Chemical Engineering
Academic Book

B.E. Chemical

(Semester-II)

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

- **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.

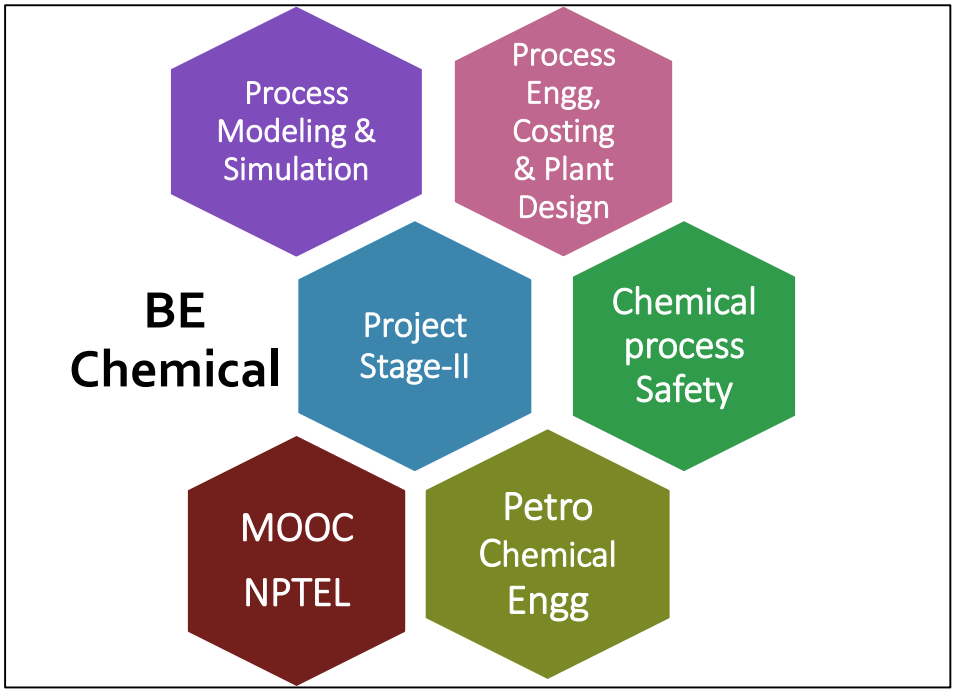
Program Educational Objectives (PEOs)

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						
409349	**Process Modeling and Simulation**	03	-	02	05	04
409350	**Process Engineering Costing & Plant Design**	03	-	02	05	04
419351	**Elective-V**	03	-	-	03	03
419352	**Elective-VI**	03	-	-	03	03
419353	**Project Phase- II**	-	-	12	12	06
409354	**Audit Course 8**	-	-	-	-	--



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 Modelling & Simulation

(409349)

[Theory & Practical]

Course Syllabus

Process Modelling and Simulation (409349)

Unit I: Introduction to Modeling **(6 h)**

Introduction, definition of modeling and simulation, different types of models, application of mathematical modeling, scope of coverage. Fundamental Laws : Continuity equation, energy equation, and equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics.

Unit II: Models in Fluid Flow Operations: **(7 h)**

The continuity equation, Flow through Packed bed column, Laminar Flow in narrow Slit, Flow of Film on the outside of circular tube, Momentum fluxes for creeping flow in to slot.

Unit III: Heat Transfer and other Equipments **(7h)**

Two heated tanks, double pipe heat exchanger, shell and tube heat exchanger, cooling towers Single effect and multi effect evaporators, agitated vessels, pressure change equipment, mixing process, fluid – solid operations.

Unit IV: Mass Transfer Equipments **(7 h)**

Flash distillation, differential distillation, and continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying equipments, adsorption, absorbers and strippers. Batch liquid- liquid extraction, continuous extraction, multistage counter current extraction, Mixer-Settler Extraction Cascades, Staged Extraction Columns.

Unit V: Reaction Equipment **(7 h)**

Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.

Unit VI: Applications of modelling and simulation **(6 h)**

Applications of modelling and simulation in distillation, Transient analysis of staged absorbers, unsteady state analysis in reactor system, Modelling and simulation of effluent treatment plant, Use of numerical methods to solve different models.

Reference Books:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, 1988.
2. Davis M. E., "Numerical Methods and Modeling for Chemical Engineers", Wiley, New York, 1984.
3. Finlayson B. A., "Nonlinear analysis in Chemical Engineering", McGraw Hill, New York, 1980.
4. Chapra S.C., R.P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications
5. Franks R.E.G., "Modeling and Simulation in Chemical Engineering", Wiley Intrscience, NY
6. John Ingam, Irving J. Dunn., "Chemical Engineering Dynamic Modeling with PC Simulation", VCH Publishers.
7. Kayode Coker A., "Chemical Process Design, Analysis and Simulation", Gulf Publishing Company.
8. Himmelblau D., K.B. Bischoff, "Process Analysis and Simulation", John wiley& Sons.
9. Wayne Blackwell, "Chemical Process Design on a Programmable Calculator", McGraw Hill.

Chemical Engineering Department

409349: Process Modelling and Simulation

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week Practical : 2 Hours / Week	In Semester: 30 End Semester: 70 Term Work: 25 Oral : 50 **Total: 175** **Credits: 3 + 1 = 4**

Course Outcomes (CO's) : Process Modeling and Simulation

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

Course Outcomes	Statements	Bloom's Taxonomy	
		Level	Descriptor
C449.1	Apply the mathematical modelling and fundamental laws governing to the models.	3	Apply
C449.2	Formulate the model equation of fluid flow, heat and mass transfer systems.	6	Formulate
C449.3	Develop the model equation to various chemical reactor systems.	6	Develop
C449.4	Analysis and development of solutions of the model equations by applying different numerical methods.	4	Analyse

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put "-"

