SCHEME & SYLLABUS

OF TEACHING & EXAMINATION

FOR

VII & VIII SEMESTERS

B.E. CHEMICAL ENGINEERING

2025-2026

[for 2022 admitted batch,

160 credit course, NEP 2.0]

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A' grade & ISO 9001:2015 Certified)

B.E. in Chemical Engineering, NEP – 2, (160 credits Program)

SCHEME OF TEACHING AND EXAMINATION (2022 Admitted Batch) (w.e.f. 2025-26)

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs/week				Examination				Credits
					Lecture L	Tutorial T	Practical/ Drawing P	Self-Study Component S	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
VII Semester													
1.	PCC	S7CH01	Transport Phenomena	ChE	4	0	0	-	3	50	50	100	4
2.	IPCC	S7CHI01	Process Equipment Design	ChE	3	0	2	-	3	50	50	100	4
3.	IPCC	S7CHI02	Computer Applications & Modelling in Chemical Engineering	ChE	3	0	2	-	3	50	50	100	4
4.	PEC		Professional Elective Course - III	ChE	3	0	0	-	3	50	50	100	3
5.	OEC	OE7X	Open Elective Course - II	Other	3	0	0	-	3	50	50	100	3
6.	PROJ	S7CHMP	Major Project Phase II	ChE	Monday to Thursday				3	100	100	200	6
			Total		**16**	**0**	**4**	**-**	**18**	**350**	**350**	**700**	**24**
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for									

Note: **IPCC**: Integrated Professional Core Course, **PCC**: Professional Core Course, **PCCL**: Professional Core Course Laboratory, **PEC**: Professional Elective Course, **OEC**: Open Elective Course, **AEC**: Ability Enhancement Course, **PROJ**: Project, **MC**: Mandatory Course. **L**: Lecture, **T**: Tutorial, **P**: Practical/ Drawing, **S**: Self-Study Component, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Examination

Professional Elective Course – III (Offered by the Department) (VII Sem)			
S7CHPE31	Introduction to Sustainable Engineering	S7CHPE32	Process Optimization
S7CHPE33	Chemical Process Integration	S7CHPE34	Biochemical Engineering

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					Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
VIII Semester													
1.	PEC		Professional Elective Course - IV	NPTEL	3	0	0	0	3	50	50	100	3
2.	OEC	OE8X	Open Elective Course - III (ONLINE)	NPTEL	3	0	0	0	3	50	50	100	3
3.	INT	INT	Internship (Research / Industry) (15 weeks)	-	0	0	20	0	3	100	100	200	10
			Total		**6**	**0**	**20**	**0**	**9**	**200**	**200**	**400**	**16**
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for									

Note: **IPCC**: Integrated Professional Core Course, **PCC**: Professional Core Course, **PCCL**: Professional Core Course Laboratory, **PEC**: Professional Elective Course, **OEC**: Open Elective Course, **AEC**: Ability Enhancement Course, **PROJ**: Project, **MC**: Mandatory Course.
L: Lecture, **T**: Tutorial, **P**: Practical/ Drawing, **S**: Self-Study Component, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Examination

Professional Elective Course – IV (NPTEL)		**Open Elective Course – III (NPTEL)**	
S8CHPE1	Chemical Process Instrumentation	OE81	Electric Vehicles
S8CHPE2	Polymers: concepts, properties, uses and sustainability	OE82	Strategies for Sustainable Design
S8CHPE3	Biomass Conversion and Biorefinery	OE83	Climate Change Science
S8CHPE4	Environmental Quality Monitoring & Analysis	OE84	Energy Resources, Economics and Environment
S8CHPE5	Fundamentals of Particle and Fluid Solid Processing	OE85	Lighter than Air Systems
S8CHPE6	Aspen Plus Simulation Software - A Basic Course for	OE86	United Nations Sustainable Development Goals
S8CHPE7	Clean Coal Technology	OE87	Safety and Risk Analytics
S8CHPE8	Chemical Process Utilities	OE88	Groundwater Hydrology and Management

Integrated Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical of the same course. Credit for IPCC can be 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper. For more details, the regulation governing the Degree of Bachelor of Engineering (B.E.) 2022-23 may please be referred.

Non-Credit Mandatory Course (NCMC):

National Service Scheme /Physical Education/Yoga/National Cadet Corps: All students have to register for any one of the courses namely National Service Scheme (NSS), National Cadet Corps (NCC), Physical Education (PE) (Sports and Athletics), and Yoga (YOG) with the concerned coordinator of the course during the first Week of III semesters. Activities shall be carried out between III semester to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the Degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, NCC and Yoga activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of Degree.

(1) Securing 40 % or more in CIE, 35 % or more marks in SEE and 40 % or more in the sum total of CIE + SEE leads to successful completion of the registered course.
(2) In case, students fail to secure 35 % marks in SEE, they have to appear for SEE during the subsequent examinations conducted by the University.
(3) In case, any student fails to register for NSS, PE or Yoga/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have not completed the requirements of the course. In such a case, the student has to fulfill the course requirements during subsequent semester/s to earn the qualifying CIE marks.
(4) Successful completion of the course shall be indicated as PP in the grade card. Non-completion of the course shall be indicated as NP.
(5) These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the courses shall be mandatory for the award of degree.

AICTE Activity Points:

Apart from technical knowledge and skills, to be successful as professionals, students should have excellent soft skills, leadership qualities and team spirit. They should have entrepreneurial capabilities and societal commitment. In order to match these multifarious requirements, AICTE has created a unique mechanism of awarding minimum 100 Activity Points for regular students and 75 Activity Points for Lateral Entry students over and above the academic grades.

The activities can be spread over entire duration of the programme and it will be reflected in the Student's VIII Semester Grade Card. It shall not be considered for computation of SGPA/CGPA and for vertical progression. The total duration of the activities for entire programme is 320 hours for regular students and 240 hours for lateral entry students.

Break-up of CIE marks for activity points:

Evaluation by the Proctor	50 marks
Evaluation by DSEC	
Report	20 marks
Presentation	20 marks
Outcome	10 marks
Total	**100 marks**

1. No SEE for AICTE Activity Points.
2. Students will be awarded either NP or P grade based on marks obtained.
3. Students will be awarded 'Degree' only on earning P grade in the Activity Points

VII Semester

TRANSPORT PHENOMENA

Contact Hours/ Week	4+0+0 (L+T+P)	Credits	4.0
Total Lecture Hours	52	CIE Marks	50
Total Tutorial Hours	00	SEE Marks	50
Sub. Code	S7CH01	Semester	7

Course objectives:	
1	Develop mathematical models for engineering processes in momentum transfer
2	Explain mathematical models for engineering processes in Heat Transfer
3	Develop mathematical models for engineering processes in Mass Transfer
4	Understand and draw analogies between heat, momentum and mass transfer
5	Study the significance and develop equation of continuity and equation of motion

UNIT I

Viscosity and the mechanism of Momentum Transport: Newton's law of viscosity (NLV), Newtonian and non-Newtonian fluids, Numerical problems on the application of Newton's law of viscosity.

Velocity distribution in Laminar Flow: Steady state shell momentum balance, general boundary conditions applicable to momentum transport problems of Chemical Engineering. The flow situations for a) flow over a flat inclined plate, b) flow through a circular tube, c) flow through annulus, d) flow between parallel plate and through a slit for laminar flow are required. Simple numerical problems using the equations derived in the above fluid flow situations.

12 Hours

UNIT II

Thermal Conductivity and mechanism of Energy Transport: Fourier law of heat conduction. Numerical problems on the application of Fourier's law of heat conduction.

Temperature Distribution in solids and in Laminar Flow: Steady state shell energy balances. General boundary conditions applicable to the heat conduction problems of Chemical Engineering for, a) heat conduction with internal generation by electrical, nuclear source b) heat conduction through compound walls, overall heat transfer coefficient, c) heat conduction in a cooling fin. Simple numerical problems using the equations derived in the above Heat transfer situations.

