GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: CHEMICAL REACTION ENGINEERING
(COURSE CODE: 3360503)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Chemical reactor design uses information, knowledge, and experience from a variety of areas like thermodynamics, chemical kinetics, fluid mechanics, heat transfer, mass transfer, and economics. Chemical reaction engineering is the synthesis of all these factors with the aim of properly designing a chemical reactor. The basic concepts of chemical reaction engineering are applied to the design and operation of various commercial reactors performing non catalytic and catalytic reactions. This course enables the diploma engineer to some extent in accomplish the task of selecting, sizing and determining the optimal operating conditions for the reactor.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate and maintain various chemical reactors to produce products of desired quality with minimum cost.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following outcomes:

i. Explain basic concepts to distinguish chemical reactions.
ii. Calculate rate, rate constant, activation energy and order of reaction.
iii. Interpret kinetic data to find order of reactions.
iv. Operate different reactors efficiently using basic knowledge about their functioning
v. Calculate volume, space time and space velocity for Ideal reactors.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	100
3	2	0	5	70	30	00	00	

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Basics of Chemical Reactions	1a. Differentiate between various types of reactions such as chemical reactions Catalytic vs. Non-catalytic and the like 1b. Describe the factors affecting rate of reaction	1.1 Scope and importance of chemical reaction engineering 1.2 Classification of chemical reactions, a. Homogeneous vs. Heterogeneous, b. Catalytic vs. Non-catalytic c. Reversible vs. Irreversible d. By Molecularity e. Exothermic vs. Endothermic f. By order of reaction 1.3 Reaction rate on various basis and variables affecting the rate of reaction.
Unit – II Kinetics of Homogeneous Reactions	2a. Derive the rate law 2b. Calculate rate constant 2c. Estimate Molecularity and order of reaction	2.1 Rate equation/ Rate law 2.2 Concentration dependent term of rate Equation, Rate constant, Elementary and non-elementary reactions 2.3 Molecularity and order of reaction
	2d. Explain temperature dependency from Arrhenius law	2.4 Temperature dependent term of rate Equation, Temperature dependency from Arrhenius law
	2e. Describe the significance of activation energy 2f. Calculate activation energy	2.5 Activation energy
Unit – III Interpretation of batch reactor data	3a. Describe the methods for analysis of kinetic data 3b. Explain the relationships for constant volume batch reaction system	3.1 Methods for analysis of kinetic data Differential vs. Integral method Half life method
		3.2 Relationship for constant volume batch reaction system 3.3 Total pressure of the system and the partial pressure of reacting material Concentration and Conversion
	3c. Derive integrated rate equations	3.4 Integrated rate equation for different order of irreversible reactions: Uni-molecular first order, Bi-molecular, Second order, Tri-molecular third order, nth order, Zero order
Unit – IV Ideal reactors	4a. Describe an ideal reactors 4b. Describe the construction, benefits, limitations and applications of different types of reactors such as batch reactors and others.	4.1 Features of ideal reactors 4.2 Different types of reactors: Batch reactor, Semi batch reactor, Flow reactors, MFR/CSTR, PFR (Tubular), Fixed bed reactors, Fluidised bed reactors

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
	4c. Describe the construction, benefits, limitations and applications of different types of multiphase reactors such as slurry reactor and others	4.3 Multi phase reactors: G-L-S reactor, Slurry reactor, Bubble column reactor, Spray reactor, Trickle bed reactor
Unit – V Design of single Ideal reactor	5a. Explain the performance equation of different types of reactors such as Ideal batch reactor and others	5.1 Performance equation of : Single Ideal reactor for Single reaction Constant density system, Ideal batch reactor, Steady state mixed flow reactor, Steady state plug flow reactor
	5b. Explain space time and space velocity 5c. Differentiate holding time and Space time 5d. Calculate time/volume of reactor.	5.2 Flow reactors: Space time, Space velocity, Holding time Vs. Space time

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Chemical Reactions	6	3	4	3	10
II	Kinetics of Homogeneous reactions	8	4	6	4	14
III	Interpretation of batch reactor data	8	4	6	4	14
IV	Ideal reactors	10	6	6	4	16
V	Design of single Ideal rector	10	4	5	7	16
Total		**42**	**21**	**27**	**22**	**70**

Legends: R = Remember**, U =** Understand**, A=** Apply and above Level (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED TUTORIALS

In tutorials numerical or conceptual problems may be given to individual or group of students. Students should be first allowed to struggle on their own to find the solution, and should try their creativity. However, faculty should remain around the students and help them if they are not able to proceed.

It is better if real life problems are case studies are given where different groups of students may come with different solutions, which can be discussed in a larger group of student to

generate more discussions. Following is the suggestive list of exercises; concerned faculty may change/add exercises to this list.

S. No.	Unit No.	Tutorial Exercises	Approx. Hours Required
1	I	Classify chemical reactions and express rate on various basis	2
2	I	Solve the given problems based on rate equation	2
3	II	Solve given problems based on molecularity and order of reaction	2
4	II	Discuss temperature dependency of rate from Arrhenius' Law and solve given problems based on Arrhenius law	4
5	III	Explain various methods of kinetic data analysis	2
6	III	Derive integrated rate equation for different order of reaction	4
7	IV	Explain different Ideal reactors with sketch	2
8	IV	Explain different multiphase reactors with sketch	2
9	V	Derive performance equation of Ideal batch, mixed flow and plug flow reactor	2
10	V	Solve given problems based on performance equation of Ideal batch reactor	2
11	V	Solve given problems based on performance equation of Ideal mixed flow reactor	2
12	V	Solve given problems based on performance equation of Ideal Plug flow reactor	2
		Total	**28**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed chemical production companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Refer books by different authors and solve as many numerical problems (related to above content) as possible. This will improve your understanding of effect of different parameters on functioning of reactors.

9. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

i. Use online course material from reputed universities
ii. Arrange expert lectures
iii. Give as many types of numerical problems to students as many possible and explain one example of each type of problem in detail.

10 SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Books	Author	Publication
1	Chemical Reaction Engineering	Octave Levenspiel	Third Edition, John Wiley and Sons
2	Essentials of Chemical Reaction Engineering	H. Scott Fogler	Fourth Edition, Prentice Hall International
3	The Engineering of Chemical Reactions	Lanny D. Schmidt	Second Edition, Oxford University Press

B) Major Equipment/Materials with Broad Specifications

--Nil--

C) Software/Learning Websites

i. http://nptel.ac.in/courses/103108097/
ii. http://www.umich.edu/~elements/toc/frames.htm
iii. http://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biological-reaction-engineering-spring-2007/lecture-notes/

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Kartik R. Desai**, Head, Chemical Engg. Dept., N. G. Patel Polytechnic, Isroli-Afwa
- **Prof. Mukesh B. Dhangar**, Lecturer, Chemical Engg. Dept., N. G. Patel Polytechnic, Isroli-Afwa
- **Prof. Shilpaben Patel**, Lecturer, Chemical Engg. Dept., Govt. Polytechnic, Gandhinagar

Coordinators andFaculty Members from NITTTR Bhopal

- **Dr. Bashirulla Shaik**, Assistant Professor, Department of Applied Sciences
- **Dr. Joshua Earnest**, Professor of Electrical & Electronics Engineering.