CO/PO	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C449.1	3	2	1	2	2	-	-	-	-	-	-	2	3	1	1
C449.2	3	3	2	2	3	-	-	-	-	-	-	2	3	2	2
C449.3	3	3	2	2	3	-	-	-	-	-	-	2	3	2	2
C449.4	3	3	2	2	3	-	-	-	-	-	-	2	3	2	2
Sum	12	11	7	7	11	-	-	-	-	-	-	8	12	7	7
Total Wt	12	12	12	12	12	-	-	-	-	-	-	12	12	12	12
% Mapping	100	91.7	58.3	58.3	91.7	-	-	-	-	-	-	66.7	100	58.3	58.3
C449	**3**	**3**	**2**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**2**	**2**

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

Chemical Engineering Department

CO Assessment Tools

Course Outcomes (COs)	Assessment Tools								
	Continuous Internal Evaluation					Semester End Exam (SEE) conducted by SPPU Pune			
	T1	T2	T3	Assignment	CIE-Pr	OR	TW	Insem	Endsem
C449.1	√			√		√	√	√	
C449.2	√	√		√	√	√	√	√	√
C449.3			√	√	√	√	√		√
C449.4			√	√	√	√	√		√

Chemical Engineering Department

Process Modelling and Simulation (409349)

Teaching Plan

Teaching Scheme:
Theory: 03 h/week

Practical: 2 h / week

Examination Scheme:
Insem: 30
Endsem:70 : Credit = 3
PR: 100 : Credit = 2

Lect. No.	Topics / Sub- Topics	CO mapped
1	PO,PSO,CO & Subject orientation	-
2	**Introduction to Modeling:** Introduction, Different types of models	1
3	Applications, model building & continuity equation	1
4	Component continuity equation	1
5	Examples & Energy balance equation	1
6	Energy equation in CSTR & PFR	1
7	Equation of motion & examples, Transport equation, Equation of state, phase and chemical equilibrium& kinetics	1
8	Modeling Examples	1
9	Innovative teaching methods- Cross word puzzle	1
10	**Models in Fluid Flow Operations:** The continuity equation	2
11	Flow through Packed bed column	2
12	Laminar Flow in narrow Slit	2
13	Flow of Film on the outside of circular tube	2
14	Momentum fluxes for creeping flow in to slot.	2
15	Modeling Problems.	2
16	Innovative teaching methods- Flipped class room	2
17	**Heat Transfer and other Equipments :** Two heated tanks.	2
18	Double pipe heat exchanger.	2
19	Shell and tube heat exchanger.	2
20	Cooling towers.	2
21	Single effect and multi effect evaporators.	2
22	Agitated vessels, pressure change equipments.	2
23	Mixing process and Problems.	2
24	Fluid – solid operations and Problems.	2
25	Innovative teaching methods- Cross word puzzle	2
26	**Mass Transfer Equipments :** Flash distillation, Differential distillation.	2
27	Continuous binary distillation in tray and packed column, Vaporizers.	2
28	Single phase and multiphase separation, Multi-component separation.	2
29	Drying equipments, Adsorption.	2

30	Absorbers and strippers.	2
31	Batch liquid- liquid extraction, Continuous extraction, Multistage counter current extraction.	2
32	Mixer-Settler Extraction Cascades & Staged extraction column	2
33	Innovative teaching methods- Flipped Class Room	2
34	**Reaction Equipments:** Batch reactor, Semi batch reactor.	3
35	Continuous stirred tank reactor, Plug flow reactor.	3
36	Slurry reactor, Trickle bed reactor.	3
37	Bubble column reactor, Packed column reactor.	3
38	Bioreactors &Reactors used in effluent treatments	3
39	Fluidized bed reactor	3
40	Innovative teaching methods- Peer Teaching	3
41	**Applications of modeling and simulation** Applications of modeling and simulation in distillation.	4
42	Transient analysis of staged absorbers.	4
43	Unsteady state analysis in reactor system.	4
44	Modeling and simulation of effluent treatment plant.	4
45	Use of numerical methods to solve different models	4
46	Innovative teaching methods - Enquiry based learning	4
47	Review of University Question Papers	1-2
48	Review of University Question Papers	3-4

Question Bank

Process Modelling and Simulation (409349)

Unit-I

Que.No.1. Define Process model? Explain the concept of process modelling and simulation in short. Give the classification of model with examples. [CO1]

Que.No.2. Explain in short the four different phases of model building.[CO1]

Que.No.3. Draw a flow chart showing the steps in process modelling. Show the interrelations between the flow chart stages. Alongside each major step, list in brief, point the key issues for each major modelling task. [CO1]

Que.No.4 . Provide a classification of the major categories of equations in a Mechanistic process model. What are the subclasses in each major category? Outline how each of the classes of equations in interrelated.[CO1]

Que.No.5. Explain the terms - Lumped parameter system and distributed parameter system. Give example of each.[CO1]

Que.No.6. Explain various difficulties encountered during the mathematical modeling of the process. [CO1]

Que.No.7. Write the basic fundamental laws for process modelling and simulation. [CO1]

Que.No.8. Write the total continuity and component continuity equation of systems.[CO1]

Que.No.9. What do you mean by simulation? Explain.[CO1]

Que.No.10. Discuss why modeling assumptions are important in the building of a model.[CO1]

Que.No.11. What are limitations of mathematical models? Give examples.[CO1]

Que.No.12. Define modelling and explain the types of model and give the scope and applications of modelling.[CO1]

UNIT-II

Que.No.1. Discuss the momentum fluxes for creeping flow in to the slot. [CO2]

Que.No.2. Derive the model equation for laminar flow in narrow slit.[CO2]

Que.No.3. Derive the model equation of flow through packed bed column.[CO2]

Que.No.4. Discuss continuity equation.[CO2]

Que.No.5. Discuss the flow of film on the outside of circular tube.[CO2]

Unit-III

Que.No.1. Develop the mathematical model for single effect evaporator.[CO2]

Que.No.2. Derive the model equation for double pipe heat exchanger.[CO2]

Que.No.3. Develop the model equations of a double pipe heat exchanger wherein the resistance to heat transfer from a condensing fluid to inner fluid can be represented by convective heat transfer coefficients on both sides of the heat transfer wall. Assume that resistance for wall is negligible but the wall has finite heat capacity.[CO 2]