10 Hours

UNIT III

Diffusivity and mechanism of Mass Transport: Fick's law of diffusion,

Concentration Distributions in solids and in Laminar Flow: Steady state shell mass balance, General boundary conditions applicable to the mass transport problems of chemical engineering, on a) Diffusion through stagnant gas and liquid film b) Equimolar counter

diffusion c) Diffusion with homogeneous and heterogeneous reaction d) Diffusion into falling film-forced convection mass transfer. **Note:** In all above 1D problems only to be considered. Simple numerical problems using the equations derived in the above situations.
10 Hours

UNIT IV
Analogies between Momentum, Heat and Mass Transport: Defining analogy among Momentum, Heat and Mass Transport and their application a) Reynolds analogy b) Prandtl's analogy c) Chilton and Colburn analogy. Applications. Simple numerical problem using the analogy
8 Hours

UNIT V
Equations of Change: Equation of continuity, equation of motion and Navier-Stokes equation, Application of this equation in developing simple steady state momentum situations Viz. a) flow between two parallel vertical plates b) Steady state laminar flow in horizontal tube
12 Hours

Text Books		
1	Bird, Stewart and Lightfoot.	*Transport Phenomena*, 2e. John Wiley, 2006, ISBN: 978-8126508082.
2	Wilke, Wikcs and Watson	*Fundamentals of Momentum, Heat and Mass Transfer*, 5e John Wiley, 2010, ISBN: 978-8126528387

Reference Books		
1	Robert S. Brodkey and Harry C. Hershey,	Transport Phenomena Unified Approach, Brodkey Publishing 2003, ISBN: 978-0070079632
2	Raj B.,	Introduction to Transport Phenomena: Momentum, Heat and Mass**,** 1e, Prentice Hall India Learning Private Limited, 2012, ISBN: 978-8120345188

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Analyze and comprehend mathematical models for situations in momentum transfer
CO2	Develop analyze and comprehend mathematical models for situations in heat transfer
CO3	Develop analyze and comprehend mathematical models for situations in mass transfer
CO4	Comprehend the analogies among heat, momentum and mass transfer and verify numerically
CO5	Formulate continuity equations for real life transport problems related to chemical engineering

		POS											PSOS			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	3											2			
	CO2		3										3			
	CO3		2										2			
	CO4		2										2			
	CO5											2	2			

PROCESS EQUIPMENT DESIGN

Contact Hours/ Week	3+0+2 (L+T+P/D)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S7CHI01	Semester	7

Course objectives:	
1	Impart knowledge on the process and mechanical design principles of chemical process equipment such as heat exchangers, evaporators, distillation columns, and reactors.
2	Enable students to analyze and determine design and working parameters such as pressure, shell and head thickness, and nozzle dimensions in compliance with relevant design standards and safety requirements.
3	Develop the ability to design equipment internals, including trays, tube arrangements, baffles, agitators, jackets, and other components for optimal performance in separation and heat transfer processes.
4	Introduce systematic methodologies for sizing and selecting equipment ensuring energy efficiency and scalability.
5	Equip students with practical skills to integrate process and mechanical aspects in equipment design, with a focus on safety, reliability, operability, and cost-effectiveness in real-world plant operations.

UNIT I
Process and mechanical design of a **Double Pipe Heat Exchanger** involving working and design pressure, shell thickness, head thickness, and nozzle sizing
8 Hours

UNIT II
Process and mechanical design of a **Shell and Tube Heat Exchanger** involving design of exchanger internals, working & design pressure, shell thickness, head thickness, nozzle sizing
8 Hours

UNIT III
Process design of a **Single-effect Evaporator** and mechanical design involving working and design pressure, shell thickness, head thickness, and nozzle sizing

8 Hours

UNIT IV
Design of a **Distillation column** with sieve-trays using McCabe Thiele method, choice of trays and tray design
8 Hours

UNIT V
Design of a **Chemical Reactor** involving estimation of reactor volume, vessel sizing, choice of agitators, design of agitator and jacket
7 Hours

Text Books		
1	S. D. Dawande	Process Design of Equipment–Vol 2, Central Techno Publications, 2012.
2	R. W. Serth	Process Heat Transfer: Principles and Applications, 2007, Elsevier.
3	S. B. Thakore and B. I. Bhatt	Introduction to Process Engineering and Design, McGraw Hill Education, 2e, 2017.

Reference Books		
1	J. R. Backhurst and J. H. Harker	Coulson and Richardson Chemical Engineering, Vol. II, 5th Ed., 2002, Butterworth-Heinemann.
2	R. K. Sinnott	Coulson and Richardson's Chemical Engineering Series: Chemical Engineering Design, Vol. VI, 4th Ed., 2005, Elsevier Butterworth-Heinemann.
3	V. V. Mahajani and S. B. Umarji	Joshi's Process Equipment Design, Laxmi Publications, 5e, 2016.
4	B. C. Bhattacharyya	Introduction to Chemical Equipment Design: Mechanical Aspects, 1e, 2008.
5	R. E. Treybal	Mass Transfer Operation, Mc Graw Hill, NY, 3e, 2012.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Understand the fundamentals of process and mechanical design for chemical engineering equipment such as double pipe heat exchangers, shell and tube heat exchangers, evaporators, distillation columns, and chemical reactors.
CO2	Apply design standards and procedures to determine key parameters like working/design pressure, shell and head thickness, and nozzle dimensions for safe and effective equipment design. (Level: Apply)
CO3	Analyze the function and configuration of internal components such as trays, baffles, tubes, agitators, and jackets, and their influence on equipment performance and process efficiency. (Level: Analyze)
CO4	Evaluate and implement appropriate process design methodologies such as the

	McCabe-Thiele method for distillation or volume estimation for reactors to size and configure chemical process equipment. (Level: Evaluate)
CO5	Design and integrate process and mechanical aspects of equipment with a focus on optimizing reliability, safety, and cost-effectiveness in real-world chemical plant operations. (Level: Create)

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	3		3		3	3						3	3		3
	CO2	3		3		3	3	3					3	3		3
	CO3	3		3		3	3	3					3	3		3
	CO4	3		3		3	3	3					3	3		3
	CO5	3		3		3	3	3					3	3		3

Note for Semester End Examination:
The question paper to contain Two full design problems (100 Marks each) for the equipment from the above list and student to answer anyone.

Perry's Chemical Engineer's Handbook shall be allowed in the examination as reference.
IS Code 4503 for Heat Exchangers (if required) shall be permitted.
The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions and drawing (Not to scale, Sectional Front View, Top/Side View and major Component Drawings with Part Template).

PROCESS EQUIPMENT DESIGN LABORATORY

Software Used: Solid Works

Guidelines: The following process equipment must be designed and drawn using Solid Works in 2D and to scale. Process design and mechanical design parameters will be provided.

Experiments:

1	2D sectional drawing of a Double Pipe Heat Exchanger showing nozzle and other relevant mechanical parts
2	2D sectional drawing of a Shell and Tube Heat exchanger showing nozzle and other relevant mechanical parts
3	2D sectional drawing of a Single-effect Evaporator showing nozzle and other relevant mechanical parts
4	2D sectional drawing of a Distillation column showing sieve-trays and other relevant mechanical parts
5	2D sectional drawing of a Chemical Reactor showing agitator, jacket and relevant mechanical parts
	26 Hours (2 Hours/week)

COMPUTER APPLICATIONS & MODELLING IN CHEMICAL ENGINEERING

Contact Hours/ Week	3+0+2 (L+T+P/D)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code:	S7CHI02	Semester	7

Course objectives: This course will enable students to:	
1	Adopt appropriate numerical methods to solve non-linear algebraic, transcendental, and ordinary differential equations, and calculate a definite integral; develop a C program to perform the numerical solution to a chemical engineering problem.
2	Apply C program principles to determine the bubble point and dew point temperature using Antoine equations; calculate the volume of reactors and time required for given conversion; and to evaluate adiabatic flame temperature using Newton Raphson method.
3	Use C program to design heat exchangers and distillation column.
4	Formulate and solve process design problems, apply appropriate mathematical model, and select an appropriate solution method to obtain required result
5	Formulate and solve process design problems, based on fundamental analysis and using mathematical models of chemical processes.

