PRAVARA RURAL EDUCATION SOCIETY
PRAVARA RURAL ENGINEERING COLLEGE
LONI

CHEMICAL ENGINEERING

ACADEMIC BOOK

B.E. CHEMICAL

SEMESTER-I

Content:

Vision and Mission of the institute

Vision: Enrich the youth with skills and values to enable them to contribute in the development of society; nationally and globally.

Mission: To provide quality technical education through effective teaching-learning and research to foster the youth with skills and values to make them capable of delivering significant contribution in local to global development.

Vision and Mission of the Department

Vision: The department is committed to provide quality technical education to students in the field of Chemical engineering to meet the global expectations of industry and society.

Mission: To prepare the students to hold authority in Chemical Engineering, pursue their education through advanced study & endow to the betterment of society.

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

- **PSO1:** Apply the knowledge of basic science and basic courses of the Chemical Engineering in industry.
- **PSO 2:** Acquire the skills of design and analysis of the Chemical process or system to meet the desired needs within the practical limits.
- **PSO3:** Ability to use the innovative techniques, skills and modern engineering tools necessary to industry and society.

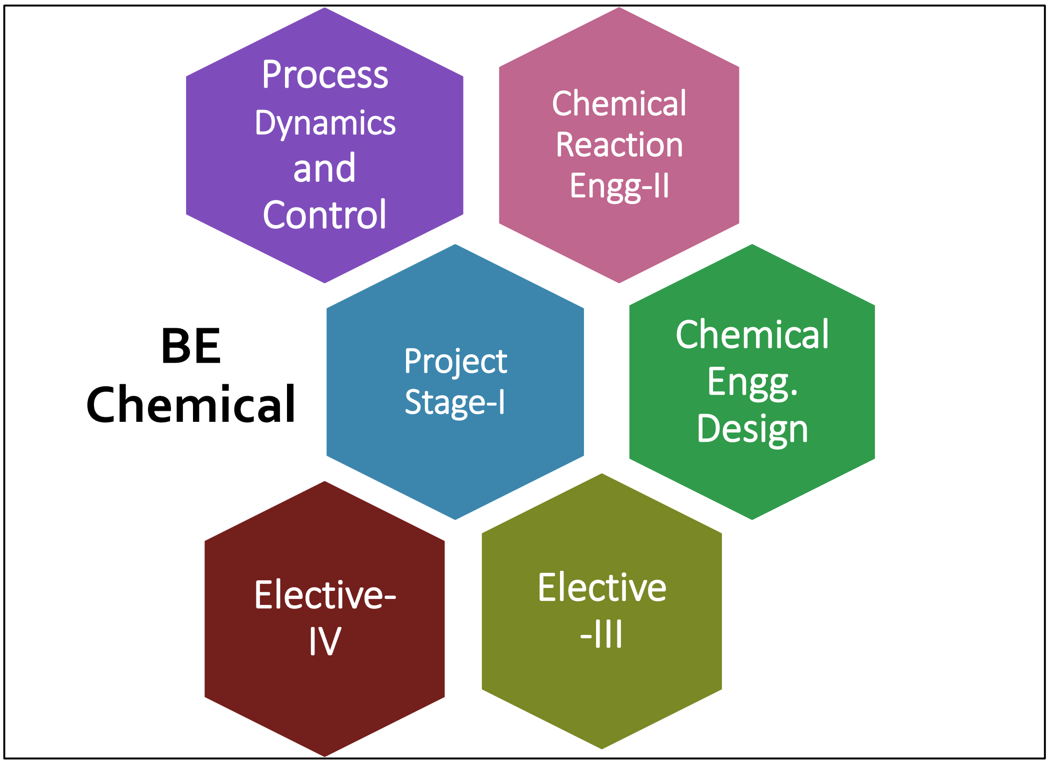
Program Educational Objectives (PEOs)

Graduates would demonstrate ability to,

- **PEO1:** To impart strong knowledge of fundamentals to the students so that they can be good practicing engineers in Chemical Engineering.
- **PEO2:** To teach basic concepts, knowledge through experimentation, scientific literature & prediction of system behavior by models & simulations.
- **PEO3:** To develop overall personality, inculcate team spirit & capability of shouldering responsibility of nation building.

Syllabus Structure

Course code	Course Title	Total number of contact hours				Total Credits
		Lecture (L)	Tutorial (T)	Practical (p)	Total	
Fourth Year						
409341	**Process Dynamics and Control**	03	-	02	05	**04**
409342	**Chemical Reaction Engineering- II**	03	-	-	03	**03**
409343	**Chemical Engineering Design**	03	-	02	05	**04**
409344	**Elective-III**	03	-	-	03	**03**
409345	**Elective-IV**	03	-	-	03	**03**
409346	**Computer Aided Chemical Engineering- II**	-	-	02	02	**01**
409347	**Project Stage I**			04	04	**02**
409348	**Audit Course 7**			-	-	**-**
	Total	**15**	**-**	**10**	**25**	**20**



Academic Calendar

Regular Activity

- HOD, Staff meeting – Twice Every Month 2nd and 4th Saturday
- Submission of monthly student Class Attendance and list of defaulter students to Dean Academic on first working day of every month
- Conduction of Test I, II and III (FE TO BE)

  Test – I - After 40 Days of Commencement of Teaching
  Test –II - After 70 Day of Commencement of Teaching
  Test – III - Before Conclusion of Semester
- Students feedback Report (FE,SE,TE and BE) submission to Principal (Twice in semester – 1st at mid semester and 2nd before the end of semester)
- Parent meets report submission by department to Principal at the mid semester.
- One week Soft skill training programme (FE,SE,TE and BE)
- Department Level Research meet of all department on 4th Saturday of every month
- Minimum one Industrial Visit per class per semester. (FE,SE,TE and BE)
- Organization of National/International level Seminar/Workshop/Conference by Departmental once in a semester.

Course: 01

Process Dynamics and Control

(409341)

B.E. Chemical (2019 Pattern)

[Theory & Practical]

Chemical Engineering Department

Course Syllabus

Process Dynamics and Control (409341)

Unit I: Dynamic behavior of simple processes **(6h)**
Objectives of Chemical Process Control, Mathematical modeling of chemical processes, State variables and state equations, Input-Output model, Linearization of nonlinear systems, Types of Forcing functions, dead-time systems, First order systems/processes – Thermometer, Liquid level tank, Liquid level tank with constant outlet (pure capacitive), isothermal and non-isothermal CSTR, Dynamic response of first order system to impulse and step inputs, basic concepts of MIMO systems.

Unit II: Design of single-loop feedback control systems **(7h)**
Second order systems/processes – Damped vibrator, Interacting and Non-interacting systems, Step response of second order system, Characteristics of under-damped system. Classical controllers – P, PI, PD, PID and ON- OFF controllers. Concept of feed-back control system, Servo & Regulatory problem, Block diagram reduction of complicated control systems, and Dynamic behavior of feed-back control processes.

Unit III: Stability Analysis of feed-back systems **(7h)**
Notion of stability, Characteristic equation, stability analysis of feedback control system using Routh-Hurwitz criteria, Root locus. Simple performance criteria – controller tuning with one-quarter decay ratio criteria, Time Integral performance criteria by ISE, IAE, ITAE, etc., selection of feed-back controller, Controller tuning using process reaction curve by Cohen-coon technique.

Unit IV: Frequency response analysis of linear processes **(7h)**
Response of first order system to sinusoidal input, Frequency response characteristics of general linear system, Bode diagrams - First order system, Second order system, Pure capacitive process, dead time system, P, PI, PD & PID, Bode stability criteria, Gain margin, Phase Margin, Nyquist Stability criteria, Ziegler Nicholes Tuning technique

Unit V: Design of complex control system **(7h)**
Design of controllers with difficult dynamics such as large time-delay systems, inverse-response systems. Analysis and design of control systems with multiple loops (cascade, selective, split range control systems) Analysis and design of advanced control systems (feed forward, ratio, adaptive and inferential control systems)

Unit VI: Digital and Computer- based Control Systems: **(6h)**
Sampling of continuous signals to discrete- time signals, reconstruction of continuous- time signals from discrete- time signals using hold elements, Digital approximation of classical controllers, Role of digital computer in process control as process interface for data acquisition

and control, Centralized control systems, supervisory control systems (SCADA), microcomputer- based control systems (PLC, DCS), Plant wide control for plants involving compressor, Heat Exchanger, Adiabatic Plug Flow Reactor.

Reference Books:

1. Chemical Process Control, George Stephanopoulos, PHI publication,
2. Process System Analysis & Control, Donald R. Coughanour, Mc Graw Hill
3. Process Control – Modelling, Design & Control, B. Wayne Bequette, PHI Publication
4. Process Dynamics & Control, Dale E. Seaborg, Thomal F. Edgar, Dancan A. Mellichamp
5. Process Dynamics, Modeling & Control – Babatunde A. Ogunnaike, W. Harmon Ray, Oxford University Press Inc.
6. Computer Control of Processes – M. Chidambaram, Alpha Science International Ltd. Instrument Engineers Handbook (Process Control) –Bella G. Liptak, Elsevier

Chemical Engineering Department

BE Chemical

409341: Process Dynamics and Control

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week Practical: 2 Hrs/ Week	Paper: (30+70) 100 Marks In semester Assessment: 30 Marks End Semester Assessment: 70 Marks. PR :50 Marks **Credits:** Theory: 3 Practical: 1 Total: 4 Credits

Course Outcomes (COs Process Dynamics and Control

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C409341.1	Understand the fundamentals of process dynamic and control	**2**	Understand
C409341.2	Design of feedback control systems.	**3**	Design
C409341.3	Carry out Stability Analysis of feed-back systems.	**4**	Analysis
C409341.4	Application of advanced control	**3**	Application

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX

COs	PROGRAM OUTCOMES (POs)												PSO		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	3	1										1	3		
2	2	2	3		1							1	1	2	1
3	2	2	2	1	1							1	1	2	1
4	2	1	1		2							1	1	1	2

Levels: 3 for ≥60 ; 2 for < 60 ≥ 40; 1 for < 40

CO Assessment Tools

Course Outcomes (CO)	Assessment Tools							
	Continuous Internal Evaluation, CIE					CIE by SPPU, Pune	Semester End Exam (SEE) by SPPU, Pune	
	T1	T2	T3	Assignment	PR	Insem	PR	Endsem
C441.1	√			√	√	√	√	
C441.2	√			√	√	√	√	
C441.3		√		√	√		√	√
C441.4			√	√	√		√	√

Chemical Engineering Department

Teaching Plan

Process Dynamics and Control Design (409341)

Teaching Scheme:
Theory: 03 h/week

Practical: 2 h / week

Examination Scheme:
Insem: 30
Endsem: 70 : Credit = 3
Tw: 25 OR: 50 : Credit = 2

Lect No.	Topics / Sub- Topics	CO mapped
1	Course Orientation	-
2	Objectives of Chemical Process Control	1
3	Mathematical modeling of chemical processes, State variables and state equations, Input-Output model,	1
4	First order systems/processes – Thermometer	1
5	Liquid level tank, Liquid level tank with constant outlet (pure capacitive),	1
6	isothermal and non-isothermal CSTR,	1
7	Dynamic response of first order system to impulse and step inputs	1
8	Second order systems/processes – Damped vibrator	1
9	Interacting and Non-interacting systems, Characteristics of under-damped system.	1
10	Classical controllers – P, PI, PD, PID and ON- OFF controllers	2
11	Concept of feed-back control system	2
12	Block diagram reduction of complicated control systems	2
13	Dynamic behavior of feed-back control processes	2
14	Notion of stability, Characteristic equation	3
15	Routh-Hurwitz criteria, Root locus	3
16	controller tuning	3
17	Time Integral performance criteria by ISE, IAE, ITAE	3
18	selection of feed-back controller	3
19	Numerical	3
20	Response of first order system to sinusoidal input	
21	Frequency response characteristics of general linear system	2
22	Bode diagrams - First order system, Second order system	3
23	Bode diagrams –P, PI, PD & PID	3
24	Bode stability criteria, Gain margin, Phase Margin,	3
25	Nyquist Stability criteria,	3
26	Design of controllers with difficult dynamics	4
27	Inverse- response systems	4
28	Cascade Control, Selective Control	4
29	Split range control systems	4
30	Feed forward control systems	4
31	Ratio Control Systems	4
32	Adaptive and inferential control systems	4

