Teaching Scheme and Syllabus

For

Bachelor of Technology

In

Honors in Chemical Engineering

Department of Chemical Engineering

Sardar Vallabhbhai National Institute of Technology

Honors in Chemical Engineering

Sr. No.	Semester	Subject	Code	Scheme	Credit	Notional hours of Learning (Approx.)
1.	IV	PROCESS INTENSIFICATION	CH220	3-1-0	4	60
2.	V	OPTIMIZATION IN CHEMICAL ENGINEERING	CH221	3-1-0	4	60
3.	VI	CARBON ACCOUNTING AND SUSTAINABLE DESIGNS	CH222	3-1-0	4	60
4.	VII	COMPUTATIONAL PROCESS DESIGN	CH223	3-1-0	4	60
5.	VII	MINI PROJECT	CH224	0-0-4	2	60

Subject Code: CH220

L	T	P	C
3	1	0	4

1. Course Outcomes:

At the end of the course, the students will be able to

CO1	Identify the scope for process intensification in chemical processes and operations.
CO2	Explain the concept of process intensification and the methodologies for PI.
CO3	Explain the operating principle of intensified technologies and its implementation.
CO4	Analyse the range of potential applications of intensified equipment.
CO5	Analyse the range of potential applications of intensified operation/process.
CO6	Appraise process challenges using intensification technologies and solve case studies.

2. Syllabus

INTRODUCTION & PROCESS INTENSIFICATION TECHNIQUES	**(06 Hours)**
Historical background & Philosophy, Principles and Domains of Process Intensification (PI), Benefits of Intensified Processes, PI Toolbox – Equipments and Methods, Active and Passive Techniques.	
COMPACT HEAT EXCHANGERS	**(06 Hours)**
Heat transfer intensification, Printed circuit heat exchangers, Foam heat exchangers, Micro-heat exchangers, etc.	
HIGH GRAVITY FIELDS	**(06 Hours)**
Process fundamentals, Rotating packed bed, Design, Applications and Scale-up.	
INTENSIFIED MIXING & REACTORS	**(10 Hours)**
PI in stirred tanks, Spinning disc reactors, Structured reactors, Microchannel reactors.	
REACTIVE SEPARATIONS	**(07 Hours)**
Reactive distillation, Reactive absorption, Reactive extraction, Reactive membrane separations.	
ENHANCED FIELDS	**(05 Hours)**
Energy based intensifications, Sonochemistry, Microwaves, Electrostatic fields.	
CASE STUDIES-APPLICATION AREAS	**(05 Hours)**
Methodology and Applications, Typical case studies from industrial sectors.	
Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Bools Recommended

1	Reay D., Ramshaw C., Harvey A., "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility", 2nd Edition, Butterworth-Heinemann, 2013.
2	Boodhoo K., Harvey A., "Process Intensification Technologies for Green Chemistry", John Wiley & Sons, 2013.
3	Stankiewicz A., Moulijn J.A., "Re-Engineering the Chemical Processing Plant: Process Intensification", Marcel Dekker, 2004.
4	Keil F. J., "Modeling of Process Intensification", WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007.
5	Stankiewicz A., Gerven T. V., Stefanidis G., "The Fundamentals of Process Intensification", Wiley VCH 2019.

Subject Code: CH221

L	T	P	C
3	1	0	4

1. Course Outcomes:

At the end of the course, the students will be able to

CO1	Identify problems arising in Chemical Engineering applications and apply the basic concept of optimization
CO2	Formulate various process optimization problems.
CO3	Solve the chemical process optimization problems.
CO4	Solve the single and multivariable optimization problems for chemical processes.
CO5	Relate the significance of numerical methods in linear and nonlinear programming.
CO6	Infer the applications of optimization methods in chemical engineering.

2. Syllabus

INTRODUCTION TO OPTIMIZATION	**(04 Hours)**
Statement of optimization problems, Classification of optimization problems, Examples from engineering applications	
OPTIMIZATION PROBLEM FORMULATION	**(04 Hours)**
Models for optimization, Optimization problems in chemical engineering	
BASIC CONCEPTS OF OPTIMIZATION	**(09 Hours)**
Continuity of functions, Unimodal and multimodal functions, Optimality criteria for unconstrained single variable functions, optimality criteria for unconstrained multivariable functions, Equality constrained problems, Lagrange multipliers, Kuhn Tucker conditions	
OPTIMIZATION OF UNCONSTRAINED SINGLE VARIABLE	**(04 Hours)**
Methods and Applications (Region elimination methods, Methods requiring derivatives: Newton-Raphson method, Bisection method, Secant method)	
OPTIMIZATION OF UNCONSTRAINED MULTIVARIABLE	**(08 Hours)**
Direct Search Methods (Simplex method, Hooke-Jeeves pattern search method, Powell's conjugate direction method), Gradient Based Methods (Cauchy's method, Newton's method, Marquardt method)	
LINEAR PROGRAMMING	**(09 Hours)**
Formulation of linear programming models, Graphical solution, Linear programs in standard form, Simplex method, Use of artificial variables, two phase method	
CONSTRAINED NONLINEAR PROGRAMMING	**(04 Hours)**
Penalty function method, Lagrange multiplier method	

SOFTWARE TOOLS FOR OPTIMIZATION	**(03 Hours)**
The utilisation of software tools for Optimization Problems.	
Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Bools Recommended

1	T. F. Edger, D. M. Himmelblau, "Optimization of Chemical Process", McGraw-Hill, New York, 2001.
2	A. Ravindran, Ken M. Ragsdell, Gintaras V. Reklaitis, "Engineering Optimization: Methods and Applications", 2nd Eds", Wiley, India, 2006.
3	S. S. Rao, "Engineering Optimization", New Age International, New Delhi, 2009.
4	N. W. Loney, "Applied Mathematical Methods for Chemical Engineers", CRS Press, Boca Raton, FL, 2015.
5	K. Deb, "Optimization for Engineering Design: Algorithms and Examples," Prentice-Hall of India, Delhi, 2012.

