation of different Dimensionless groups; Coefficient of thermal expansion, Grashoff and Rayleigh number; Reynolds, Prandtl and Colburn Analogy; Wilson Equation, Analysis of free convection in hot vertical plate, and over cylinder, Concept of LMTD, LMTD correction factor, Dirt factor, Individual and overall heat transfer coefficient. Design aspects of Double Pipe and Shell & Tube Heat Exchangers, construction and design procedure of shell and tube heat exchanger-Kern's method, effectiveness-NTU method, Construction aspects in brief.	
Module 3: Radiation Heat transfer (14 hours) Introduction to Radiative heat Transfer, Black body radiation, Plank's distribution law, Monochromatic emissive power, Wein's displacement law, Kirchoff's law, Emissivity of solids, Concept of gray body, Radiation between surface, View factor, Radiation shield, Absorption and emission in gaseous medium, Design aspects of Furnaces.	
Module 4: Heat transfer involving phase change (14 hours) Fundamentals of Heat transfer involving phase change- Introduction to boiling, Leidenfrost Phenomenon, Hysteresis, Mechanism of nucleate boiling, pool and forced convection boiling; Introduction to condensation, Drop-wise and film-wise condensation, Film condensation on vertical surface, Nusselt equation, Condensation outside horizontal and vertical tube bank; Evaporation: Classification, Capacity, Steam economy, Boiling point elevation (Duhring rule), Material and energy balance of single effect evaporator, Design procedure of single effect evaporator, Introduction to	

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multiple effect evaporator: Forward feed, Backward feed, Mixed feed, Parallel feed evaporator; Design aspects of Condensers, Re-boilers, and Evaporators.

Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	2	2	1
CO3	2	2	-
CO4	3	3	2

Learning Resources:

1. B. K. Dutta, Heat Transfer–Principles and Applications 2nd Edition, W.J. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, Sixth Edition, McGraw-Hill (2005)
2. J.P. Holman, S. Bhattacharya, Heat Transfer, 10th Ed., Tata McGraw-Hill (2011).
3. Er. R. K. Rajput, Heat and Mass Transfers, S. Chand Publications
4. Bejan, A., A.D. Kraus, Heat Transfer Handbook, John Wiley (2003).
5. D.Q. Kern, Process Heat Transfer, Tata-McGraw-Hill (1997).
6. R. Welty, C.E. Wicks, R.E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed., Wiley (2007).

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Course Code: PC-CHE 402	Category: Professional Core Course
Course Title: Separation Process I	Semester: 4 th
L-T-P: 3-0-0	Credit: 4
Pre-Requisites: Material and Energy Balance Calculations, Knowledge of Differential Equations, and Integration	Branch: Chemical Engineering Total Lectures: 56 L
Course Outcomes: Upon successful completion of this course, students will have the ability in:	
CO1: Understanding the basics of mass transfer operations.	
CO2: Applying the principles of mass transfer for transfer coefficients, rate equations, and transfer units.	
CO3: Analysing the working of various mass transfer equipment of distillation, absorption, and humidification.	
CO4: Designing mass transfer equipment of distillation, absorption, and humidification	
Module 1: Diffusion and Mass Transfer (17 hours) General principles of convective and diffusive mass transfer processes in fluids; Measurement of diffusivity; multi-component diffusion; Diffusion through a variable area. Mass-transfer coefficients; Dimensionless groups in mass transfer; Diffusion in solids. Theories of mass transfer (Film theory, Penetration theory, Surface renewal theory); Inter-phase mass transfer theory; overall and local mass transfer coefficients.	
Module 2: Gas Absorption and Stripping (Binary system, isothermal operation) (12 hours) Equipment for Gas-Liquid Operations: Selection of equipment for mass transfer operation; Introduction to Absorption; Equilibrium data representation; Minimum liquid-gas ratio; Concept of Transfer Units (HTU and NTU); Design of height of packed tower; Estimation of number of stages in a tray tower; Kremser Equation; HETP.	
Module 3: Distillation (16 hours) VLE Phase diagram; relative volatility; azeotropism; steam distillation; single-stage flash distillation; Simple distillation (Rayleigh Equation); Continuous multistage fractionation; Number of trays by McCabe-Thiele method; Minimum Reflux; Total Reflux; Optimum Reflux; Fenske Equation; Introduction to Ponchon-Savarit method; Principles of Azeotropic and Extractive distillation; Vacuum distillation.	
Module 4: Humidification & Dehumidification Operations (11 hours) Principles of Humidification & Dehumidification; adiabatic saturation curve, wet bulb temperature line, Psychrometric chart and its use, Types of cooling towers, Design calculations of cooling towers, Make-up water calculation of cooling tower, Dehumidifier design concept, Adiabatic humidifier.	

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Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	-	-	-	-	-	-	-	-
CO 2	3	3	2	1	1	-	-	-	1	-	-
CO 3	3	3	2	2	2	1	-	3	1	-	1
CO 4	3	3	2	2	2	1	-	3	1	-	1

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	2	2	1
CO2	2	2	1
CO3	2	2	1
CO4	3	2	2

Learning Resources:

1. R.E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw-Hill, New Delhi, 1983.
2. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, 2nd edition, Prentice Hall of India, 2007
3. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, 1993.
4. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill International Edition,
5. Coulson, J. M., Richardson, J. F., Backhurst, J. R., & Harker, J. H., Chemical Engineering, Volume 1 & 2, 6th Edition
6. Sieder J.D., Ernest J. Henley. Separation Process Principles (2011).
7. A.P. Sinha, Parameswar De, Mass Transfer Principles and Operations, PHI Learning Pvt. Ltd., India, 2012

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Course Code: PC-CHE-403	Category: Professional Core Courses
Course Title: Petroleum Engineering and Petrochemicals	Semester: 4 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Fundamentals of Chemical Engineering and Chemical Process Calculations.	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Explain the properties of crude oil and analyze the principles of major petroleum refining and conversion processes, including distillation, thermal cracking, and catalytic cracking.	

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CO2: Describe hydro processing technologies, hydrogen production and management systems, and evaluate their role in refinery operations and clean fuel production.
CO3: Explain the production routes, process chemistry, and industrial applications of major petrochemicals derived from refinery feedstocks.
CO4: Analyze the manufacturing processes, properties, and applications of synthetic detergents, polymers, elastomers, and synthetic fibres used in petrochemical industries.
Module 1: Crude Oil Processing and Conversion Technologies (14 Lectures) Crude oil properties, Crude desalting, Crude oil distillation processes, Thermal Cracking Processes, Thermal conversion processes, Visbreaking and design variables of visbreaking, Catalytic cracking processes, Catalytic conversion processes, Fluid catalytic cracking with special reference to catalyst and reactor design configurations, Residual FCC
Module 2: Hydrogen-Based Refining Processes and Hydroconversion Technologies (14 Lectures) Hydroconversion processes, Hydrocracking: catalyst and reactor design configurations, Hydrogen production, purification and management, Hydrotreating and hydrodesulphurization processes, catalyst, reactor design configuration.
Module 3: Petrochemical Feedstocks and Production Processes (14 Lectures) Petrochemical feedstocks, impurities and their removal; classification of first-, second- and third-generation petrochemical products, Synthesis gas and methanol production, Naphtha cracking and recovery of petrochemical intermediates, Production of major petrochemicals from ethylene, propylene and butadiene, Production and separation of benzene, toluene and xylene isomers.
Module 4: Detergents, Polymers and Synthetic Fibres (14 Lectures) Classification of synthetic detergents, production of Linear Alkyl Benzene (LAB), detergent additives, and hard and soft detergents, Polymerization methods and mechanisms; production and applications of polyethylene (LDPE, LLDPE and HDPE), PVC, polystyrene and polypropylene; Elastomers and engineering plastics: Production of SBR, ABS plastics and polyamides; Synthetic fibres: Manufacture and applications of Nylon 6, Nylon 6,6, polyester and acrylic fibres.

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	2	1	-	1	0	1	1
CO2	3	2	2	1	2	3	-	1	1	1	1
CO3	3	2	2	-	2	1	-	1	1	2	1
CO4	3	2	1	-	1	1	-	1	1	2	2

CO-PSO Mapping Matrix:

CO/PSO	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	3	2
CO3	3	2	1
CO4	3	2	2

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Learning Resources:

1. Fundamentals of Petroleum and Petrochemical Engineering, U. Ray Chaudhuri, CRC Press, Taylor & Francis group, 2013.
2. Fundamentals of Petroleum Refining, M. A. Fahim, T.A. Alsahhaf, A. Elkilani, Elsevier, 2010.
3. Petrochemical Processes: Chauvel, Gulf Publishing
4. Handbook of Petroleum Refining, James G. Speight, CRC Press, Taylor & Francis group, 2017.
5. A text on Petrochemicals: B. K. B. Rao, Khanna Publishers
6. The petroleum Chemicals Industry: R. F. Goldstein and A. L. Waddams.
7. Advanced petrochemicals; Dr. G. N. Sarkar, Khanna Publishers
8. Introduction to Petrochemicals; Sukumar Maity, Oxford and IBH Publishing Co.

Course Code: HM-CHE 401	Category: Humanities and Social Science, including Management
Course Title: Principles of Management	Semester: 4 th
L-T-P: 2-0-0	Credit: 2
Pre-Requisites: Basic knowledge of organizational and business environments	Branch: Chemical Engineering Total Lecture: 28 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Learn the basic concepts, principles and practices of management and exploring the roles and skills required for managers	
CO2: Generate ideas to effectively plan, organize, lead and control varied managerial operations.	
CO3: Understand the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities	
CO4: Application of management knowledge to diagnose and solve organizational problems and develop optimal managerial decisions that would help implementing new technology in the area of finance, marketing and operations to bring in effectual outcomes.	
Module 1: Fundamentals of Management (6 hours) Basic concepts of management: Definition - Essence, Functions, Roles, Level. Functions of Management: Planning - Concept, Nature, Types, Management by objectives.	
Module 2: OB & HR (6 hours) Organization Structure: Concept, Structure, Centralization, Decentralization, Span of Management, Organizational Effectiveness. People Management: Overview, Recruitment & Selection, Training & Development, Stress Management, Communication, Motivation, Leadership, Team Effectiveness	
Module 3: Economics, Finance, and Marketing (8 hours) Economic: Factors affecting Production, Types of Markets, Financial Function & Goals Decision Making: Concept, Nature, Process, Tools & Techniques. Customer Management: Market Planning & Research, Marketing Mix, Advertising & Brand Management.	

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Module 4: Operations, Technology Management and Entrepreneurship (8 hours)

Operations & Technology Management: Role of Operations Management, Logistics & Supply Chain Management, TQM, Kaizen & Six Sigma, MIS.

Introduction to Entrepreneurship: Starts ups, Prospects & Challenges, Sustaining business

Management and Society: Concept, External Environment, CSR, Corporate Governance, Ethical Standards.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	-	-	-	-	-	2	-	3	3	1
CO 2	1	-	-	-	-	1	2	-	3	3	1
CO 3	1	-	2	2	-	-	2	-	2	3	-
CO 4	2	2	-	-	1	-	3	1	3	3	-

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	-	2
CO 2	2	-	2
CO 3	2	-	2
CO 4	2	1	3

Learning Resources:

1. Principles of Management- Competencies, Processes & Practices - Bhat, A & Kumar, A (OUP).
2. Essentials for Management - Koontz, H. Tata McGraw Hill (TMH)
3. Fundamentals of Management – Robbins, S., M. Coulter & M, Cenzo, D. Pearson
4. Principles of Management and Administration, Bose, D.C. Prentice Hall of India
5. Principles of Management – Tripathi, P.C., Reddy, P.N. & Bajpai, A., McGraw Hill

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Paper Name: Energy Engineering Laboratory	Category: Engineering Science Courses
Paper Code: ES-CHE 491	Semester: 4 th
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic knowledge of combustion principles and the operation of basic laboratory instruments used for energy measurement and analysis.	Branch: Chemical Engineering Total Lecture: 42 L

Name of the Experiments:

1. Proximate analysis of Coal:
 - (a) Determination of moisture content of Coal under Proximate analysis.
 - (b) Determination of volatile matter of Coal under Proximate analysis.
 - (c) Determination of ash content of Coal under Proximate analysis.
2. Determination of carbon residue of fuel oil using Conradson Apparatus.
3. Determination of the aniline point of fuel oil.
4. Determination of moisture content of fuel oil by Dean & Stark apparatus.
5. Atmospheric Distillation of a petroleum product.
6. Determination of Flash Point & Fire Point of oil by Abel apparatus.
7. Determination of Flash Point & Fire Point of oil by closed-cup Pensky Martin apparatus.
8. Determination of kinematic viscosity of oil by Redwood Viscometer I and II.
9. Determination of calorific value of gaseous fuel by Junker's apparatus.
10. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.
11. Determination of vapor pressure of petroleum product using Reid apparatus.
12. Experiments on Non-conventional Energy Sources using Solar Cookers/ Flat Plate Collectors/ Bio Gas Reactor
13. Analysis of a gaseous mixture by Orsat apparatus.
14. Determination of viscosity by Ostwald Viscometer.

Course outcomes:

After completion of this course, the students will be capable of

CO1: Understanding the principles and techniques involved in the determination of moisture content, volatile matter, and ash content of coal through Proximate analysis.

CO2: Applying appropriate laboratory techniques to determine the aniline point, carbon residue of fuel oil using the Conradson apparatus, and moisture content of fuel oil using the Dean & Stark apparatus.

CO3: Analyzing the results from atmospheric distillation of petroleum products, Flash Point & Fire Point determination, kinematic viscosity measurement, calorific value determination, and vapor pressure analysis to assess fuel quality and characteristics.

CO4: Evaluating the performance and reliability of various energy lab apparatus including Abel, Pensky Martin, Redwood Viscometer, Junker's, Bomb Calorimeter, Reid, Orsat, and Ostwald Viscometer.

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Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	2	2	3	3	2	3	3	2
CO 2	3	3	3	3	2	3	3	2	3	3	2
CO 3	3	3	3	3	2	2	2	2	3	3	2
CO 4	3	3	3	2	2	3	2	2	3	3	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	2	3
CO 2	3	2	3
CO 3	3	2	3
CO 4	3	2	3

Learning Resources:

1. Samir Sarkar. Fuels and Combustion (3rd Ed.), Universities Press, 2009.
2. Stephen R. Turns. An Introduction to Combustion: Concepts and Applications, (3rd Ed.), McGraw-Hill Science Engineering, 2011.

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Paper Name: Heat Transfer Laboratory	Category: Professional Core Courses
Paper Code: PC-CHE 491	Semester: 4 th
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Basic Chemical Engineering Knowledge	Branch: Chemical Engineering Total Lecture: 42 L

Name of the Experiments

1. Determination of thermal conductivity of a good conducting material (e.g. Brass)
2. Determination of thermal conductivity of Lagged pipe insulation and to plot the radial temperature distribution
3. Determination of thermal conductivity of insulating powder in a spherical metallic bowl.
4. Determination of heat transfer coefficient of air in forced convection
5. Determination of overall heat transfer co-efficient in parallel flow and counter flow Heat Exchanger
6. Determination of heat transfer coefficient in Filmwise and Dropwise condensation
7. Determination of Stefan-Boltzmann constant of radiation heat transfer

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8. Determination of Emissivity of an unknown test surface in radiation heat transfer
9. Determination of overall heat transfer co-efficient in Shell and Tube Heat Exchanger
10. To study unsteady state heat transfer by lumped capacitance

Course Outcomes (COs)

CO1: Remembering and understanding the previously learned basic science & engineering concepts in the heat transfer operations to interpret the experimental data.