33	Sampling of continuous signals to discrete- time signals	4
34	Role of digital computer in process control	4
35	Centralized control systems, SCADA	4
36	Plant wide control for compressor, Heat Exchanger	4
37	Adiabatic Plug Flow Reactor	4
38	University QP	
39	University QP	
40	University QP	

Question Bank

Process Dynamics and Control (409341)

	Unit-I	CO
Q.1	What is a mathematical model of a physical process and what do we mean when we talk about mathematical modeling?	CO1
Q.2	Discuss the incentives for Chemical process control	CO1
Q.3	What are the state variables and what are the state equations? What are they used for?	CO1
Q.4	What are the design elements of control system? Explain with examples.	CO1
Q.5	Derive the Input-output model for stirred tank heater system	CO1
Q.6	Derive the transfer function and time domain equation for a pure Capacitive process subjected to unit step input. Sketch the dynamic response of the same	CO1
Q.7	A thermometer showing steady state temperature of **25**^{0} C is suddenly immersed into a hot bath at **100**^{0} C. If the time constant of thermometer is 5 sec, determine the following; 1. Thermometer reading after 5 sec. 2. Time required reading 75^{0}C on Thermometer. 3. Time required for 75% response.	CO1
Q.8	Define modeling and derive the Input-output model for CSTR.	CO1
Q.9	Discuss the history and importance of Chemical process control	CO1
	Unit-II	
Q.1	Derive the transfer function for damped oscillator / vibrator system. Comment on type of dynamic response of the system	CO1
Q.2	Discuss the characteristics of underdamped response. Sketch the overshoot and decay ratio versus damping factor ξ if damping factor ξ is varied from 0 to 1.	CO1
Q.3	Define second order system and derive the transfer function for non-interacting tanks system. Comment on type of dynamic response of the system.	CO1
Q.4	A second order process with following transfer function is subjected to unit step change in input. Determine the damping factor ξ and the ultimate value of response $Gp = \frac{1}{s^2 + s + 1}$	CO1
Q.5	Derive the transfer function for U-Tube manometer.	
Q.6	Define P, I & D controller and derive their transfer functions. Discuss their open loop response.	CO2
Q.7	A first order process with following transfer function is controlled by P controller. Assuming servo problem and neglecting the dynamics of final control element and measuring instrument i.e. Gf(s) = Gm(s) = 1; The open loop process is $Gp(s) = \frac{1}{s+1}$	CO2

	Determine the following; i. Closed loop transfer function ii. Order of response iii. Closed loop gain and time constant iv. Offset.	
Q.8	Derive the open loop transfer function for P and PI controller and sketch the unit step response.	CO2
Q.9	Derive the closed loop transfer function and discuss the servo and regulatory problem.	CO2
	Unit-III	
Q.1	Define stability of the process and discuss Characteristic equation and Routh-Hurwitz criteria for stability.	CO3
Q.2	Draw the root locus diagram for the system with following transfer function; $Gp(s) = \frac{Kp}{s(s+1)(s+2)}$	CO3
Q.3	Draw the root locus diagram for the system with following transfer function; $Gp(s) = \frac{1}{(s+5)^2}$	CO3
Q.4	What is the major advantage of the Routh-Hurwitz criterion for examining the stability of a system?	CO3
Q.5	If a closed-loop response is stable with respect to changes in the set point, is it stable to changes in the load? If yes, why?	CO3
Q.6	How does the pole location determine the stability of an uncontrolled or controlled process?	CO3
Q.7	What conclusions can be drawn if one element in the first column of the Routh array is zero?	CO3
Q.8	Define what is known as bounded input, bounded output stability.	CO3
	Unit-IV	
Q.1	What is meant by controller tuning	CO3
Q.2	Discuss the Ziegler Nichols Method of controller tuning	CO3
Q.3	What means could you use to represent the results of the frequency response analysis for a dynamic system	CO3
Q.4	Sketch the Bode diagram for the given first order system $Gp(s) = \frac{1}{(5s+1)}$	CO3
Q.5	Sketch the Nyquist diagram for PD controller.	CO3
Q.6	Sketch the Bode diagram for PD controller	CO3
Q.7	Sketch the Nyquist diagram for PI controller	CO3
Q.8	Sketch the Bode diagram for PI controller	CO3
Q.9	Discuss the following; • Gain margin & phase margin.	CO3

	• Nyquist stability criteria.	
Q.10	Define controller tuning and discuss the Time integral performance criteria And process reaction curve method for tuning of controller.	CO3
Q.11	Compare the Bode and Nyquist Stability Criterion with suitable example	CO3
	Unit-V	
Q.1	Feedback v/s Feed forward control.	CO4
Q.2	Give the Importance of controller tuning.	CO4
Q.3	ISE, IAE, ITAE performance criteria	CO4
Q.4	Draw a neat sketch and write short notes on Cascade control	CO4
Q.5	Draw a neat sketch of Inverse- response systems and explain with suitable examples.	CO4
Q.6	Apply the ratio control system to suitable case study.	CO4
Q.7	Apply the adaptive control system to suitable case study.	CO4
Q.8	Apply the Auctioneering control system to suitable case study.	CO4
	Unit-VI	
Q.1	Draw the instrumentation diagram for CSTR control and discuss in detail about its functioning.	CO4
Q.2	Discuss Role of digital computers in control.	CO4
Q.3	Discuss PLC & SCADA	CO4
Q.4	Discuss Model Predictive control.	CO4
Q.5	Controller Robustness.	CO4
Q.6	Draw the instrumentation diagram for Plant wide control for plants involving compressor and discuss in detail about its functioning	CO4
Q.7	Discuss DCS Control Case study	CO4
Q.8	Discuss Data Bus concept.	CO4
Q.9	Discuss Digital approximation of Analog signals.	CO4
Q.10	Explain the plant wide control with suitable case study.	CO4

Process Dynamics and Control (409341)

List of Practical:

Expt. No.	Name of Experiment	CO Mapped
1	Dynamic response of Thermometer	CO1
2	Dynamic response of liquid tank level system	CO1
3	Dynamic response of two interacting systems	CO1
4	Dynamic response of two non-interacting systems	CO1
5	Dynamic response of U-Tube manometer	CO1
6	Dynamic response of P, PI and PID controllers	CO2
7	Cascade control system	CO4
8	PID control loop simulation for a first order process (Ex. SIMULINK)	CO2
9	Root locus analysis on software (Ex. MATLAB)	CO3
10	Bode plot on software (Ex. MATLAB)	CO3

Course: 02

Chemical Reaction Engineering-II

(409342)

B.E. Chemical (2019 Pattern)

[Theory]

Chemical Engineering Department

Course Syllabus

Chemical Reaction Engineering-II (409342)

Unit I: Heterogeneous Reactions **(7 h)**

Types, rates, contacting patterns. Fluid-Particle reactions: Selection of model unreacted core model, progressive conversion model, Rate of reaction for shrinking spherical particles. Determination of rate controlling step, application to design, application to fluidized bed with entrainment.

Unit II: Fluid – Fluid Reaction **(7 h)**

Rate equation for reaction, kinetic regimes (case A to H), film conversion parameter, slurry reaction kinetics, aerobic fermentation, application to design (fast and slow reactions), mixer settler, Semi batch contacting pattern, reactive distillation and extractive reactions

Unit III: Catalysis and Adsorption **(7 h)**

Surface chemistry and adsorption, adsorption isotherms and rates of adsorption. Catalysis: Determination of surface area by BET method, void volume and solid density, pore-volume distribution, catalyst selection, preparation of catalyst and its deactivation, poisoning and regeneration, nature and mechanism of catalytic reactions.

Unit IV: Reaction and Diffusion in porous catalyst **(7 h)**

Gaseous diffusion in single cylindrical pore, diffusion in liquids, in porous catalyst, surface diffusion, mass transfer with reaction: effectiveness factor, experimental and calculated effectiveness factor, selectivity’s for porous catalysts, rates for poisoned porous catalysts.

Unit V: Solid- catalyzed Reaction **(7 h)**

Rate equation (Film resistance, surface phenomenon, pore diffusion) experimental methods for finding rates, determining controlling resistances and rate equation, product distribution in multiple reactions.

Unit VI: Design of Heterogeneous Catalytic Reactors and Biochemical Reaction Systems **(7 h)**

Fluidized bed reactor, isothermal and adiabatic fixed bed reactor, fluidized bed reactor, slurry reactor, enzyme fermentation: Michaelis–Menten (M-M) kinetics, inhibition by foreign substance.

Reference Books:

1) Chemical Reaction Engineering: Octave Levenspiel (2nd & 3rd Edition)
2) Chemical Engineering Kinetics: J. M. Smith (3rd Edition)
3) Elements of Chemical Reaction Engineering: H. Scott Fogler (4th Edition)
4) Heterogeneous Reactions: Analysis Examples and reactor Design. Vol.1 & 2- Doraiswamy L. K. and Sharma M. M.
5) An Introduction to Chemical Reaction Kinetics & Reactor

Chemical Engineering Department

BE Chemical

409342: Chemical Reaction Engineering-II

Teaching Scheme: Lectures: 3 Hrs/ Week	**Examination Scheme:** Paper: (30+70) 100 Marks In semester Assessment: 30 Marks End Semester Assessment: 70 Marks. **Credits:** Theory: 3 Credits

Course Outcomes (COs) Chemical Reaction Engineering-II

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C442.1	Analyze the fluid-particle heterogeneous reaction and kinetics applies to design of packed bed and fluidized bed reactor.	**4**	**Analyze**
C442.2	Analyze the kinetics of fluid-fluid reaction and apply to design of fluid-fluid contacting devices.	**4**	**Analyze**
C442.3	Apply the concept of adsorption isotherm for analyze the physical properties of catalyst and mechanism of deactivation of catalysis.	**3**	**Apply**
C442.4	Analysis of mass transfer with chemical reaction in porous catalyst.	**4**	**Analyze**
C442.5	Develop the rate equation and mechanism of the solid-catalyzed reaction.	**4**	**Develop**
C442.6	Examine the design of heterogeneous catalytic reactors and concept of biochemical reaction system.	**3**	**Examine**

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX															
COs	PROGRAM OUTCOMES (POs)												PSO		
	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
C442.1	3	2	2	2	-	-	-	-	-	-	-	-	3	2	1
C442.2	2	2	2	2	-	-	-	-	-	-	-	-	3	2	1
C442.3	2	2	1	1	-	-	-	-	-	-	-	-	2	2	1
C442.4	2	2	1	2	-	-	-	-	-	-	-	-	2	2	1
C442.5	3	2	2	2	-	-	-	-	-	-	-	-	2	1	1
C442.6	2	2	2	1	-	-	-	-	-	-	-	-	2	1	1
Total	14	12	10	10	-	-	-	-	-	-	-	-	14	10	6
Total Wt	18	18	18	18	-	-	-	-	-	-	-	-	18	18	18
% Mapping	77.7	66.6	55.6	55.5	-	-	-	-	-	-	-	-	77.7	55.5	33.3
C442	3	3	2	2	-	-	-	-	-	-	-	-	3	2	1

Chemical Engineering Department

CO Assessment Tools

Course Outcomes (CO)	Assessment Tools							
	Continuous Internal Evaluation, CIE					CIE by SPPU, Pune	Semester End Exam (SEE) by SPPU, Pune	
	T1	T2	T3	Assignment	PR	Insem	OR	Endsem
C442.1	√	-	-	√	-	√	-	-
C442.2	√	-	-	√	-	√	-	-
C442.3	-	√	-	√	-	-	-	√
C442.4	-	√	-	√	-	-	-	√
C442.5	-	-	√	√	-	-	-	√
C442.6	-	-	√	√	-	-	-	√

Chemical Engineering Department

Teaching Plan

Chemical Reaction Engineering-II (409342)