UNIT I
Numerical Techniques: (Algorithm and C program) Simultaneous linear algebraic equation- Gauss Jordan (material balance for distillation and mixing), Non-linear algebraic equation-Newton Raphson (Specific volume of binary mixture using real gas equations), Ordinary Differential Equation- R-K Method ($dC_A/dt= KC_A^2$), Numerical Integration-Simpson's 1/3rd Rule (Batch Reactor to find time), Curve Fitting- Least Square Method (Arrhenius).
8 Hours

UNIT II
Applications: (Algorithm and C program) P–X,Y and T–X, Y evaluation, Calculation of Bubble Point and Dew Point for an Ideal multi-component system. Flash Vaporization for multi-component systems, Design of Adiabatic Batch Reactor, PFR, CSTR, Adiabatic Flame Temperature.
9 Hours

UNIT III
Design: (Algorithm and C Program) Double pipe Heat Exchanger (Area, Length and Pressure drop), Shell Tube Heat Exchanger (Area, Number of tubes, Pressure drop) Distillation Column (Bubble cap- Stage wise calculation for binary mixture).

7 Hours

UNIT IV
Modelling: Models and model building, principles of model formulations, precautions in model building, Fundamental laws: Review of shell balance approach, continuity equation, energy equation, equation of motion, transport equation of state equilibrium and Kinetics, classification of mathematical models.
7 Hours

UNIT V
Mathematical modeling and solution to Process Engineering Operations: Basic tank model -level v/s time, multi component flash drum, Batch distillation - Vapor composition with time, Batch reactor, Heat exchanger (co-current and counter current) - Steady state energy balance.
8 Hours

Text Books		
1	Pradeep Ahuja	Introduction to Numerical Methods in Chemical Engineering, PHI Learning, 2010, 1e, ISBN: 9788120340183
2	Raul Raymond A. Kapuno	Programming for Chemical Engineers Using C, C++ and MATLAB, 2010, 1e, ISBN:978-9380298207
3	William. L. Luyben	Process Modelling Simulation and Control for Chemical Engineers, McGraw Hill, 2e, 1990 ISBN: 9780071007931
4	Kotur P. B.	Computer Concepts & C Programming, 23rd edition, 2013, ISBN: 9788128001109

Reference Books		
1	H. Scott Fogler	Elements of Chemical Reaction Engineering, Prentice Hall, 5e, 2015, ISBN: 9780133887518.
2	Smith J.M. and H. C. Vanness	Introduction to Chemical Engineering Thermodynamics, McGraw-Hill, 8e, 2017, ISBN: 9781259696527.
3	Amiya K. Jana	Chemical Process Modelling and Computer Simulation, PHI Learning Private Limited, 1e, 2017,ISBN-13: 978-9387472075

Course Outcomes: Upon completion of this course, the student will be able to:	
CO1	Apply appropriate numerical methods and C programming skills to solve chemical engineering problems

CO2	Develop an algorithm and program to evaluate bubble and dew point values for a given multicomponent mixture.
CO3	Develop an algorithm and C program to design a heat exchanger, a distillation column, and a reactor.
CO4	Apply the principles of modelling and build models for process operations.
CO5	Develop mathematical models for process systems using modelling concept and physical laws.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3				3							3		3	
CO2	3				3							3		3	
CO3	3				3							3		3	
CO4	3				3							3		3	
CO5	3				3							3		3	

COMPUTER APPLICATIONS AND MODELLING LAB

PART A: C Program **30 marks**

1	Application of Newton-Raphson method for determining the Specific volume of a binary mixture.
2	Application of the Runge-Kutta Method to find the concentration profile in a reactor.
3	Application of Simpson’s 1/3rd for determining the time required for the given reaction in a Batch Reactor.
4	Estimation of Curve fitting by least square method (Re Vs. f).
5	Application of Newton Raphson method to find Bubble Point and Dew Point for Ideal multi-component system.
6	Application of Newton Raphson method to determine Flash Vaporization for multi-component system.
7	Application of Newton Raphson method to Design of Adiabatic Batch Reactor, PFR.
8	Application of Newton Raphson method to evaluate the Adiabatic Flame Temperature.
9	Design of Double pipe Heat Exchanger (Area, Length and Pressure drop).
10	Design of Distillation Column (Bubble cap).

PART B: MATLAB & SIMULATION SOFTWARE 20 Marks

1	Determination of specific volume using Equation of state.
2	Estimation of the rate constants in a series reaction, each of first order kinetics.
3	Determination of heat to be removed in a crystallizer.
4	Solution to the system of linear equations using matrix inversion and matrix left division.
5	Introduction to suggested software available (flow sheeting)
6	Simulation studies of Flash Drum, Distillation Column, PFR, CSTR,
7	Process simulation study of mixing, reactor, distillation, and Heat Exchanger for any of the following processes: a. Ethylene Glycol from Ethylene oxide b. Atmospheric distillation of crude oil

NOTE:

- One question from PART-A, excluding Numerical Techniques: 30 marks
- One question from PART-B (Simulation of any above process): 20 marks

SOFTWARE SUGGESTIONS:

C Program, DESIGN-II, UNISIM, MATLAB

PROFESSIONAL ELECTIVE COURSE – III

INTRODUCTION TO SUSTAINABLE ENGINEERING

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S7CHPE31	Semester	7

Course objectives:	
1	Introduce the fundamental knowledge of issues, principles, concepts, processes, and practices related to sustainability engineering.
2	Enable students with an understanding of principles and frame work of sustainable engineering.
3	Provide students with an understanding of Life Cycle Assessment tool in sustainable engineering.
4	Build the capacity to consider sustainability factors in conceptualizing, designing and operating the engineering systems to create tomorrow's sustainable environment and sustainable products.

UNIT I
Sustainable Development and Role of Engineers: Introduction, Why and What is Sustainable Development, THE SDFs, Paris Agreement and Role of Engineering, Sustainable Development and the Engineering Profession, Key attributes of the Graduate Engineering. **Sustainable Engineering Concepts**: Key concepts – Factor 4 and Facto 10: Goals of sustainability, System Thinking, Life Cycle Thinking and Circular Economy.
8 Hours

UNIT II
Sustainable Engineering and Concepts, Principles and Frame Work: Green Economy and Low Carbon Economy, Eco Efficiency, Triple bottom Line, Guiding principles of sustainable engineering, Frameworks for sustainable Engineering. **Tools for sustainability Assessment:** Environmental Management System, Environmental Auditing, Cleaner Production Assessment, Environmental Impact Assessment, Strategic Environmental Assessment Life Cycle Management.
8 Hours

UNIT III
Fundamentals of Life Cycle Assessment: Why and What is LCA, LCA Goal and Scope, Life cycle inventory, Life Cycle Impact Assessment, Interpretation and presentation of Results, Iterative Nature of LCA, Methodological Choices, LCI Databases and LCA Softwares, Strength and Limitations of LCA.
8 Hours

UNIT IV
Environmental Life Cycle Costing, Social Life Cycle Assessment, and Life Cycle Sustainability Assessment: Introduction, Environmental Life Cycle Costing, Social Life Cycle Assessment, Life Cycle Sustainability **LCA Applications in Engineering**: Environmental Product Declarations and Product Category Rules, Carbon and Water Foot Printing, Energy systems, Buildings and the Built Environment**,** Chemical and Chemical Production Food and Agriculture.
8 Hours

UNIT V
Integrating Sustainability in Engineering Design: Problems Solving in Engineering, conventional to Sustainable Engineering Design Process, Design for Life Guidelines and Strategies, Measuring Sustainability, Sustainable Design through sustainable procurement criteria, Case studies on sustainable Engineering Design Process – Sustainable Process Design, Sustainable Production Design Sustainable product design in Electronic Engineering.
8 Hours

Textbooks		
1	Toolseram Ramjeawon	Introduction to Sustainability for Engineers, CRC Press, 1^{st} Edn., 2020, ISBN: 978-0367254452

2	David Allen,David Shonnard	Sustainability Engineering: Concepts, Design and Case studies, Prentice Hall, 1st Edn., 2015, ISBN: 978-0132756549

Reference Books		
1	Ni bin Chang	System Analysis for sustainable Engineering: Theory and applications, Mc Graw Hill Publications, 1st Edn., 2010, ISBN: 978-0071630054
2	Rag. R.L. and Ramesh Lakshmi Dinachandran	Introduction to Sustainable Engineering, PHI Learning Pvt. Ltd., 2nd Edn, 2016 ISBN: 978-8120352636

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Identify key themes and principles in sustainability development
CO2	Analyse Green Economy and Low Carbon Economy
CO3	Apply the Principle, and methodology of Life Cycle Assessment Tool to engineering systems.
CO4	Examine the interaction between agriculture, food, natural resources and communities using a systems approach.
CO5	Design for Life Guidelines and Strategies.