CO2: Applying the fundamental knowledge of experimented heat transfer operations and basic principles for that heat transfer device to solve experimental problem.

CO3: Analyzing the experimental condition to **develop** and **simplify** the solution techniques for solving any problem primarily in different way as per requirement in new situation.

CO4: Evaluating the key properties / parameters from the experimentation to **assess & justify** the real process in comparison with ideal process and finally to **develop** the skill of presenting the results in form of written reports.

Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	3	3
CO 2	3	3	3
CO 3	2	2	3
CO 4	3	3	3

Learning Resources:

1. Laboratory manual
2. Process Heat Transfer: D Q Kern
3. Heat Transfer: Principles and Applications: B. K. Dutta

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Course Code: AU-481	Category: Mandatory Courses [Non-Credited]
Course Title: Environmental Sciences	Semester: 4 th
L-T-P: 0-0-0	Credit: Non-Credit
Pre-Requisites: Basic knowledge of biology, Chemistry, physics, earth science, and fieldwork	Branch: Chemical Engineering Total Lecture: 14 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understanding the basic reasons of air pollution, water pollution, solid waste management, process plant safety, hazardous chemicals, and their adverse effects on the environment.	
CO2: Applying the theoretical information to control pollution as well as its impact on public health, safety and environment.	
CO3: Analyzing the framework of potential methodologies in different field of application related to different environmental issues.	
CO4: Evaluating the pertinence of technologies with respect to environment as well as health, safety and industrial hazards.	
(a) Awareness Activities (7 hours) i) Small group meetings about water management, promotion of recycle use, generation of less waste, avoiding electricity waste ii) PPT/model presentation focusing on awareness iii) Poster making event iv) Video or short movie making event v) Story or poem writing on the specific environmental issue and posting through online platform	
(b) Actual Activities (7 hours) i) Plantation ii) Cleanliness drive iii) Drive for segregation of waste iv) To live some big environment at least for a week or so to understand this work v) To know about the different varieties of plants vi) Shutting down the fans and ACs of the campus for an hour or so	

Course Articulation Matrix:

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

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CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	1	3	2
CO2	3	2	3
CO3	1	2	1
CO4	3	2	1

Learning Resources:

1. Text book of Environmental Studies, Erach Bharucha, University Press.
 2. Environmental Studies, M P Poonia & SC Sharma, Khanna Publishing House.
 3. Environmental Studies, Rajagopalan, Oxford University Press.
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Paper Code: VSEC- 481	Category: VSEC
Paper Title: Soft Skills for Professional Development - II	Semester: 4th
L-T-P: 0-0-2	Credit: 1
Pre-Requisites: Basic English knowledge, computer skills, confidence, and readiness for group participation.	Total Classes: 28 (For all Engineering Branches)
Course Outcomes: Upon completion of the course, the student will be able to	
CO1: Apply effective English communication and aptitude skills in academic and professional contexts.	
CO2: Analyze problems and demonstrate teamwork using design thinking and group discussion techniques..	
CO3: Demonstrate persuasive speaking, debate, and presentation skills for effective communication.	
CO4: Develop professional readiness through resume writing, interview performance, and workplace communication skills.	
Module 1: Advanced English Communication & Aptitude Skills (6 L) Vocabulary enhancement; Pronunciation and fluency practice; Listening skills; Paragraph writing; Verbal aptitude basics; Reading comprehension; Current affairs and general awareness.	
Module 2: Design Thinking, Group Discussion & Team Communication (8 L) Design Thinking: Empathy mapping, Problem identification, Brainstorming; Team-building activities; Managing team roles and responsibilities; Conflict resolution; Negotiation skills; Situational GDs; Leading difficult group discussions; Reaching agreement in teams; Giving constructive feedback; Reviewing team performance.	

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Module 3: Debate, Public Speaking & Presentation Techniques (6 L)

Public speaking basics; Debate formats; Argument building; Impromptu speaking; Persuasive speaking; PowerPoint slide design; Presentation delivery; Audience interaction.

Module 4: Professional Development & Interview Readiness (8 L)

Professional email writing; Resume preparation; Personal branding; Interview etiquette; HR question practice; Verbal Communication Assessment; Mock interviews; Workplace ethics; Stress management.

Assessment Scheme: English Language Proficiency: 20 | Design Thinking: 20 | GD: 20 | Debate/PowerPoint Presentation: 20 | Interview: 20 | Total: 100

CO & PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	1	-	-	-	-	-	-	3	-	2
CO 2	1	2	2	1	-	1	1	3	3	1	2
CO 3	1	3	1	1	1	1	1	2	3	-	2
CO 4	1	1	-	-	-	1	2	2	3	2	3

Learning Resources

1. Debashis Bandyopadhyay and Malathy Krishnan, *Connect: A Course in Communicative English*, Cambridge University Press, 2018.
2. Sanjay Kumar and Pushp Lata, *Communication Skills*, Oxford University Press, 2015.
3. Nira Konar, *Communication Skills for Professionals*, Prentice Hall of India, 2nd edition, 2011.
4. Wren and Martin, *Modern English Grammar & Composition*, S Chand Publishing, 2025.
5. S. Prasad & K.P. Thakur, *Common Errors in English*, Bharati Bhawan Publishers, 2021.
6. Susmit Maity & Arpita Mazumdar, *Crack Campus Placements*, SelfyPage Developers Pvt. Ltd., 2024.

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SEMESTER-V

Course Code: PC–CHE-501	Category: Professional Core Courses
Course Title: Separation Process II	Semester: 5 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Basic concept on process calculations on mass transfer unit operations	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Recall the basics of mass transfer theory and understanding the principles of Liquid-liquid extraction, leaching, drying, adsorption, crystallization and membrane separation	
CO2: Calculate process parameters of these mass transfer processes.	
CO3: Analyse working of various mass transfer equipment of drying, adsorption, crystallization and membrane separation	
CO4: Design mass transfer equipment of extraction, leaching, adsorption, etc.	
Module 1: Liquid-liquid Extraction (14 hours) Introduction; Equilibrium data representation; selectivity and choice of solvent; Stage-wise contact; Method of calculation for single stage, Multistage Cross-current and Counter-current operation by graphical methods; Extraction efficiency; Types of extraction Equipment.	
Module 2: Leaching & Adsorption (14 hours) Introduction to leaching; Factors affecting the rate of leaching; Equilibrium data representation; Method of stage calculation; Introduction to Supercritical Fluid Extraction; Leaching Equipment. Introduction; Nature of adsorbents; Equilibrium data representation; Design of Fixed bed Adsorber - Break-through curves, Determination of time required to reach breakthrough point, length of unused bed; Equipment. Biosorption and biochar basics with applications.	
Module 3: Drying & Crystallization (14 hours) Introduction; theory and mechanism of drying; drying equilibria and drying rate curve; classification and selection of dryers; Calculation of rate of drying and time of drying for batch and continuous dryers; Introduction to freeze drying. Introduction to crystallization; Mass transfer theory of crystallization; Batch and continuous Crystallizers; Design calculations for crystallizers.	
Module 4: Membrane Separation Process (14 hours) Membrane separation basics; classification of membrane separation processes; Different types of membranes including ionic membrane, reactive membrane and Liquid membrane; Dialysis, Electrodialysis, Pervaporation, microfiltration, ultrafiltration, nanofiltration, reverse Osmosis, Gas permeation, membrane fouling and cleaning.	

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Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

COs \ PSOs	PSO1	PSO2	PSO3
CO 1	3	2	1
CO 2	3	2	1
CO 3	3	2	1
CO 4	3	2	2

Learning Resources:

1. R.E. Treybal, Mass Transfer Operations, 3rd Edition, Mc Graw Hill, New Delhi, 1983.
2. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, 2nd edition, Prentice Hall of India, 2007
3. C.J. Geankoplis, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, 1993.
4. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill International Edition,
5. Coulson, J.M., Richardson, J.F., Backhurst, J.R., & Harker, J.H., Chemical Engineering, Volume 1 & 2, 6th Edition
6. Sieder J.D., Ernest J. Henley. Separation Process Principles (2011).
7. A.P. Sinha, Parameswar De, Mass Transfer Principles and Operations, PHI Learning Pvt. Ltd., India, 2012

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Course Code: PC-CHE 502	Category: Professional Core Courses
Course Title: Chemical Reaction Engineering	Semester: 5 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Material and Energy Balance	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the kinetic data analysis to get the kinetic rate expressions for different types of	

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reactions.
CO2: Apply the performance equation of different types of reactors for sizing the reactors
CO3: Analyze the role of catalysts and catalytic phenomena in the design and performance of heterogeneous catalytic reactors.
CO4: Evaluate the effects of mass transfer limitations and reactor non-ideality on the design and performance of different reactors.
Module 1: Reaction Stoichiometry, Kinetics, and Experimental Data Analysis (14 hours) Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity, Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory Analysis and correlation of experimental kinetic data - data collection & plotting, differential and integral method of analysis
Module 2: Ideal Reactor Design and Analysis of Multiple Reaction Systems (14 hours) Ideal reactors –Sizing and analysis of ideal batch, mixed flow (CSTR), plug flow, semi- batch and recycle reactors -solving design equations for constant and variable density systems, graphical interpretation, reactors in series and parallel Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions
Module 3: Fundamentals of Catalysis and Catalytic Reaction Engineering (14 hours) Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterization of catalysts. Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the catalyst. Kinetics of solid catalyzed gas phase reaction. Laboratory reactors for catalytic gas solid reactions. Design concepts.
Module 4: Catalytic Reactor Design and Analysis of Non-Ideal Reactors (14 hours) Mass transfer, Diffusion and Chemical reactions in catalysts. Effects of external mass transfer and heat transfer, Effectiveness factor. Design aspects of catalytic reactors. RTD theory and analysis of non-ideal reactors

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	1	-	1	2	2	1	2	2
CO 2	3	3	2	2	-	2	1	2	2	1	2
CO 3	3	3	3	1	-	2	2	2	1	2	2
CO 4	3	2	3	2	-	1	1	2	2	1	2

Course Articulation Matrix:

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	PSO1	PSO2	PSO3
CO 1	3	3	3
CO 2	3	2	3
CO 3	3	2	3
CO 4	2	3	2

Learning Resources:

1. Elements of Chemical Reaction Engineering, 4th.Edition, H.Scott Fogler, Prentice Hall
2. Chemical Reaction Engineering, 2nd. & 3rd.editions, O. Levenspiel: Wiley Eastern Ltd.
3. Chemical Reactor Analysis and Design Fundamentals, J.B. Rawlings and J.G. Ekerdt. Nob Hill Publishing.
4. Chemical Engineering Kinetics, 3rd. Edition, J.M.Smith, MGH.
5. Chemical Engineering Kinetics and Reactor Design, C.G.Hill, Wiley
6. The Engineering of Chemical Reactions, 2nd.Edition, L. D. Schmidt, Oxford
7. Experiments in Catalytic Reaction Engineering, J.N. Berty, Elsevier.



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Course Code: PC-CHE 503	Category: Professional Core Courses
Course Title: Chemical Process Technology	Semester: 5 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Basic knowledge of Chemical Process Calculations, Material and Energy Balances, Unit Operations, and Process Flow Diagram (PFD).	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand various manufacturing processes used in chemical process industries.	
CO2: Analyze major engineering problems encountered in chemical process industries.	
CO3: Evaluate the process aspects like yield, by products formed, generation of waste.	
CO4: Create and apply the concept of problem-solving approach for industrial solutions.	
Module 1: Industrial processes with flow diagram for manufacture of inorganic chemicals (14 hours) Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of inorganic chemicals, such as: Chlor-alkali Industry for Soda Ash & Brine electrolysis for NaOH, Chlorine manufacturing. Industrial manufacturing process of NH ₃ , HNO ₃ & H ₂ SO ₄ , Manufacturing process with flow diagram for Urea, Superphosphate & Mixed fertilizer.	
Module 2: Manufacturing of Oil and Soap (14 hours) Manufacturing of Oil and Soap: Classification of oil. Properties of vegetable oil: acid value, saponification value and iodine value (Definition and Significance). Process description with flow diagram of oil extraction from oil seed. Hydrogenation process of oil. Raw materials, chemical reaction, process description with flow diagram for manufacturing of soap by continuous process. Cleansing action of soap. Production of detergents.	
Module 3: Cement, Glass, Ceramics, Paints (14 hours) Cement: Chemical composition of Portland cement, raw materials, dry and wet process for manufacturing cement clinker, setting and hardening of cement. Glass: Composition of glass, raw materials, manufacturing method of glass- pot furnace and tank furnace, annealing of glass. Ceramics: Basic raw materials, white-wares, manufacturing process of porcelain and their forming operations. Paints (Surface Coatings): Types, Compositions, applications & paint-failure and its remedies.	
Module 4: Industrial processes with flow diagram for manufacture of Petrochemicals (14 hours) Industrial process with flow diagram for manufacture of Petrochemicals: C1(methanol, formaldehyde, chloromethanes), C2 (ethylene, ethanol, polyethylene, vinyl chloride), C3 (isopropanol, Acetone, cumene, Acrylonitrile), C4 (butadiene via dehydrogenation of Butane), benzene, toluene, xylene and other petrochemicals (Phenol-by cumene process and styrene-from benzene and ethylene) from these basic building blocks.	