Teaching Scheme: **Examination Scheme:**

Theory: 03 h/week
Insem: 30
Endsem:70 : Credit = 3

Lect No.	Topics / Sub- Topics	CO mapped
1	Mission , Vision, PEO, PO,PSO & COs of & Introduction of heterogeneous reaction	--
2	***Unit-I*** **:** Fluid-particle reaction – Selection of model & Shrinking unreacted core model	1
3	Diffusion through a gas film control	1
4	Ash layer diffusion control step & Surface reaction control step	1
5	Shrinking core model & gas film diffusion step	1
6	Application of unreacted core model of spherical particle to the design of fluid-particle reactors.	1
7	Numerical on Unit-I	1
8	Numerical on Unit-I	1
9	***Unit-II*** **: Fluid – fluid reaction-**Kinetic regimes for mass transfer in fluid-fluid reaction	1
10	Rate equation for instantaneous reaction	2
11	Rate equation for fast & slow fluid-fluid reaction	2
12	Film conversion parameter & Numerical	2
13	Design of fluid-fluid tower for straight mass transfer without & with the reaction	2
14	Numerical on Unit-II	2
15	Numerical on Unit-II	2
16	Reactive distillation and extractive reaction	2
17	**Unit-III: Catalysis & Adsorption**: Concept of adsorption	2
18	Adsorption isotherm	3
19	BET Method & Numerical	3
20	Pore volume, solid density & pore volume distribution	3
21	Catalysis– Characteristics & preparation methods	3
22	Deactivation of catalysis	3
23	**Unit-IV: Reaction and Diffusion in porous catalyst:** Diffusion Porous catalyst	3
24	Gaseous diffusion in single cylindrical pore	4
25	Liquid diffusion, Surface diffusion and Effectiveness factor	4
26	Effectiveness factor of single cylindrical pore for first order reaction	4
27	Effectiveness factor of spherical catalyst pallet	4
28	Thiele Modulus	4
29	Selectivity of porous catalyst	4

30	**Unit V: Solid- catalyzed Reaction**: Mechanism of solid catalyzed reaction	4
31	Experimental method for determination of Rate of solid catalyzed reaction	5
32	Numerical on Mechanism of reaction	5
33	Numerical on Mechanism of reaction	5
34	Numerical on Unit-V	5
35	Numerical on Unit-V	5
36	**Unit-VI: Design of Heterogeneous Catalytic Reactors and Biochemical Reaction Systems:** Fluidized bed catalytic reactor	5
37	Fixed bed reactor	6
38	Slurry reactor	6
39	Michaelis–Menten (M-M) kinetics	6
40	Features of M-M equation	6
41	Inhibition by foreign substance	6
42	Numericals	6
43	University question paper solution	1-6
44	University question paper solution	1-6

Chemical Engineering Department

Question Bank

Chemical Reaction Engineering-II (409342)

	Unit-I	CO
Q.1	List the different selection criteria's for models in case of the non-catalytic reactions of particles with surrounding fluid? Explain each model in detail.	CO1
Q.2	Derive and expression for time and conversion for gas film, and Chemical reaction control of spherical particle of unchanging in size.	CO1
Q.3	In the fluid particle reaction, derive the expression for the time for given conversion, time for complete conversion with suitable sketch for spherical shrinking core model with particles of unchanging size with Ash layer diffusion as the rate controlling step.	CO1
Q.4	Derive the equation for stokes regime in case of gas film control rate of spherical shrinking particles.	CO1
Q.5	The reduction of iron ore of density ρ_B= 4.6 gm /cm3 and size R = 5 mm by H_2 can be approximated by the unreacted core model with no water vapor present, the stoichiometry of the reaction is- $4H_2 + Fe_3O_4 \rightarrow 4 H_2O + 3 Fe$ With rate approximately proportional to the concentration of H_2 in the gas stream. The first order rate constant has been measured to be Ks = $1.93 \times 10^5 e^{-24000/RT}$ cm /sec. Taking De = 0.03 cm^2/sec as the average value of the diffusion coefficient for hydrogen penetration of the product layer. Calculate the time necessary for complete conversion of a particle from oxide to metal at 600 C.	CO1
Q.6	Particles react with gas of given composition and at given temperature to give a solid product. What can you say about the kinetics of the reaction if the rate of reaction per gram of solid is (i) proportional to the diameter of particle (ii) proportional to the square of the diameter of particle (iii) independent of particle size?	CO1
Q.7	Two small samples of solids are introduced into a constant environment oven and kept there for one hour. Under these conditions the 4mm particles are 58% converted, the 2mm particles are 87.5 % converted. Find the rate controlling mechanism for the conversion of solids. Find the time needed for complete conversion of 1mm particles in this oven.	CO1
Q.8	A feed consisting of 30% of 50-μ-radius particles, 40% of 100-μ-radius particles and 30% of 200-μ-radius particles is to be fed continuously in a thin layer onto a moving grate crosscurrent to a flow of reactant gas. For the planned operating conditions the time required for complete conversion is 5, 10 and 20 min for the three sizes of particles. Find the conversion of solids for a residence time of 8 min in the reactor.	CO1

Q.9	A feed consisting of 30% of 50-μ-radius particles, 40% of 100-μ-radius particles and 30% of 200-μ-radius particles with rate 1000 gm solids/min is to be reacted in a fluidized bed (contains 10 kg solids) steady state flow reactor. A fluidizing reactant is in the gas phase and the time required for complete conversion is 5, 10 and 20 min for the three sizes of feed at operating condition. The solids are hard and unchanged in size and weight during reaction. Without cyclone separator the solids are entrained by the fluidizing gas. The elutriation velocity constant for the operating conditions and bed height is estimated to be $\kappa=(500\ \mu^2/\text{min})R^2$ Where R is the particle radius in microns. Calculate the conversion with chemical reaction control and compositions of all streams (Underflow, Carryover, and fluidized bed).	CO1
Q.10	Explain the controlling steps for fluid –particle reaction.	CO1
Q.11	A solid feed consisting of 20% by weight of 1 mm and smaller particle, 30% by weight of 2 mm particles, rest 4 mm particles is fed into a rotating tubular reactor where the particles react with the gas of uniform composition to give a hard non friable product. Time for complete conversion is 4 hrs for 4mm particles and chemical reaction controls the rate. Find the amount of residence time required for i) 75% conversion of solid, ii) 95% conversion of solid and iii) 100% conversion of solids.	CO1
	Unit-II	
Q.1	Construct an equation for calculation of tower height for fast reaction when straight mass transfer without takes place.	CO2
Q.2	Discuss fluid-fluid reaction examples. Explain the importance resistances involved in the process.	CO2
Q.3	What is the film conversion parameter? and give the detail application of this.	CO2
Q.4	The concentration of undesirable impurity in air (1 bar) is to be reduced from 0.1% to 0.02% by absorption in pure water. Determine the height of tower required for countercurrent operations. Data: k_{Ag}=0.32 mol/hr.m3.pa; k_{Al}= 0.1/hr.; H_A=12.5Pa.m3/mol; Flow rates F_g/ Acs=1*105 mol/hr.m2 ; F_1/Acs=7*105 mol/hr.m2 ; Total molar density of liquid= 56000 mol/m^3.	CO2
Q.5	We plan to remove about 80 % of the A present in a gas stream by absorption in water containing reactant B. Material B react with A as per the following reaction: $A_{(g)} + B_{(l)} \rightarrow R_{(l)}$ The reaction is extremely rapid. Determine the height of the tower for countercurrent operation using following data. Data: G = 1x 10^5mol/h m^2 at $\pi = 10^5$ Pa. ; L = 7 x 10^5mol/h m^2, H_A = 12.5 Pa.m^3/ mol, C_T = 56,000 mol/ m^3.; P_{Ain} = 100 Pa, K_{Aga} = 0.32 mol/ h m^3 Pa , K_{Ala} = 0.1 h^{-1}	CO2

	C_{Bin} = Concentration of reactant B in water entering the tower = 800 mol/ m^3. Assume that the diffusivities of A & B in water are the same.	
Q.6	Construct the rate equation for the fluid-fluid instantaneous reaction with phase resistance.	CO2
Q.7	Give the kinetic regimes with mass transfer in fluid-fluid reaction.	CO2
Q.8	A fluid-fluid reaction of type A (From Gas) + bB(Liquid)→Product (Liquid) takes place in reactor. A reaction is fast with (i) moderate C_B and (ii) High $C_{B.}$ Formulate the rate expression for both cases.	CO2
Q.9	Construct an equation for calculation of tower height for fast reaction when straight mass transfer with reaction takes place	CO2
	Unit-III	
Q.1	How the BET method used for determination of surface area of catalyst?	CO3
Q.2	What is void volume and pore density in case of solid catalyst? Give suitable equations for determination of this parameters.	CO3
Q.3	What is catalyst Poisoning explain with various types of poisons.	CO3
Q.4	The following data were obtained at 70°C for the equilibrium adsorption of n-hexane on silica gel particles. Partial pressure of C_6H_{14} in gas, atm C_6H_{14} adsorbed, g mol/(g gel) 0.0020 10.5 × 10–5 0.0040 16.0 × 10–5 0.0080 27.2 × 10–5 0.0113 34.6 × 10–5 0.0156 43.0 × 10–5 0.0206 47.3 × 10–5 Determine the values of constants Cm and Kc for Langmuir isotherm by least-square-analysis.	CO3
Q.5	Give the methods of determination of catalyst pore volume in detail.	CO3
Q.6	Explain the mercury penetration method for determination of catalyst pore size?	CO3
Q.7	Describe are the major steps involved in the preparation of the catalyst?	CO3
Q.8	Give the characteristics of the catalyst.	CO3
Q.9	What is the “Promoters” and “Inhibitors” used in the catalytic reaction?	CO3
Q.10	Give the different type of adsorption isotherm observed in case of heterogeneous catalytic chemical reaction.	CO3
Q.11	For 8 gm of catalyst sample is studied with N2 adsorption at -195.8 C. the following data were obtained. The vapor pressure of N2 at -195.8C ia taken as 1 atm. Estimate surface area of the catalyst. P in mm Hg- 6 25 140 230 285 320 430 505 N_2 adsorbed 61 127 170 197 215 230 277 335 (O^{0}C & 1 atm)	CO3
	Unit-IV	

Q.1	What is the diffusion? Give the gaseous, liquid and solid diffusion.	CO4
Q.2	Derive an expression for diffusion of gaseous in single cylindrical pore of catalyst.	CO4
Q.3	What is an effectiveness factor? Derive the expression for effectiveness factor of single cylindrical pore of the catalyst.	CO4
Q.4	Write a short note on mass transfer with reaction with the help of effectiveness factor in catalytic reactions.	CO4
Q.5	What is the surface diffusion in porous catalysts?	CO4
Q.6	What is significance of pore diffusion resistance?	CO4
Q.7	How will you test catalyst for strong pore and negligible pore resistance?	CO4
Q.8	Analyze the selectivity for a porous catalyst in parallel and series catalytic reaction?	CO4
Q.9	What is Thiele modulus? and give the significance of the Thiele modulus.	CO4
Q.10	The ethylene stream is fed to the reactor in which the catalyst is poisoned by acetylene. The ethylene is prepared by catalytically dehydrogenating ethane. The first order reaction are: $C2H6 \xrightarrow{K1} C2H6 \xrightarrow{K3} C2H2$ for one catalyst k1/k3 = 16. It is suspected that interpallet diffusion strongly retards both dehydrogenation. Estimate the potential improvement in selectivity if diffusion resistance could be eliminated. Make the estimate for concentration ratio (CB/CA)b = 1. Neglect differences in De between ethane and ethylene.	CO4
	Unit-V	
Q.1	Write a note on integral and differential analysis of catalytic reactors.	CO5
Q.2	What are the different steps involved in solid catalyzed reaction? Give the neat diagram.	CO5
Q.3	The catalytic reaction A→ 4R is studied in a plug flow reactor using various amounts of catalyst and 20 lit/hr of pure A feed at 3.2 atm and 117°C. The concentration of A in the effluent stream is recorded for the various runs as follows: Run 1 2 3 4 5 Catalyst Used, kg 0.020 0.040 0.080 0.120 0.160 CA, out, mol/lit 0.074 0.060 0.044 0.035 0.029 Find a rate equation for this reaction, using the integral method of analysis.	CO5
Q.4	Explain the experimental method for finding rates in case of mixed and recycles reactors.	CO5
Q.5	The kinetics of the reaction is as follows: $A \rightarrow 4R, \quad -r_A = 96\ C_A$, mol/hr kg cat. The feed rate is 2000 mol/hr of pure A at 3.2 atm and 117 0C temperature. The conversion in the packed bed reactor is 35% of A to R. determines the amount of catalyst needed in a packed bed reactor with	CO5