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

PROCESS OPTIMIZATION

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S7CHPE32	Semester	7

Course objectives: This course will enable students to:	
1.	Identify the different types of optimization problems encountered in chemical engineering
2.	Determine the minima and maxima of single and multivariable objective functions
3.	Solve optimization problems using Lagrange and Karush-Kuhn and Tucker method
4.	Evaluate the optimum points by numerical methods
5.	Explain linear programming

UNIT I
Introduction to Optimization – Definition, Benefits, Scope for optimization, Statement of an optimization problem, Classification of optimization problems, applications of optimization in engineering. (Review of linear algebra) **Optimization Problem Formulation** – Process models for optimization, classification of process models, degree of freedom analysis, and Optimization problem formulation
8 Hours

UNIT II
Single and multivariable Optimization: Continuity of functions, Unimodal and multimodal functions, and multivariate functions. (Review of Matrix, Gradient Vector, and Hessian Matrix). Convex and concave functions, Monotonic functions, Global and local minimum (or maximum), Saddle point – Necessary and sufficient conditions
8 Hours

UNIT III
Unconstrained and constrained problems: Optimality criteria for unconstrained single variable functions, Optimality criteria for unconstrained multivariable functions, Equality constrained problems – Variable elimination method and method of Lagrange Multipliers. Inequality constrained problems – method of Lagrange Multipliers and Karush-Kuhn-Tucker (KKT) conditions
8 Hours

UNIT IV
Numerical methods of Optimization: Numerical precision, Scaling, Error and Convergence criteria, Direct Search method [Bracketing methods (Exhaustive search method and Bounding phase method) and Region elimination methods (Dichotomous search method, Interval Halving method, Fibonacci search method, Golden Section search method)], Methods requiring derivatives (Gradient based methods): Newton-Raphson, Bisection & Secant method
8 Hours

UNIT V
Linear Programming Problem (LPP) – Introduction, applications, Formulation of linear programming models, Graphical solution of LPP, Linear programs in standard form. Solving system of linear equations. The Simplex Method – Simplex method, Use of artificial variables, Two phase method
8 Hours

Text Books		
1	T. F. Edgar, D. M. Himmelblau and L. S. Lasdon	Optimization of Chemical Processes, 2nd Edition, McGraw Hill, 2001. ISBN: 9780070393592

2	A. Ravindran, K. M. Ragsdell, G. V. Reklaitis	Engineering Optimization: Methods and Applications, 2nd Edition, Wiley India, 2006. ISBN: 9780471558149

Reference Books		
1	A. Ravindran, K. M. Ragsdell, G. V. Reklaitis	Engineering Optimization: Theory and Practice, 4th Edition, John Wiley & Sons, Inc, 2009. ISBN: 9780470183526
2	S. S. Rao	Engineering Optimization – A modern approach, Universities Press, 2011. ISBN: 9788173717390

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply concepts of optimization for problem formulation.
CO2	Predict the convexity or Concavity of objective functions
CO3	Evaluate the optimum of constrained and unconstrained functions using variable elimination method, Lagrange and Karush-Kuhn and Tucker method
CO4	Apply bracketing and region elimination methods to determine optimum conditions for a process
CO5	Analyze Simplex method to chemical engineering problems

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	1	3					2					2		2	
CO2	1	3					2					2		2	
CO3	1	2					2					2		2	
CO4	1	2					2					2		2	
CO5	1	3					2					2		2	

CHEMICAL PROCESS INTEGRATION

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S7CHPE33	Semester	7

UNIT I
Introduction to Process Integration: Categories of Process Integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh material utilities, mass integration strategies for attaining targets.
8 Hours

UNIT II
Direct-Recycle Strategies: Source-Sink mapping diagram, lever-Arm rules, Selection of

Sources, Sinks and recycle routes, direct recycle targets through material recycle pinch diagram, Design rules from the material recycle Pinch diagram. Algebraic approach to targeting direct recycle.
8 Hours

UNIT III
Synthesis of Mass Exchange Networks (MENs): Design of Individual mass exchangers cost Optimization of mass exchangers; Mass exchange Pinch Diagram, Algebraic approach to the targeting of Mass exchange networks – Composition Interval Diagram (CID), Cascade diagram.
8 Hours

UNIT IV
Synthesis of Heat Exchange Networks (HENs): Thermal Pinch Diagram, minimum utility targeting through an algebraic procedure – Temperature Interval Diagram (TID), Cascade diagram. Screening of multiple utilities using the Grand Composite Representation – Grand Composite Curve (GCC).
8 Hours

UNIT V		
Combined Heat and Power Integration: Heat Engines, Heat Pumps, Heat engines and Thermal Pinch Diagram, Heat pumps and Thermal Pinch Diagram, Cogeneration targeting, Extractable power cogeneration targeting Pinch diagram.		
8 Hours		
TextBooks		
1	Mahmoud M. & El-Hawlgi	Process Integration, Elsevier, 2006, ISBN: 9780128098233.
2	Robin Smith	Chemical Process Design and Integration, Wiley, 2005, ISBN: 9781119990130.

Reference Books		
1	Kemp I. C.	Pinch Analysis and Process Integration – A user guide on process integration for efficient use of energy, Butterworth-Heinemann, 2e, 2006, ISBN: 9780750682602.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Synthesize and analyze processing facilities, impact on environmental contexts and need for sustainable development.
CO2	Manipulate, synthesize and analyze open-ended problems involving multiple units and streams in engineering problems like Heat Exchanger networks.
CO3	Synthesize and evaluate targeting techniques that determines process potential, attractive opportunities, root causes of complex problems, and performance benchmarks ahead of detailed design and without commitment to the specific

	selection of units or technologies.
CO4	Optimize methodical tools and techniques while enhancing creativity and incorporating relevant data and expertise as an individual, and as a member or leader in diverse teams.
CO5	Apply techniques and communicate effectively that describes numerous industrial complex activities and applications with impressive track record and results.

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	3	2	2									2			
	CO2	3	2	2									1			
	CO3	3	2	2									2			
	CO4	3	2	2									2			
	CO5	3	2	2									2			

BIOCHEMICAL ENGINEERING

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S7CHPE34	Semester	7

Course Objectives:	
1	Disseminate knowledge of microbiology, biochemistry, and chemical engineering concepts for industrial biotechnology applications.
2	Introduce the concepts of enzyme kinetics and cell growth kinetics in the context of bioprocessing.
3	Describe the various downstream bioprocessing methods and be able to choose the appropriate product recovery techniques.
4	Educate students about the latest and emerging bioprocess technologies relative to healthcare, agriculture, food, and energy.