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Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1	1	2	1	-	-	-	2
CO 2	2	3	2	2	1	2	-	-	1	2	1
CO 3	3	2	2	3	1	2	3	3	2	3	2
CO 4	2	3	2	3	3	2	2	3	3	3	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	2	2
CO 2	3	2	2
CO 3	2	3	2
CO 4	2	3	3

Learning Resources

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, Marshall Sittig, East West Press, 1997
3. Chemical Process Technology, O. P. Gupta, Khanna Publishing House, 2018 (AICTE Recommended Textbook – 2018)
4. Chemical Project Economics, Mahajani V. V. and Mokashi S M., Mac-Millan India Ltd. 2005
5. Plant Design and Economics for Chemical Engineers, Max Peters, Klaus Timmerhaus, Ronald West, McGraw Hill International Edition, 2013

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Course Code: PE-CHE 501A	Category: Professional Elective Courses
Course Title: Polymer Science and Engineering	Semester: 5 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Foundational knowledge in chemistry and physics.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Connect properties of polymeric materials to their structures and explain how different material parameters and external factors affect the mechanical properties.	
CO2: Correlate structure-processing-properties relationships for polymers, blends and composites.	
CO3: Decide which test methods are suitable for measurement of mechanical & rheological properties.	
CO4: Select a suitable processing and manufacturing technique for a given polymer.	
Module 1: Basic Concepts & Polymerization Mechanism & Synthesis: (12 hours) Concepts and classification of polymers, Functionality, Structure and property relationship. Step-growth and chain-growth polymerization; Poly disparity, concept & significance of molecular weight averaging; Bulk, solution, emulsion and suspension polymerization; Comparison of polymerization processes.	
Module 2: Polymerization Kinetics (10 hours) Mechanism and kinetics of poly condensation reactions, Relationship between average functionality, extent of reaction and degree of polymerization. Mechanism and kinetics of free radical chain polymerization, kinetic chain length, and chain transfer reactions, Inhibit ion and retardation, kinetics of copolymerization.	
Module 3: Polymer Rheology & Polymer Degradation: (10 hours) Viscoelastic behavior, Flow curve concept, Melt & solution viscosity; Melting temperature & Glass transition temperature; Melt instability & Melt flow index. Factors affecting polymer stability; Thermal degradation, mechanical degradation, Chemical degradation, Hydrolysis, oxidative degradation & Ozonolysis; Stabilization.	
Module 4: Polymer Processing: (10 hours) Polymer compounding ingredients; compression, transfer, injection, jet & blow molding; casting; extrusion, calendaring, lamination, spinning & finishing.	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1	1	-	-	-	-	-	2
CO 2	3	3	2	1	1	1	-	-	-	-	2
CO 3	2	2	-	3	2	-	-	-	-	-	1
CO 4	2	2	3	1	2	2	-	-	-	1	1

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Curriculum for B. Tech courses in Chemical Engineering
(Applicable from the Academic Session 2026-2030)

CO–PSO Mapping Matrix:

	PS01	PS02	PS03
CO 1	3	1	2
CO 2	3	2	3
CO 3	2	3	1
CO 4	2	3	3

Learning Resources:

1. Text Book of Polymer Science, F.W. Billmeyer, John Wiley, New York
2. Polymer Science & Technology, P.Ghosh, TMC
3. J.R.Fried, Polymer Science and Technology, Prentice-Hall.,3rdEd.,2014
4. The elements of Polymer Science & Engineering, Alfred Rudin, Academic Press, 2nd Edition.
5. Introduction to Polymers, R.J. Young, Chapman & Hall, London.

Course Code: PE-CHE 501B	Category: Professional Elective Courses
Course Title: Advanced Separation Processes	Semester: 5 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Foundational high school or early university-level knowledge.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Remember, understand and identify different membrane separation processes and assess the life time of membranes under different process environments.	
CO2: Solve and analyze problems to any complex membrane separation processes by applying acquired knowledge, fact, techniques and characterize different types of membranes with the material of construction, advantages and disadvantages of different types of process and its engineering applications.	
CO3: Evaluate the modern industrial problems using different separation techniques. Gain knowledge about overall concept of membrane separation processes and mathematical modelling of different types of membranes.	
CO4: Compile different membrane separation techniques as well as design or modify structure of membrane as per requirements of process and the chemicals involved.	
Module 1: Fundamentals of Membrane Separation Processes (10 hours) Membrane Separation Process: Types of membranes, properties of membranes. Organic & Inorganic membranes, advantages & disadvantages and applications of various membranes, membrane modules, transport mechanism in membrane process, introduction to liquid membrane, advantages & disadvantages of liquid membrane.	

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Module 2: Pressure-Driven Membrane Separation Processes: Ultrafiltration and Reverse Osmosis (12 hours)

Ultrafiltration: UF modules, applicability, concentration polarization, basic numerical problems. Reverse Osmosis: Fundamentals of RO, Osmotic pressure, relation between chemical potential & osmotic pressure, factors affecting the performance of RO plant, RO membrane module, membrane age, advantages, disadvantages and application of RO process, Numerical problems.

Module 3: Advanced Membrane, Chromatographic and Electrophoretic Separation Processes (12 hours)

Pervaporation: Osmotic Distillation, advantages of pervaporation, temperature drop at membrane interface, application of pervaporation. Chromatographic Separation: Liquid Chromatography, Liquid-Solid Chromatography, High performance liquid chromatography; Advantages & Disadvantages of Chromatographic Separation.

Electrophoresis: Basic principles, Proteins and amino-acids separation, SDS- PAGE Electrophoresis.

Module 4: Gas Separation, Dialysis and Supercritical Fluid Extraction (8 hours)

Gas Separation: Theory of gas separation and permeability, permeability ratio and Knudsen diffusivity, factors affecting permeability, separation factors, application of gas separation process. Dialysis: Theory of Dialysis, mass transfer in Dialysis, Supercritical fluid extraction: supercritical fluid, supercritical solvent, advantages of SCF extraction, basic techniques in SCF technology.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	-	1	-	-	-	-	2
CO 2	3	3	2	2	1	2	-	-	-	-	2
CO 3	3	3	3	3	2	2	-	-	-	-	3
CO 4	3	2	3	2	2	2	-	-	-	-	3

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	1	-
CO 2	3	2	-
CO 3	3	3	1
CO 4	3	3	1

Learning Resources:

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1. J.D. Seader and Ernest J. Henley; Separation Process Principles.
2. Anil K.Pabby, Syed S.H. Rizvi, Ana Maria Sastre: Hand Book of Membrane separations.
3. Membrane Separation Processes by Kaushik Nath
4. Membrane Handbook by Ho and Sircar.
5. Ultrafiltration Handbook by Munir Cheriyan, CRC Press.
6. Practical Biochemistry: Principles & Techniques, Wilson & Walker, 5ed. Cambridge Univ. pre

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Course Code: PE-CHE 501C	Category: Professional Elective Course
Course Title: Biochemical Engineering	Semester: 5 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basics of Biology, Unit Operations, Chemical Process Calculations.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the principles of biochemical engineering, microbiology, thermodynamics, and enzyme kinetics in biological systems and processes.	
CO2: Analyze microbial growth, substrate utilization, metabolic pathways, and biochemical reaction kinetics under varying environmental and operational conditions.	
CO3: Apply material and energy balance, mass transfer, and reactor operation concepts for the study of bioprocess and fermentation systems.	
CO4: Design and evaluate fermenters, bioreactors, and downstream processing techniques for efficient biochemical product formation, recovery, and purification.	
Module 1: Basics of biochemical engineering (8 hours) Definition and extent of biochemical engineering; Comparison between chemical and biochemical processes; Unit operations involved in biochemical processes; Basics of microbiology and microbial diversity; Cell Construction; Cell Nutrients; Material and energy balance in microbial processes; Primary and secondary metabolites, Metabolic reaction stoichiometry and energetics, Fundamental principles of thermodynamics; Thermodynamic considerations of biological processes	
Module 2: Enzyme Kinetics and metabolic pathway (10 hours) Enzyme–substrate interaction and enzymatic activity; Basic enzyme kinetics involving single or dual substrates; Determining Rate Parameters for Michaelis–Menten Kinetics: Derivation and graphical determination of kinetic parameters; Control and regulation of enzyme activity, inhibition behaviour kinetics; Enzyme deactivation; Enzyme immobilization kinetics; Industrial-scale enzyme production; Metabolic pathway coupling: ATP and NAD involvement; carbon catabolism; cellular respiration; photosynthetic processes; biosynthetic pathways; and membrane transport mechanisms	
Module 3: Kinetics of microbial growth (12 hours) Growth patterns and kinetics in batch culture; Monod growth kinetics and its different modifications; concept of nutrient limitation and the influence of nutrient concentration on microbial growth; Environmental factors influencing growth kinetics; Substrate consumption kinetics; Dynamic growth kinetics and product generation rate studies; Material balance in biochemical reactions: Concept of limiting and surplus reactants; percent conversion; product yield; and reaction selectivity; Gibbs energy dissipation for aerobic, fermentative and autotrophic cell growth	

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Module 4: Bioreactor engineering and downstream processing (12 hours)

Gas-Liquid mass transfer and heat transfer in bioprocess systems; Evaluation of oxygen transfer rates and estimation of overall k_{La} values; factors affecting k_{La} ; Sterilization of fluids; Comparison between batch and continuous microbial cultivation in reactors; Modifying batch and continuous reactors; Chemostat with recycle; Fed-batch operation; Anaerobic fermentation technology; Design of fermenter; Strategies to recover and purify products; Separation of insoluble products using centrifugation, coagulation; Separation of soluble products applying liquid-liquid extraction, ultrafiltration, reverse osmosis, dialysis, chromatography.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	-	-	-	1	-	-	-	-	2
CO 2	2	2	-	2	2	1	-	-	-	-	2
CO 3	3	2	1	2	2	1	-	1	-	-	2
CO 4	3	1	3	3	2	3	-	1	-	-	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	1
CO 2	1	1	-
CO 3	2	1	-
CO 4	2	3	2

Learning Resources:

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.
2. Shuler, M. L.; Kargi, F. Bioprocess Engineering: Basic Concepts, (2nd Ed.), Prentice Hall, 2002.
3. Introduction to Biochemical Engineering by D. G. Rao, Tata McGraw-Hill Education, 2005.
4. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
5. David M. Himmelblau, James B. Riggs, PHI Learning Pvt. Ltd, 7th edition, 2006. Basic Principles & Calculations in Chemical Engineering"

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Course Code: OE-CHE 501A	Category: Open Elective Courses
Course Title: Introduction to AI Driven Chemical	Semester: 5 th

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Processes	
L-T-P: 2-1-0	Credit: 3
Pre-Requisites: Basics of mathematics and computer programming.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the fundamentals of AI/ML tools.	
CO2: Analyze the working principles of AI/ML tools.	
CO3: Develop pseudocodes, programs and implement AI/ML techniques.	
CO4: Solve various types of problems related to Chemical Engineering using the developed AI/ML tools.	
Module 1: Nature-inspired Optimization Techniques (10 hours) Introduction to Optimization, Principle of Optimization, Traditional methods of Optimization and their limitations, Nature-inspired Optimization Tools, Introduction to Genetic Algorithms (GA), Binary-coded GA: selection, crossover and mutation, Real-coded GA, Micro-GA, Visual Interactive GA, Scheduling GA, Simulated Annealing, Particle Swarm Optimization.	
Module 2: Fuzzy Logic and Fuzzy Systems (10 hours) Introduction to Fuzzy Sets, Crisp vs. Fuzzy sets, Membership functions, Fuzzy set operations, Fuzzy Reasoning Tools: Mamdani Approach, Takagi and Sugeno's Approach, Fuzzy Clustering: Fuzzy C-Means and Entropy-based Fuzzy Clustering.	
Module 3: Artificial Neural Networks and Hybrid Systems (12 hours) Fundamentals of Neural Networks, Training of Neural Networks, Multi-Layer-Feed-Forward Neural Networks, Back-Propagation Algorithm, Deep Neural Networks, Combined Genetic-Fuzzy System, Genetic-Neural System, Neuro-Fuzzy System, Genetic-Neuro-Fuzzy System.	
Module 4: Applications to Chemical Engineering Processes (10 hours) Applications of AI/ML tools in Process Optimization, Data-driven Input-Output Modeling, Reactor design, Predictive Maintenance of Chemical Plants and Process Control.	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	-	-	1	1	-	3
CO 2	3	3	2	2	3	-	-	2	1	-	2
CO 3	3	3	3	3	3	-	1	3	3	-	3
CO 4	3	3	3	3	3	2	1	3	3	2	3

CO-PSO Mapping Matrix:

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	PS01	PS02	PS03
CO 1	3	1	2
CO 2	3	1	2
CO 3	3	2	2
CO 4	3	3	3

Learning Resources:

1. Soft Computing and AI: Fundamentals and Applications by D.K. Pratihari, Narosa Publishing House Pvt. Ltd., New-Delhi, 2024 (3rd Edition).
2. Genetic Algorithms in Search, Optimization, and Machine Learning by David E. Goldberg, Addison Wesley, 1989.
3. Fuzzy Sets and Fuzzy Logic: Theory and Applications by George J. Klir and Bo Yuan, Pearson Education India, 2015.
4. Neural Networks and Learning Machines by Haykin, Pearson Education India, 2016.
5. Artificial Intelligence in Process Engineering by Michael L. Mavrovouniotis, Academic Press, 1990.

Course Code: OE-CHE 501B	Category: Open Elective Courses
Course Title: Fuel Cell & Battery Technology	Semester: 5 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basics and types of Fuel Cell and battery, Design of Fuel Cell and battery	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand electrochemistry principles	
CO2: Analyze different energy storage and conversion technologies	
CO3: Evaluate their performance, efficiency, and environmental impact	
CO4: Apply this knowledge to design and troubleshoot practical systems like batteries and fuel cells.	
Module 1: Introduction to Fuel Cells (12 hours) Introduction – working and types of fuel cell – low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell solid oxide, hydrogen fuel cells– thermodynamics and electrochemical kinetics of fuel cells.	
Module 2: Fuel Cells for Automotive Applications (10 hours) Fuel cells for automotive applications – technology advances in fuel cell vehicle systems –onboard hydrogen storage – liquid hydrogen and compressed hydrogen – metal hydrides, fuel cell control system – alkaline fuel cell – road map to market.	

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Module 3: Introduction to Electrochemical Energy Storage (8 hours)

Introduction to battery technologies- Electromotive force- Reversible cells- Relation between electrical energy and energy content of a cell-Free energy changes and electromotive force in cell- Current challenges in Energy storage Technologies.

Module 4: Major Battery Chemistries Development and Testing (12 hours)

Battery performance evaluation- Primary battery - Service time- Voltage data- Service life –ohmic load curve- Effect of operating temperature on service life. Secondary batteries-Discharge curves- Terminal voltages- Plateau voltage –Lead acid Batteries – Construction and Application.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	-	1	2	-	1	2
CO 2	2	2	2	2	2	-	1	2	2	1	2
CO 3	3	2	2	2	-	2	1	-	-	1	2
CO 4	3	3	2	2	2	3	2	3	3	2	2

CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	1	2	-
CO 2	1	-	1
CO 3	-	1	1
CO 4	2	-	2

Learning Resources:

1. Ryan O'Hayre, Whitney Colella, Fritz B. Prinz . Fuel Cell Fundamentals. Wiley, 2016.
2. Alexander Börger. Battery Technology: Fundamentals of Battery Electrochemistry, Systems and Applications, Wiley 2025.
3. Kirby W. Beard. Linden's Handbook of Batteries, 5th Edition, McGraw-Hill Education, 2019.

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Course Code: OE-CHE 501C	Category: Open Elective Courses
Course Title: Cryogenic Engineering	Semester: 5 th

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L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Engineering Thermodynamics, Fluid Mechanics, Heat Transfer, Separation Processes	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Explain thermodynamic principles governing cryogenic processes and low-temperature behavior of materials.	
CO2: Analyze and design cryogenic refrigeration, liquefaction, and gas separation systems.	
CO3: Select appropriate materials, insulation, storage, and transportation systems for cryogenic applications considering safety and economics.	
CO4: Evaluate modern cryogenic technologies in LNG, hydrogen economy, carbon capture, space technology, and medical applications.	
Module 1: Fundamentals of Cryogenic Engineering (10 hours) Introduction and history of cryogenics, Temperature scales and cryogenic temperature ranges, Physical properties of cryogenic fluids, Phase equilibria at low temperatures, Thermodynamic properties, Supercritical fluids, Superfluid helium, Low-temperature behaviour of metals, polymers, ceramics, and composites, Industrial applications of cryogenics.	
Module 2: Cryogenic Refrigeration and Liquefaction Systems (10 hours) Joule–Thomson effect, Isentropic expansion, Claude cycle, Linde–Hampson cycle, Collins cycle, Brayton refrigeration cycle, Cascade refrigeration systems, Mixed refrigerant processes, Hydrogen liquefaction, Ortho-para hydrogen conversion, Helium liquefaction, Thermodynamic efficiency analysis, Exergy analysis of cryogenic systems.	
Module 3: Cryogenic Separation and Process Equipment (12 hours) Cryogenic distillation fundamentals, Air separation units (ASU), Production of oxygen, nitrogen, argon, Helium purification, Hydrogen purification, LNG pretreatment, Cryogenic CO ₂ separation, Pressure Swing Adsorption (PSA), Vacuum Swing Adsorption (VSA), Membrane separation, Hybrid separation technologies. Plate-fin heat exchangers, Spiral heat exchangers, Cryogenic pumps, Compressors, Turbo-expanders, Cold boxes, Distillation columns, and Vacuum systems. Process optimization and energy integration.	
Module 4: Storage, Transportation and Safety (10 hours) <u>Cryogenic Storage:</u> Dewar vessels, Vacuum insulated tanks, Double-wall storage tanks, LNG storage terminals, Cryogenic pipelines. <u>Insulation:</u> Vacuum insulation, Multi-layer insulation, Powder insulation, Foam insulation <u>Safety:</u> Oxygen deficiency hazards, Hydrogen hazards, Material embrittlement, Thermal stresses, Pressure relief systems, Risk assessment, International safety codes and standards.	