	i) Very large recycle rate and ii) No recycle rate	
Q.6	Derive the expression for design equation for mixed flow and plug flow reactor containing porous catalyst.	CO5
Q.7	The following mechanism has been proposed for a catalytic reaction. $A_{(g)} + B_{(g)} \rightarrow C_{(g)}$ (1) $A_{(g)} + X == AX$ (2) $AX + B_{(g)} == CX$ (3)$CX == C_{(g)} + X$ Where, X indicates an active site on the catalyst. Derive an expression for the rate of reaction if the surface reaction step is a rate controlling.	CO5
Q.8	The catalytic reaction A→ 4R is run at 3.2 atm and 100 C in tubular reactor which contains 0.01 kg of catalyst and uses a feed consisting of partially converted product of 20 lit/hr of pure A and following data was recorded. Determine the rate equation for this reaction. C_{Ain}, mol/lit 0.1 0.08 0.06 0.04 C_{Aout}, mol/hr.kg 0.084 0.070 0.055 0.038	CO5
Q.9	The results of the kinetic runs on the reaction A → R made in an experimental packed bed reactor using a fixed feed rate F_{Ao} = 10 kmol/h are as follows. W, Kg catalyst- 1 2 3 4 5 6 7 X_A - 0.12 0.2 0.27 0.33 0.37 0.41 0.44 i)find the reaction rate at 40 % conversion, ii) for feed rate of 400 kmol/h to large scale packed bed reactor, find the amount of catalyst needed for 40 % conversion	CO5
Q.10	For the following reaction occurring on the catalyst; derive the rate expression for surface reaction to be rate controlling and dual site mechanism. S1 are the site occupied by H2O and CH3OH and S2 are occupied by O2. $CH_3OH + ½ O_2$ ------------→ $CH_2O + H_2O$ A + ½ B ----------------→ C + D A (g) + S1 -----------→ A.S1 B (g) + S2 ------------→ B.S2 A.S1 + B.S2 -----------→ C (g) + D.S1 + S2 D.S1 -----------------→ D (g) + S1	CO5
Q.11	The second order reaction A->R is studied in a recycle reactor with large recycle ratio and the following data are recorded: Void volume of reactor = 1 lit Weight of catalyst using : 3 gm Feed to the reactor : C_{A0}= 2 mol/lit, vo = 1 lit/hr Exit stream concentration = C_{Aout}= 0.5 mol/lit a) Find the rate constant for this reaction b) How much catalyst is needed in a packed bed reactor for 80% conversion of 1000 lit/hr of feed of concentration, C_{A0} = 1 mol/lit.	CO5

	C) Repeat part (b) if the reactor is packed with 1 part of catalyst to 4 part inert solid. This addition of inert helps maintain isothermal conditions and eliminate hot spots.	
Q.12	A small experimental packed bed reactor (w= 1 Kg) using very large recycle of product stream given the following kinetic data: A -->R , and C_{Ao} = 10 mol/m^3. CA, mol/m^3 : 1 2 3 6 9 Vo, lit/hr : 5 20 65 133 540 Find the amount of catalyst needed for 75% conversion for a flow rate of 1000 mol A/hr of C_{Ao}= 8 mol/m^3 feed stream (a) in a packed bed reactor with no recycle of exit fluid, (b) in a packed bed reactor with very high recycle.	CO5
	Unit-VI	
Q.1	What is the Michaelis-Menton Kinetics? What are its model parameters?	CO6
Q.2	Derive the M-M kinetic equation.	CO6
Q.3	Give the features of M-M kinetic equation	CO6
Q.4	Give the design of fluidized bed reactor.	CO6
Q.5	Give the design of slurry reactor.	CO6
Q.6	Give the design of staged adiabatic reactor.	CO6
Q.7	Give the design of trickle bed reactor	CO6
Q.8	Give the design of fixed bed reactor.	CO6
Q.9	Explain the procedure for determining the M-M kinetic constants in batch or plug flow and mixed flow reactor.	CO6
Q.10	Explain the inhibition in the enzyme catalyzed reaction.	CO6

Course: 03

Chemical Engineering Design

(409343)

B.E. Chemical (2019 Pattern)

[Theory & Practical]

Chemical Engineering Department

Course Syllabus

Chemical Engineering Design (409343)

Unit 1: Agitators and Reaction vessels **6Hrs**

Study of various types of agitators, their selection, applications, baffling, agitator shaft diameter calculations which includes twisting moment, equivalent bending moment, power requirement calculations for agitation systems.

Reaction vessels: introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil, study and design of internal coil reaction vessels, heat transfer coefficients in coils.

Unit 2: Storage Vessels **7 Hrs**

Study of various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and non-volatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, Design of cylindrical storage vessels as per IS: 803- design of base plates, shell plates, roof plates, wind girders, curb angles for self-supporting and column supported roofs. Design of rectangular tanks as per IS: 804.Stresses in the shell of a tall vertical vessel, and period of vibration.

Vessel supports- introduction and classification of supports, design of skirt supports considering stresses due to dead weight, wind load, seismic load, design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates Design of saddle supports, ring stiffeners.

Unit 3: Heat Exchangers **7 Hrs**

Shell and tube heat exchanger- General design considerations- LMTD correction factor, fluid allocation, fluid velocities, stream temperatures, pressure drop, shell side and tube side heat transfer coefficients, overall heat transfer coefficient, mechanical design of shell and tube heat exchanger thickness of shell and shell cover, channel cover, tube sheet, size and number of tie rods and spacers.

Design of double pipe heat exchanger. Plate heat exchanger: advantages, disadvantages, design procedure, temperature correction factor, heat transfer coefficients, pressure drop.

Evaporators: classification, criteria for selection, design of calendria type evaporator.

Unit 4: **Design of distillation column** **7 Hrs**

Design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors, and plate hydraulic design.

Unit 5: Design of Packed column **6Hrs**

Choices of plates or packing, packed column design procedure, packed bed height (distillation and absorption), HTU, Cornell’s method, Onda’s method, column diameter, column internals, wetting rates, column auxiliaries.

Unit 6: Piping Design **7 Hrs**

A brief revision covering friction factor, pressure drop for flow of non-compressible and compressible fluids, (Newtonian Fluids), pipe sizing, economic velocity. Pipe line networks and their analysis for flow in branches, restriction orifice sizing. Pipe supports, non-Newtonian fluids – types with examples, pressure drop calculations for non-Newtonian fluids. Pipe line design on fluid dynamic parameter. Design of pipeline for natural gas, Pipeline design for transportation of crude oil.

Term work: Process and Mechanical design and drawing of any five equipment's from unit 1 to 6 which should include at least two sheets based on AUTOCAD/Autodesk or design software.

Reference Books:

1. "Process equipment design" by L.E. Brownell and E. Young, John Wiley, New York, 1963.
2. "Introduction to Chemical Equipment Design" by B.C. Bhattacharya C.B.S. Publications.
3. "Process Equipment Design" by M.V. Joshi, McMillan India.
4. "Chemical Engineering Vol. 6" by J.M. Coulson, J.F. Richardson and R.K. Sinott, Pergamon Press.
5. "Chemical Engineering volume 2" by J. M. Coulson, J. F. Richardson, and R. K. Sinott Pergamon Press.
6. "Applied Process Design for Chemical and Petrochemical Plants" vol 1 and 2, Ludwig E.E., Gulf Publishing Company, Texas.
7. "Indian standards Institution" code for unfired pressure vessels, IS – 2825.
8. "Chemical Process Equipment-Selection and design" Walas S.M. Butterworth Heinamen, McGraw Hill book company, New York.
9. "Mass Transfer Operations" by Treyball R.E., McGraw Hill, New York.
10. Pipe Drafting and Design by Roy A Parisher& Robert A. Rhea, Gulf Professional Publishing, 2012.
11. Hydraulics and Fluid Mechanics by Modi and Seth, Standard Publishers Distributors.
12. "Process Design of Equipments" by S. D. Dawande, Central Techno Publication

Chemical Engineering Department

BE Chemical

409343: Chemical Engineering Design

Teaching Scheme:	**Examination Scheme:**
Lectures :3 Hours / Week Drawing: 2 h / week	In Semester: 30 End Semester: 70 OR: 50 **Total: 150** **Credits: 3+1**

Course Outcomes (COs Chemical Engineering Design)

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C443.1	Design agitated reaction vessel using given process parameters	**4**	Extend
C443.2	Design of vessel supports by considering different loads on vessel and storage vessels for storing volatile and non-volatile liquids using given process conditions	**4**	Analyze
C443.3	Design Heat Transfer Equipment's like Shell and Tube Heat exchanger, Double pipe Heat exchanger, Evaporator	**4**	Creating
C443.4	Design distillation column and methods for binary system used in Chemical process industry	**4**	Creating
C443.5	Apply Cornell's and Onda's method and design packed column for distillation and absorption operation	**3**	Applying
C443.6	Design of pipe line and Pipe supports by considering fluid dynamic parameter	**4**	Evaluate

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX														
COs	PROGRAM OUTCOMES (POs)											PSO		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	2	3	3	1	1	-	-	-	-	-	-	2	2	3	1
2	2	3	3	1	-	-	-	-	-	-	-	2	2	2	-
3	2	3	3	2	2	-	-	-	-	-	-	2	2	3	2
4	1	3	3	2	2	-	-	-	-	-	-	-	1	-	2
5	2	3	3	1	-	-	-	-	-	-	-	1	2	-	-
6	2	3	3	1	-	-	-	-	-	-	-	2	2	-	-

Levels: 3 for ≥60 ; 2 for < 60 ≥ 40; 1 for < 40

Chemical Engineering Department

CO Assessment Tools

Course Outcomes (CO)	Assessment Tools							
	Continuous Internal Evaluation, CIE					CIE by SPPU, Pune	Semester End Exam (SEE) by SPPU, Pune	
	T1	T2	T3	Assignment	PR (Drawing)	Insem	OR	Endsem
C443.1	√			√	√	√	√	
C443.2	√			√	√	√	√	
C443.3		√		√	√		√	√
C443.4		√		√	√		√	√
C443.5			√	√	√		√	√
C443.6			√	√	√		√	√

Chemical Engineering Department

Teaching Plan

Chemical Engineering Design (409343)

Teaching Scheme:
Theory: 03 h/week

Practical: 2 h / week

Examination Scheme:
Insem: 30
Endsem: 70 : Credit = 3
OR: 50 : Credit = 1

Lect No.	Topics / Sub- Topics	CO mapped
1.	PO,PSO & CO of Subject & Introduction	--
2.	***Unit-I* : Agitators -**Study of various types of agitators, their selection, applications	1
3.	Baffling, agitator shaft diameter calculations which includes twisting moment	1
4.	Agitator shaft diameter calculations which includes equivalent bending moment.	1
5.	Power requirement calculations for agitation systems.	1
6.	**Reaction vessels-** introduction, classification, heating systems, design of vessels	1
7.	Study and design of various types of jackets like plain, half coil.	1
8.	Study and design of various types of jackets like channel, limpet coil	1
9.	Study and design of internal coil reaction vessels, heat transfer coefficients in coils.	1
10	***Unit-II* : Storage Vessels-** Study of various types of storage vessels and applications	2
11	Atmospheric vessels, vessels for storing volatile and non-volatile liquids, storage of gases	2
12	Losses in storage vessels, Various types of roofs used for storage vessels	2
13	Design of cylindrical storage vessels as per IS: 803- design of base plates, shell plates, roof plates, wind girders curb angles for self-supporting and column supported roofs	2
14	Design of rectangular tanks as per IS: 804.Stresses in the shell of a tall vertical vessel, and period of vibration	2
15	Vessel supports- introduction and classification of supports	2
16	Design of skirt supports considering stresses due to dead weight, wind load, seismic load	2
17	Design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates	2
18	Design of saddle supports, ring stiffeners.	2
19	**Unit-III: Heat Exchangers-** Shell and tube heat exchanger- General design considerations	3
20	LMTD correction factor, fluid allocation, fluid velocities, stream temperatures, pressure drop	3
21	Shell side and tube side heat transfer coefficients, overall heat transfer coefficient	3