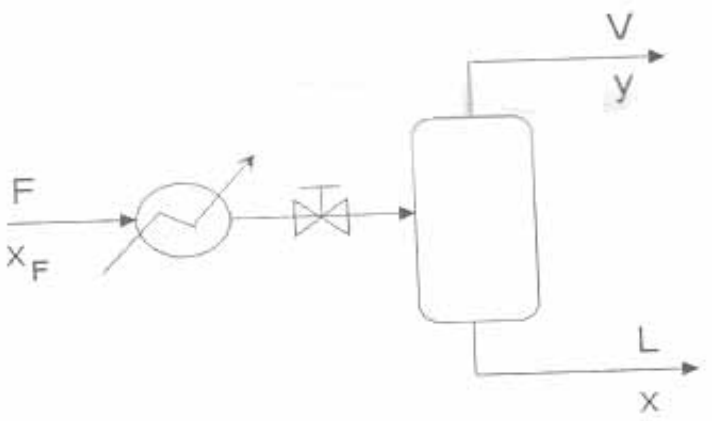
Que.No.4. Develop the modelling equation for the Shell and tube Heat Exchanger. Assume the necessary data and notations. [CO2]

Que.No.5. Explain the steady state model and Liquid phase dynamics model for LPG vaporizer with a neat diagram [CO2]

Unit-IV

Que.No.1. Derive the model equation for continuous binary distillation in tray and packed column.[CO2]

Que.No.2. Develop a model for Flash distillation column. Write modelling assumptions.[CO2]



Que.No.3. Derive a dynamic model for batch distillation column with another side column as shown in fig. A multi - component system is being separated. State the assumptions clearly.[CO2]

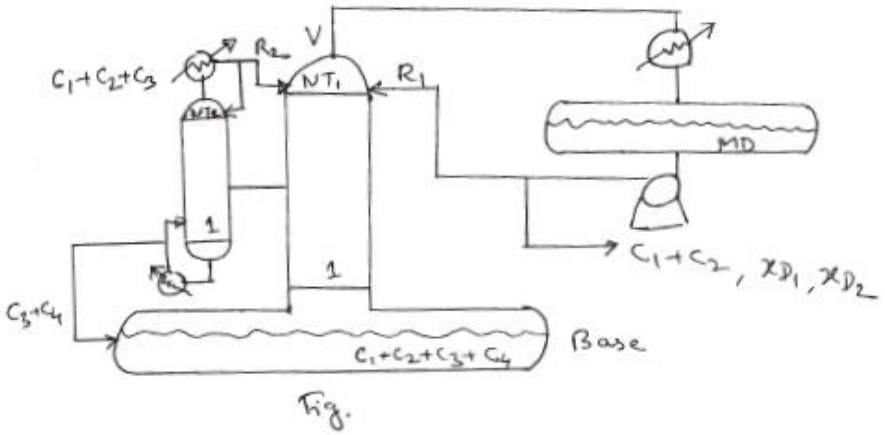


Fig.

Que.No.4. Develop the model equation for a direct heated counter current rotary dryer (continuous dryer) in which simultaneous heat and mass transfer takes place between gas phase and solid phase. In this dryer three zones exists, (i) Preheating zone (ii) Evaporation zone (iii) Reheating zone. In evaporation zone actual removal of water from wet solids takes place and solid surface remain at temperature equal to wet bulb temperature of gas.[CO2]

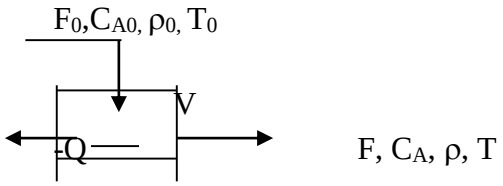
Que.No.5. Develop the state model for an ideal binary mixture of component A and B to be separated into two product streams using conventional distillation.[CO2]

Que.No.6. Consider an ideal binary distillation column and write all the model equations to describe the system.[CO2]

Que.No.7. Develop a model for counter current cooling tower with neat figure.[CO2]

Unit-V

Que.No.1. Consider the CSTR system shown in fig.1. The cooling coil inside the tank, that can remove the exothermic heat of reaction λ (cal/gmol of A reacted) . The rate of heat generation (energy per time) due to the reaction is the rate of consumption of A times λis $Q_G = -\lambda V C_A k$



Write the energy equation for the CSTR in which first order reaction occur with exothermic heats of reaction (λ). [CO3]

Que.No.2. A mixture of two miscible liquids is fed in to a decanter. The heavier liquid α settles to the bottom of the tank. The lighter liquid β forms a layer on the top. The two interfaces are detected by floats and are controlled by manipulating the two flows $F_\alpha$and F_β.

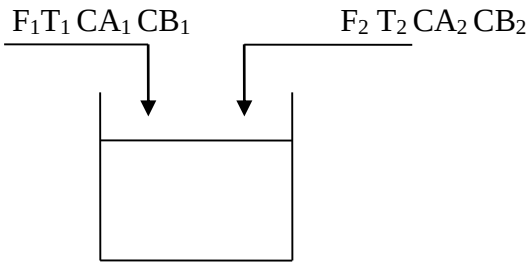
$$F_\alpha = K_\alpha h_\alpha$$

$$F_\beta = K_\beta(h_\alpha + h_\beta)$$

The controllers increase or decrease the flows as the levels rise or fall. The total feed rate is F_0 . The weight fraction of liquid α in the feed is x_α . The two densities $\rho_\alpha$and $\rho_\beta$are constant. Write the equations describing the dynamic behavior of this system. [CO3]

Que.No.3. Develop the state model for the batch mixing of two solutions. Initially the tank is empty. The volume of tank is V m^3. The flow rates are volumetric and the concentrations are in mol/vol.

a) How long does it take to fill up the tank.
b) Show how you would find the composition & temperature of the mixture in the tank during the same time that the tank is being filled up. Assume that the heat of solution depends on the composition.[CO3]