Course Articulation Matrix:

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	1	-	1	-	-	1	1
CO 2	3	3	3	2	2	-	1	-	-	1	2
CO 3	2	3	2	2	2	2	2	1	1	1	2
CO 4	2	2	3	3	2	3	3	2	2	2	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	-
CO 2	3	2	1
CO 3	2	3	2
CO 4	2	3	3

Learning Resources:

1. K. D. Timmerhaus & T. M. Flynn, *Cryogenic Process Engineering*, Springer.
2. M. Mukhopadhyay, *Fundamentals of Cryogenic Engineering*, PHI Learning.
3. R. F. Barron, *Cryogenic Systems*, Oxford University Press.
4. George Haselden, *Cryogenic Fundamentals*, Academic Press.
5. G. Walker, *Cryocoolers*, Springer US.
6. Yuri A. Tikhonov, *Cryogenic Engineering*, CRC Press / Taylor & Francis.
7. Arthur H. Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow* (selected topics), John Wiley & Sons

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Paper Name: Separation Process Laboratory	Category: Professional core courses
Paper Code: PC-CHE 591	Semester: 5 th
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Theory of Mass Transfer	Branch: Chemical Engineering Total Lecture: 42 L

Name of the Experiments:

1. Determination of mass transfer co- efficient for diffusion of water vapor into air(while heating / boiling of bath water under natural convection)

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2. Determination of diffusivity of volatile organic liquid(CCl_4 / acetone / benzene) while its vapor diffusing in air.
3. Determination of properties of moist air.
4. Experimental study on the drying characteristics curve at different periods of drying using Rotary Vacuum Dryer.
5. Experimental study on the drying characteristics curve at different periods of drying using Forced Draft Tray Dryer.
6. Determination of boiling point diagram and equilibrium diagram of a binary liquid mixture using Othmer Still.
7. Experimental verification of Rayleigh's Equation based on simple batch distillation.
8. Experimentation on binary distillation in a sieve plate column.
9. Experimentation on batch adsorption (to verify adsorption isotherms).
10. Determination of efficiency of extraction of liquid-liquid mixture using solvent in three stage operation.
11. Experimentation on Absorption in packed column.

Course Outcomes (COs)

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

CO1: Recall and relate the previously learned engineering / basic science concepts or knowledge with the major mass transfer operations.

CO2: Interpret the experimental data on the basis the fundamentals of experimented mass transfer operations.

CO3: Apply basic design principles for mass transfer equipment to solve primarily any complex mass transfer problem facing in day-to-day life by industry.

CO4: Examine and classify the causes of technical problem during experimentation in various mass transfer areas.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	2	3	3	2	2	3	3	1
CO 2	2	2	3	3	2	3	3	3	3	3	-
CO 3	2	2	2	2	3	3	2	3	2	3	-
CO 4	3	2	3	2	3	3	3	3	3	3	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO1	3	3	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3

Learning Resources

1. J.D Seader, E.J. Henly, Separation Processes and principles, John Wiley, 2nd edition, 2006
2. Ross Taylor and R. Krishna, Multi component Mass Transfer, John Wiley, New York, 1993
3. Materials used during experimentation:

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4. Laboratory manual

Paper Name: Process Equipment Design and Drawing	Category: Professional Core Courses
Paper Code: PC-CHE 592	Semester: 5 th
L-T-P: 0-0-4	Credit: 2
Pre-Requisites: Basic knowledge Basic knowledge of Mass balance, Energy balance, Engineering Drawing, Strength of Materials, and Process Equipment Design is required for understanding and designing chemical process equipment and systems.	Branch: Chemical Engineering Total Lecture: 56 L

Name of the Experiments

1. Introduction to basic knowledge of flow meter and process design of Orifice meter/Venturi meter/Rotameter along with their mechanical design,
2. Introduction to basic knowledge of Heat exchanger. Complete process design and mechanical design of Shell & tube heat exchanger.
3. Introduction to basic knowledge of Evaporator. Process design and mechanical design of Multi-effect evaporator.
4. Design and Drawing of a Reactor Pressure vessel (Batch Reactor/PFR /CSTR).
5. Design and Drawing of Distillation column/ Bubble cap tray Introduction to the basic principles of distillation process and its applications.
6. Design and Drawing of Absorption tower. Design of Absorption column with its process design and various parts of column and drawing of internals of Absorption tower.

Course Outcomes (COs)

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

CO1: Remember and understand the standards for the mechanical design of equipment used in the process industry to demonstrate and explain the general fabrication techniques.

CO2: Apply the useful guide lines and the various principles of designing different process equipment of unit operations.

CO3: Analyze the probable processing constraints to acquire the ability to identify design problems in industrial equipment.

CO4: Evaluate and Create in aspects of ability to develop the skill to represent the process and mechanical design of specific equipment as well as the requisite accessories using engineering drawing tools.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3	2	2	-	-	1	1	2
CO 2	3	3	3	2	2	3	1	1	2	1	2

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CO 3	3	2	3	3	2	2	-	2	2	1	2
CO 4	3	3	3	3	2	2	1	1	2	1	3

CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	2	2
CO 2	3	3	2
CO 3	3	3	3
CO 4	3	3	3

Learning Resources

1. Introduction to Chemical Equipment Design: Mechanical Aspects by B.C. Bhattacharya
2. Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus.
3. Chemical Process Equipment: Selection and Design by James R. Couper.

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Course Code: SEM-CHE 591	Category: Seminar
Course Title: Technical Seminar	Semester: 5 th
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Fundamental knowledge of chemical engineering	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the elementary knowledge to give a seminar presentation more professionally and develop their leadership quality through this process.	
CO2: Apply the knowledge to solve problems and discuss innovative solutions supported by evidence and reasoning in the technical seminar.	
CO3: Analyze the significance of complex technical evidence in the literatures, theories, and methodologies relevant to the chosen topic	
CO4: Evaluate the strengths and weaknesses of existing concepts, methodologies, and research findings relevant to the chosen topic to assess the validity, reliability, and relevance of information presented in both written and oral form.	
Contents: Students have to choose a seminar topic according to his/her subject of interest. A thorough report has to be prepared on his/her selected topic. Students have to give seminar presentation on his/her selected topic and have to face question-	

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answer session followed by the seminar. Assessment of the student would be done on the basis of presentation, performance in the question - answer session and quality & originality of the submitted report.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	-	1	1	2	3	3	2	1
CO 2	3	1	1	1	1	1	-	1	1	1	2
CO 3	3	2	-	1	1	2	-	-	1	1	1
CO 4	3	3	-	2	2	2	1	1	2	2	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	-	2
CO 2	3	1	1
CO 3	1	1	1
CO 4	3	1	2

Course Code: VSEC-581	Category: Vocational and Skill Enhancement Course
Course Title: MATLAB based Process Simulation & Optimization	Semester: 5 th
L-T-P: 0-0-4	Credit: 2
Pre-Requisites: Engineering Mathematics, Chemical Process Calculation, Fundamentals of Chemical Engineering, Basic Computer Skills, Programming knowledge	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand MATLAB programming fundamentals and numerical computing techniques.	
CO2: Apply MATLAB tools for solving process engineering and chemical engineering problems.	
CO3: Analyze steady-state and dynamic process systems through simulation studies	
CO4: Evaluate and optimize process performance using MATLAB optimization techniques	

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Module 1: MATLAB Fundamentals (14 Hours)

Variables, vectors, matrices; Mathematical operations; Built-in functions; Script files and function files; Conditional statements; Loops and iterative calculations; Data visualization and plotting

Module 2: Numerical Techniques for Process Engineering (14 Hours)

Solution of nonlinear equations; Newton-Raphson Method; Bisection Method; Numerical integration; Numerical differentiation; Curve fitting; Interpolation; Solving systems of equations

Module 3: Process Simulation Using MATLAB (14 Hours)

Mathematical modeling fundamentals; Material and energy balance simulation; ODE solving using MATLAB; Dynamic process simulation; Tank systems; CSTR simulation; Batch reactor simulation; Introduction to Simulink

Module 4: Process Optimization Applications (14 Hours)

Introduction to optimization; Objective functions and constraints; Single-variable optimization; Multi-variable optimization; MATLAB Optimization Toolbox; Process parameter estimation; Economic optimization; Industrial case studies

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1	2	-	-	-	-	-	1
CO 2	3	2	1	1	1	-	-	-	-	-	1
CO 3	3	3	2	1	2	-	-	-	-	-	1
CO 4	3	3	1	2	2	-	-	-	-	-	1

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	3
CO 2	2	3	1
CO 3	1	2	3
CO 4	2	3	1

Learning Resources:

1. Chapra, S. C., Applied Numerical Methods with MATLAB for Engineers and Scientists, 4th Edition, McGraw-Hill Education, 2018.
2. Palm III, W. J., Introduction to MATLAB for Engineers, 4th Edition, McGraw-Hill Education, 2020.
3. Bequette, B. W., Process Dynamics: Modeling, Analysis and Simulation, 1st Edition, Prentice Hall, 1998.
4. Edgar, T. F., Himmelblau, D. M., and Lasdon, L. S., Optimization of Chemical Processes, 2nd Edition, McGraw-Hill Education, 2001.
5. Seborg, D. E., Edgar, T. F., Mellichamp, D. A., and Doyle III, F. J., Process Dynamics and Control, 4th Edition, John Wiley & Sons, 2016.

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Semester VI

Course Code: PC-CHE 601	Category: Professional Core Courses
Course Title: Transport Phenomena	Semester: 6 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Unit operations of Chemical Engineering	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the analogies and the theoretical relations between Momentum, Heat and Mass Transport	
CO2: Apply in the shell balances to solve transport problems	
CO3: Analyze the technique to formulate and solve one-dimensional transport problems by using the conservation equations	
CO4: Evaluate the technique to formulate simple multi-dimensional transport problems the application of energy balances and rate equations, Dimensional analysis, equations of Continuity to develop various shell and mass transfer model and to solve Chemical Engineering real problems concern with Transport phenomena	
Module 1: Basic Knowledge of Transport Phenomena (14 hours) Introduction to Transport Phenomena, Formulation of transport problems from nature. Concept of unified approach to Momentum, Heat and Mass Transport through Transport Phenomena Assumptions of Transport phenomena; Similarity of Mass, Momentum and Energy transfer, Diffusivities, Transport Theorem. Vector and Tensor Analysis: Basic concepts Basics of momentum transport: Euler/ Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor	
Module 2: Momentum Transport (14 hours) Shell momentum balances, Falling film Flow, Flow of Newtonian or Non- Newtonian fluid through a circular tube, Flow of Newtonian or Non- Newtonian fluid through annulus, Flow of two adjacent immiscible fluids, Flow of a film on outside of circular tube, Creeping flow around a sphere. Equations of change, dimensional analysis, applications to isothermal flow of Newtonian & non-Newtonian fluids.	
Module 3: Energy Transport (14 hours) Basics of energy transport, conductive, convective and viscous dissipation energy fluxes. Shell energy balance and boundary conditions – Heat conduction with electrical, nuclear, viscous and chemical heat source, Heat conduction through composite walls, Heat conduction in fins, Heat conduction from a sphere to stagnant fluid. Equations of change for non-isothermal systems, dimensional analysis, and applications to steady- state conduction and convection.	
Module 4: Mass Transport (14hours) Basics of mass transport, mechanisms, and mass and molar fluxes. Shell mass balance and boundary conditions – Diffusion through stagnant gas film, Diffusion in a falling film, Diffusion with heterogeneous chemical reaction, Equations of Continuity for binary mixture, simplification of general equation for special cases. Derivation of equation of continuity for A binary mixture and its application to convection-diffusion problems. Unsteady-state momentum, heat and mass transport, formulation of basic equations and similarity transform method.	

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Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1	2	-	-	-	-	-	1
CO 2	3	2	1	1	1	-	-	-	-	-	1
CO 3	3	3	2	1	2	-	-	-	-	-	1
CO 4	3	3	1	2	2	-	-	-	-	-	1

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	3
CO 2	2	3	1
CO 3	1	2	3
CO 4	2	3	1

Learning Resources:

1. R. B. Bird, W. E. Stewart, and E. S. Lightfoot. Transport Phenomena, 2nd ed., Wiley India Pvt. Ltd., 2002.
2. Transport Processes and Unit Operations, C. J. Geankoplis, Prentice Hall, III Edition, 1993.
3. Welty, C. E. Wicks, R. E. Wilson, and G. L. Rorrer. Fundamentals of Momentum, Heat, and Mass Transfer. 5th ed., Wiley India Pvt. Ltd., 2007.
4. W.M. Deen, Analysis of Transport Phenomena, Oxford University Press, 1998.
5. Transport Phenomena, R.S. Brodkey and H.C. Hershey, Mc.Graw Hill, 1988.
6. W.J. Thompson, Introduction to Transport Phenomena, Prentice Hall, 2000.

Course Code: PC-CHE 602	Category: Professional Core Courses
Course Title: Instrumentation and Process Control	Semester: 6 th
L-T-P: 3-1-0	Credit: 4
Pre-Requisites: Basic Concepts of Mathematics and Unit Operation.	Branch: Chemical Engineering Total Lecture: 56 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the basic knowledge on statics and dynamics of process control and measuring instruments, and their behavior.	
CO2: Apply the knowledge of different forcing functions and the schemes encountered in operations for first and higher order systems.	
CO3: Analyze different types of controllers, control valves, components of a control loop and block diagram of different chemical process units for various mode of control operations	

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CO4: Evaluate the stability of the control system and controller tuning, frequency response, and other characteristics relevant to process instrumentation and control

Module 1: Basic Instrumentation (15 hours)

Introduction: Principles of measurement. Error Analysis, Static and dynamic characteristics of instruments.

Temperature measurement: Filled system Thermometer, Thermo couples, Resistance Thermometers, radiation and optical pyrometers.

Pressure: Manometers: U tube manometer, inclined limb manometer, Ring balance manometer, elastic deformation: bourdon, bellows, diaphragm and electrical type gauges: strain gauge, piezoelectric, pressure transducers Vacuum gauges: mechanical, electrical and ionization types

Flow: Head flow meters, area flow meters, and positive displacement flow meters, mass and magnetic flow meters Level: Direct and inferential type; composition.