22	Mechanical design of shell and tube heat exchanger thickness of shell and shell cover, channel cover, tube sheet, size and number of tie rods and spacers	3
23	Design of double pipe heat exchanger. Plate heat exchanger: advantages, disadvantages	3
24	Design procedure, temperature correction factor, heat transfer coefficients, pressure drop.	3
25	Evaporators: classification, criteria for selection	3
26	Design of calendria type evaporator	3
27	**Unit-IV: Design of distillation column-** Design variables in distillation,	4
28	design methods for binary systems	4
29	plate efficiency,	4
30	approximate column sizing	4
31	plate contactors	4
32	plate hydraulic design	4
33	Problems	4
34	**Unit V: Design of Packed column-** Choices of plates or packing	5
35	Packed column design procedure	5
36	Packed bed height (distillation and absorption)	5
37	HTU, Cornell’s method, Onda’s method	5
38	Column diameter, column internals	5
39	Wetting rates, column auxiliaries	5
40	**Unit-VI: Piping Design-** A brief revision covering friction factor	6
41	Pressure drop for flow of non-compressible and compressible fluids, (Newtonian Fluids)	6
42	Pipe sizing, economic velocity	6
43	Pipe line networks and their analysis for flow in branches	6
44	Restriction orifice sizing	6
45	Pipe supports, non-Newtonian fluids – types with examples	6
46	Pressure drop calculations for non-Newtonian fluids	6
47	Pipe line design on fluid dynamic parameter	6
48	Design of pipeline for natural gas	6
49	Pipeline design for transportation of crude oil	

Chemical Engineering Department

Question Bank

Chemical Engineering Design (409343)

	Unit-I	CO
Q.1	Explain Criteria for jacket selection in reactor.	CO1
Q.2	A jacketed, agitated reactor consists of a vertical cylinder 1.5 m diameter, with a hemispherical base and a flat, flanged, top. The jacket is fitted to the cylindrical section only and extends to a height of 1 m. The spacing between the jacket and vessel walls is 75 mm. The jacket is fitted with a spiral baffle. The pitch between the spirals is 200 mm. The jacket is used to cool the reactor contents. The coolant used is chilled water at 10°C; flow-rate 32,500 kg/h, exit temperature 20 °C. Estimate the heat transfer coefficient at the outside wall of the reactor and the pressure drop through the jacket. The value of j_h=3.2 × l0^{-3}. Physical Properties at mean temperature l5^{o}C. Density =999kg/m^{3}, viscosity=l.l36mN.S/m^{2}, Pr =7.99, K=595×l0^{-3} W/m^{o}C.	CO1
Q.3	Explain in detail Components of agitation system	CO1
Q.4	Design an agitator on the basis of critical speed of shaft with the help of neat sketch; explain different types of agitators in detail.	CO1
Q.5	Write short notes on 1. The selection criteria (or factors) of agitators 2. Significance of power curve	CO1
Q.6	How is vortex formation avoided? What problems are encountered when vortex is formed?	CO1
Q.7	Design a turbine agitator shaft and blade only with the following specifications for a vessel of 1500 mm diameter. Data: Diameter of agitator: 450 mm Internal pressure in the vessel:0.5 N/mm^{2} Speed:250 rpm Sp.Gravity of liquid in the vessel-1.3 Viscosity of liquid in the vessel-600cp Overhang of the agitator shaft between bearing and agitator 1350mm No. of Agitator blades(Flat):6 nos., Width of the blade: 75 mm Thickness of the blade: 8 mm No.of baffles at tank wall: 4nos. Shaft material-commercial cold rolled steel Permissible shear stress in the shaft:55 N/mm^{2} Elastic limit in tension:246 N/mm^{2}, Modulus of elasticity: 1.95 x 10^{5} N/mm^{2} Value of Power No.:4.3	CO1
	Unit-II	
Q.1	Discuss the stresses in cone type of roof.	CO2
Q.2	Give step by step method for designing of rectangular tank as per IS: 804.	CO2

<table>
<tr><td>Q.3</td><td>A storage vessel of diameter 12m is proposed to have a self-supporting conical roof with permissible shape of 1 in 5. Check the suitability of 10mm thick plates for conical roof construction. MOC is structural carbon steel having density 7850 kg/m^3. Superimposed load is 1250 N/m^2. If the plates of given thickness are not suitable, suggest the required thickness. Modulus of elasticity is 2 x 10^5 N/mm^2.</td><td>CO2</td></tr>
<tr><td>Q.4</td><td>A storage tank of diameter 12m is proposes to have self-supporting conical roof with permissible slop of 1 in 5. Check the suitability of 10 mm thick plates for conical roof construction. Material of construction is structural carbon steel having density of 7850kg/m^3, Superimposed load is 1250N/m^2. If plates of given thickness are not suitable, suggest the required thickness for roof plates. Modulus of elasticity for material is 2X10^{5}N/mm^2.</td><td>CO2</td></tr>
<tr><td>Q.5</td><td>Explain the procedure for the design of skirt support with necessary equations.</td><td>CO2</td></tr>
<tr><td>Q.6</td><td>Explain the procedure for the design of saddle support with necessary equations.</td><td>CO2</td></tr>
<tr><td>Q.7</td><td>Explain Various losses associated with the storage of volatile liquids.</td><td>CO2</td></tr>
<tr><td>Q.8</td><td>Explain Designing steps for the stresses generated in the tall vessels.</td><td>CO2</td></tr>
<tr><td>Q.9</td><td>Explain Horton spheres as storage vessels and give its any two applications.</td><td>CO2</td></tr>
<tr><td>Q.10</td><td>Explain the hydrostatic head at the bottom of the tank.</td><td>CO2</td></tr>
<tr><td>Q.11</td><td>Classification of storage vessel based on type of roofs.</td><td>CO2</td></tr>
<tr><td>Q.12</td><td>Explain the codes for designing the storage vessel.</td><td>CO2</td></tr>
<tr><td>Q.13</td><td>Types of evaporation losses of volatile liquids from storage vessels</td><td>CO2</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td>Unit-III</td><td></td></tr>
<tr><td>Q.1</td><td>What is temperature correction factor? How is it calculated in design of heat Exchanger?</td><td>CO3</td></tr>
<tr><td>Q.2</td><td>1.2 kg/sec of an organic liquid is to be cooled from 45ºC to 20ºC. The organic liquid is cooled by chilled water supplied from a refrigeration unit at a temperature of 5ºC and can be heated upto 10ºC. Use tubes of 12 mm ID and 2 mm wall thickness. Length of tubes is 1.5 m. Properties of organic liquid and water are: (SDDNP63)
<table>
<tr><td>Properties</td><td>Organic liquid</td><td>Water</td></tr>
<tr><td>Specific heat, J/Kg K</td><td>2150</td><td>4180</td></tr>
<tr><td>Viscosity, Ns/m^2</td><td>0.25×10^{-3}</td><td>0.8×10^{-3}</td></tr>
<tr><td>Density, kg/m^3</td><td>716</td><td>1000</td></tr>
</table>
</td><td>CO3</td></tr>
</table>

<table>
<tr><td></td><td><table><tr><td></td><td></td><td></td></tr><tr><td>Thermal conductivity, W/m.K</td><td>0.133</td><td>0.61</td></tr></table>Fouling resistance for organic liquid = 0.0002 m² K/W, Fouling resistance for water = 0.0004 m² K/W, Correction factor for LMTD = 0.86. Steel tubes are to be used. Thermal conductivity of steel tube = 45W/mK. Design a suitable heat exchanger.</td><td></td></tr>
<tr><td>Q.3</td><td>Discuss on fluid allocation on tube side and shell side in shell and tube Exchanger</td><td>CO3</td></tr>
<tr><td>Q.4</td><td>Discuss on baffles in shell and tube Exchanger</td><td>CO3</td></tr>
<tr><td>Q.5</td><td>Problem Statement: 150000 lb per hour of kerosene will be heated from 75 to 120°F by cooling a gasoline stream from 160 to 120°F. Inlet pressure will be 50 psia for each stream and the maximum pressure drop of 7 psi for gasoline and 10 psi for kerosene are permissible. Published fouling factors for oil refinery streams should be used for this application. Design a shell and tube heat exchanger for this service.</td><td>CO3</td></tr>
<tr><td>Q.6</td><td>Explain the step wise design procedure of shell and tube heat exchanger with neat diagram</td><td>CO3</td></tr>
<tr><td>Q.7</td><td>Write a short note on plate type of heat exchanger.</td><td>CO3</td></tr>
<tr><td>Q.8</td><td>1800 kg/hr of ethylene glycol is to be cooled from 100 ºC to 60 ºC by water available at 15 ºC . The maximum temperature to which water can be heated is 42 ºC. Ethylene glycol is circulated through the tubes while water flows through the annulus of a concentric tube heat exchanger.
Inside tube is of copper while outside tube is of steel.
Inside diameter of copper tube = 12.5 mm.
Outside diameter of copper tube = 14.5 mm.
Inside diameter of steel tube = 22 mm.
Fouling resistance and metal wall resistance can be neglected.
Suggest a suitable design of concentric tube heat exchanger.
The properties of ethylene glycol and water at mean temperature are:
(SDDNP77)<table><tr><td>Properties</td><td>Ethylene glycol</td><td>Water</td></tr><tr><td>Specific heat, J/Kg K</td><td>2650</td><td>4180</td></tr><tr><td>Viscosity, N-s/m²</td><td>3.2 × 10⁻³</td><td>0.853 × 10⁻³</td></tr><tr><td>Density, kg/m³</td><td>1078</td><td>995</td></tr><tr><td>Thermal conductivity, W/mK</td><td>0.261</td><td>0.614</td></tr></table></td><td>CO3</td></tr>
</table>

Q.9	Discuss mechanical design of shell and tube heat exchanger with necessary equations**?(SDDN48)**	CO3
Q.10	Write procedure for design of Calendria type evaporator	CO3
Q.11	Describe advantages and disadvantages of Double Pipe Heat Exchangers.	CO3
	Unit-IV	
Q.1	Explain design variables in distillation	CO4
Q.2	Write short note on: i) Smoker equation ii) Plate pressure drop	CO4
Q.3	Give comparison of plate contactor used in plate distillation column.	CO4
Q.4	Give equations for down corner back-up and plate pressure drop (in terms of head) & explain all the terms.	CO4
Q.5	What is the effect of the following on plate column design: plate spacing, weir height, vapour velocity and down comer backup.	CO4
Q.6	Explain the following method of calculating plate and column efficiencies. i) AIChE method ii) Van winkles method	CO4
Q.7	Give the AIChE method for prediction of plate efficiency.	CO4
Q.8	Compare the performance of different types of plates.	CO4
Q.9	Explain down comer backup and its effect with relevant equations.	CO4
Q.10	Explain in which cases packed columns are preferred over plate columns.	CO4
Q.11	Explain the AICHE method. What factors affect efficiency?	CO4
Q.12	Describe the total plate pressure drop for the plate column in distillation.	CO4
Q.13	What is the function of weir on a plate and what is effect of weir height on column performance?	CO4
Q.14	What are the different design methods for binary systems? Explain any one in detail.	CO4
Q.15	Explain the estimation of packed bed height for an absorption column with all the relevant equations. Discuss the general guidelines for the choice between plate and packed columns.	CO4
Q.16	Describe the Van Winkle method for predicting plate efficiency.	CO4
Q.17	Describe in brief internal components of packed absorption column with neat diagrams.	CO4
Q.18	Draw a neat sketch of a sieve plate performance diagram.	CO4
Q.19	Calculate the column diameter for a sieve plate column with the following specification for an acetone-water system. Maximum feed rate: 10,500kg/h, Minimum feed rate70% of maximum Number of stages: 15 Slope of the bottom operating line: 5.0 slope of top operating line:0.57 Top product composition: 94 mol%, Bottom product Composition Essentially water, Reflux Ratio: 1.35 Column efficiency: 60% At bottom conditions: Vapour Density: 0.72 Kg/m^3, Liquid Density: 954 Kg/m^3 Surface tension: 0.057Nm k_1: 0.075 For top conditions: Vapour Density: 2.05 Kg/m^3, Liquid Density: 753 Kg/m^3 Surface tension: 0.023N/m, k_1:0.09	CO4

