GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: ENVIRONMENTAL SCIENCE & TECHNOLOGY

SUBJECT NAME: ENVIRONMENTAL REACTION ENGINEERING

SUBJECT CODE: 2173514
B.E. Semester: VII

Type of course: Environmental Science & Technology

Prerequisite: Basic knowledge of material and energy balances in chemical engineering applications, laws of thermodynamics

Rationale: This subject introduces concepts of reaction rate, derivation of rate expressions from reaction mechanism, ideal reactor types, principles of chemical reactor analysis and design, experimental determination of rate equations, design of batch and continuous reactors, how to choose the most appropriate reactor for a given feed, catalyst, catalyst deactivation, external diffusion effects on heterogeneous reaction, diffusion and reaction in spherical catalyst pellets ,multiphase reactors etc

Teaching Scheme			Credits	Examination marks						Total Marks
L	T	P	C	Theory marks			Practical marks			
				ESE (E)	PA(M)		ESE(V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No	Content	Total Hr	% weight
1	**Mole Balances, conversion and reactor sizing** : Rate of reaction , the general mole balance equation, batch reactor, batch reactor design equations, continuous flow reactors , design equation for continuous flow reactor, reactors in series, combinations of CSTRs and PFR in series	7	16
2	**Rate laws and stoichiometry** : Rate laws, the reaction order and the rate law, the reaction constant, stoichiometry in batch system and flow system, Design of CSTR, tubular reactors, mole balances written in terms of concentration and molar flow rate around CSTRs & PFRs	7	16

3	**Multiple reactions**: Parallel reaction, maximizing the desired product in series reactions, algorithm for solution of complex reaction, multiple reactions in a PFR/PBR,CSTR etc.	6	12
4	**Catalysis and catalytic reactors**: Catalysis, steps in a catalytic reactions, synthesizing a rate law, mechanism and rate limiting steps, heterogeneous data analysis for reactor design, catalyst deactivation,	12	16
5	**External diffusion effects on heterogeneous reactions :** Diffusion fundamentals, Binary diffusion, external resistance to mass transfer, the shrinking core models	9	16
6	**Diffusion and reaction:** Diffusion and reaction in spherical catalyst pellets, internal effectiveness factor, overall effectiveness factors, estimation of diffusion and reaction limited regimes, mass transfer and reaction in a packed bed, determination of limiting situations from reaction data, multiphase reactors, fluidized bed reactors	9	16
7	**Distributions of residence times for chemical reactor:** RTD function, measurement of RTD, Mean residence time, other moments of RTD, RTD in Batch and plug-flow reactors, single-CSTR RTD	4	8

Suggested Specification table with Marks (Theory):

Distribution of theory marks					
R level	U level	A level	N level	E level	C level
10	25	21	7	7	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels

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.

Reference Books:

1. H. Scott Fogler, Elements of Chemical Reaction Engineering, 4 th Edition, Prentice Hall of India Pvt. Ltd

2.Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, Wiley-India Pvt. Ltd.

3. J.M. Smith, Chemical Engineering Kinetics, 2nd edition, McGraw-Hill.

4. L. D. Schmidt, the Engineering of Chemical Reactions, Oxford Press.

Course Outcome:

After learning this course the students should be able to

- Understand all the types of reactions

- Build basic knowledge of kinetics including rates and forms of rate expression and relationship between moles, concentration and conversion
- Choose the right reactor among single, multiple, recycle reactors
- Derive CSTR, PBR/PFR and batch design equations from mole balances

List of experiments

1. To determine kinetics of reaction by integral methods
2. To determine kinetics of reaction by differential methods
3. Kinetics by half life methods
4. Determination of activation energy and frequency factor
5. Study of isothermal CSTR
6. Plug flow reactor
7. Cascade CSTR in series
8. Combined flow reactor
9. Packed bed reactor
10. Continuous recycle reactor
11. RTD studies in CSTR
12. RTD studies in plug flow reactor

Open ended project

Minimum 5 practical to be performed and remaining time should be allotted to 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 Project / Study Report / Latest outcome in technology.
2. Literature survey including patents and research papers of fundamental process - 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 basic concept field which may help them in chemical engineering.
3. These can be done in a group containing maximum three students each.
4. Faculties should cultivate problem based project to enhance the basic mental and technical level of students
5. Evaluation should be done on approach of the student on his/her efforts (not on completion) to study the design module of given task
6. In the semester student should perform minimum 5 set of experiments and complete one small open ended dedicated project based on engineering applications. This project along with any performed experiment should be EVALUATED BY EXTERNAL EXAMINER.

Open Ended Project Fields:

- Non working models of batch, plug and mixed flow reactors.
- Designing reactors for exemplary reactions.
- Analyzing reactor data for higher order reactions.
- Studies related to advancements in reaction kinetics

List of open sources software

- NPTEL lecture series
- Literature available on Chemical Reaction Engineering.
- MIT Open course lecture on Chemical Reaction Engineering.

ACTIVE LEARNING ASSIGNMENTS:

- Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work –
- The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered.
- The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.