Module 2: Analysis of forcing function and different controller (15 hours)

Different forcing functions: Step, Impulse, Ramp, Sinusoidal and frequency inputs & their graphical representation, Laplace transform. First order system; transfer function; response of different forcing functions; two first order systems in series, interacting & non-interacting system.

Second order system: under- damped, critically damped & over damped, Transportation lag.

Classical feed-back controllers-P, PI, PD, PID & their transfer function, different types of control valves; characteristic curve & transfer function, Development of block diagrams, block diagram reduction techniques.

Module 3: Analysis of Closed Loop System (15 hours)

Closed loop response-servo & regulatory control. Block diagram of different chemical process units, open loop & closed loop transfer function, simple models: stirred tank, shell & tube heat exchanger, distillation column, different types of controllers.

Definition of stability, concept of unbound function, Routh stability criterion, Routh Array.

Module 4: Advance Control System (11 hours)

Introduction to frequency response, Bode stability analysis, Controller tuning: Zeigler-Nichol's controller settings, Cohen-Coon tuning.

Introduction to advanced controllers: cascade control, feed forward control, ratio control, Adaptive & digital control. Concept of PLC & DCS

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	2	1	-	-	1	2	1

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CO 2	3	3	2	2	1	1	-	-	-	1	1
CO 3	3	3	2	1	2	-	-	1	-	1	1
CO 4	3	3	3	2	2	1	-	1	-	-	1

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	3
CO 2	2	3	1
CO 3	1	2	3
CO 4	2	3	1

Learning Resources:

1. D. Patranabis, "Principles of Industrial Instrumentation", Tata McGraw Hill, Publishing Ltd, New Delhi, 1999
2. Process system analysis & Control-D. R. Coughanowr MGH.
3. Chemical Process Control-G. Stephanopoulos PHI.
4. Industrial Instrumentation Fundamentals, A. E. Fribance, McGraw-Hill Education

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Course Code: PC-CHE 603	Category: Professional Core Courses
Course Title: Project Engineering	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic understanding of Fluid Dynamics, Heat transfer, Mass Transfer.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Define the basic principles of project engineering and its objectives.	
CO2: Explain the relevant methodologies of project management and parameters.	
CO3: Prepare the optimum design parameter.	

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CO4: Distinguish among the different case studies of projects as well as criticize network analysis

Module 1: Basic Understandings of Project Engineering (10 hours)

Role of a project engineer, Typical design steps for chemical and biochemical processes. Development of project- Laboratory bench scale experiment to pilot & semi-commercial plant operation, scale up and scale down techniques, pre-design cost estimation, fixed capital and working capital, Manufacturing cost, Feasibility survey, plant location factors, selection of plant site, process design development, plant lay-out.

Module 2: Interest and Depreciation (12 hours)

Time value of money, simple interest, Nominal & effective interest rates, continuous interest, present worth & discount, Annuities, present worth of an annuity, perpetuities and capitalized cost. Depreciation: Types of depreciation, Depletion, Concepts of service life, Salvage value and Book value; unamortized value, net realizable value, Depreciation calculation by straight line method, Text book and double declining balance method, sum-of-the-years digit method and sinking fund method.

Module 3: Optimization (10 hours)

Profitability analysis method: effect of inflation on profitability, Alternative investment, Choices among various alternatives, Replacements, Methods of profitability evaluation for replacements. Optimum design, Break-even point, Optimum production rate, Optimum conditions in cyclic operations, optimum economic pipe diameters, optimum flow rate, cooling water, optimum reflux ratio.

Module 4: Network Analysis (10hours)

Project scheduling: Bar chart, Milestone chart, Concept of network analysis: PERT, CPM, statistical distribution associated with PERT network, earliest expected time, and latest allowable occurrence time calculation, Slack, determination of critical path, concept of float.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	-	1	-	2	3	3	3	2	2
CO 2	3	3	3	3	-	2	3	3	3	2	3
CO 3	3	3	3	3	-	2	3	3	3	2	3
CO 4	3	3	3	3	-	2	3	3	3	2	3

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	2	3
CO 2	3	2	3

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CO 3	3	-	2
CO 4	3	-	2

Learning Resources:

1. Plant Design & Economics for Chemical Engineers- By M. Peter & K.D. Timmerhaus, 4th edn, MGH
2. Chemical Engineering Plant Design - By Himmelblau.
3. PERTCPM, L. S. Srinath, East West Press

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Course Code: PC-CHE 604	Category: Professional Core Courses
Course Title: Industrial Process Health and Safety	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Hazard Identification and Risk Assessment, Competency, and Safety Awareness, Safe Equipment, Maintenance, and Emergency Preparedness	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Explain the fundamental concepts, principles, and regulations related to industrial process health and safety, and identify workplace hazards associated with industrial processes.	
CO2: Analyze chemical, mechanical, electrical, fire, and environmental hazards in industrial operations and evaluate their potential impact on personnel, equipment, and the environment.	
CO3: Apply risk assessment techniques, safety management systems, and control measures to prevent accidents, occupational illnesses, and process-related incidents.	
CO4: Demonstrate the ability to develop emergency preparedness plans, incident investigation procedures, and safety improvement strategies for maintaining a safe and healthy industrial workplace.	
Module 1: Fundamentals of Occupational Health and Safety (10 hours) Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Windroses, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.	
Module 2: Tools for Hazards Identification (10 hours) Checklists, Job Safety Analysis (JSA), Job Hazard Analysis (JHA), What-If Analysis, HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index, Safety Audits	

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Module 3: Risk Analysis concept and Methodology (10 hours)

Risk concept and measure of risk, Risk analysis process, Risk control and monitoring, Risk acceptance criteria, Legal and regulatory requirements related to risk management, Risk ranking methods, Risk matrix approach, Likelihood and consequence assessment, Risk prioritization techniques, Quantitative risk analysis, Probit number.

Module 4: Engineering Control of Chemical Plant Hazards (12 hours)

Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England), Bhopal (India), Seveso (Italy), Pasadena (Texas).

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	2	1	2	3	1	2
CO 2	3	2	2	2	2	2	1	2	2	1	2
CO 3	2	2	2	3	2	2	2	2	2	2	1
CO 4	2	3	2	2	2	3	2	3	3	2	1

CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	3	3
CO 2	3	2	3
CO 3	3	2	3
CO 4	3	2	3

Learning Resources:

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1. Chemical Process Safety: Fundamentals with Applications: D. A. Crowl and J.F.Louvar, Prentice Hall, 1990
2. Elements of Hazardous Waste Management, O.P. Gupta, Khanna Publishing House, 2018.
3. Industrial Safety, S.C. Sharma, Khanna Publishing House, 2018.
4. Safety in Chemical Process Industries: O. P. Kharbanda, E. A. Stallworthy, Heinmann Professional Publishing LTD.,1988.
5. Hazardous Waste management: C. A. Wentz, MGH.
6. Environmental Risks & Hazards, S.L. Cutter, Prentice Hall,1994
7. Chemical Process Technology, O.P. Gupta, Khanna Publishing House, 2019. (AICTE Recommended)

Course Code: PE-CHE 601A	Category: Professional Elective Courses
Course Title: Fertilizer Technology	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Foundational knowledge in chemistry and unit operations.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the reactions and unit operations steps in the manufacturing of various fertilizers.	
CO2: Analyze and apply the fertilizers on the basis of different properties.	
CO3: Evaluate engineering problems in fertilizer manufacturing Industries.	
CO4: Analyzing appropriate synthesis and handling of the fertilizers.	
Module 1: Fundamentals of Fertilizer Technology and Plant Nutrition (12 hours) Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crops. Nutrient contents of fertilizers; Bio-fertilizers, Nutrient-Secondary nutrients and micronutrients; Fluid fertilizers, Granular fertilizers, Controlled release fertilizers, Slow-release fertilizers.	
Module 2: Nitrogenous fertilizers (10 hours) Nitrogenous fertilizers: Feedstock and raw materials for nitrogenous fertilizers. Methods of production of ammonia and nitric acid. Ammonium sulphate, Urea, Ammonium chloride, Ammonium nitrate and Calcium ammonium nitrate, Characteristics and specification, Storage and handling.	
Module 3: Phosphatic Fertilizers (10 hours) Phosphatic Fertilizers: Raw materials – phosphate rock, Sulphur, pyrites etc. Processes for the production of sulphuric and phosphoric acids. Phosphatic fertilizers – ground rock phosphate, bonemeal–Single super-phosphate, Triple super-phosphate, thermal phosphates, characteristics and specifications.	
Module 4: Potassic fertilizers (10 hours) Potassic fertilizers: Potassium Chloride, Potassium sulphate, Potassium magnesium sulphate, Potassium hydroxide, Potassium nitrate – Methods of production: their characteristics and specifications.	

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NPK fertilizers: Urea ammonium phosphate, ammonium phosphate sulphate, Nitro-phosphates, and various grades of NPK fertilizers produced in the country. Pollution from fertilizer industry, Solid, liquid and gaseous pollution control and standards.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	-	-	1	-	-	-	-	1
CO 2	3	3	1	1	-	2	-	-	-	-	1
CO 3	2	3	2	2	1	2	-	-	-	-	1
CO 4	2	2	3	2	1	3	1	-	-	-	1

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	2	-
CO 2	3	2	1
CO 3	3	3	1
CO 4	2	3	2

Learning Resources:

1. Handbook of Fertilizer Technology Association of India, New Delhi, 1977
2. Fertilizer Manual, United Nations Industrial Development Organization, United Nations, New York, 1967.
3. Rao G., Sittig M., Dryden's Outlines of Chemical Technology, 3rd ed., East West Press, India, 2010.
4. Austin T. G., Shreve's Chemical Process Industries, 5th ed., Tata Mc Graw-Hill Education Pvt. Ltd, USA, 2012.

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Course Code: PE-CHE 601B	Category: Professional Elective Courses
Course Title: Nanoscience and Nanotechnology	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Fundamentals of Science subjects	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Fundamentals of nanomaterials and structure and bonding of materials.	
CO2: Different synthesis approaches of nanomaterials.	
CO3: Characterization techniques of nanomaterials.	
CO4: Specific properties of the nanomaterials and its applications.	
Module 1: (11 hours) Introduction: Definition, History, What makes nanoscale so different from other length scales, key examples of nanotechnology. Scope of nanotechnology, nanoscale in perspective. Physics of solid state: Structure & Bonding in solids. Synthesis of nanomaterials: General approaches (Top-down and Bottom-UP), Physical Methods, Chemical Methods, Biological Methods, hybrid methods.	
Module 2: (10 hours) Characterization techniques of nanomaterials: Microscopy, Spectroscopy and Diffraction techniques. Some special nano materials: Fullerene, Carbon nanotubes, Nanowires, Quantum dots, Core-shell nanoparticles, Doped nanoparticles.	
Module 3: (10 hours) Properties of nanomaterials: Mechanical, Structural, Thermal, Electrical & Optical properties	
Module 4: (11hours) Applications of nanomaterials: Nanolithography, Nanoparticles as catalyst, Drug delivery, Bio-imaging, Nanomedicines, Sensor applications.	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1	1	2	-	-	-	-	-	1
CO 2	3	2	1	1	1	-	-	-	-	-	1
CO 3	3	3	2	1	2	-	-	-	-	-	1
CO 4	3	3	1	2	2	-	-	-	-	-	1

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CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	3	3
CO 2	3	2	3
CO 3	3	2	3
CO 4	3	3	3

Learning Resources:

- 1.NANOTECHNOLOGY: Principles & Practices; Sulabh K. Kulkarni, Capital Publishing Company, Kolkata.
- 2.Nanoscience and Nanotechnology: Fundamentals of Frontiers, M. S. Ramchandra Rao, S. Singh, Wiley, 2013.
- 3.Introduction to Nanotechnology, C.P.Poole Jr., F. J. Owens, Wiley, 2007.
- 4.Principles of nanotechnology: N. Phani kumar; Sci tech, Kolkata.
- 5.Introduction to nanotechnology: Charles P. Poole & Frank Li Owens, Wiley India (p) Ltd, NewDelhi.

Course Code: PE-CHE 601C	Category: Professional Elective Courses
Course Title: Industrial Pollution Control	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Identification and Assessment of Pollution Sources, Compliance with Environmental Laws and Standards, Availability of Pollution Control Technology	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand the sources, types, and impacts of industrial pollution on air, water, soil, and the environment.	
CO2: Analyze industrial effluents, emissions, and waste generation processes and evaluate their environmental effects.	
CO3: Apply appropriate pollution prevention, control, and treatment technologies for air pollution, water pollution, and solid/hazardous waste management.	
CO4: Interpret environmental regulations, standards, and sustainable industrial practices to ensure compliance and effective pollution control in industries.	

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Module 1: Types of air emissions and effluent discharges from Chemical industries (8 hours)
Sources, types and environmental effects of air/water pollutants; Types of industrial air emissions and air emission standards; Type of industrial water pollutants and effluent discharge standards. Characterization of effluent streams, Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve mathematical, Controlling of BOD curve.

Module 2: Waste Water Treatment: Primary and Tertiary Methods (10 hours)
Screening, Sedimentation, Flotation, Neutralization, and methods of tertiary treatment. Brief studies of waste water treatment by Carbon absorption, Ion exchange, Reverse osmosis, Ultra filtration, Chlorination, Ozonation, and disposal.

Module 3: Waste Water Treatment: Secondary (Biological) (12 hours)
Introduction to Biological treatment of waste water, Bacterial and bacterial growth curve, Aerobic processes, Suspended growth processes, Activated Sludge Process; Aerated lagoons and stabilization ponds; Attached growth processes, Trickling filters, Rotary drum filters, and Anaerobic processes.

Module 4: Air pollution Monitoring and Control (12 hours)
Ambient air sampling: Collection of gaseous air pollutants, Collection of particulate air pollutants. Stack emission sampling: Sampling system, Particulate sampling, and gaseous sampling. Air pollution control methods and equipment: Source correction methods: raw material changes, process changes, and equipment modification. Control of gaseous and particulate emissions, Collection efficiency, Control equipment like gravitational settling chambers, Cyclone separators, fabric filters, ESP, Scrubbers and absorber.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	2	1	2	3	1	2
CO 2	2	2	3	2	2	2	1	2	2	1	1
CO 3	2	2	2	2	3	2	2	2	2	2	2
CO 4	2	3	2	2	2	3	2	3	3	2	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	1	1	1
CO 2	1	2	2
CO 3	1	-	-
CO 4	2	-	2

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Learning Resources:

1. Environmental Pollution and Control Engineering, Rao C. S., Wiley Eastern Limited, India, 1993.
2. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. Environmental Engineering, McGraw Hill International (1985).
3. Metcalf & Eddy, Wastewater Engineering, Tata McGraw-Hill Education Private Limited (2009).
4. Pollution Control in Process Industries, S.P. Mahajan, TMH., 1985.
5. Waste Water Treatment, M.Narayana Rao and A.K.Datta, 3rd Edition, Oxford and IHB, 2008.
6. Industrial Pollution Control and Engineering, Swamy AVN, Galgotia publications, 2005.
7. Masters, G.M., Introduction to Environmental Engineering and Science, Prentice Hall off India, (2008).
8. Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern (2010).
9. De Nevers, N., Air Pollution Control Engineering, McGraw-Hill (2000).