Q.20	A sieve plate column is to be designed for the separation of a dilute aqueous Feed. The following data is available: **(RC VI)** Maximum feed rate 10,000 kg/h Minimum feed rate 70% of maximum Number of stages 17 Slope of the bottom operating line 5.0, Slope of top operating line 0.57 Top product composition 94 mol%, Bottom Product Composition Essentially water Reflux Ratio 1.5, Column efficiency 60% At bottom conditions: Vapour Density 0.72 kg/m^3, Liquid Density 954 kg/m^3 Surface tension 0.057 Nm, $K_1 = 0.075$ For top conditions: Vapour Density 2.05 kg/m3, Liquid Density 753 kg/m^3 Surface tension 0.023 Nm K_1= 0.09, K_2 = 30.6 Thickness of plate/hole dia. = 1 Ah/Ap = Ah/Aa = 0.1 C_0 = 0.84 Check for weeping, plate pressure drop, down comer back-up entrainment.	CO4
Q.21	Find the diameter of the plate column for the following: **(RC VI)** System: Acetone - water distilled to recover acetone. Minimum feed rate to the column = 9100 kg/h, Turn down ratio = 70% Molar feed rate = 673 kmol/h No. of ideal stages = 16 Slope of bottom operating line = 5.0, Slope of top operating line = 0.57 Top composition = 94 mol% acetone, Bottom composition = essentially water Reflux ratio = 1.35 Vapour rate at the top = 55.5 kmol/h., Vapour rate at the bottom = 162.3 kmol/h. At the bottom ρ; V = 0.73 kg/m^3, L = 954 kg/m^3 Bottom pressure = 1.26 bar, Liquid surface tension = 57×10^{-3} N/m At the top : ρ; V = 2.05 kg/m^3, L = 754 kg/m^3, Pressure = 1 bar, Surface tension = 23×10^{-3} N/m Assume tray spacing = 0.5m K_1 bottom = 7.5×10^{-2}, K_1 top = 9×10^{-2}	CO4
Q.22	A mixture of benzene and toluene containing 50 mole% benzene is to be continuously distilled in a plate column, to give distillate containing 90 mole% benzene and bottom product containing 90 mole % toluene. The feed enters the column @10,000 kg/day. The relative volatility is 2.28 and the reflux ratio is 1.5 times the minimum. If the overall plate efficiency is 0.75 calculate the actual number of plates required. Find the column height if plate spacing in 450 mm.	CO4
	Unit-V	
Q.1	Explain design procedure with equations for packed column in details.	CO5

Q.2	Explain packing support, liquid distributors, and liquid redistributors in the column internals with neat sketch.	CO5
Q.3	Discuss on choice of plate or packing’s in distillation column for separation	CO5
Q.4	Explain cornell’s method for prediction of height of transfer units in details.	CO5
Q.5	Give Cornell’s method for calculating height of transfer unit based on gas and liquid phase.	CO5
Q.6	Explain Onda’s method for prediction of height of transfer units	CO5
Q.7	Give reasons why channelling and bypassing may occur in a packed column.	CO5
Q.8	What is the effect of size of packing on the performance of packed column?	CO5
Q.9	What are liquid distributors, their types & function?	CO5
Q.10	Explain the use of hold - down plate in packed column.	CO5
Q.11	Explain the difference between random packing and structured packing	CO5
Q.12	In which method for estimation of H_{OG} for a packed column is wetted area considered? Give details.	CO5
Q.13	Write about column internals.	CO5
Q.14	How does channelling and bypassing occur in a packed column? What are its ill effects? How can they be rectified?	CO5
Q.15	Explain the characteristics & functioning of Liquid distributors. ii) Liquid redistributors. iii) Supports for packing’s.	CO5
Q.16	Write in short about i) Installation of packing ii) Liquid hold - up and iii) Wetting rates iv) Hold - down plate.	CO5
Q.17	What is the significance of mGm/Lm in the design of packed column.[	CO5
Q.18	What are the effects of liquid distribution in packed column?	CO5
Q.19	Estimate using Onda's method using the following data: **(RC VI)** Liquid Flow rate 16.6 kg/m^{2}s, Gas flow rate 0.79 kg/m^{2}s Critical surface tension 0.06 N/m, Surface tension for liquid 0.07 N/m Viscosity of liquid 0.001 Nm/s2, Interfacial area (a) 194 m^2/m^3 Density of liquid : 990 kg/m^3, Temperature: 20^{O}C, Pressure:1.013, ρ_v = 1.21 kg/m^3 Diffusivity in liquid: 1.7 x 10^{-9}m^2/s, Diffusivity in gas: 1.45 x 10^{-5}m^2/s Diameter of packing material: 38mm, k_5:5.23 Viscosity of gas: 0.018 x 10^{-3} Ns/m^2 Molecular weight of liquid: 18, Molecular weight of gas: 29	CO5
Q.20	Estimate the height of packing using Cornell’s Method with the help of following data: Number of transfer unit N_{OG}= 8 **(RC VI)** The liquid mass flow rate (L^*_w) = 16.7 kg/m^{2}s Diffusivity D_L = 1.7 x 10^{-9}m^2/s and D_v = 1.45 x 10^{-5} m^2/s Viscosity μ_v = 0.018 x 10^{-3} Ns/m^2 and μ_L = 1 x 10^{-3} Ns/m^2 Density ρ_L = 1000kg/m^3 and ρ_v = 1.21kg/m^3 With 60 % flooding condition, K_3 = 0.85, H_G Factor Ψ_h = 80 and φ_h = 0.1 ,Dc =2.3	CO5

Q.21	Estimate H_{OG} using Cornell's Method. **(RC VI)** Data: $D_L = 1.9 \times 10^{-9}$ m^2/s; $D_V = 1.6 \times 10^{-5}$ m^2/s $\mu_V = 0.015 \times 10^{-3}$ Ns/m^2, $\mu_l = 1 \times 10^{-3}$ Ns/m^2 $L_W* = 16$ kg/s.m^2 ; K_3 (60% flooding) = 0.85 $\psi_h = 80$, $\varphi_h = 0.1$ $N_{OG} = 8$; $\rho v = 1.3$ kg/m^3, $M_{avg} = 29$, $\rho_L = 998$ kg/m^3 , $D_C = 1.5$m. The liquid phase is assumed to have water - like properties.	
Q.22	Calculate the column diameter for a packed column using the following data: Gas flow rate = 4500 kg/h. m L_m /G_m 0.5 0.6 0.7 0.8 0.9 1.0 NOG 4.8 5.2 6.5 8 10. 8 19 FP = 170 m–1 $\mu_L = 1 \times 10^{-3}$ Ns/m^2 Operating temperature = 25ºC. K_4 at operating pressure drop of 20 mm of H_2 O/m of packing = 0.35 At flooding K_4 = 0.8 Assume gas properties same as air & liquid properties same as water.	CO5
	Unit-VI	
Q.1	Write the equations & design considerations for natural gas pipe line.	CO6
Q.2	What are the various types of supports used for piping?	CO6
Q.3	Give the design considerations in condensate pipeline.	CO6
Q.4	Water flows through a pipeline @ 1 kg/s., over a distance of 2 km. The impressed head of water = 9.8 m. What is the diameter of pipeline if ρ = 1000 kg/m^3 & μ = 1 mNs/m^2 [Dawande]	CO6
Q.5	Water flows through a pipeline @ 1 kg/s., over a distance of 2 km. The impressed head of water = 9.8 m. What is the diameter of pipeline if ρ = 1000 kg/m^3 & μ = 1 mNs/m^2	CO6
Q.6	How is appropriate material selection important for piping? Explain with example.	CO6
Q.7	What are the different types of gaskets?	CO6
Q.8	Write short notes on Material for corrosion resistance Pipe fittings Pipe supports Gasket Types, material and selection criteria	CO6
Q.9	What are codes and standards and their importance in piping design	CO6
Q.10	Explain the pipeline design for transportation of crude oil.	CO6
Q.11	Write a note on non-stream heating systems using thermic fluids.	CO6
Q.12	Why are standards required? Name a few standards followed in piping design.	CO6
Q.13	Explain Pipe line networks and their analysis for flow in branches	CO6
Q.14	Explain the factors which affect orifice size in a pipeline.	CO6
Q.15	Explain in brief design of a pipeline on the basis of fluid dynamic parameters.	CO6

Chemical Engineering Design (409343)

List of Practical:

Expt. No.	Name of Experiment	CO Mapped
1	Design of Reaction Vessel	CO1
2	Design of Shell and Tube Heat Exchanger	CO3
3	Design of Evaporator	CO3
4	Design of Various types of vessel support	CO2
5	Design of Agitator	CO1
6	AutoCAD Drawing	
7	AutoCAD Drawing	
8	AutoCAD Drawing	

Course: 04

Environmental Engineering

(409344)

B.E. Chemical (2019 Pattern)

[Theory]

Chemical Engineering Department

Course Syllabus

Environmental Engineering (409344)

Unit I: Introduction (7 h)

An over view of environmental engineering, pollution of air, water and soil, impact of population growth on environment, environmental impact of thermal, hydro and nuclear energy, chemical pollution ,solid wastes, prevention and control of environmental pollution, water and air pollution laws and standards ,clean development mechanisms (CDM), Kyoto protocol.

Unit II: Air Pollution- Sources, Effects and Measurement (7 h)

Definition of air pollution, source scales of concentration and classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, Economic effects of air pollution, sampling and measurement of air pollutants, air pollution control standards: WHO, BIS, MPCB, CPCB.

Unit III: Air Pollution Control Methods and Equipment (7 h)

Particulate pollution: cleaning methods, collection efficiency, particulate collection systems, Basic design and operating principles of settling chamber, cyclone separator, fabric filter, electrostatic precipitator. Operating principles of spray tower, centrifugal scrubber, venturi scrubber, selection of particulate collector. Gaseous pollution: Principles of control by absorption, adsorption, combustion or catalytic oxidation, removal of SOx, NOx .Numerical problems based on the theory.

Unit IV: Water Pollution (7 h)

Domestic and industrial wastewater, types, sources and effects of water pollutants .Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colorant odor, bacteriological quality, oxygen deficit, determination of BOD constants. Water quality standards: ICMR, WHO, MPCB and CPCB.

Unit V: Waste water Treatment (7 h)

Principles of primary treatment and secondary treatment, process design and basic operating principles of activated sludge (suspended growth) process, sludge treatment and disposal, trickling filter. Advanced methods of wastewater treatment: UASB, photo catalytic reactors, wet-air oxidation, and biosorption.

Unit VI: Tertiary Water Treatment and Solid Waste Management (7 h)

Tertiary treatment: disinfection by chlorine, ozone and hydrogen peroxide, UV rays, recovery of materials from process effluents, micro-screening, biological nitrification and denitrification,granularmediumfiltration.LandPollution:Sourcesandclassificationofsolid wastes, disposal methods, incineration, composting, recovery and recycling.

Reference Books:

1. Rae C. S. “Environmental Pollution Control Engineering”, Wiley Eastern
2. Publications.
3. Metcalf and Eddy “Waste water Engineering”, Tata McGraw Hill Publishers.
4. Mahakam S.P. “Pollution Control in Process Industry”, Tata McGraw Hill Publishers
5. J.C.Mycock, John. McKenna, Louis Theodore “Handbook of Air Pollution Control
6. Engineering and Technology”.
7. FlaganR.C.and SeinfieldJ.H. “Fundamentalsof Air Pollution Engineering”Prentice-Hall,Inc. , Englewood Cliffs, New Jersey.
8. PeavyH.S.and RoweD.R.and TchobanoglousG.“Environmental Engineering”
9. McGraw-Hil International Ed., 1985,
10. Martin Crowford “Air Pollution Control theory”McGraw-Hill Inc.,US.
11. Stern “Air Pollution”, Vol.-Iand Vol.-II, 2ndEdition, Academic Press, New York.
12. G. Kiely, Environmental Engineering, McGraw Hill1997.