Subject Code: CH222

L	T	P	C
3	1	0	4

1. Course Outcomes:

At the end of the course, the students will be able to

CO1	Describe the concept of productivity, sustainability and carbon footprint.
CO2	Analyze the Green manufacturing processes.
CO3	Constructing the concept of product lifecycle management.
CO4	Evaluate and apply the PLM integration with the carbon accounting.
CO5	Employ the concept of carbon accounting, modeling, business data and different database terminologies.
CO6	Assessing carbon accounting user interface.

2. Syllabus

PRODUCTIVITY AND SUSTAINABIITY	**(04 Hours)**
Productivity and Sustainability, Measuring Productivity, Measures Affecting Productivity, Environmental Management System	
INTRODUCTION TO CARBON FOOTPRINT SYSTEMS	**(04 Hours)**
Green system, Carbon footprint, Carbon credit trading, Industrial ecology and carbon footprint examples of carbon footprint calculations	
CARBON FOOTPRINT AND GREEN MANUFACTURING	**(04 Hours)**
Examples of carbon footprint calculations, Some more green thoughts and footprints, Green manufacturing, Partnership for a new generation of vehicles (PNGV)	
ROAD TO PRODUCT LIFECYCLE MANAGEMENT	**(04 Hours)**
Smart design and engineering, Road to product lifecycle management	
SUSTAINABILITY AND GREEN SUPPLY CHAIN	**(04 Hours)**
Sustainability and green supply chain, energy transformations, PLM components and levels	
PLM INTEGRATION WITH THE CARBON ACCOUNTING	**(05 Hours)**
PLM integration, Facility carbon accounting, Activities of emission	
CARBON ACCOUNTING, MODELING AND BUSINESS DATA	**(8 Hours)**
Carbon and business data, Carbon accounting model	
DBMS: DESIGN AND TERMINOLOGIES	**(08 Hours)**
Database management systems, Database design, Terminologies in database design, Database schema, Database normalization	

CARBON ACCOUNTING USER INTERFACE	**(04 Hours)**
Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Books Recommended

1	Elangovan, U., "Product lifecycle management(plm): a digital journey using industrial internet of things (iiot)". CRC Press, 2020.
2	Franchetti, M.J., Apul, D., "Carbon footprint analysis: concepts, methods, implementation, and case studies.", CRC press, 2012.
3	Subramanian S. M., "The Carbon Footprint Handbook", 1st Ed., CRC press, 2016.
4	Enrico B., Kilian G., Mélanie G., "Designing Sustainable Technologies, Products and Policies", Springer, 2018.
5	Antti S., Anselmi I., "Product Lifecycle Management", 2nd Ed., Springer, 2005.

Subject Code: CH223

L	T	P	C
3	1	0	4

1. Course Outcomes:

At the end of the course, the students will be able to

CO1	Describe the concept of the process design synthesis and sustainability.
CO2	Explain concept of process flowsheet development and material balance.
CO3	Solve problem based on equipment sizing.
CO4	Analyze and apply the economic evaluation to the process flowsheet.
CO5	Employ the concept of simulation and optimization for the process.
CO6	Solve the complex problem encountered in heat and power integration and sustainable process.

2. Syllabus

INTRODUCTION TO PROCESS DESIGN AND SUSTAINABILITY	**(03 Hours)**
Preliminary design steps, Scenario for chemical process design, Sustainability, Sustainable design through process integration	
FLOWSHEET SYNTHESIS, MASS AND ENERGY BALANCE	**(06 Hours)**
Steps in process design synthesis, Basic steps in flowsheet synthesis, Decomposition strategies for process synthesis, Mass and energy balance of complete flowsheet	
EQUIPMENT SIZING AND ECONOMIC EVALUATION	**(06 Hours)**
Equipment sizing for vessels, Heat transfer equipment, Reactors, Distillation and absorption columns, Compressors, Pumps, Refrigeration, and Cost estimation with case study	
OVERVIEW OF PROCESS ECONOMICS	**(10 Hours)**
Cost types and estimation, Depreciation, Break-even analysis, Time value of money, Profitability analysis, Case studies and problems	
SIMULATION AND OPTIMIZATION FOR PROCESS FLOWSHEET	**(05 Hours)**
Process simulation modes, methods for solving non-linear equations, Recycle partitioning and tearing, Process optimization with modular simulators, Equation-oriented process optimization, Examples	
HEAT AND POWER INTEGRATION	**(10 Hours)**
Heat exchanger network synthesis, Pinch analysis, Integration of combined heat and power systems, Heat engine, Heat pumps, Steam turbine and power plants, Case study and examples	
SUSTAINABLE PROCESS DESIGN	**(05 Hours)**
Quantifying sustainability for design, Process network analysis and footprint assessment, Energy, exergy and energy, Overall strategy for chemical process design and integration	
Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Books Recommended

1	Lorenz T. B., Ignacio E. G., Arthur W. W., “Systematic Methods of Chemical Process Design”, 1st Ed, Prentice Hall, NJ, 1997.
2	Robin S., “Chemical Process Design and Integration”, 2nd Ed., John Wiley & Sons, England, 2005.
3	Mahmoud M. E., “Sustainable Design Through Process Integration”, Butterworth Heinemann, 2011.
4	Bhatt B.I., Vora S.M., "Stoichiometry”, 4th Ed., Tata-McGraw-Hill, New Delhi, 2004.
5	Bhavik R. B., “Sustainable Engineering: Principles and Practice”, Cambridge University Press, UK, 2019.