Que.No.4. As semi-batch reactor is run at constant temperature by varying the rate of addition of one of the reactants "A". The irreversible exothermic reaction is first order in reactants "A" & "B". The tank is initially filled to its 40% level with pure reactant "B" at a concentration C_{Bo}. Maximum cooling water flow is begun, and reactant "A" is slowly added to the perfectly stirred vessel. Write the equations describing the system. Without solving the equations, try to sketch the profiles of F_A, C_A, & C_B with time during the batch cycle. [CO4]

Que.No.5. Develop the modelling equation for the following Bio-chemical reactor by considering that the biochemical reactor is perfectly mixed.[CO3]

Que.No.6. Develop the modelling equation for the following Plug Flow Reactor by considering axial position.[CO3]

Que.No.7. Derive the model equation for: [CO3]

i. Plug flow reactor
ii. C.S.T.R. Reactor
iii. Effluents treatment reactor
iv. Semi-batch Reactor

Que.No.8. Derive modeling equations for batch reactor. [CO3]

Que.No.9. Derive a Mathematical Model for the Batch reactor in which the First order consecutive reactions A—>B—>C (k1, k2, k3 rate const) takes place to get the product B.[CO3]

Que.No.10 Discuss an algorithm for solving the model equations of Non-isothermal CSTR in which an exothermic reaction A -→ B takes place. The reactor is provided with a cooling jacket for the removal of heat. Assume constant holdup in the reaction vessel.[CO3]

Unit-VI

Que.No.1. Write short notes on use of numerical methods to solve the differential equations.[CO4]

Que.No.2. List out the software's available for the simulation of process plant. Explain any one.[CO4]

Que.No.3. For a perfectly mixed CSTR with following reaction (first order, isothermal) $A \rightarrow B \rightarrow C$, Derive the material balance equations. Write down the unsteady state material balance equations, if the reaction occurs in non-isothermal conditions, where heat needed for endothermic reaction is supplied through electrical coil.[CO4]

Que.No.4. Classify and explain the methods of treatment of nonlinear models.[CO4]

Que.No.5. Give the types of process simulation problems.[CO4]

Que.No.6. What is process simulation? Explain in detail.[CO4]

Que.No.7. Give the scope of process simulation with an example.[CO4]

Que.No.8. Discuss the various Numerical methods used to solve the model equations.[CO4].

Chemical Engineering Department

Process Modelling and Simulation (409349)

Practical: University Guidelines

Ten practical will be conducted with the use of mathematical and chemical engineering CAD software's such as ***Hysys,*****Aspen plus*****, ChemCAD, EnviroPro, Mathcad, Matlab, Unisim, DWSim*** etc. development of programs for numerical methods and process simulation.

List of Practical

Sr. No.	Name of Experiment	CO Mapped
1	Modeling and simulation of ideal binary distillation column	CO2
2	Mixed closed reactor to find out the optimum residence time	CO4
3	Simulation of reactor using Euler's integration	CO4
4	Developing model for batch reactor	CO3
5	Simulation of three CSTR in series	CO4
6	Mixed closed reactor	CO4
7	Sequential irreversible reactions	CO4
8	Complex batch reactions	CO4
9	Complex batch reaction sequence	CO4
10	Tubular reactor example	CO4

Course: 02

Process Engineering Costing & Plant Design

(409350)

[Theory & Practical]

Course Syllabus

Process Engineering Costing & Plant Design
(409350)

Unit I: Process Development (6 h)

Process selection, study of alternative processes, pilot plant, scale up methods, flow sheet preparation, sketching techniques, equipment numbering, stream designation, material and energy balances. Plant Design: Design basis, process selection - selection of equipment, specification and design of equipment's, material of construction, plant location, plant layout and installation, safety, start up, shutdown and operating guidelines, loss prevention and Hazop study.

Unit II: Cost Engineering (7 h)

Time value of money and equivalence, interest-simple, compound and continuous, present worth and discount, annuities, perpetuities and capitalized cost methods, depreciation, nature of depreciation, methods of determining depreciation, taxes and insurances, types of taxes and insurances, procedure for cost comparison after taxes.

Unit III: Cost Estimation (7 h)

Cash flow for industrial operations, cumulative cash position of cash flow for an industrial operations, capital investments, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index, cost factors in capital investment, methods of estimating capital investment, estimation of plant cost, estimation of total product cost, manufacturing cost, general expenses. Profitability: Criteria of profitability, payout period, return on investment, present value, cash flow analysis, alternative investment analysis.

Unit IV: Economic Optimization and Optimum Design (7 h)

Nature of optimization, uni-variable and multivariable systems, analytical, graphical and incremental methods of solution, Lagrange multiplier method, linear programming, other techniques and strategies establishing optimum conditions, break even chart for production schedule, optimum production rates in plant operation, optimum conditions in batch and cyclic operation.

Unit V: Optimization of Different Process Equipment (6 h)

Transportation systems, heat exchangers, evaporators, mass transfer equipment and reactors, determination of height and diameter of different process equipment at conditions of optimum cost. Pinch technology analysis. Preparation of techno-economic feasibility report.

Unit VI: Scheduling and Networking of Project (7 h)

Role of project engineering in project organization, start up and shut downs of project; preliminary data for construction projects; process engineering; plot plans, scheduling the

project; engineering design and drafting, the design report, organization of design report. Critical path method (CPM): events and activities; network diagramming; earliest start time and earliest finish time ;latest start time and latest finish time; float, advantage of CPM; cost to finish t h e projects earlier than normal cost; precedence diagramming. Programme evaluation and review technique (PERT): pert network and time estimates.

