

# GUJARAT TECHNOLOGICAL UNIVERSITY

## CHEMICAL ENGINEERING (30) ADVANCED PROCESS OPTIMIZATION SUBJECT CODE: 2723010 SEMESTER: II

**Type of course:** Chemical Engineering (Major Elective-II)

**Prerequisite:** Concepts of Optimization of undergraduate level.

### Rationale:

Process Optimization is intended to teach students how to use optimization algorithms to improve the design and operation of chemical processes. This course emphasizes problem formulation; i.e., how one develops mathematical statements for the objective function (usually economic model) to be minimized or maximized and the equality and inequality constraints (the process model) and selection of optimization technique which is best suited to the problem characteristics.

### Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	ESE (V)		PA (I)			
		ESE			OEP	PA	RP			
3	2#	2	5	70	30	20	10	10	10	150

### Content:

Sr. No.	Content	Total Hrs	%Weightage
1	<b>The Nature and Organization of Optimization Problems</b> Scope and Hierarchy of Optimization, Examples of applications of Optimization, The Essential Features of Optimization Problems, General Procedure for Solving Optimization Problems, Obstacles to Optimization	4	7
2	<b>Developing Models for Optimization</b> Classification of Models, How to Build a Model, Selecting Functions to Fit Empirical Data, Factorial Experimental Designs, Degrees of Freedom, Examples of Inequality and Equality Constrains in Models ,Formulation of the Objective Function Economic Objective Functions, The Time Value of Money in Objective Functions, Measures of Profitability	7	13
3	<b>Basic Concepts of Optimization</b> Continuity of Function, NLP Problem Statement, Convexity and Its Applications, Interpretation of the Objective Function in Terms of its Quadratic Approximation, Necessary and Sufficient Conditions for an Extremum of an Unconstrained Function	8	15
4	<b>Optimization of Unconstrained Functions</b> One-Dimensional Search Numerical Methods for Optimizing a Function of One Variable, Scanning and Bracketing Procedures, Newton and Quasi-Newton Methods of Unidimensional Search, Polynomial Approximation Methods, How One-Dimensional Search is Applied in a Multidimensional Problem, Evaluation of Unidimensional Search	8	15

	Methods		
<b>5</b>	<b>Unconstrained Multivariable Optimization</b> Methods Using Function Values Only, Methods That Use First Derivatives, Newton's Method, Quasi-Newton Methods	<b>7</b>	<b>13</b>
<b>6</b>	<b>Linear Programming (LP) and Applications</b> Geometry of Linear Programs, Basic Linear Programming Definitions and Results, Simplex Algorithm, Barrier Methods, Sensitivity Analysis, Linear Mixed Integer Programs, LP Software, A Transportation Problem Using the EXCEL Solver Spreadsheet Formulation, Network Flow and Assignment Problems	<b>8</b>	<b>15</b>
<b>7</b>	<b>Introduction to Non linear Programming with Constraints and Mixed-Integer Programming</b> Examples of Optimization in Chemical Processes like optimizing recovery of waste heat, Optimal Shell and Tube Heat Exchanger Design, Optimal Design and Operation of binary Distillation Column, Optimal pipe diameter etc.	<b>6</b>	<b>11</b>
<b>8</b>	<b>Chemical reactor Design and operation</b> Optimization of a Thermal Cracker Via Linear Programming, Optimal Design of an Ammonia Reactor Solution of an Alkylation Process by Sequential Quadratic Programming, Predicting Protein Folding, Optimization of Low-Pressure Chemical Vapor Deposition, Reactor for the Deposition of Thin Films Reaction Synthesis	<b>6</b>	<b>11</b>

#### Reference Books:

1. Optimization of Chemical Processes, Edger, Himmelblau, Lasdon, McGraw-Hill International Edition.
2. Optimization: Theory and Practice, Gordon S. G. Beveridge and Rober S. Schechter, McGraw-Hill Book Company.
3. Optimization for Engineering Design, K. Deb, Prentice-Hall.
4. Optimization: Theory and Practice by MC Joshi and K M Moudgalya, Narosa Publishing. ISBN: 81-7319-424-6.
5. Numerical Optimization by J Nocedal and S J Wright, Springer Verlag. ISBN:0-387-98793-2.
6. Introduction to Linear Optimization, Dimitris Bertsimas, John N. Tsitsiklis, John Tsitsiklis, Athena Scientific Series in Optimization and Neural Computation,(Book 6) ISBN-10: 1886529191.

#### Course Outcome:

At the end of this course, the student should

- Be able to use economics to derive an objective function.
- Be able to use principles of engineering to develop equality and inequality constraints.
- Be familiar with the preferred software packages and optimization techniques to solve linear programming and nonlinear programming problems.
- Learn how to think about and use optimization as a tool in process design and operation.
- Be able to use the Excel, MATLAB, GAMS, ChemCAD, Aspen plus, etc.
- Be proficient in the applications of optimization for optimizing important industrial processes.

#### LIST OF PRACTICALS AND OPEN ENDED PROJECTS :

Minimum 5 practical's to be performed and remaining Open-ended Projects / Study Reports / Latest outcomes in technology study :-

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Projects / Study Reports / Latest outcomes in technology. Literature survey including patents and research.
  - Design based small project **or**
  - Study report based on latest scientific development **or**
  - Technology study report/ modeling/ simulation/collection report **or**
  - Computer based simulation/ web based application/ analysis presentations of applied science field which may help them in their branches especially in their UDP/IDP projects.
2. These can be done in a group containing maximum three students in each.
3. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.
4. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to study the design module of given task.
5. In the semester student should perform **minimum 5 set of experiments** and complete **one small open ended project** based on engineering applications. This project along with any performed experiment should be **EVALUATED BY EXTERNAL EXAMINER.**

**List of Open Source Software/learning website:**

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.

**Review Presentation (RP):** The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website