UNIT I
Introduction to Biochemical Engineering and Microbiology- Role of chemical engineering in Bioprocessing. **Microbiology:** Introduction to Prokaryotic and Eukaryotic cells, cellular machinery, nutritional requirements, microbial taxonomy. Industrially important organisms - Bacteria, Yeasts, Molds, Algae and Protozoa.
7 Hours

UNIT II
Biochemistry: Chemicals of life – Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids (RNA, DNA) and their derivatives.
7 Hours

UNIT III
Enzyme Catalyzed Reactions: Enzyme nomenclature, mechanism and kinetics using various models, evaluation of kinetic parameters, factors affecting enzyme activity: Effect of inhibitors, temperature, pH etc. Determination of kinetic parameters for various types of inhibitions. Batch and continuous enzyme reactor kinetics. Multi-substrate enzyme kinetics. Enzyme immobilization: Types, reaction kinetics and applications.
9 Hours

UNIT IV
Microbial Biomass and Product Formation: Cellular metabolism, quantification of cell concentration, growth cycle, cell growth kinetics in batch cultures, product formation, death kinetics, effect of pH, dissolved oxygen and temperature. Monod cell growth kinetics, substrate inhibition, kinetic models with growth inhibitors. Cell growth in continuous reactors - Chemostat for measurement of cell growth & product formation kinetics.
8 Hours

UNIT V
Fermentation Technology: Ideal fermenters, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations, design of sterilization Equipment, introduction to Single-use technology for upstream Bioprocessing. **Downstream Processing**: Steps involved in product recovery operations, typical operations involved – filtration, centrifugation, sedimentation, chromatography and emerging technologies including single-use systems, tangential-flow filtration, membrane chromatography.
9 Hours

Text Books		
1	Shuler, M.L., Kargi, F., and DeLisa M.P.	Bioprocess Engineering-Basic Concepts, Prentice-Hall Inc., Upper Saddle River, NJ, 3e, 2017, ISBN: 978-0-13-706270-6

Reference Books		
1	Wei-Shou Hu	Engineering Principles in Biotechnology, John Wiley & Sons, Inc., Hoboken, NJ, USA,1e, 2018, ISBN: 978-1-11-915904-9
2	Rao, D.G	Introduction to Biochemical Engineering, Tata McGraw-Hill Education Pvt Ltd, New Delhi., 2e, 2010, ISBN: 0-07-015138-5
3	Eibl R., Eibl D.	Single-Use Technology in Biopharmaceutical Manufacture, John Wiley & Sons, Inc., Hoboken, NJ, USA, 2e, 2019, ISBN: 9781119477839

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Formulate appropriate criteria for selecting bioprocess technologies. by applying the knowledge of biology, biochemistry, and chemical engineering and communicate the solutions
CO2	Identify and communicate appropriate criteria for selecting bioprocess technologies by applying the knowledge of biochemistry
CO3	Apply the concepts of enzyme kinetics to analyze and derive rate equations and solve problems related to enzyme-based bioprocesses
CO4	Solve problems related to fermentation and sterilization by applying the concepts of microbial cell growth kinetics and using rate equations
CO5	Perform basic design of upstream and downstream bioprocess equipment by applying biochemical engineering concepts and communicate the solutions

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	3	2										3			
	CO2	3	2			2							3			
	CO3	3	2	2		2							2	2	2	2
	CO4	3	2	2	2	2	2	2		2	3	2	2	2		

OPEN ELECTIVE COURSE – II

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39+0+0	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	OE7X	Semester	7

MAJOR PROJECT PHASE II

Contact Hours/ Week	0+0+24 (L+T+P)	Credits	6.0
Total Lecture Hours	0	CIE Marks	100
Total Practical Hours	312	SEE Marks	100
Sub. Code	S7CHMP	Semester	7

Course Objectives	
1	Train the students to identify societal and industrial unmet needs needing chemical engineering solutions.
2	Introduce research methods including design of experiments and data analysis to provide valid conclusions after conducting investigations.
3	Guide students to develop process engineering solutions or design process equipment to the selected problem/unmet need.
4	Acquaint students to societal, health, safety, finance and legal issues in addition to responsibility to the professional engineering practice.
5	Teach modern engineering tools including process modelling, simulation and optimization to solve the selected problem.

6	Exemplify ethical behavior in the context of conduction of experiments, data analysis and reporting.
7	Train to function effectively as an individual, and as a member or leader in a team, and in multidisciplinary settings to solve problems within the area of expertise.
8	Give directions to students to evaluate and critically assess results and be able to document and present one's own work.
9	Illustrate the need for life-long learning including innovation and entrepreneurship.

Course Outline:
Students must identify an industrially or societally relevant problem and solve using chemical engineering principles and economics. This must be done in consultation with faculty of the department or a practicing chemical engineer from the industry. The students are advised to take up projects that can be performed using the facilities and infrastructure of the department and the institute. However, students are encouraged to think "out of the box" and take up challenging projects. If the projects are innovative and potentially has high impact, then the department would consider approving on a case by case basis. The department also encourages students to take up projects towards developing a "technology" or a "product". SIT's technology incubation centre will facilitate any subsequent commercialization. The major project can be performed by a team of 3 to 4 students. One or more faculty of the department can advise the project and can be performed within the department or in an Industry or a Research Institute. A co-guide from the Industry or Research Institute is also allowed.

The major project is evaluated over two semesters (VI and VII). It carries 2 credits in the VI semester and is evaluated for 100 marks (100% CIE only). In the VII semester, it carries 6 credits and evaluated for 100 marks [50% CIE & 50% SEE].

The project can be taken by group of 4 students and major project can be carried out in the dept. under a guide or outside the department in institute/ company with a guide from the dept. and co guide from the institute/ company.

Break-up of CIE marks for Major Project Work

Project presentation (seminar) highlighting literature review, problem statement, hypothesis, objectives and feasibility of the project (Phase 1)	10 marks
Project report (hard copy of the presentation slides)	20 marks
Assessment of the project by the guide and co-guide (if any)	25 marks
Project presentation (seminar) highlighting objectives and progress of the project (Phase 2)	30 marks
Viva Voce – by Internal Examiners	15 marks
TOTAL	**100 marks**

Break-up of SEE marks for Major Project Work

Project Report	25 marks
Presentation and Demonstration	30 marks
Quality of Work	25 marks
Viva-voce (Q&A Session)	20 marks
TOTAL	**100 marks**

Summary of Evaluation pattern - Major Project Work

Components	Conducted for	Marks reduced to	Min. pass marks (40%)
CIE	100 marks	50 marks	20 marks
SEE	100 marks	50 marks	18 marks
TOTAL		**100 marks**	**40 marks**

Reference Books:

1	Lazic, Z.R	Design of Experiments in Chemical Engineering; A Practical Guide, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2004, ISBN: 3-527-31142-4
2	Piemonte, V., De Falco, M., Basile, A	Sustainable Development in Chemical Engineering: Innovative Technologies, Wiley, West Sussex, United Kingdom, 2013, ISBN: 978-1-119-95352-4
3	Kakava, N.	Technopreneurship: Conceptualized, Lap Lambert Academic Publishing GmbH KG, Germany, 2012, ISBN: 978-3-659-24027-0
4	Leong, E.C., Heah, C.L-H., Ong, K.K.W.	Guide to Research Projects for Engineering Students: Planning, Writing and Presenting. CRC Press, 2015, ISBN: 9781482238778

Course Outcomes: On completion of the course, the student will be able to	
1	Identify a problem from literature review and knowledge of chemical engineering technology.
2	Consolidate the literature review to identify issues/gaps and formulate the hypotheses.
3	Formulate objectives and prepare project schedule for the identified design methodology and budget analysis.
4	Conduct investigations and analyze, interpret and draw valid conclusions from experimental results.
5	Apply modern engineering tools like process modelling, simulation and optimization to the problem with an understanding of the constraints.
6	Apply basic concepts of science, engineering, design and economics to develop sustainable process engineering solutions or design process equipment.
7	Consider societal, health, safety, legal and cultural issues and concern for the environment while implementing the process solutions.
8	Display professional ethics in the conduction of experiments, data analysis and reporting.

9	Demonstrate effective written communication in the form of project report or research publication.
10	Engage in effective oral communication through power point presentation and project demonstration.
11	Function effectively as an individual or as a member or leader in a team, and in multidisciplinary settings to solve the given problem.