Reference Books:

1. 1. M. S. Peters & K. D. Timmerhaus, "Plant Design and economics for chemical engineers." Mc Graw Hill (2002).
2. Richard Turton, R.C. Bailie, W.B. Whiting, J.A. Shaeiwitz, "Analysis, Synthesis and Design of Chemical Processes", Prentice Hall
3. R.K Sinnot," Coulson & Richardson's Chemical Engineering- Chemical Engineering Design", Vol. 6, Butterworth-Heinemann
4. Kalyanmoy Deb, "Optimization For Engineering Design-Algorithms and Examples", PHI Learning Private Limited
5. S.S. Rao, "Engineering Optimization- Theory and Practice", New Age International
6. T.F.Edgar, D.M. Himmelblau,"Optimization of Chemical Processes", McGraw Hill
7. Srinath L. S., “PERT AND CPM.” affiliated East Press Pvt. Ltd., New York (1973)
8. Perry J. H.,”Chemical engineering handbook” 7TH ed. Mc Graw Hill (1997)

Chemical Engineering Department

BE Chemical

409350: Process Engineering Costing & Plant Design

Teaching Scheme: Lectures: 3 Hrs/ Week Practical: 2 Hrs/ Week	**Examination Scheme:** Paper: (30+70) 100 Marks In semester Assessment: 30 Marks End Semester Assessment: 70 Marks. TW: 25 Marks Oral:50 Marks **Credits:** Theory: 3 Practical: 1 Total: 4 Credits

Course Outcomes (COs): Process Engineering Costing & Plant Design

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

Course Outcomes	Statements	Bloom's Taxonomy	
		Level	Descriptor
C409350.1	Apply the knowledge of overall aspects of the Chemical Engineering Plant Design	**3**	Apply
C409350.2	Implement the various terms of cost engineering and analyze the engineering cost estimation of the chemical manufacturing process	**4**	Analysis
C409350.3	Apply Techniques for economic optimization and optimum design.	**3**	Apply
C409350.4	Apply network Techniques such as CPM and PERT for the Chemical Engineering Project management.	**3**	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

CO-PO CORRELATION MATRIX															
COs	**PROGRAM OUTCOMES (POs)**												**PSO**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
1	3	2	2									1	2	2	
2	2	1									3	1	1		
3	2	1	2								1	1	1	1	
4	2	1			2							1	1		1

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

Chemical Engineering Department

CO Assessment Tools

Course Outcomes (COs)	Assessment Tools								
	Continuous Internal Evaluation					Semester End Exam (SEE) conducted by SPPU Pune			
	T1	T2	T3	Assignment	CIE-Pr	OR	TW	Insem	Endsem
C450.1	√			√	√	√	√	√	
C450.2	√	√		√		√	√	√	√
C450.3		√	√	√		√	√		√
C450.4			√	√	√	√	√		√

Chemical Engineering Department

Teaching Plan

Process Engineering Costing & Plant Design (409350)

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	PO,PSO,CO & Subject orientation	-
2	Process selection, study of alternative processes	1
3	Pilot plant, scale up methods, flow sheet preparation,	1
4	Equipment numbering, stream designation, material and energy balances.	1
5	Plant Design: Design basis,	1
6	Plant location, plant layout and installation, safety,	1
7	Start up, shutdown and Hazop study	1
8	Time value of money and equivalence,	2
9	Interest-simple, compound and continuous,	2
10	Present worth and discount, annuities, perpetuities	2
11	Capitalized cost methods,	2
12	Depreciation, nature of depreciation, methods of determining depreciation,	2
13	Taxes and insurances, types, procedure for cost comparison after taxes.	2
14	Cash flow for industrial operations, cumulative cash position of cash flow.	2
15	capital investments, fixed capital cost, working capital cost	2
16	Process equipment cost estimation, cost index,	2
17	Cost factors in capital investment, methods of estimating capital investment,	2
18	Estimation of plant cost, total product cost, manufacturing cost, general expenses.	2
19	Profitability: Criteria of profitability,	2
20	Payout period, return on investment,	2
21	Cash flow analysis, alternative investment analysis	2
22	Nature of optimization,	3
23	Uni-variable and multivariable systems,	3
24	Analytical, graphical and incremental methods of solution,	3
25	Lagrange multiplier method, linear programming	3
26	Other techniques and strategies establishing optimum conditions	3
27	Break even chart for production schedule, optimum production rates	3
28	Optimum conditions in batch and cyclic	3
29	Transportation systems, heat exchangers, evaporators,	3

30	Mass transfer equipment and reactors,	3
31	Determination of height and diameter of different process equipment at optimum cost.	3
32	Pinch technology analysis.	3
33	Preparation of techno-economic feasibility report	3
34	Role of project engineering in project organization,	3
35	Start up and shut downs of project, preliminary data for projects,	3
36	Scheduling the project; engineering design and drafting, the design report,	3
37	Organization of design report. Critical path method (CPM)	3
38	Events and activities; Network diagramming;	3
39	Case studies	3
40	Advantage of CPM	3
41	Programme evaluation and review technique (PERT) and time estimates.	4
42	Numerical	4
43	Numerical	4
44	University QP practice	4
45	University QP practice	4

Chemical Engineering Department

Question Bank

Process Engineering Costing & Plant Design (409350)

	Unit-I	CO
Q.1	What are the factors affecting on process selection and discuss the process flow sheet preparation?	CO1
Q.2	What are the factors affecting on selection of Plant layout and plant location?	CO1
Q.3	Ethylene is produced commercially in a variety of different processes. Feed stocks for these various processes range from refinery gas, ethane, propane, butane, natural gasoline, light and heavy naphthas to gas and oil and heavier fractions. Prepare three different qualitative flow sheets to handle a majority of these feed stocks. What are the advantages and disadvantages of each selected process?	CO1
Q.4	A distillation unit has been designed to handle a very hazardous material. The unit utilizes a reflux drum and buffer storage. List several ways in which the inventory of the hazardous material can be reduced or eliminated. Sketch and instrument the system that is recommended	CO1
Q.5	What are the factors affecting on selection of Equipment?	CO1
Q.6	Discuss the Pilot plant and scale up method.	CO1
Q.7	What are the steps for plant design?	CO1
Q.8	What are the steps to be followed for plant commissioning and plant design?	CO1
	Unit-II	
Q.1	A standard type of Reactor with a negligible scrap value costs $4000 and will have a useful life of 6 years. Another proposed Reactor of equivalent design capacity costs $6800 but will have a useful life of 10 years and a scrap value of $800. Assuming an effective compound interest rate of 8 percent per year, determine which Reactor is cheaper by comparing the capitalized costs.	CO2
Q.2	Differentiate between Nominal and Effecting interest rate and derive the equation to determine the effective interest rate.	CO2
Q.3	The original value of a piece of equipment is $22,000, completely installed and ready for use. Its salvage value is estimated to be $2000 at the end of a service life estimated to be 10 years. Determine the asset value of the equipment at the end of 5 years using: (a) Straight-line method. (b) Textbook declining-balance method.	CO2
Q.4	The purchased cost of a shell-and-tube heat exchanger with 100 ft^2 of heating surface was $3000. What will be the purchased cost of a similar heat exchanger with 200 ft^2 of heating surface if the purchased-cost-capacity exponent is 0.60 for surface area ranging from 100 to 400 ft^2?	CO2