Course Code: OE-CHE 601A	Category: Open Elective Course
Course Title: Waste to Energy	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basics of Renewable Energy, different types of waste, Chemical Process Calculations.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Apply the knowledge about the operations of Waste to Energy plants.	
CO2: Analyse the various aspects of Waste to Energy Management Systems.	
CO3: Carry out Techno-economic feasibility for Waste to Energy plants.	
CO4: Apply the knowledge in planning and operations of Waste to Energy plants.	
Module1: Introduction (10 L) The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource and Alternate Energy source.	
Module :2 Waste sources & characterization (12 L) Waste production in different sectors such as domestic, industrial, agriculture, post-consumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.	
Module 3: Technologies for waste to energy (10 L) Biochemical Conversion – Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies.	

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Module 4: Waste to energy options (10 L)

Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers. Conversion of wastes to fuel resources for other useful energy applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	1	2	2	1	2	-	1	2
CO 2	2	3	2	2	2	2	1	-	2	1	-
CO 3	3	2	2	2	3	-	1	2	-	1	-
CO 4	3	3	2	2	2	3	2	3	3	2	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	1	2	1
CO 2	1	1	1
CO 3	-	-	2
CO 4	2	1	-

Learning Resources:

1. Waste-to-Energy Technologies and Global Applications (2nd Edition) by Efstratios N. Kalogirou
2. Waste-to-Energy: Technologies and Project Implementation (3rd Edition) by Marc J. Rogof
3. Waste to Energy: Prospects and Applications by Brijendra Kumar Kashyap

Course Code: OE-CHE 601B	Category: Open Elective Courses
Course Title: Waste Management and Recycling	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic understanding of Solid Waste and Wastewater Management practices.	Branch: Chemical Engineering
	Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Understand different sources of waste materials and their associated sources.	
CO2: Understand different types of wastes and various associated activities with the management of waste materials.	
CO3: Describe different techniques and methods used in recovery of materials and energy from waste materials.	

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CO4: Define management of the hazardous waste.

Module 1: Fundamentals of Waste Management and Recycling (10 hours)

Introduction to waste management, Waste management: Reduce, Reuse, Recycle, Definitions and characterization of various wastes, Transport of various wastes, Types of wastes: solid, liquid and gas, Sources of various wastes, Environmental impacts of various wastes, Materials recycling.

Module 2: Solid Waste Management and Resource Recovery (12 hours)

Generation of solid waste, Storage and processing of solid waste, Collection of solid wastes, Transport of solid waste, Various processing techniques of solid waste, Resource and energy recovery from solid waste, Disposal of solid waste, Sanitary land-fills, Leachate collection & treatment, Integrated SW Management concepts.

Module 3: Fundamentals of Liquid Waste and Wastewater Management (12 hours)

Liquid Waste: Definitions and Classifications, Characteristics of liquid waste and its associated health impacts, Collection and transport of liquid waste, Primary treatment of liquid waste, Secondary treatment of liquid waste, Tertiary treatment of liquid waste, Resource recovery and recycling of liquid waste, Treatment of generated sludge and its disposal, Industrial wastewater management.

Module 4: Advanced Waste Management, Recycling Technologies and Resource Recovery (8 hours)

Gaseous wastes: definition, sources and characteristics, Environmental impact, Different control technologies of particulate matters, Recycling of gaseous pollutants, Advanced techniques for recycling of gaseous waste, Carbon Capture and Utilization (CCU), Waste-to-Energy (WtE) generation, Management of hazardous waste, Characteristics of hazardous waste; Transportation and disposal of hazardous waste, E- waste management, Integrated Solid Waste Management (ISWM), Zero Liquid Discharge, Waste management regulations.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	-	-	3	-	-	-	-	1
CO 2	3	3	2	1	1	3	1	-	-	-	1
CO 3	2	3	3	2	2	3	1	-	1	1	2
CO 4	2	3	2	2	2	3	3	-	1	1	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	1
CO 2	2	2	1
CO 3	3	3	2
CO 4	3	2	2

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Learning Resources:

- J. Pichtel. Waste Management Practices: Municipal, Hazardous and Industrial, 2nd Edition, CRC Press, 2014.
- D. Reinhart, P. A. Vesilind, and W. Worrell. Solid Waste Engineering, 2nd Edition., Brooks/Cole Thomson Learning Inc., 2010.
- Metcalf & Eddy, Inc. (George Tchobanoglous, Franklin L. Burton, and H. David Stensel). Wastewater Engineering: Treatment and Resource Recovery, 5th Edition., McGraw-Hill Education, 2014.
- C. S. Rao. Environmental Pollution Control Engineering, Revised Edition., New Age International.

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Course Code: OE-CHE 601C	Category: Open Elective courses
Course Title: Food Processing Technology	Semester: 6 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: To familiarize Chemical Engineering students with the physical, thermal and rheological properties of foods, the unit operations and preservation technologies used in food processing, and the engineering and quality-management aspects of setting up and running a food and biochemical processing plant.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Explain the composition, and the physical, thermal and rheological properties of food materials along with the fundamentals of food engineering.	
CO2: Apply appropriate unit operations such as size reduction, mechanical separation, heat transfer, evaporation and drying for processing of food materials.	
CO3: Analyze and select suitable thermal and non-thermal food preservation techniques, together with appropriate packaging methods, to enhance food shelf life and quality.	
CO4: Design and evaluate food processing plants incorporating food safety, quality management systems (HACCP/GMP) and sustainable waste-management practices.	
Module 1: Introduction to Food Engineering (11 hours) Scope, importance and status of the food processing industry in India; role of a chemical engineer in food engineering, Structure and composition of food materials: carbohydrates, proteins, lipids, vitamins and minerals; water in foods and water activity, Physical properties of food materials: size, shape, volume, density, porosity and their measurement, Thermal properties of foods: specific heat, thermal conductivity, thermal diffusivity, enthalpy and freezing point of foods, Rheological properties of food: Newtonian and non-Newtonian behaviour, viscosity and its measurement, texture of foods, Sorption phenomena: moisture sorption isotherms and their significance in food stability, Green extraction of bioactives for chemical engineers	
Module 2: Food Processing Unit Operations (11 hours) Size reduction of food solids: crushing, grinding and cutting; energy laws of size reduction (Rittinger's, Kick's and Bond's laws), Mixing, emulsification and homogenization of food materials, Mechanical separation techniques in food processing: filtration, sedimentation, centrifugal separation and membrane processes (RO/UF), Heat transfer operations in food processing: blanching, pasteurization (LTLT, HTST) and sterilization (UHT), Evaporation and concentration of liquid foods; evaporator types used in the food industry, Drying and dehydration of foods: drying curves and kinetics; tray, drum, spray and freeze dryers.	

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Module 3: Food Preservation and Packaging Technology (10 hours)

Principles of food preservation and mechanisms of food spoilage (microbial, enzymatic and chemical), Thermal processing of foods: canning and retorting; concept of D-value, Z-value and F₀; process lethality calculations, Aseptic processing and packaging; low-temperature preservation: refrigeration, freezing and freeze concentration, Non-thermal preservation methods: irradiation, high-pressure processing, pulsed electric field, ohmic and microwave heating, Chemical preservation and fermentation technology in food processing, Food packaging materials (glass, metal, plastics, laminates) and techniques: modified atmosphere packaging (MAP), vacuum and aseptic packaging.

Module 4: Food Plant Engineering, Safety and Quality Management (10hours)

Food plant location, layout and design considerations; material handling and plant utilities, Food hygiene, sanitation practices and Cleaning-in-Place (CIP) systems, Food safety management systems: Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and HACCP, Food quality standards and regulatory framework: FSSAI, ISO 22000 and Codex Alimentarius, Effluent treatment and solid waste management in the food processing industry, Emerging trends in food engineering: nanotechnology in food, 3D food printing and smart/intelligent packaging

CO & PO Mapping:

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

CO & PSO Mapping:

CO / PSO	PSO1	PSO2	PSO3
CO1	2	1	1
CO2	3	2	1
CO3	3	2	2
CO4	2	2	3

Text book and Reference books:

1. R. P. Singh and D. R. Heldman, Introduction to Food Engineering, Academic Press.
2. P. Fellows, Food Processing Technology: Principles and Practice, Woodhead Publishing.
3. N. N. Potter and J. H. Hotchkiss, Food Science, CBS Publishers.
4. S. Ranganna, Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw-Hill.

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5. M. Shafiur Rahman, Handbook of Food Preservation, CRC Press.

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Course Code: AU-681	Category: Mandatory Non-Credit Course (MC)
Course Title: Constitution of India	Semester: 6 th
L-T-P: 1-0-0	Credit: 0
Pre-Requisites: Basics of Political Science.	Branch: Chemical Engineering Total Lecture: 14 L
Course Outcomes: Upon successful completion of this course, the student will be capable of:	
CO1: Understand the Indian Constitution's meaning, sources, historical development, and key features like citizenship, preamble, fundamental rights, duties, etc.	
CO2: Apply knowledge of the Indian Union's structure and federalism to analyze the relationship between its government and administration, including key roles and powers.	
CO3: Analyze the structure and functioning of State Government and its administration, including key roles like Governor, Chief Minister, and Council of Ministers.	
CO4: Evaluate the functioning of local administration, including district, municipal, and panchayati raj institutions, to assess elected and appointed officials' roles in grassroots democracy.	
Module 1: Introduction to Indian Constitution & Union Government (6 hours) Meaning of the term Indian Constitution, Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy, Union Government and its Administration, Structure of the Indian Union: Federalism, Center-State relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha.	
Module 2: State Government and its Administration (2 hours) Governor: Role and Position, CM and Council of Ministers, State Secretariat: Organization, Structure and Functions.	
Module 3: Local Administration (4 hours) District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Panchayati Raj: Introduction, PRI: Zila Panchayat, Elected officials and their roles, CEO Zila Panchayat: Position and role, Block level: Organizational Hierarchy across various departments, Village level: Role of Elected and Appointed officials, Importance of grass root democracy.	
Module 4: Election Commission & Welfare Institutions (2 hours) Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.	

Course Articulation Matrix:

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1	1	2	-	-	2	3	1	2	3	3
CO 2	2	3	2	1	-	3	2	1	3	2	3
CO 3	2	2	2	2	-	3	2	3	3	3	3
CO 4	1	1	2	2	-	3	3	3	2	3	3

CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	3
CO 2	2	1	3
CO 3	2	1	3
CO 4	2	2	3

Learning Resources:

1. Indian Polity by M. Laxmikanth, McGraw Hill, 2025.
2. Our Constitution by Subhash C. Kashyap, National Book Trust, 2021.
3. Introduction to the Constitution of India by D. D. Basu, LexisNexis, 2024.
4. Indian Administration by Avasti & Avasti, Lakshmi Narain Agarwal, 2020.

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Paper Name: Chemical Reaction Engineering Laboratory	Category: Professional Core Courses
Paper Code: PC-CHE 691	Semester: 6 th
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Fundamentals of chemical reaction engineering	Branch: Chemical Engineering Total Lecture: 42 L

List of Experiments:

1. Experimental studies on kinetics of a noncatalytic homogeneous liquid phase reaction in an isothermal batch reactor.
2. Experimental studies on effect of temperature and determination of activation energy for a noncatalytic homogeneous liquid phase reaction in an isothermal batch reactor.
3. Experimental studies on kinetics of a homogeneous liquid phase reaction in an isothermal semi batch reactor.
4. Experimental studies on kinetics of a non-catalytic homogeneous liquid phase reaction in a tubular plug flow reactor. (ideal plug flow reactor)
5. Experimental studies on kinetics of a non-catalytic homogeneous liquid phase reaction in a Spiral plug flow reactor.
6. Experimental studies on kinetics of a noncatalytic homogeneous liquid phase reaction in an isothermal CSTR.

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7. Experimental studies on RTD in a packed bed reactor using pulse input of tracer and measurement of axial dispersion coefficient.
8. Experimental studies on RTD in a straight tube PFR using pulse input of tracer and measurement of axial dispersion coefficient.
9. Experimental studies on kinetics of hydrolysis of ethyl acetate in presence of acid catalyst in an adiabatic batch reactor.
10. Kinetic studies of sulfonation of toluene in an isothermal batch reactor
11. Kinetic studies on hydrolysis of benzoyl chloride in an adiabatic batch reactor.

Course Outcomes (COs)

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

CO1: Understanding and remembering the Steady and unsteady state reactors and study its performance during experiment.

CO2: Explaining all stages of experiment for batch, semi-batch and continuous reactor mode of operation in various ideal reactors and also for non-ideal reactor of RTD experiment. While conducting the experiment, the student will be able to exercise and illustrate tidiness, safety in the laboratory and cleanliness of the lab area.

CO3: Applying the raw data generated in performance equation of reactors, including units in the title of data table for the steady or unsteady state operation and analyzing the data in various ways such as, charts, tables, graphs to compare the results.

CO4: Verifying the efficiency and kinetics of various mode of operation for different reactors.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	1	1	-	1	-	1	2	1	2
CO 2	3	3	2	1	-	-	1	3	3	1	2
CO 3	3	3	2	1	1	-	1	3	3	2	3
CO 4	3	3	1	-	1	1	1	3	3	2	2

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	3	3
CO 2	3	3	2
CO 3	3	2	3
CO 4	3	3	2

Learning Resources:

3. Laboratory Manuals.
4. Elements of Chemical Reaction Engineering, 4th.Edition, H. Scott Fogler, Prentice Hall
5. Chemical Reaction Engineering, 2nd & 3rd editions, O Levenspiel: Wiley Eastern Ltd.

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Paper Name: Instrumentation and Process Control lab	Category: Professional Core Courses
Paper Code: PC-CHE 692	Semester: 6 th
L-T-P: 0-0-3	Credit: 1.5
Pre-Requisites: Process Instrumentation, Process Dynamics and Control	Branch: Chemical Engineering Total Lecture: 42 L

Name of the Experiments

1. Temperature Measurement using Thermocouple.
2. Study of RTD Characteristics & use in Temperature sensitive bridge.
3. Calibration of pressure gauge by Dead Weight Tester.
4. Study of Load Cell.
5. Liquid-Level Measurement using Air-Purge Method
6. Studies on Characteristics of Pneumatic Pressure Controller (PI Control Valve)
7. Liquid level dynamics-single tank system
8. Dynamics of two tank non-interacting liquid-level system
9. Dynamics of two tank interacting liquid-level system
10. Studies on the Stability and tuning of a Flow Controller
11. Response of a P& PI Controller

Course Outcomes (COs)

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

CO1: Understand the working principles, construction, and applications of Thermocouple and RTD for temperature measurement.

CO2: Apply standard calibration techniques using a Dead Weight Tester for pressure gauge calibration.

CO3: Analyze the operational characteristics and measurement accuracy of liquid-level measurement using the Air-Purge Method.