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1		3											3		
	CO2			3							2			3		
	CO3			3	3									3		
	CO4					3						3			3	
	CO5	3		2									3			3
	CO6						3							3		
	CO7							3						3		
	CO8									3		2		3		
	CO9									3		2		3		
	CO10								3					3		
	CO11		3											3		

AICTE ACTIVITY POINTS

Contact Hours/ Week	0+0+0 (L+T+P)	Credits	0
Total Lecture Hours	0+0+0	CIE Marks	50
Total Practical Hours	40	SEE Marks	50
Sub. Code	AAP	Semester	7

VIII Semester

PROFESSIONAL ELECTIVE COURSE - IV (ONLINE)

CHEMICAL PROCESS INSTRUMENTATION

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	00	SEE Marks	50
Sub. Code	S8CHPE1	Semester	8

Contents:

- General Principles and Representation of Instruments
- Performance Characteristics of Instruments and Data Analysis
- Transducer Elements
- Pressure Measurement: Moderate and High Pressure Measuring Instruments
- Measurement of High Vacuum, Pressure, Temperature, Flow, Level, Composition.
- Pneumatic control valve

40 Hours

POLYMERS: CONCEPTS, PROPERTIES, USES AND SUSTAINABILITY

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	00	SEE Marks	50
Sub. Code	S8CHPE2	Semester	8

Contents:

- Why are polymers so common?
- Renewable sources for polymers: Polymerization / depolymerisation, States of interest, Reuse and repurpose, Molecular conformations, Size, mobility and flexibility, Polyelectrolytes
- Structures in biopolymers: Amorphous / crystalline states, Orientation, Interactions, Kinetics of crystallization, Glass transition
- States in environment: Liquid crystalline polymers, Copolymers, Blends
- Microstructure in polymers: Composites, Stress strain response, Additives for polymeric systems, Blends / composites in recycling, Physical / chemical crosslinking, Mechanical properties
- Physical and chemical aging: Solutions: properties, Conducting polymers, Dielectric response, Plasticity, Properties of composites
- Viscoelasticity: Introduction, Thermal response, characterization, Viscoelasticity - simple models, Dynamic Mechanical analysis, Damping Applications, Time Temperature superposition, Impact and energy absorption
- Testing for applications: Properties of blends, Biomimetic polymers, Advanced mechanics,

Viscoelastic response: examples, Polymer packaging, Porous polymers / membranes, Polymer at interfaces, Diffusion in polymers • Compatibilizers: Biopolymer applications, Adhesives and Paints, Dissolution and recovery, Polymerization kinetics, Polymerization reactors, Polymer processing • Flow simulations: Processing for recycling, Recycle, up-down cycling, Flow behaviour – rheology, Crosslinking, Conversion of polymers • Rheology and entanglement: Rheological models, Rheology and processing, Absorption and leaching, Swelling of polymers, Viscosity for polymer processing • Microplastics, aerosols, sediments, biodegradation of polymers
40 Hours

BIOMASS CONVERSION AND BIOREFINERY

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	S8CHPE3	Semester	8

Contents:

- Energy and Environment scenario, Need for biomass based industries
- Biomass basics: Dedicated energy crops, Oil crops and microalgae, Enhancing biomass properties
- Biorefinery: Basic concepts and types, Feedstocks and properties, Economics and LCA
- Biomass Pre-treatment: Barriers and Types, Dilute acid, alkali, ozone, Hybrid methods
- Physical and Thermal Conversion Processes: Physical Processes, Gasification and Pyrolysis, Products and Commercial Success Stories
- Microbial Conversion Processes: Details of various processes, Types, fundamentals, equipment’s, applications, Products and Commercial Success Stories
- Biodiesel: Diesel from vegetable oils, microalgae and syngas, Transesterification; FT process, catalysts, Biodiesel purification, fuel properties
- Bio-oil and Biochar: Bio-oil and biochar production, reactors, Factors affecting bio-oil, biochar production, fuel properties characterization, Bio-oil up gradation technologies
- Bioethanol and Biobutanol: Microorganisms, current industrial ethanol production technology, Cellulase production, SSF and CBP, ABE fermentation pathway and kinetics, product recovery technologies
- Hydrogen, Methane and Methanol: Biohydrogen production, metabolics, microorganisms, Biogas technology, fermenter designs, biogas purification, Methanol production and utilization
- Organic Commodity Chemicals from Biomass: Biomass as feedstock for synthetic organic chemicals, lactic acid, polylactic acid, Succinic acid, propionic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanedioil, PHA
- Integrated Biorefinery: Concept, lignocellulosic Biorefinery, Aquaculture and algal biorefinery, waste Biorefinery, Techno-economic evaluation, Life-cycle assessment.

40 Hours

ENVIRONMENTAL QUALITY MONITORING AND ANALYSIS

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	S8CHPE4	Semester	8

Contents:

- Introduction: Chemicals of Concern, Water Quality Screening Parameter, Water Quality Parameters, Air quality parameters; Sustainability, Particulate Matter
- Physical/Chemical properties of interest, Partition Constants, Soil-air partition constants, Application/Example of Equilibrium Partitioning
- Introduction to Environmental Monitoring and Sampling: Environmental Sampling, Environmental Analysis: Quality Control, Environmental Analysis of Organics in Water, Environmental Analysis: Quality Control
- Analysis Methods - Introduction and Water Quality Parameters: Water Quality Parameters, Review of Standard Methods, Organics in water, Overall Methodology for Organics, Chromatography Fundamentals, Gas Chromatography, Mass Spectrometry, Liquid Chromatography
- Monitoring methods for Air – Vapor, Measurement of Microorganisms
- Transport of Pollutants – Introduction: Transport of Pollutants - Box Models in Water, Box Models in Air, Dispersion
- Transport of Pollutants - Gaussian Dispersion Model, Regulatory Models
- Introduction to Interphase Mass Transfer: Application to Environmental Interfaces, Flux and mass transfer resistance, Boundary Layer and Mass Transfer Coefficient, Individual and Overall Mass Transfer Coefficients, Overall Mass Transfer Coefficient
- Estimation of the Mass Transfer Coefficients: Air-Water Exchange, Evaporation from different surfaces, Sediment -Water exchange
- Application of Interphase mass transfer
- Contamination of Sediments, Release from Sediments, Unsteady state release from sediments, Other mechanisms of chemical release from sediments, Soil - Air Transfer
- Remediation of contaminated sediments - Application of transport models

40 Hours

FUNDAMENTALS OF PARTICLE AND FLUID SOLID PROCESSING

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	S8CHPE5	Semester	8

Contents:
• Solid particle characterization • Particle size distribution • Fluid - particle mechanics • Flow through packed beds • Fluidization • Sedimentation • Filtration • Centrifugal Separation • Particle size reduction • Particle size enlargement • Fluid - solid transport • Colloids and nanoparticles
40 Hours

ASPEN PLUS SIMULATION SOFTWARE: A BASIC COURSE FOR BEGINNERS

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	S8CHPE6	Semester	8

Contents:
• Significance of software with example -Simulation on pen & paper vs. simulation on Aspen Plus: Understanding Resources and My Exchange, Start using Aspen Plus, Overview of setting up of property environment • Using Model Pallete: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Hydrocarbon Treatment, Setup, Components, Property Methods, Property Methods and Property Sets with example • Analysis tools: Pure Components and Binary mixtures, Ternary mixtures, Data and Regression, Property Estimation • Practice problems on pure components, binary mixtures and case studies • Model Analysis Tools • Separation of Hydrocarbon Mixture: Synthesis of Acetaldehyde from Ethanol, BTX Separation through Distillation, Synthesis of Methanol from Syngas, Synthesis of Dimethyl Ether from Carbon Dioxide and Hydrogen, Synthesis of Ammonia in Cryogenic Process, Production of Cumene • Design, Rating and Simulation of Heat Exchanger, Absorption and Distillation, Hydrodealkylation of Toluene, Isobutene Production Plant, Nitric Oxide Production Plant, • Plant Economy and Utilities, Plant Dynamics and Control
40 Hours

CLEAN COAL TECHNOLOGY

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	S8CHPE7	Semester	8

Contents:

- Coal Quality Parameters
- Coal Cleaning Methods, Coal Combustion Fundamentals, Effects of Coal Properties on Combustion
- Industrial Coal Combustion Methods, Emission Control from Combustion Utilities
- SOx Control Strategies, NOx Emission Control, Oxy Fuel Combustion
- Carbon Dioxide Capture and Storage
- Fundamentals of Coal Gasification, Chemical Reactions in Coal Gasification
- Fuel Properties and Gasification, Scope of Coal Gasification
- Updraft and Down Draft Gasifier, Lurgi Gasifier, Fluidized Bed and other Gasifier, Syn Gas Cleaning
- Coal Gasification Downstream Plants, Coal Based Power Generation
- Combined Cycle Power Generation & IGCC, Underground Coal Gasification
- Coal Bed Methane, Clean Coal Technology : Case Studies

40 Hours

CHEMICAL PROCESS UTILITIES

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	S8CHPE8	Semester	8

Contents:

- Introduction to Chemical Process Utilities: Energy Perspective to the Utilities, Power Cycle, Fuel Analysis, Practice problems related to power cycle and fuel analysis
- Heat Transfer Utilities: Plate and Frame Heat Exchangers Types, Solar Energy, Heat Transfer Media and Solar energy
- Water: Water Chemistry, Inhibition and Water Treatment, Boiler Water treatment, Water Governance, Water Quality standards, Steam
- Boilers: Industrial Boiler Types, Steam Generation Unit, Steam Generation Unit-Heaters, Attemperator and Steam Drum
- Steam Traps, Centralization, and Fuel Selection
- Economizer, Super heaters, and Safety devices, Safety valve selection for boilers, Insulation of Steam Generators
- Air: Air Filtration and Pneumatic Conveying, Introduction to Pneumatic Conveying

System, Conveying System Types, Material Properties and Pipeline Feeding Devices, Gas-solid flows

- Design of Pipelines 'Elements of Pipeline Design, Natural Gas Transmission
- Pipeline Mechanical design-Natural Gas Transmission-IV
- Cooling Tower; Theory and Some Basic Calculations: Concept of heat transfer in cooling tower and it's components, Types and components of cooling tower, Components and Materials of Construction & Applications of Cooling Tower, Control and Maintenance in cooling towers
- Pressure Levels and Terminology: Gauges for Pressure Measurement
- Refrigerants and Refrigeration: Introduction to Refrigeration, Refrigeration System Components, Refrigeration System Components and Refrigeration Cycle, Refrigeration Systems.
- Refractories: Thermodynamic Principles & Corrosion in Refractories, Slag Attack & Kinds of Refractories in Uses, Brief history of Insulations and its fundamental principles, Heat transfer in Insulations materials.

40 Hours

OPEN ELECTIVE COURSE - III (ONLINE)

ELECTRIC VEHICLES

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39+0+0	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE81	Semester	8

Contents:

- Intro EV: Historical Background, Benefits of Using EVs, Overview of types of EVs and its Challenges, Motor Drive Technologies, Energy Source Technologies, Battery Charging Technologies, Vehicle to Grid
- Subsystems and Configurations: HEV Subsystems and Configurations, Subsystems and Modes of Operation
- Vehicle Dynamics intro and tractive effort, Vehicle Dynamics simulation dynamic equation constant FTE, Vehicle Dynamics Modelling and simulation in Simulink
- Basics of DC Motor Drive, Realization of DC Chopper, Open Loop Operation of Chopper Fed DC Motor Drive
- Review of Control Theory, Modelling and Current Controller Design for Separately Excited DC Motor Drive, Speed Controller Design and Performance Evaluation of DC Motor Drive
- Fundamentals of Three Phase Induction Motor, Equivalent Circuit and Torque-Speed Characteristics of Induction Motor, Starting and Speed Control of Induction Motor, Realisation of DC to AC Power Converter
- Impact of Non-Sinusoidal Voltage on Induction Motor
- Selective Harmonic Elimination and Optimal Pulse Width Modulation Techniques

- Switching energy losses and Sine-Triangle PWM, Analysis of Sine-Triangle PWM, Simulations study on open loop Induction motor drive, Modelling of cylindrical rotor machine, Modeling of surface mounted PMSM Drive, Sensored vector control of PMSM drive, Dynamic modelling of squirrel cage induction machine
- Controller Design for RFO Vector Controlled IM Drive, Estimation of Rotor Flux Vector and Mechanical Speed
- Case Study - Indian Railway Propulsion System, Simulation Exercise - PMSM and IM Drives, Basics of Electromagnetic Circuit, SRM and BLDC Motor Drives

40 Hours

STRATEGIES FOR SUSTAINABLE DESIGN

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE82	Semester	8

Contents:

- Strategies for Sustainable Design - Welcome Lecture, Various Perspectives around Sustainability, Spheres of Energy Efficient / Green / Environmental / Sustainable Designs
- Environmental Sustainability, Social Sustainability, Economic Sustainabilty, Climate Change Mitigation and the Way Forward, Future of Human Habitation Design
- Relevance of Sustainable Design in Contemporary Context, Built Environment and Energy Consumption, Reliance and Dependence of Building Design on Energy
- Current Scenario of Sustainable Design: Indian, International
- Designing Strategically for Preventing pollution: Air, Water, Soil, Noise, Light Radiation, etc, Low Environmental Impact, Thinking for Alternatives through Systemic Design
- Consumption and Consumerist Lifestyle, Environmental impact Assessment, Lifecycle Analysis Part , Growth and Development in Construction and Allied Sectors
- Policy Push in Real Estate and Manufacturing Sectors, Policy Push for Development of the Low Economic Regions
- Sustainable Building Materials, Reduce/Reuse/Recycle
- National Building Code 2016 - Part 11 and Energy Conservation Building Code, Guidelines for Building Design by SA Methods: GRIHA
- UN SDG for Sustainable Development, LeNS Design Method and Tools such as SPSS, MSDS, DE, Vernacular Design Case Example, Climate Responsiveness, Thinking the Unthinkable: Need for Innovation in Design Process, Design for Net-Zero Energy, Lighting, Ventilation, Views and Human Comfort, D4S with Inspiration from Nature, D4S for Optimization of Manufacturing, International Conventions, Laws and Emerging Technologies for SD, Environmental Laws, Emerging Technologies and their Possible Intervention in Design
- Case 1: Campus Planning and Design of IIT Gandhinagar
- Case 2: A Comparative Analysis of Product Designs

• Case 3: Design of First Net-Zero Building of India • A Comparative Analysis of International Design Projects
40 Hours

CLIMATE CHANGE SCIENCE

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE83	Semester	8

Contents:

- Introduction: Global Mean Temperature, Blackbody Radiation, Properties of Real Surfaces, Planetary Albedo
- Simple Energy Balance Model: Multiple-Equilibrium States, General Circulation Models, Feedbacks in the Climate System, Feedback Analysis, Cloud Feedbacks
- Radiative transfer in gases, Global warming potential, Ozone depletion, Montreal Protocol, Two-layer model, Meridional variation, Paleoclimate
- Last ice age, Atlantic meridional ocean circulation, Simulation of AMOC
- AMOC during deglaciation, Dansgaard-Oeschger events, Theory of Ice ages
- Milankovitch Theory, Stochastic resonance, Glacial to interglacial transition, Simulation of glacial to interglacial, Snowball earth, Simulation of snowball earth, snowball earth cycle, Impact of aerosols on climate
- Relative roles of CO2 and aerosols, Kyoto Protocol, climate model, Approximations in climate models
- How good is the model simulation, Model biases, The impact of model resolution, Cascade of uncertainty, Extreme events, Humid heat waves
- Extreme rainfall, Monsoons, Simulation of monsoon
- Why is Venus hot? Venus energy balance
- Denial of global warming, Wrap up

40 Hours

ENERGY RESOURCES, ECONOMICS AND ENVIRONMENT

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE84	Semester	8

Contents:

- Energy Flow Diagram
- Global Trends in Energy Use, Energy Use in India: Some Calculations, Energy and Environment