	If the purchased-cost-capacity exponent for this type of exchanger is 0.81 for surface areas ranging from 400 to 2000 ft^2, what will be the purchased cost of a heat exchanger with 1000 ft^2 of heating surface?	
Q.5	The purchased and installation costs of some pieces of equipment are given as a function of weight rather than capacity. An example of this is the installed costs of large tanks. The 1980 cost for an installed aluminum tank weighing 100,000 lb was $390,000. For a size range from 200,000 to 1,000,000 lb, the installed cost-weight exponent for aluminum tanks is 0.93. If an aluminum tank weighing 700,000 lb is required, what is the present capital investment needed?	CO2
Q.6	A new storage tank can be purchased and installed for $10,000. This tank would last for 10 years. A worn-out storage tank of capacity equivalent to the new tank is available, and it has been proposed to repair the old tank instead of buying the new tank. If the tank were repaired, it would have a useful life of 3 years before the same type of repairs would be needed again. Neither tank has any scrap value. Money is worth 9 percent compounded annually. On the basis of equal capitalized costs for the two tanks, how much can be spent for repairing the existing tank?	CO2
	Unit-III	
Q.1	Discuss the cash flow for industrial operations. Draw the cumulative cash flow diagram for industrial operations	CO2
Q.2	Discuss the six tenth factor rule for equipment cost estimation.	CO2
Q.3	Differentiate between the Balance sheet and Income statement. Give the formats for the Balance sheet and Income statement.	CO2
Q.4	What is the cash flow for industrial operations? Draw the tree diagram for industrial operations	CO2
Q.5	A process plant making 2000 tons per year of a product selling for $0.80 per lb has annual direct production costs of $2 million at 100 percent capacity and other fixed Costs of $700,000. What is the fixed cost per pound at the break-even point? If the selling price of the product is increased by 10 percent, what is the dollar increase in net profit at full capacity if the income tax rate is 34 percent of gross earnings?	CO2
Q.6	The total capital investment for a proposed chemical plant which will produce $1,500,000 worth of goods per year is estimated to be $1 million. It will be necessary to do a considerable amount of research and development work on the project before the final plant can be constructed, and management wishes to estimate the permissible research and development costs. It has been decided that the net profits from the plant should be sufficient to pay off the total capital investment plus all research and development costs in 7 years. A return after taxes of at least 12 percent of sales must be obtained, and 34 percent of the research and development cost is tax-free (i.e., income-tax rate for the company is 34 percent of the gross earnings). Under these conditions, what is the total amount the company can afford to pay for research and development?	CO2