Chemical Engineering Department

BE Chemical

409344: Environment Engineering

Teaching Scheme: Lectures: 3 Hrs/ Week	**Examination Scheme:** Paper: (30+70) 100 Marks In semester Assessment: 30 Marks End Semester Assessment: 70 Marks. **Credits:** Theory: 3 Total: 3 Credits

Course Outcomes (Cos Environment Engineering)

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C409344.1	Understand the fundamental knowledge of pollutions, pollution laws and standards.	**2**	**Understand**
C409344.2	Ability to understand and analyses the air pollution sources, effects, measurements control methods and equipment.	**4**	**Analyze**
C409344.3	Ability to understand analyze the basic parameters of water and wastewater and their control and regulations to develop guidelines, procedures and processes for health and safety issues while working as chemical engineer.	**3,4**	**Apply , Analyse**
C409344.4	To acquaint the students about recognize tertiary water treatment and solid waste management and know about land pollution.	**3**	**Apply**

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX															
COs	PROGRAM OUTCOMES (POs)												PSO		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	3	2	1				1						2	1	
2	3	2	2				2						3	2	
3	3	1	-				2						3	2	
4	3	2	2				1						2	2	

Levels: 3 for $\geq$60 ; 2 for < 60 $\geq$ 40; 1 for < 40

COAssessmentTools

Course Outcomes (CO)	Assessment Tools							
	Continuous Internal Evaluation, CIE					CIE by SPPU, Pune	Semester End Exam (SEE) by SPPU, Pune	
	T1	**T2**	**T3**	**Assignment**	**PR**	**Insem**	**OR**	**Endsem**
C444.1	√			√		√		
C444.2	√			√		√		
C444.3		√		√				√
C444.4		√		√				√

Teaching Plan

Environmental Engineering (409344)

Teaching Scheme:
Theory: 03 h/week

Examination Scheme:
Insem: 30
Endsem:70 Credit = 3

Lect No.	Topics / Sub- Topics	CO mapped
	Subject Orientation	
1	**Unit-I- Introduction-** An overview of environmental engineering	CO1
2	Pollution of air, water and oil.	CO1
3	Impact of population growth open environment, environmental impact of thermal, hydro and nuclear energy,	CO1
4	Chemical pollution, solid wastes.	CO1
5	Prevention and control of environmental pollution	CO1
6	Water and air pollution laws and standards	CO1
7	Cleaned development mechanisms (CDM), Kyoto protocol	CO1
8	Innovative teaching methods	CO1
9	**Unit-II- Air Pollution- Sources, Effects and Measurement:** Definition of air pollution.	CO2
10	Sources scales of concentration and classification of air pollutants.	CO2
11	Effects of air pollutants on human health, plants, animals, materials.	CO2
12	Economic effects of air pollution.	CO2
13	Sampling and measurement of air pollutants	CO2
14	Air pollution control standards: WHO, BIS	CO2
15	Air pollution control standards: MPCB, CPCB	CO2
16	Innovative teaching methods	CO2
17	**Unit-III – Air Pollution Control Methods and Equipment -** Particulate pollution: cleaning methods.	CO3
18	Collection efficiency, particulate collection systems	CO3
19	Basic design and operating principles of settling chamber, cyclone separator.	CO3
20	Fabric filter, electrostatic precipitator. Operating principles of spray tower	CO3
21	Centrifugal scrubber, venturi scrubber, selection of particulate collector	CO3
22	Gaseous pollution: Principles of control by absorption, adsorption, combustion or catalytic oxidation	CO3
23	Removal of SOx, NOx. Numerical problems based on the theory	CO3
24	Innovative teaching methods	CO3
25	**UNIT-IV-Water Pollution** Domestic and industrial waste water.	CO4
26	Types, sources and effects of water pollutants.	CO4
27	Waste water characteristics–DO, BOD, COD, TOC	CO4
28	Total suspended solids, color and odor,	CO4

29	Bacteriological quality, oxygen deficit, Determination of BOD constants	CO4
30	Water quality standards :ICMR, WHO, MPCB and CPCB	CO4
31	Water quality standards :MPCB and CPCB	CO4
32	Innovative teaching methods	CO4
33	**UNIT-V-Wastewater Treatment** – Principles of primary treatment.	CO5
34	Principles of secondary treatment, process design	CO5
35	Basic operating principles of activated sludge(suspended growth)process,	CO5
36	Sludge treatment and disposal, trickling filter.	CO5
37	Advanced methods of wastewater treatment: UASB	CO5
38	Advanced methods of waste watert treatment: Photo catalytic reactors, wet-air oxidation, and bio sorption	CO5
39	Advanced methods of waste water treatment: Wet-air oxidation, and bio sorption	CO5
40	Innovative teaching methods	CO5
41	**Unit-VI-Tertiary Water Treatment and Solid Waste Management-** Tertiary treatment.	CO6
42	Disinfection by chlorine, ozone and hydrogen peroxide	CO6
43	Disinfection by UV rays, recovery of materials from process effluents.	CO6
44	Recovery of materials from micro-screening, biological nitrification and denitrification.	CO6
45	Granular medium filtration. Land Pollution: Sources and classification of solid wastes.	CO6
46	Solid wastes: Disposal methods, incineration,	CO6
47	Solid wastes: Composting, recovery and recycling.	CO6
48	Innovative teaching methods	CO6

Question Bank

Environment Engineering (409344)

	Unit-I	
Q.1	What is water pollution? Discuss the causes and effects.	CO1
Q.2	What is soil pollution? Discuss the causes and effects.	CO1
Q.3	What is impact of population growth on environment?	CO1
Q.4	What is prevention and control of environmental pollution?	CO1
Q.5	What are water and air pollution laws and standards?	CO1
Q.6	Explain clean development mechanisms (CDM).	CO1
Q.7	Give the classification of air pollutants along with suitable examples.	CO1
Q.8	Classify various sources of air pollutants and discuss the control methods for each of them. Give examples.	CO1
	Unit-II	
Q.1	Define air pollution? Discuss the causes and effects.	CO2
Q.2	Explain the sources scales of concentration and classification of air pollutants.	CO2
Q.3	What are the effects of air pollutants on human health, plants and animals?	CO2
Q.4	Explain economic effects of air pollution.	CO2
Q.5	Enumerate and explain the sampling and measurement of air pollutants.	CO2
Q.6	What are the air pollution control standards?	CO2
Q.7	Explain the terms WHO, BIS, MPCB, CPCB.	
	Unit-III	
Q.1	Enumerate and explain the mechanism used in removal of particulate matter from gas stream.	CO3
Q.2	Explain the working and the principle of a cyclone separator with a suitable diagram.	CO3
Q.3	Give the advantages and disadvantages of a cyclone separator and give its application.	CO3
Q.4	What is a fabric filter? Give its classification and explain fiber characteristics.	CO3
Q.5	With a neat sketch explain the principle, construction and working of an electrostatic precipitator along with its advantages and disadvantages.	CO3
Q.6	What do you understand by wet gas scrubbing and where is it used?	CO3
Q.7	Name widely used scrubbers in industries.	*CO3*
	Unit-IV	*CO*
Q.1	Differential between Domestic and industrial wastewater.	CO4
Q.2	Explain the types and sources of water pollutants	CO4

Q.3	What are the effects of water pollutants on environment?	CO4
Q.4	Explain the waste water characteristic.	CO4
Q.5	What is meant by DO, BOD, COD, TOC?	CO4
Q.6	What is meant by total suspended solids?	CO4
Q.7	Explain how determine the BOD constants.	CO4
	What is meant by ICMR, WHO, MPCB and CPCB	
	Unit-V	
Q.1	What is the difference between absorption and adsorption?	CO5
Q.2	Explain the term trickling filter.	CO5
Q.3	Explain in details UASB.	CO5
Q.4	Explain in details photo catalytic reactors.	CO5
Q.5	Explain in details wet-air oxidation, and biosorption	CO5
Q.6	Explain difference between physical adsorption & chemical adsorption.	CO5
Q.7	Define salient features of adsorption process.	CO5
Q.8	What is operating adsorption efficiency and its usual range?	CO5
	Unit-VI	
Q.1	What is meant by Tertiary treatment? Explain with example.	CO6
Q.2	What do you understand disinfection by chlorine, ozone and hydrogen peroxide.	CO6
Q.3	What do you understand disinfection by hydrogen peroxide, UV rays.	CO6
Q.4	Explain the term de nitrification. With example.	CO6
Q.5	What is meant by granular medium filtration?	CO6
Q.6	What is land pollution?	CO6
Q.7	Write sources and classification of solid wastes.	CO6
Q.8	Explain the Ion exchange process for wastewater.	CO6
Q.9	What is meant by Tertiary treatment? Explain with example.	CO6

Course: 05

Chemical Process Synthesis

(409341)

B.E. Chemical (2019 Pattern)

[Theory]

Course Syllabus

Chemical Process Synthesis (409345A)

Unit I: Introduction to Chemical Process Design (6h)

Introduction, approach to process development, development of new process, different considerations, development of particular process, overall process design, hierarchy of process design, onion model, approach to process design.

Unit II: Choice of Reactor (7h)

Reaction path, types of reaction systems, reactor performance, idealized reactor models, reactor concentration, temperature, pressure, phase, catalyst.

Unit III: Choice of Separator (7h)

Separation of heterogeneous mixtures, separations of homogeneous mixtures, distillation, azeotropic distillation, absorption, evaporation, drying etc

Unit IV: Distillation Sequencing (7h)

Distillation sequencing using simple columns, heat integration of sequences of simple distillation columns, distillation sequencing using thermal coupling, optimization of reducible structure.

Unit V: Heat Exchanger Network and Utilities (7h)

Energy targets, composite curves, heat recovery pinch, threshold problems, problem table algorithm, process constraints, utility selection, furnaces, combined heat and power, integration of heat pump, integration of refrigeration cycles, overall heat exchanger network and utilities.

Unit VI: Safety and Health Considerations (6h)

Fire, explosion, toxic release, intensification of hazardous materials, attenuation of hazardous materials, quantitative measures of inherent safety, overall safety and health considerations.

Reference Books:

1. Chemical process design- Robin Smith, Wiley.
2. Conceptual design of chemical process-James Douglas, McGraw Hill Book Company.
3. Unit process in organic synthesis – P.H. Groggins, Tata McGraw Hill Publishing Company Ltd.
4. Dryden’s Outline of Chemical Engineering, Rao and M Gopala, East-West Press.