CO4: Evaluate the dynamic response and comparative performance of single-tank and two-tank liquid-level systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	1	3	2	3	-	-	-	-	-	-
CO 2	3	2	3	2	3	-	-	-	-	-	-
CO 3	3	1	2	3	2	-	-	-	-	1	-
CO 4	3	1	1	3	2	-	-	-	1	1	2

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CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	1	3
CO 2	3	2	3
CO 3	3	1	2
CO 4	3	1	1

Learning Resources

1. Process Control Instrumentation Technology
2. Process Dynamics and Control
3. Chemical Process Control
4. Instrumentation and Control Systems
5. Principles of Industrial Instrumentation
6. Modern Control Engineering

Semester VII

Course Code: PE–CHE-701A	Category: Professional Elective Courses
Course Title: Chemical Process Intensification	Semester: 7 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic knowledge of Fluid Mechanics, Heat Transfer, Mass Transfer, Chemical Reaction Engineering, and Unit Operations.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Demonstrate an understanding of the principles, strategies, and technologies of process intensification, and explain their role in sustainable chemical process development.	
CO2: Apply advanced design methods, computational tools, and optimization procedures to analyze and develop intensified chemical processes.	
CO3: Evaluate and design intensified reactor, separation, and transport systems (e.g., cavitation reactors, monolith reactors, microreactors, and membrane systems) for industrial applications.	
CO4: Integrate knowledge of reaction and separation engineering to propose innovative and green processing solutions based on process intensification concepts.	

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Module 1: Principles of process intensification (10 hours)

Introduction, History, Philosophy and Concept, Principal Features, Strategies and domain-based techniques, Intensification by fluid flow process, Mechanism of Intensification by mixing, Intensification in Reactive system, Problems leading to sustainable development, Concept, Issues and Challenges, Strategies in process design.

Module 2: PI Design and microprocess technology (11 hours)

Design Techniques for Process Intensifications: Scales and stages of process intensification, Methods and Tools for Achieving sustainable design, Multi-level Computer aided tools Stochastic; Optimization for Process Intensification: Introduction on Stochastic Optimization, Optimization Algorithms, Applications of Optimization Algorithms; Micro Process Technology in process intensification: Introduction to microprocess technology, Process Intensification by Microreactors, Hydrodynamics and transport in microchannel based microreactor

Module 3: Reactor-based process intensification (11 hours)

Process intensification by cavitation: Introduction and Mechanism of Cavitation-based PI, Cavitation Reactor Configurations and activity, Parametric effects on cavitation; Process Intensification by monolith reactor: Introduction of monolith reactor, Preparation of monolithic catalyst, Application of monolithic catalyst, Hydrodynamics, transport of monolithic reactor; Interfacial area based Process intensification: Overview of interfacial area based processes, Ejector induced downflow system for PI, Hydrodynamics and transport in downflow system

Module 4: Intensified separation and membrane processes (10 hours)

Process intensification in distillation: Introduction and Principles, Types of Intensified Distillation Units, Design of membrane-assisted distillation; Process intensification in extraction: Introduction and Principles, Supercritical extraction for process intensification; Process intensification by membrane: Introduction to membrane and its principles, Membrane engineering in process intensification.

Course Articulation Matrix:

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	1	1	0	0	1	0	2
CO2	3	3	3	2	2	1	0	2	2	0	2
CO3	3	2	2	2	2	1	0	1	2	0	2
CO4	2	2	2	2	1	2	1	1	2	0	3

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	3	2
CO 2	3	3	1
CO 3	3	3	1
CO 4	3	3	2

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Learning Resources:

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. Wiley, 2013.
2. Juan Gabriel Segovia-Hernández, Adrián Bonilla-Petriciolet, Editors, Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
3. David Reay, Colin Ramshaw, and Adam Harvey, Process Intensification: Engineering for efficiency, sustainability and flexibility, IchemE, 2nd edition, 2013, Elsevier.
4. S. K. Majumder, Hydrodynamics and Transport Processes of Inverse Bubbly Flow, 1st ed. Elsevier, Amsterdam (2016).

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Course Code: PE-CHE 701B	Category: Professional Elective Courses
Course Title: Computational Fluid Dynamics	Semester: 7 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Fluid Mechanics, Heat Transfer, Numerical Methods	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to	
CO1: Understand the basic principles of mathematics and numerical concepts of fluid dynamics.	
CO2: Develop governing equations for a given fluid flow system.	
CO3: Analyze Finite difference and Finite volume method for diffusion	
CO4: Analyze Flow field problems, Turbulence models and Mesh generation techniques.	
Module 1 Fundamentals of computational fluid dynamics and conservation principles (12 hours) Introduction to Computational Fluid Dynamics and Principles of Conservation; Basic of Computational Fluid Dynamics: Governing Differential Equations and Finite Difference Method, CFD Applications, Numerical / Analytical technique. Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Mathematical classification of Partial Differential Equation, Error Minimization Principles, Boundary conditions: Primary and secondary variables, least square method, Rayleigh-Ritz method.	
Module 2 Finite difference, finite volume, and finite element methods (11 hours) Discretization principles: Preprocessing, Solution, Post-processing, Finite Element Method, 3 Finite difference method, Simple Methods – General Methods for first and second order accuracy –Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term. Finite Volume Method for Convection Diffusion Steady one-dimensional convection and diffusion –Central, upwind differencing schemes, Physical consistency, Overall balance, properties of discretization schemes, Power-law	

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Module 3 Momentum equation discretization (10 hours)

Discretization of the Momentum Equation: Primitive variable approach, Staggered grid and Collocated grid, SIMPLE, SIMPLER, PRESTO. Structured Grid generation – Unstructured Grid generation, Mesh generation, Mesh refinement, Green Gauss Node based gradient, cell-based gradient.

Module 4 Turbulent flow simulation and modeling techniques (11 hours)

Turbulence Model: Turbulence models, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity 2 models, Mixing length model, Turbulent kinetic energy and turbulent dissipation energy, The κ - ϵ model, Advantages and disadvantages of κ - ϵ model, More two-equation models: RNG κ - ϵ model and κ - ω model, Reynolds stress model (RSM), software tools.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	1	2	1	-	-	-	-	-	1
CO 2	3	3	2	3	2	-	-	-	-	-	1
CO 3	3	3	3	3	3	-	-	-	-	-	1
CO 4	3	3	2	3	3	1	1	-	-	-	1

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	3	2	2
CO 2	3	2	2
CO 3	3	1	1
CO 4	3	2	1

Learning Resources:

1. Ghosh Dastidar, P. S., "Computer Simulation of flow and heat transfer", Tata Mc Graw Hill Publishing Company Ltd., 2017.
2. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd, Second Edition, 2007.
3. John David Anderson, "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill, New York.

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Course Code: PE-CHE 701C	Category: Professional Elective Courses
Course Title: Computer aided Process Design	Semester: 7 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Fundamentals of Process Calculations, Thermodynamics, Transport Processes, Chemical Reaction Engineering, and basic computer applications.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to	
CO1: Different approach for process design, Economic analysis of process design through modelling.	
CO2: Demonstrate a comprehensive understanding of batch versus continuous processes, materials and energy balance for recycle structure.	
CO3: Overview for General structure of the separation system, location of vapour and liquid recovery system, sequencing of columns.	
CO4: At various condition distillation process design and heat integration of the process.	
Module 1 Fundamentals of process design (11 hours) Aspects of process design, pre-project objectives, project classification, hierarchical approach to process design, measures of process profitability, simplified model for economic analysis of process design. Basic design of absorber, distillation columns, energy integration of distillation columns, case study for economic decision making for an absorber.	
Module 2 Batch and continuous process design with recycle systems (11 hours) Batch versus continuous processes, comparative analysis, input information, Hierarchy of decision for the recycle structure, materials and energy balance for recycle structure, equilibrium limitations, and modifications of reactor design for recycle.	
Module 3 Design and Integration of separation systems (10 hours) General structure of the separation system, location of vapour and liquid recovery system in the process, sequencing of non-integrated distillation columns for minimum vapour load, sequencing of columns with more than 2 products, thermal coupling of columns.	
Module 4 Process Integration and Energy-Efficient Distillation Design (10 hours) Azeotropic distillation, residue curve maps, azeotropic systems at total and minimum reflux, distillation with entrainer, Composite curves, heat recovery pinch, threshold problems, problem table algorithm, process constraints, number of exchanger units, heat exchanger area target.	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	2	2	-	2	1	-	1	1	-	2
CO 2	3	2	1	1	2	2	-	1	1	-	2
CO 3	3	2	1	1	1	1	-	2	-	-	2
CO 4	3	2	2	1	2	3	1	3	3	-	3

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CO–PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	1	1
CO 2	1	1	-
CO 3	3	2	-
CO 4	2	3	2

Learning Resources:

1. Douglas, James M., Conceptual Design of Chemical Processes, McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (1988).
2. Biegler, L.T., I.E. Grossmann and A.W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall (Pearson Education), New Jersey, USA (1997).
3. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003).
4. Mahajani, V.V., Chemical Project Economics, Macmillan Indian Ltd., New Delhi, India (2005).
5. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, West Sussex, UK (2005).

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Course Code: EE- CHE 791	Category: Employment Enhancement Course
Course Title: Project Work I	Semester: 7 th
L-T-P: 0-0-24	Credit: 6
Pre-Requisites: basic engineering science and engineering laws & technical concept	Branch: Chemical Engineering Total Lecture: 168 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Remember and understand the idea about the current scope of research in the particular field.	
CO2: Relate the idea in the project work and explain the methodology, resources required, critical issues involved in the project by interpreting the data available in the literature	
CO3: Apply the knowledge and information gathered from literature review in research work as an individual or as a member of team.	
CO4: Compare the experimental data with the literature data available and analyze the data to develop the technical knowledge and skill in investigation of the specific field of research and to report while working as an individual or as a member of team.	
Contents:	

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Project work for B. Tech students has to be allotted to the student at the beginning of 7th semester and it is expected to be partially completed in this semester. Each group of students will be required under the supervision of a faculty/ joint supervision of a faculty. The research work has to be carried out by the students themselves with prior concern of Head of the dept and respective faculty supervisor(s). Each group of students is expected to design the research methodology to start the investigation technically in the relevant area of research. The project work is included of identifying particular area of investigation, literature review, preliminary investigation, field excursion, conducting of experiments as far as possible, and interim project report writing based on the execution of project work and results obtained. The course contents of Project work are research topic determination, literature review, primary investigation on selected research topic, and a comprehensive report writing.

The documented report copy of the project work for this project part -I has to be submitted in typed & spiral bound form. It is to be submitted on or before the date commencement for power point presentation on the project topic during 7th semester examination. Assessment would be made on the basis of the submitted report and the presentation & viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1	1	1	-	1	1	1	2
CO 2	3	2	2	2	1	1	-	1	1	2	2
CO 3	3	3	2	2	2	1	1	2	2	2	2
CO 4	3	3	3	3	2	2	1	3	3	3	3

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	1	-	2
CO 2	2	1	2
CO 3	3	2	2
CO 4	3	3	2

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Course Code: EE- CHE 792	Category: Employment Enhancement Course
Course Title: Industrial Internship	Semester: 7 th
L-T-P:	Credit: 3
Pre-Requisites: basic engineering science and engineering laws & technical concept	Branch: Chemical Engineering Total Lecture: 160 L

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Course Outcomes: Upon successful completion of this course, the student will be able to:

CO1: Understand and Participate in the projects in industries during his or her industrial training

CO2: Describe use of advanced tools and techniques encountered in the Process.

CO3: Interact with industrial personnel and follow engineering practices and discipline prescribed in industry

CO4: Develop awareness about general workplace behavior and build interpersonal and team skills.

Contents:

Students will be sent for training to a chemical industry for a period of 4 to 6 weeks after completion of 6th semester examination. After completion of the training, the students will submit a comprehensive report consisting of general overview of the plant, process description of with process flow diagram, details of different equipment with specifications, process instrumentation and control, product with production capacity, raw materials utility and energy consumed per unit of product. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and training coordinator with Head of the Department as Chairman during.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	2	1	1	2	2	2	1	2	2
CO 2	3	3	1	2	2	2	2	2	2	2	2
CO 3	3	2	2	3	1	2	3	3	2	3	2
CO 4	3	3	2	2	2	2	2	3	3	3	3

CO-PSO Mapping Matrix:

	PSO1	PSO2	PSO3
CO 1	2	2	3
CO 2	2	3	2
CO 3	3	2	2
CO 4	3	3	2

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SEMESTER–VIII

Course Code: OE–CHE 801A	Category: Open Elective Courses
Course Title: Statistical Quality Control	Semester: 8 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic Engineering Mathematics and Elementary Statistics.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: To help students understand the concepts underlying statistical quality control and to develop their ability to apply those concepts to the design and management of quality control processes in industries.	
CO2: Major topics include history and overview of the state of the art of quality control methodologies, tools for descriptive and predictive statistical analysis.	
CO3: Analyzing, designing and usage of various control charts for quality control, process characterization and capability analysis, R&R gauge capability studies, design of experiments, acceptance sampling and continuous improvement.	
CO4: The emphasis will be on ensuring that the students gain both a broad perspective of quality control as well as the technical skills necessary to implement quality control in any industrial setting.	
Module 1: Introduction to fundamentals (10 hours) Introduction: Basic concept of quality control, Conformance, Cost of Quality, Benefits of SQC, modern quality control philosophy. Total Quality Management (TQM): Concept, Philosophy & Benefits of TQM. Product Quality Management, TQM Models, Benchmarking, Kaizen & Kairyo system.	
Module 2: Quality Assurance (11 hours) Quality Assurance: Quality Survey, Quality Inspection Planning, Statistical Process Control (SPC), Quality policy deployment, Error proofing.	
Module 3: Mathematical Concepts (10 hours) Basic Statistical Concept: Variations, Variables & Attributed data, frequency distribution, Normal curve, Probability & Probability distribution. Binomial distribution. Control charts for variables & attributes	
Module 4: Sampling and reliability (11 hours) Sampling: Methods, Sampling planes, Continuous sampling plan, Standard sampling plan, Selection of sampling plan for normal inspection, Reliability: Quality & Reliability, Elements, Total Productive Maintenance (TPM), Quality Circle, ISO: 9000 series standards.	

Course Articulation Matrix:

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

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CO-PSO Mapping Matrix:

COs \ PSOs	PSO1	PSO2	PSO3
CO 1	1	2	2
CO 2	1	-	2
CO 3	3	3	-
CO 4	2	1	2

Learning Resources:

1. Montgomery D. C. (2013). Introduction to Statistical Quality Control(7thed.), John Wiley & Sons, Inc.
2. R.C. Gupta, Statistical Quality Control & Quality Management, 9th Edition, Khanna Publishers.
3. John T. Burr, Elementary Statistical Quality Control, 2ndEdition, 2004, by Taylor & Francis Ltd.
4. Grant E.L. and Leavenworth, Statistical Quality Control, TMH, 2000.
5. IS 2500 Standard sampling plan.