<table>
<tr><td>Q.7</td><td>A proposed chemical plant will require a fixed-capital investment of $10 million. It is estimated that the working capital will amount to 25 percent of the total investment, and annual depreciation costs are estimated to be 10 percent of the fixed-capital investment. If the annual profit will be $3 million, determine the standard percent return on the total investment and the minimum payout period</td><td>CO2</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td>Unit-IV</td><td></td></tr>
<tr><td>Q.1</td><td>Describe the break even chart for production schedule and derive the formula to determine the Breakeven point.</td><td>CO3</td></tr>
<tr><td>Q.2</td><td>Discuss the optimum production rates in plant operation</td><td>CO3</td></tr>
<tr><td>Q.3</td><td>Give the importance of linear programming in optimization.</td><td>CO3</td></tr>
<tr><td>Q.4</td><td>Discuss the analytical, graphical and incremental methods of solution for determining the optimum condition.</td><td>CO3</td></tr>
<tr><td>Q.5</td><td>Discuss Optimum conditions in batch and cyclic operation.</td><td>CO3</td></tr>
<tr><td>Q.6</td><td>Following figures for profit and sales are obtained from the company account;
<table>
<tr><th>Financial Year</th><th>Sales, $</th><th>Profit, $</th></tr>
<tr><td>2020-21</td><td>20,000</td><td>2,000</td></tr>
<tr><td>2021-22</td><td>30,000</td><td>4,000</td></tr>
</table>
Calculate the following;
a. Profit Volume Ratio
b. Fixed Cost
c. Break Even Point (Sales, $)
d. Profit at Sales of $40,000
e. Sales to earn profit of $ 5,000.</td><td>CO3</td></tr>
<tr><td>Q.7</td><td>A multiple-effect evaporator is to be used for evaporating 400,000 lb of water per day from a salt solution. The total initial cost for the first effect is $18,000, and each additional effect costs $15,000. The life period is estimated to be 10 years, and the salvage or scrap value at the end of the life period may be assumed to be zero. The straight-line depreciation method is used. Fixed charges minus depreciation are 15 percent yearly based on the first cost of the equipment? Steam costs $1.50 per 1000 lb. Annual maintenance charges are 5 percent of the initial equipment cost. All other costs are independent of the number of effects. The unit will operate 300 days per year. If the pounds of water evaporated per pound of steam equals 0.85 x number of effects, determine the optimum number of effects for minimum annual cost.</td><td>CO3</td></tr>
<tr><td>Q.8</td><td>Derive an expression for the optimum economic thickness of insulation to put on a flat surface if the annual fixed charges per square foot of insulation are directly proportional to the thickness, (a) neglecting the air film, (b) including the air film. The air-film coefficient of heat transfer may be assumed as constant for all insulation thicknesses.</td><td>CO3</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td></td><td>Unit-V</td><td></td></tr>
<tr><td>Q.1</td><td>The OD of an uninsulated steam pipe is 4.5 in. The outside-surface temperature of the pipe is constant at 300”F, and the pipe is located in a large room where the surrounding temperature is constant at 70°F. The heat content of the steam is valued at $1.60 per lo6 Btu. The emissivity of the pipe surface is 0.7, and the heat-transfer coefficient for heat loss from the surface by convection is 1.4 Btu/(hXft2X”F). Under these conditions, determine the cost per year for heat losses from the uninsulated pipe if the length of the pipe is 100 ft.</td><td>CO3</td></tr>
<tr><td>Q.2</td><td>Discuss the Pinch technology analysis.</td><td>CO3</td></tr>
<tr><td>Q.3</td><td>Discuss the analytical, graphical and incremental methods of solution for determining the optimum condition.</td><td>CO3</td></tr>
<tr><td>Q.4</td><td>Discuss the determination of height and diameter of different process equipment at conditions of optimum cost.</td><td>CO3</td></tr>
<tr><td>Q.5</td><td>Calculate the optimum design cost of Heat Exchanger.</td><td>CO3</td></tr>
<tr><td>Q.6</td><td>Discuss the Optimization of Process Equipment with suitable case study.</td><td>CO3</td></tr>
<tr><td>Q.7</td><td>Focus on importance of optimum flow rate of cooling water in condenser.</td><td>CO3</td></tr>
<tr><td>Q.8</td><td>Prepare the techno-economic feasibility report of XYZ Fertilize company.</td><td>CO3</td></tr>
<tr><td>Q.9</td><td>Calculate the optimum design cost of Heat Exchanger</td><td>CO3</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td>Unit-VI</td><td></td></tr>
<tr><td>Q.1</td><td>The following details are available regarding a project:
<table>
<tr><th>Activity</th><th>Predecessor Activity</th><th>Duration (Weeks)</th></tr>
<tr><td>A</td><td>-</td><td>3</td></tr>
<tr><td>B</td><td>A</td><td>5</td></tr>
<tr><td>C</td><td>A</td><td>7</td></tr>
<tr><td>D</td><td>B</td><td>10</td></tr>
<tr><td>E</td><td>C</td><td>5</td></tr>
<tr><td>F</td><td>D,E</td><td>4</td></tr>
</table>
Determine the critical path, the critical activities and the project completion time.</td><td>CO4</td></tr>
<tr><td>Q.2</td><td>Differentiate between the CPM and PERT. Illustrate the same with suitable example.</td><td>CO4</td></tr>
<tr><td>Q.3</td><td>Discuss the Role of project engineering in project organization.</td><td>CO4</td></tr>
<tr><td>Q.4</td><td>Write a short Notes on Critical path method (CPM).</td><td>CO4</td></tr>
<tr><td>Q.5</td><td>Describe the Project scheduling</td><td>CO4</td></tr>
<tr><td>Q.6</td><td>Write a short Notes on Start up and shut downs of project.</td><td>CO4</td></tr>
<tr><td>Q.7</td><td>Write a short Notes on Engineering design and drafting</td><td>CO4</td></tr>
<tr><td>Q.8</td><td>Define HAZOP study.</td><td>CO4</td></tr>
<tr><td>Q.9</td><td>Define Events and Activities</td><td>CO4</td></tr>
</table>

Process Engineering Costing & Plant Design (409350)

List of Practical:

Sr. No.	Name of Experiment	CO Mapped
1	Standard symbols as per IS code	CO1
2	Process flow diagram.	CO1
3	Piping and instrumentation diagram	CO1
4	Utility diagram	CO1
5	Plant layouts and elevations	CO1
6	Piping isometrics.	CO1
7	CPM	CO4
8	PERT	CO4

Course: 03

Chemical Process Safety (C409351 (B)

Theory

Chemical Engineering Department

Chemical Process Safety

Course Syllabus

Unit I: **(6 h)**

Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.

Unit II: **(7 h)**

Industrial hygiene: government regulations, identification, evaluation: evaluating exposures to volatile toxicants by monitoring, evaluating worker exposures to dusts, evaluating worker exposures to noise, estimating worker exposures to toxic vapors.

Unit III: **(7 h)**

Technology and process selection, scale of disaster, fire triangle, distinction between fires and explosion, definitions of ignition, auto-ignition temperature, fire point, flammability limits, mechanical explosion deflagration and detonation, confined explosion, unconfined explosion, vapour cloud explosions, boiling liquid expanding vapour explosion (BLEVE), dust explosion, shock wave, flammability characteristics of liquids and vapours, minimum oxygen concentration (MOC) and inerting.

Unit IV: **(7 h)**

Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management, Design to prevent Fires and Explosions: Inerting, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion.

Unit V: **(6h)**

Hazards identification: process hazards checklists, hazard surveys, hazard and operability studies (HAZOP), safety reviews. Risk assessment: review of probability theory, interaction between process units, revealed and unrevealed failure, and probability of coincidence, event trees and fault trees.

Unit VI: **(7h)**

Safety versus production, Hazard models and risk data. Tackling disasters, plan for emergency. Risk management routines, Emergency shutdown systems, Role of computers in safety, Prevention of hazard human element, Technology and process selection.

References:

1. Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with applications, Prentice Hall, Inc, 1990.
2. P. P. Leos, Loss prevention in process Industries, Vol 1 and 2 Butterworth, 1983
3. R. W. King and J. Magid, Industrial Hazards and Safety Handbook, Butterworth, 1982
4. Khulman, Introduction of Safety Science, TUV Rheinland, 1986
5. W. E. Baker, Explosion, hazards and Evaluation, Elsevier, Amsterdam, 1983
6. O. P. Kharbanda and E. A. Stallworthy, Management of Disasters and How to Prevent Them. Grower 1986

Chemical Engineering Department

BE Chemical

C409351 (B) : Chemical Process Safety (2019 Pattern)

Teaching Scheme:	**Examination Scheme:**
Lectures :3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Course Outcomes (CO's) : Chemical Process Safety