Chemical Engineering Department

BE Chemical

409345A: Chemical Process Synthesis

Teaching Scheme: Lectures: 3 Hrs/ Week	**Examination Scheme:** Paper: (30+70) 100 Marks In semester Assessment: 30 Marks End Semester Assessment: 70 Marks. **Credits:** Theory: 3 Total: 3 Credits

Course Outcomes (COsProcess Dynamics and Control

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C409345.1	Understand the basic fundamental knowledge of Chemical Process design and development of new process.	2	Understand
C409345.2	Apply the knowledge of selection methodology to correct choice of chemical reactors and separators during synthesis of new process.	2	Creating
C409345.3	Apply suitable concept of distillation sequencing, heat integration and thermal coupling of distillation columns and to understand the methodology of overall heat exchanger network and utilize.	2	Apply
C409345.4	Apply relevant knowledge of overall safety and health considerations of design and development of new process with examples.	2	Apply
C409345.5	Design of new process by applying the process synthesis knowledge for new products.	3	Design

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX															
COs	PROGRAM OUTCOMES (POs)												PSO		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	3	2	3	3	1	-	-	-	-	-	-	-	3	2	1
2	3	2	3	2	1	-	-	-	-	-	-	-	3	2	1
3	2	2	1	2	1	-	-	-	-	-	-	-	3	3	1
4	2	2	1	2	1	-	-	-	-	-	-	-	2	2	1
5	2	2	2	3	1	-	-	-	-	-	-	-	2	2	1

Levels: 3 for $\geq$60 ; 2 for < 60 $\geq$ 40; 1 for < 40

COAssessmentTools

Course Outcomes (CO)	Assessment Tools							
	Continuous Internal Evaluation, CIE					CIE by SPPU, Pune	Semester End Exam (SEE) by SPPU, Pune	
	T1	T2	T3	Assignment	PR	Insem	OR	Endsem
C445.1	√	--	--	√	--	√	--	-- --
C445.2	√	--	--	√	--	√	--	--
C445.3	--	√	--	√	--	--	--	√
C445.4	--	√	√	√	--	--	--	√
C445.5	--	--	√	√	--	--	--	√

Chemical Engineering Department

Teaching Plan

Chemical Process Synthesis (409345A)

Teaching Scheme:
Theory: 03 h/week

Credit = 3

Examination Scheme:
Insem: 30
Endsem: 70

Lect No.	Topics / Sub- Topics	CO mapped
1	Introduction, Approach to process development	1
2	Development of new process, different considerations	1
3	Development of particular process, overall process design	1
4	Hierarchy of process design	1
5	Onion model	1
6	Approach to process design.	1
7	Reaction path	2
8	Types of reaction systems	2
9	Reactor performance	2
10	Idealized reactor models	2
11	Reactor concentration	2
12	Temperature, pressure	2
13	Phase and catalyst	2
14	Separation of heterogeneous mixtures	3
15	Separations of homogeneous mixtures	3
16	Distillation	3
17	Azeotropic distillation	3
18	Absorption	3
19	Evaporation	3
20	Drying	3
21	Distillation sequencing Introduction	4
22	Distillation sequencing using simple columns	4
23	Heat integration of sequences	4
24	Heat integration of sequences	4
25	Simple distillation columns	4
26	Distillation sequencing using thermal coupling	4
27	Optimization of reducible structure	4
28	Energy targets, composite curves, , ,	4
29	Process constraints, utility selection,	4
30	Problem table algorithm	4
31	Furnaces	4
32	Integration of heat pump, combined heat and power	5
33	Integration of refrigeration cycles,	5
34	Overall heat exchanger network and utilities	5

35	Heat recovery pinch, threshold problems,	5
36	Safety in Chemical Plant	5
37	Fire explosion	5
38	Toxic release	5
39	Intensification of hazardous materials	5
40	Attenuation of hazardous materials	5
41	Quantitative measures of inherent safety	5
42	Overall safety and health considerations	5

Question Bank

Chemical Process Synthesis (409345A)

	Unit-I	**CO**
Q.1	What are the different considerations in process design?	CO1
Q.2	Write short note different considerations in development of new process.	CO1
Q.3	Explain Hierarchy of process design.	CO1
Q.4	Explain in brief overall process design.	CO1
Q.5	Explain the concept of Onion Model.	CO1
Q.6	Write in brief different steps involved in process design	CO1
Q.7	What are the different approaches to process design?	CO1
Q.8	Write note on process synthesis	CO1
	Unit-II	
Q.1	Discuss idealized reactor model.	CO2
Q.2	Explain in short different parameters in choice of reactor.	CO2
Q.3	Explain the effect of following parameters on choice of reactor: a) Time b) material of construction.	CO2
Q.4	Explain idealized reactor model for ideal batch reactor, mixed and plug flow reactor.	CO2
Q.5	Explain the role of temperature and catalyst in reactor performance.	CO2
Q.6	Explain in detail different Reaction paths during choice of reactors.	CO2
Q.7	Explain different types of reaction systems in choice of reactors.	CO2
Q.8	Explain the effect of following parameters on choice of reactor: a) Phase b) Catalyst C) Pressure d) Temperature.	CO2
	Unit-III	
Q.1	Explain evaporation with suitable example.	CO3
Q.2	Explain absorption with suitable example.	CO3
Q.3	Explain steam distillation with suitable example.	CO3
Q.4	Explain Azeotropic distillation with suitable example.	CO3
Q.5	Explain the following: a) Electrostatic Precipitation. b) Flotation.	CO3
Q.6	Explain fractional distillation with suitable example.	CO3
Q.7	Write notes on following for separation of mixtures: a) Filtration b) Flotation.	CO3
Q.8	Discuss various types of dryers.	CO3
	Unit-IV	
Q.1	Write short note on Process Constraints	CO3
Q.2	Write short note on Furnace	CO3

Q.3	Explain the composite curves. Write down a simple heat recovery problem with one hot stream and one cold stream.	CO3
Q.4	Explain threshold problems in heat exchanger network.	CO4
Q.5	Discuss integration of refrigeration cycle.	CO4
Q.6	Explain threshold problems in integration of heat pump network.	CO4
	Unit-V	
Q.1	Explain the concept overall heat exchanger network and utilities.	CO4
Q.2	Explain the concept overall heat exchanger network and utilities.	CO4
Q.3	Explain the Problem Table Algorithm in Pinch technology.	CO4
Q.4	Explain the Problem Table Algorithm in Pinch technology.	CO4
Q.5	Explain with sketches the concept of heat integration of sequences of simple Distillation Column.	CO4
Q.6	Write short notes on Process constraints.	CO4
Q.7	Write short notes on Utility selection	CO4
Q.8	Write short note on Energy Targets	CO5
Q.9	Write short note on Composite Curves.	CO5
	Unit-VI	
Q.1	Write short notes on Fire Hazards in Chemical Industry.	CO5
Q.2	Write in brief on: Explosion hazard in Chemical industry	CO5
Q.3	Write short notes on Hazard triangle.	CO5
Q.4	Explain the attenuation of hazardous materials on human health.	CO5
Q.5	Write in brief role of safety engineer in chemical industry.	CO5
Q.6	Explain the attenuation of hazardous materials on human health.	CO5
Q.8	Effect of toxic release on society	CO5

Course: 06

Computer Aided Chemical Engineering-II

(409346)

B.E. Chemical (2019 Pattern)

[Practical]

Chemical Engineering Department

Course Syllabus

Computer Aided Chemical Engineering-II (409346)

Minimum 10 Practical Assignments must be completed using computational as well as simulation softwares. **Aspen plus**, ***Hysys, ChemCAD, EnviroPro, ANSYS, Mathcad, Matlab, Unisim, DWSim etc***. can be used for solving practical assignments.

1. Computer program for solving basic linear algebra involving matrix operations
2. Computer program for solving non-linear algebraic equation/s
3. Computer program for solving steady state staged operation (distillation, gas absorption, L-L extraction, etc.)
4. Computer program for solving un-steady state staged operation (distillation, gas absorption, L-L extraction, etc.)
5. Computer program for plotting P-x-y and T-x-y diagram
6. Computer program for design of reactor/ heat exchangers, distillation column/or any chemical equipment
7. Computer program for solving ODE or PDE using finite difference method
8. Simulation of mass transfer equipment using simple and rigorous methods
9. Simulation of product synthesis using different reactors
10. Simulation of steady state flow sheet synthesis
11. Simulation of dynamic flow sheet synthesis
12. Simulation of fluid flow problems with or without heat/mass transport

Chemical Engineering Department

BE Chemical

409346: Computer Aided Chemical Engineering-II

Teaching Scheme: Practicals: 2 Hrs/ Week	**Examination Scheme:** Term Work: 50 Marks. **Credits:** Practical: 1 Credit

Course Outcomes (COs) Computer Aided Chemical Engineering-II

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C446.1	Formulate and analyze the engineering problems by using process software.	**4**	**Analyze**
C446.2	Illustrate the effects of design operating parameters on the process simulation and interpretation of the experimental data	**3**	**Illustrate**

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX															
COs	PROGRAM OUTCOMES (POs)												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C446.1	2	3	-	1	3	-	-	-	-	-	-	1	2	3	3
C446.2	2	1	-	3	3	-	-	-	-	-	-	1	2	3	3
Total	4	4		4	6	-	-	-	-	-	-	2	4	6	6
Total Wt	6	6		6	6	-	-	-	-	-	-	6	6	6	6
% Mapping	66.6	66.6		66.6	100	-	-	-	-	-	-	33.3	66.67	100	100
C449	2	2		2	3	-	-	-	-	-	-	1	2	3	3

Chemical Engineering Department

List of Practical

Computer Aided Chemical Engineering-II (409346)

Expt. No.	Name of Experiment	CO Mapped
1.	Simulation of steady state flow sheet in DWSIM	CO1
2.	TP-xy diagram of binary mixtures in DWSIM	CO1
3.	Absorption column simulation using DWSIM	CO2
4.	Distillation column simulation in DWSIM	CO2
5.	Shell & Tube Heat Exchanger in DWSIM	CO2
6.	Simulation of flash drum DWSIM	CO2
7.	CSTR simulation	CO2
8.	PFR simulation	CO2
9.	Solving ODE using finite difference method	CO1
10.	Solving Basic Linear Algebra using matrix operation	CO1
11.	Process Flow sheet synthesis in Hysis	CO1
12.	Introduction to CHEMCAD and Physical Properties	CO1

Course: 07

Project Stage-I

(409347)

B.E. Chemical (2019 Pattern)

[Practical]

Chemical Engineering Department

Course Syllabus

Project Stage-I (409347)

The department should display the list of approved teachers (guides) along with the project titles proposed by them. The students should be given liberty to choose the project area and project guide of their own choice. The student can also choose a state-of-the-art problem of their own interest based on the recent trends in Chemical Engineering / Science in consultation with the guide. They shall work on the designated problem either individually or in groups.
During the first term the students are required to:
1. Define the research problem.
2. Write a *research proposal*, which should contain –
a. Project title
b. Introduction
c. Origin of the problem
d. Literature review of research and development at national & international level
e. Significance of the problem
f. Objective
g. Methodology
h. Details of collaboration (if any)
3. Carry out *preliminary* experimental investigations or product design or process design etc.
4. Summarize the results (if any).

The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student at the mid of the term and should be **submitted along with project report** at the end of respective terms to the examiners as a supporting document for evaluation. Every student will be examined orally based on the topic of his/her project and relevant area to evaluate his understanding of the problem and the progress made by the student during the term. Students should submit a neatly typed and spiral bound *research proposal* at the end of the first term in the following format.
Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc.

Referencing style:
1. Guo J. X. and Gray D. G., Chiroptical behavior of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, M*acromolecules*, *22*, (1989), 2086.
(Reference numbers should be mentioned in the main text as a superscript)
The proposal should contain:
Page 1: The cover page - should mention: Project title, Name of the student, Name of the guide, Exam seat number and Year.
Page 2: Certificate
Page 3: Index
Page 4 onwards: Research proposal (as above), experimental investigation details and result if any. Last page: References
The department should prepare a template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports.
Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.
Note: The project guides are required to educate the students about antiplagiarism policy of SPPU and apply the same while doing the project.

Chemical Engineering Department

BE Chemical

409347: Project Stage-I

Teaching Scheme:	**Examination Scheme:**
Practicals: 4 Hrs/ Week	Term Work: 50 Marks. **Credits:** Practical: 2 Credit

Course Outcomes (COs) Project Stage-I

After successful completion of this course, students will be able to:

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C447.1	Conduct the research literature survey and to identify and formulate the engineering problem.	**2**	**Understand**
C447.2	Apply the mathematical concepts, science concepts, engineering concepts, management principles and engineering tools necessary to solve the identified engineering problem.	**3**	**Apply**

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX

COs	PROGRAM OUTCOMES (POs)												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C447.1	3	2	2	2	3	2	2	2	3	3	2	3	3	2	3
C447.2	3	3	2	2	3	2	2	2	3	3	2	3	3	3	3
Total	6	5	4	4	6	4	4	4	6	6	4	6	6	5	6
Total Wt	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
% Mapping	100	83.3	66.7	66.6	100	66.6	66.6	66.6	100	100	66.6	100	100	83.3	100
C447	3	3	2	2	3	2	2	2	3	3	2	3	3	3	3