- The Kaya Identity, Emission Factor
- Energy and Quality of Life: Energy Inequality, Energy Security, Introduction to Country Energy Balance assignment
- Energy Economics, Energy resources, Materials for Energy, Utility and Social Choice, Public and Private Good/Bads
- Energy Project Financing, Input Output Analysis, Primary Energy Analysis
- Net Energy Analysis, Energy Policy, Future Energy Systems

40 Hours

LIGHTER THAN AIR SYSTEMS

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE85	Semester	8

Contents:

- Introduction to the Course Content: Differences between LTA and HTA systems, Introduction of Skyship 600 and USP of Airships, Tethered Aerostat systems
- Historical developments of LTA systems, Overview of PADD, Remote Controlled Airships, Autonomous Airships, Biomimetic Airships
- Introduction to Buoyancy, Basic Concepts of Aerostatics, Effect of Humidity & Vapour Pressure, Effect of change in Atmospheric Pressure
- Determination of Inflation Fraction, Effect of Change in Operating Altitude
- Envelope Materials, Fabric Testing Machines, Ground Handling of Airships
- Airship Design Methodology, Transportation Problems Faced by Remote Regions, Airships vs Helicopters, Chaar Dham Yatra
- History of Propulsive Systems on Airships, Aerodynamic Stability, Overview of Aerostat Design Methodology, Sizing of Reusable Indoor Hot Air Balloon, Future Energy Systems

40 Hours

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE86	Semester	8

Contents:

- Introduction, United Nations and a World in Order, Definition of Sustainability, | Aspects of Sustainability, | Transition from MDGs to SDGs, The Role of UN and the Need for SDGs and Adoption by the World, Scope and Inclusion and Agenda 2030
- Our Common Future and Philosophy behind SDGs, Causal Mapping, Systemic Mapping

and Problem Identification

- Identifying probable interventions for SD, Framework and Structuring of Seventeen SDGs, No Poverty, Zero Hunger, Good Health and Well-being
- Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Industry, Innovation and Infrastructure, Sustainable Cities and Communities, Responsible Consumption and Production
- Analyzing SDG connections, grouped into People, Ecological, and Spiritual categories, Financing the SDGs and Global Funds, Implementation Planning, Capacity Building and Finance

40 Hours

SAFETY AND RISK ANALYTICS

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE87	Semester	8

Contents:

- Introduction to Safety and Risk Management, Hazard and Risk Data
- Incident Investigation Data, Inspection and Audit Data
- Behavioral and Organizational Safety Data, Missing Data Handling
- Data Transformation, Data Reduction, Safety Data Visualization Tools
- Leading and Lagging Indicators for Measuring Safety Performance, Control Charts for Safety Performance Evaluation and Monitoring, Safety Capability Analysis, Safety Reports and Use of Text Analytics
- Bow-Tie Construction, Introduction to Predictive Safety and Risk Analytics
- Logistic Regression, Statistical Measures of Safety Program Effectiveness
- Support Vector Machine, Risk Based Decision Making, Behavioral Safety Data Collection and Preliminary Analysis

40 Hours

GROUNDWATER HYDROLOGY AND MANAGEMENT

Contact Hours/ Week:	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours:	39	CIE Marks	50
Total Tutorial Hours:	00	SEE Marks	50
Sub. Code:	OE88	Semester	8

Contents:

- Introduction to Groundwater, International importance of groundwater and India, Physics and hydrology of Groundwater
- Groundwater governing equations

• Groundwater recharge and discharge, Constructing aquifers using groundwater data, Conceptual model for groundwater • Groundwater data in India, Application of Groundwater data in India • Introduction to Groundwater modelling, Case studies in India
40 Hours

INTERNSHIP (RESEARCH / INDUSTRY) (15 WEEKS)

Contact Hours/ Week:	0+0+20 (L+T+P)	Credits	10.0
Total Lecture Hours:	0+0+15 weeks	CIE Marks	100
Total Tutorial Hours:	00	SEE Marks	100
Sub. Code:	INT	Semester	8

Internship is meant to supplement students' learning with real-world experience beyond what they can obtain in the conventional classroom. Internship is a 15 credits course offered during the 8^{th} Semester of B.E programme. For award of the degree, all the students must compulsorily undergo 15 weeks industry internship in any chosen industry or research internship in premier institutions of national importance including IISc, IITs, IIMs, CMTI, DRDO, ISRO etc.

Each student will be assigned a faculty member from the respective department as their Internship mentor. Mentors should be chosen based on their area of expertise relevant to the student's internship project. Mentors must be familiar with industry/research organization expectations, assessment criteria, and how to effectively guide and monitor students.

Course Objectives:	
1	To expose technical students to the industrial environment thereby creating competent professionals.
2	To provide possible opportunities to learn, understand and sharpen the real time technical / managerial skills required.
3	To enable students to apply the technical knowledge learnt in the classroom in real industrial situations.
4	To empower them in writing technical reports.
5	To expose students to the engineer's responsibilities and ethics.
6	To promote academic, professional and/or personal development.
7	To expose the students to future employers.
8	To make them understand the social, economic and administrative considerations that influences the working environment of industrial organizations.
9	To make them understand the psychology of the workers and their habits, attitudes and approach to problem solving.

Guidelines:

General Procedure: Student will join concerned Industry/research organization for Internship on the date as communicated in the final offer letter/Email Confirmation. If the student wishes to change the industry, he/she is permitted to do so only in the first week of internship. Student can avail one day casual leave per month. Student has to complete the internship in only one industry/research organization for 15 weeks, no split up allowed.

Regular Updates: Student shall write the synopsis for the work assigned within a week of joining. The synopsis shall be verified by the industry/research supervisor and faculty mentor. Student shall maintain internship diary. Student shall update the diary with the daily progress and share the same to their faculty mentor at the end of the day. This helps maintain consistent communication and ensures that the student is on track with their work. Regular updates also allow the mentor to provide timely feedback, guidance, and support if needed. Head of the Department shall take a note of the progress on weekly basis.

Periodic Reviews: Continuous internal evaluation (CIE) will be carried out in three phases. The percentage weightage for the three phases of evaluation shall be 30:30:40. Evaluations shall be done at the end of 5, 10, and 15 weeks after joining the internship. Students should be present in person in the institute for all reviews. Students shall submit the diary and report during every review and present the work done. The report shall comprise of the objectives, design methodology, results, and observations made during the training period. The report template shall be shared by the institute. The diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the diary. The training report shall be signed by the internship supervisor. After completing the internship, the student shall submit the internship certificate issued by the industry/research organization. Industry/research supervisor shall send the final evaluation of the intern to the HoD in a sealed cover (format provided in the internship diary). To be eligible for semester-end exam, the student shall have secured at least 40% in CIE.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Formulate the given engineering problem and review literature
CO2	Design a methodology using engineering knowledge and analytical abilities
CO3	Implement the methodology and propose a meaningful solution by using problem solving skills considering health, safety issues
CO4	Gain practical/research knowledge to existing classroom knowledge, such as new tools or skills ort and oral presentation
CO5	Effectively communicate the solution through report writing
CO6	Demonstrate time management, punctuality and life-long learning skills
CO7	Expand the professional network and explore career options
CO8	Demonstrate individual and team work, ethics required for success in a professional work environment

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	3	3										3			
	CO2	3	2	2									2	3		3
	CO3	3	3		2		3					3		3	3	3

	CO4					3						3		3		
	CO5									3				3		
	CO6										3	3		3		
	CO7										3	3		3		
	CO8							3	3					3		

Scheme of Evaluation:

Every student will be evaluated for 100 marks CIE and 100 marks SEE. Evaluation committee
includes head of the department and two faculty members (one shall be guide) from the department. Industry/research supervisor can also be part of the evaluation committee. Weightage for different components are given here.

Diary	25
Report	25
Presentation and viva-voce	50
Total Marks	**100**

AICTE ACTIVITY POINTS

Contact Hours/ Week:	0+0+0 (L+T+P)	Credits	0.0
Total Lecture Hours:	0+0+40 Hours	CIE Marks	100
Total Tutorial Hours:	00	SEE Marks	..
Sub. Code:	AAP	Semester	8