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Course Code: OE-CHE 801B	Category: Open Elective Courses
Course Title: Additive Manufacturing	Semester: 8 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Basic knowledge of Engineering Materials, Manufacturing Processes, and Engineering Drawing.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Recall geometric transformation techniques, STL file issues and repair methods, and the mathematical representation of curves, surfaces, and solids.	
CO2: Apply geometric transformation techniques and mathematical models for the representation and manipulation of engineering components in CAD systems.	
CO3: Analyze slicing algorithms and tool path generation methods for efficient additive manufacturing and improved part quality.	
CO4: Design optimized workflows for STL repair, part orientation, slicing, and tool path generation in additive manufacturing processes.	
Module 1: Fundamentals of Additive Manufacturing and Rapid Prototyping (10 Lectures) Rapid Prototyping, Overview of Rapid Prototyping. Product development process. Design for Modularity (Manufacturing). Subtractive versus Rapid Manufacturing. Reverse Engineering: Use of CMM and 3-D Camera for making virtual model.	
Module 2: Additive Manufacturing Processes and 3D Printing Technologies (11 Lectures) Powder based processes. Extrusion based processes. Sheet Stacking processes. Beam Deposition processes. 3 D printing processes: Basic Process-CAD Model Creation, Conversion to STL format, Slicing the STL	

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File, Layer by layer construction, Clean and finish.

Module 3: Materials, Product Development and Stereolithography in Additive Manufacturing (10 Lectures)

Materials in Rapid Manufacturing. Post-processing concerns. Product costing for Rapid Manufacturing. Rapid Product Development, CAE and CIM. Stereo-lithography (SLG): Principles, systems, relative advantages and application.

Module 4: Advanced Additive Manufacturing Technologies and Applications (11 Lectures)

Selective laser sintering (SLS): Principles, systems, relative advantages and applications. Fused deposition modeling (FDM): Principles, systems, relative advantages and applications. Laminated objects manufacturing (LOM): Principles, systems, relative advantages and applications. 3D Inkjet Printing: Principles, systems, relative advantages and applications.

Course Articulation Matrix:

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

CO-PSO Mapping Matrix:

COs\ PSOs	PSO1	PSO2	PSO3
CO 1	2	2	3
CO 2	3	2	1
CO 3	3	2	3
CO 4	2	3	1

Learning Resources:

1. Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Third Edition, Pearson Education, New Delhi (2008).
2. Groover, M. P. and Zimmers, E. W., CAD/CAM: Computer-Aided Design and Manufacturing, Prentice Hall of India Pvt. Ltd., New Delhi (2003).
3. Radhakrishnan, P., Subramanyan, S. and Raju, V., CAD/CAM/CIM, Fourth Edition, New Age International Publishers, (2018).
4. Gibson, I., Rosen, D. W. and Stucker, B., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Second Edition, Springer Nature (2014)
5. Chua, C. K., Leong, K. F. and Lim, C. S., Rapid Prototyping: Principles and Applications, Third Edition, World Scientific Publishing Co. Pte. Ltd., Singapore (2010).

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Course Code: OE-CHE 801C	Category: Open Elective courses
Course Title: Operations Research	Semester: 8 th
L-T-P: 3-0-0	Credit: 3
Pre-Requisites: Engineering Mathematics, System of linear Equations, Probability, Fundamental Calculus.	Branch: Chemical Engineering Total Lecture: 42 L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Apply graphical, simplex, Big-M, and duality methods to formulate and solve Linear Programming Problems and analyze feasible and optimal solutions.	
CO2: Formulate and solve Transportation and Assignment Problems using appropriate optimization techniques and evaluate optimality conditions.	
CO3: Analyze decision-making and network optimization problems using concepts of Game Theory, Maximal Flow, PERT, and CPM techniques.	
CO4: Apply inventory control models and queuing theory concepts to solve deterministic, probabilistic, and Poisson queue-based operational problems.	
Module 1: Linear Programming Problem (12 hours) Formulation of Linear Programming Problems, Definitions: Feasible Solution, Basic and non-basic Variables, Basic Feasible Solution, Degenerate and Non-degenerate Solution, Convex set and explanation with examples. Solution of LPP by Graphical Method; Simplex Method; Charnes' Big-M Method; Duality Theory.	
Module 2: Transportation and Assignment Problem (10 hours) Basic concept of Transportation problem, Different solution methods, Optimality test. Problem formulation of Assignment problem, Solution methods, Travelling Salesman Problem.	
Module 3: Game Theory and Network Analysis (10 hours) Introduction of Game theory; 2-Person Zero-sum Game; Saddle Point; Mini-Max and Maxi-Min Theorems (statement only) and problems; Games without Saddle Point; Graphical Method; Principle of Dominance. Maximal Flow Problem: Ford-Fulkerson; PERT & CPM.	
Module 4: Inventory Control and Queuing Theory (10 hours) Introduction to EOQ Models of Deterministic and Probabilistic; Safety Stock; Buffer Stock. Introduction of Queuing theory; Basic Definitions and Notations; Axiomatic Derivation of the Arrival & Departure (Poisson Queue). Poisson Queue Models: (M/M/1): (∞ / FIFO) and (M/M/1: N / FIFO) and problems.	

Course Articulation Matrix:

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

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CO & PSO Mapping:

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	2	2
CO3	2	3	2
CO4	3	3	2

Learning Resources:

6. H. A. Taha, "Operations Research", Pearson
7. P. M. Karak – "Linear Programming and Theory of Games", ABS Publishing House
8. Ghosh and Chakraborty, "Linear Programming and Theory of Games", Central Book Agency
9. Ravindran, Philips and Solberg - "Operations Research", WILEY INDIA

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Course Code: EE-CHE 891	Category: Employment Enhancement Courses
Course Title: Project Work II	Semester: 8 th
L-T-P: 0-0-24	Credit: 6
Pre-Requisites: Basic engineering science and engineering laws & technical concept	Branch: Chemical Engineering Total Lecture: 168L
Course Outcomes: Upon successful completion of this course, the student will be able to:	
CO1: Recall the information of documented report comprising of summary of literature survey, project specifications in this field of research and work done in previous term along with its detailed objectives etc.	
CO2: Summarize the concept or functionality of project phase I results and apply the knowledge and information gathered to extend the research work.	
CO3: Analyze and interpret the generated experimental data to assess the record of continuous progress in research while working as an individual or as a team member.	
CO4: Modify/design the new technique(s)/ model for evaluating the process optimization parameters, and propose the justified of method(s) used in research while working professionally as an individual or as a team member.	
Contents:	
Project work for B. Tech students is expected to be completed fully in the 8 th semester. Each group of students will be required under the supervision of a faculty/ joint supervision of faculty members. The research work has to be carried out by the students themselves, consulting his or her supervisor(s). Each group of students is expected to design and develop a complete system or make an investigative analysis	

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of a technical problem in the relevant area. The project work includes identifying a particular area of investigation, summarizing relevant literature review, continuous investigation in continuation of project phase-I work held in 7th semester, field excursion, conducting of extended experimentation, numerical modeling to validate experimental data (if any), interpretation of results, and report writing. The course contents of 'Project II' are: Research topic determination, relevant literature review, thorough investigation and analysis, & inference based on the outcomes of the project work.

The hard copies of the final project report have to be submitted on or before the commencement of the 8th semester examination. Assessment would be made on the basis of the submitted report and the presentation & viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee.

Course Articulation Matrix:

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

CO & PSO Mapping:

COs/PSOs	PSO1	PSO2	PSO3
CO1	2	-	2
CO2	3	1	2
CO3	3	2	2
CO4	3	3	3

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Course Code: PC-CHE 891	Category: Professional Core Courses
Course Title: Grand Viva	Semester: 8 th
L-T-P: ---	Credit: 2
Pre-Requisites: Basics of chemical engineering concepts and fundamentals	Branch: Chemical Engineering
Course Outcomes: Upon successful completion of this course, the student will be able of:	
CO1: Memorizing technical knowledge, gathered throughout the course.	
CO2: Understanding the overall technical aptitude for industry readiness.	
CO3: Applying technical knowledge in virtual environment of professional interview.	

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CO4: Analyzing different technical puzzles and industrial troubleshooting

Contents:

This is a Viva–Voce examination to ascertain the student's overall grasp of the principles of Chemical Engineering and allied subjects. Assessment would be made on the basis of the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of three faculty members with the Head of the Department as Chairman, during 8th Semester examination.

Course Articulation Matrix:

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

CO & PSO Mapping:

COs/PSOs	PSO1	PSO2	PSO3
CO1	2	2	2
CO2	3	1	2
CO3	3	2	2
CO4	3	3	3

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APPENDIX – A

GUIDELINES OF MASSIVE OPEN ONLINE COURSES (MOOCS) SCHEME

MOOCs for B.Tech. Honours Degree

For the award of a **B.Tech. Honours** Degree, a regular **4-year B.Tech. student** must earn an additional **20 credits** through MOOCs (Massive Open Online Courses) offered by any recognized and established MOOC platform, over and above the prescribed credits required for the B.Tech. degree.

Similarly, **B.Tech. lateral entry students** are required to earn an additional **16 MOOC credits**, in addition to the prescribed credits for the B.Tech. degree. Credit will be distributed over four year as :

1 st year	4-8 credits
2 nd year	4-8 credits
3 rd year	4-8 credits
4 th year	4 credits

A student of first year has to cover courses from at least three skills:

1. Computer Programming with Python / R
2. Soft skills
3. Values and Ethics

Students of all streams are to be equipped with Programming skill in the language that is in high demand worldwide in the first year itself so that they can apply this skill in the subsequent semesters in their different areas including their core area of study.

Soft skill is very essential for grooming of the student and student must be exposed to it in the very beginning of the 4 year long program.

Ethics is something that one should practice. Students are to be made aware of the ethics right in the beginning of the 4 year long program so that they can practice at least some of the ethical norms as applicable to Institutional environment and society, and be prepared to practice ethics in their working life.

All of the MOOCs courses are to be taken any MOOCs platform as per following scheme of credit points. There would not be any concept of fixed basket anymore. However, during choosing courses in the online platform students would essentially avoid the courses taught / offered through the curriculum in the offline / class room mode.

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For NPTEL / Swayam platform: Credit points as specified in the platform

Courses of 4 weeks to 7 weeks: 1 credit point
Courses of 8 weeks to 11 weeks: 2 credit point
Courses of 12 weeks to 15 weeks: 3 credit point
Courses of 16 weeks or more: 4 credit point

Where duration of MOOCs courses are available in hours

For every 8 hours of course: 1 credit point (< 8 hours = No credit)

16 hours = 2 credits (> 8 - < 16 hours = 1 credit)

24 hours = 3 credits (> 16 - < 24 hours = 2 credits)

32 hours = 4 credits [Max.] (> 24 - < 32 hours = 3 credits)

However, for the courses with duration less than 8 hours, multiple courses could be taken together (preferably in the same area) to consider 1 credit point. But where duration is available in week, count of hours will not be applicable.

The above structure is indicative only. And BoS / DC concerned may propose credit points of the courses offered through MOOCs platform based on the content and level (beginner / intermediate / advanced) of the courses.

Evaluation of the MOOCs courses:

Evaluation of the MOOCs courses would be done by the organization by whom it is being offered. In extraordinary circumstances, the modality of evaluation through certified personnel, online or offline will be decided by the appropriate authority.

Uploading of MOOCs Data:

Every UG Department has to upload the details of MOOCs data in respect of each student time to time in Institute's examinations portal and / or hard / soft copy as per instruction of the Controller of Examinations of the Institute.

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APPENDIX – B

GUIDELINES OF MANDATORY ADDITIONAL REQUIREMENT (MAR) FOR EARNING B. TECH DEGREE

The additional requirement of MAR points applies to - every student, who is admitted to the 4 years B.Tech program under Autonomy, as per following:

Level of Entry in B. Tech Course	Total duration for earning Points	Minimum Points
1 st Year from the academic year 2026-27 onwards	1 st to 4 th Year	100
2 nd Year from the academic year 2027-28 onwards (Lateral Entry)	2 nd to 4 th Year	75

Mandatory Additional Requirement is compulsory for acquiring B.Tech./B.Tech. (Honours) degree for all the students under autonomy.

Total hundred (100) points are required in different fields mentioned in the MAR table in syllabus to achieve B.Tech./B.Tech. (Honours) degree in the four years of study. For lateral entry students the total MAR points will be 75.

These 100 (75 for 3 years B.Tech/Lateral Entry) points are equally divided in four/three (for lateral entry) years of study, i.e., students have to acquire minimum 25 points in each and every year. If any candidate is failed to achieve the minimum MAR points, it will be treated as backlog and he/she should clear it in the immediate next year. For final year students, no degree will be conferred if he/she has unable to achieve total 100/75 (for 3 years B.Tech/ Lateral Entry) points from MAR.

Certification and awarding on the activities of MAR for outstanding activities/special achievements in these areas would be considered.

Students may achieve more than maximum admissible points and total MAR points would be reflected in the final certificate.

These points must be earned on the basis of active participation in co-curricular and extracurricular activities spanning through all the semesters of study. Every student may choose, as per his/her liking, activities in order to achieve the mandatory points (as per Table- I, depending on his/her entry level), before becoming eligible for award of the Degree. These activities can be spread over the years, as per convenience of the student.

Notes:

- Every student shall participate in the co-curricular and extra-curricular activities and produce documentary proof to the designated Faculty Members appointed by the Head of Department / Principal / Director in the respective college. Thereby the student should earn the required Points before *her* she appears for his/ her Final Examinations.
- A student's result of his/her Final Examinations will be withheld until he/she completes the minimum Activity Points by the end of his/her B.Tech Program.
- In every semester, every student is required to prepare a file containing documentary • proofs of activities, done by

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him / her. This file will be duly verified and Activity Points will be assigned by the teachers as appointed above, at the end of every semester. • The college will form a 3 members committee and finalize the Activity Points for each • student before entering them into the Online Point Entry System of the Institute • Every student has to earn at least 100 / 75 (for lateral) activity points. The points students have earned will be reflected in the student's mark sheet. • Activity points earned by Lateral Entry students will be multiplied by 1.33.

Table I provides a List of Activity Heads and Sub-Activity Heads along with their capping of the Activity Points that can be earned by the students during the entire B.Tech duration.

Sl. No.	Name of the Activity	Points	Maximum Points Allowed
1.	MOOCS (SWAYAM/NPTEL/Spoken Tutorial) (per course)	2 weeks: 5 4 weeks: 10 8 weeks: 16 12 weeks: 20	40
2.	Tech Fest/Teachers Day/Freshers Welcome		
	Organizer	5	10
	Participants	3	6
3.	Rural Reporting	5	10
4.	Tree Plantation (per tree)	1	10
5.	Participation in Relief Camps	20	40
6.	Participation in Debate/Group Discussion/ Tech quiz/Seminar/Workshop	10	20
7.	Publication of Wall magazine in institutional level (magazine/article/internet)	10	20
8.	Publication in News Paper, Magazine & Blogs	10	20
9.	Research Publication (per publication)	15	30
10.	Innovative Projects (other than course curriculum)	30	60
11.	Blood donation	8	16
	Blood donation camp Organization	10	20
12.	Participation in Sports/Games		

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	College level	5	10
	University Level	10	20
	District Level	12	24
	State Level	15	30
	National/International Level	20	20
13.	Cultural Programme (Dance, Drama, Elocution, Music, etc.)	10	20
14.	Member of Professional Society	10	20
15.	Student Chapter	10	20
16.	Relevant Industry Visit & Report	10	20
17.	Photography activities in different Club (Photography club, Cine Club, Gitisansad)	5	10
18.	Participation in Yoga Camp (Certificate to be submitted)	5	10
19.	Self-Entrepreneurship Programme	20	20
20.	Adventure Sports with Certification	10	20
21.	Training to under privileged/Physically challenged	15	30
22.	Community Service & Allied Activities	10	20