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

Course Outcomes	Statements	Bloom's Taxonomy	
		Level	Descriptor
C451.1	Apply the basic concepts of safety and safety culture and industrial hygiene to ensure the safety and protection of workers safety in industries	**2**	Extend
C451.2	Analyze the parameters related to technology and process selection, handling toxic chemicals, fire triangle for safety of materials and manpower in industries.	**4**	Analyse
C451.3	Design and development of process systems to maintain safe working conditions to protect the loss/damage of manpower and material resources in industries.	**6**	Creating
C451.4	Apply techniques of hazards identification, HAZOP(Hazards and Operability Studies) and risk assessment for disaster management and safety	**3**	Applying
C451.5	Evaluate the exposure of workers to toxic chemicals, vapours to identify the level of risks in industries. Also evaluating the permissible limits process parameters leading to accidents/disasters in industries.	**5**	Evaluate

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

COs	PROGRAM OUTCOMES												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C451.1	2	2	2	2								2	3	2	1
C451.2	2	3	2	2								2	2	2	
C451.3	2	2	3	2								2	3	3	
C451.4	2	2	2	3								2	2	2	
C451.5	2	2	2										2	1	
Total	10	11	11	9								8	12	10	1
Total Wt	15	15	15	12								12	15	15	3
% Mapping	66.66	73.33	73.33	75								66.66	80	66.66	33.33
C451(B)	3	3	3	3								3	3	3	1

CO Assessment Tools

Course Outcomes (COs)	Assessment Tools								
	Continuous Internal Evaluation					Semester End Exam (SEE) conducted by SPPU Pune			
	T1	T2	T3	Assignment				Insem	Endsem
C349.1	√			√				√	
C349.2		√		√					√
C349.3		√		√					√
C339.4			√	√					√
C349.5			√	√					√

Chemical Process Safety (C409351 (B)

Teaching Plan

Teaching Scheme:	**Examination Scheme:**
Lectures :3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Lect. No.	Topics / Sub- Topics	CO Mapped
1	**Unit I** : PO,PSO,CO & Subject orientation	1,4
2	Introduction to the Subject, Concepts and definition of process safety	1
3	Safety culture, storage of dangerous materials	1
4	Plant layout safety systems, OSHA incidence rate, FAR, FR	1
5	The accident process: Initiation, propagation, and termination	1
6	Toxicology: ingestion, inhalation, injection	2
7	Dermal absorption, dose versus response curves	2
8	Relative toxicity, threshold limit values.	2
9	**Unit II:** Industrial hygiene	2
10	Government regulations	2
11	Identification, evaluation: evaluating exposures to volatile toxicants by monitoring	3
12	Evaluating worker exposures to dusts	3
13	Evaluating worker exposures to noise	3
14	Estimating worker exposures to toxic vapors	3
15	**Unit III:** Technology and process selection, scale of disaster, fire triangle	3
16	Distinction between fires and explosion, definitions of ignition, auto-ignition temperature, fire point, flammability limits	3
17	Mechanical explosion deflagration and detonation, confined explosion	4
18	Unconfined explosion, vapour cloud explosions	4
19	Boiling liquid expanding vapour explosion (BLEVE)	4
20	Dust explosion, shock wave, flammability characteristics of liquids and vapour,	4
21	Minimum oxygen concentration (MOC) and inerting.	4
22	**Unit IV**: Control of toxic chemicals	5
23	Control of toxic chemicals, Storage and handling of flammable and toxic chemical	5
24	Runway reactions, Relief system risk and hazards management	4

25	Design to prevent Fires and Explosions	3
26	Inerting, static Electricity, Explosion proof equipment and Instrument	4
27	Ventilation, sprinkler systems	2
28	Miscellaneous Design for preventing Fires and Explosion	2
29	**Unit V:** Hazards identification: Introduction	2
30	Process hazards checklists	2
31	Hazard surveys, hazard and operability studies (HAZOP)	2
32	safety reviews	3
33	Risk assessment: review of probability theory	2
34	Interaction between process units, revealed and unrevealed failure	2
35	Probability of coincidence, event trees and fault trees.	2
36	**Unit VI:** Safety versus production	3
37	Hazard models and risk data	3
38	Tackling disasters, plan for emergency	3
39	Risk management routines, Emergency shutdown systems	3
40	Role of computers in safety, Prevention of hazard human element	3
41	Technology and process selection.	3

Question Bank

QN	Chemical Process Safety-BE Chemical
	UNIT-I
1.	Safety aspects are more vital to the factory concerned rather than the environment. Discuss in detail the favorable and unfavourable points [CO1]
2.	Safety training from the lowest paid worker to the general manager will pay dividends. Discuss in detail [CO1]
3.	Certain factory has a very high-pressure reactor working. Discuss the possible hazards and reasons for the same [CO2]
4.	List out the safety factors to be adopted in a solvent extraction plant [CO1]
5.	Taking case of a safety-matches factory, explain how periodical inspections could help mitigating dangers [CO2]
6.	It is customary to use equipment till they fail. Explain your views with examples from industry [CO2]
7.	A certain personnel have received severe acid bums. Explain the step[CO2]
8.	What are the possible reasons for fire in chemical factories? Write in details[CO1]
9.	A Gentleman wants to start a chemical –Manufacturing unit . What are the legal aspects that have to look into carefully? [CO2]
10.	A Cracker manufacturing factory can be protected in several ways including legal- write your views in details[CO1]
11.	Explain Dose versus Response curves?
12.	How Toxicants enter Biological Organisms?
13.	Explain about Accident and Loss Statistics?
14.	Explain what are the ingredients of a successful safety program?
15.	Explain Inherent Safety Techniques?
16.	Explain plant layout safety systems & OSHA incidence rate?
17.	Explain Hazard, Toxicity, Threshold limit Value, Safety, Accident & Flammability with appropriate example?
18.	Explain the importance of Safety in Chemical Process Industry?
	UNIT-II
1.	Elaborate on the guidelines for the safe handling of chemicals [CO1]

2.	Discuss the importance of safety training in chemical industries [CO2]
3.	.Explain in detail job safety analysis [CO2]
4.	What are the safety measures to be adopted in high pressure and high temperature operations? [CO1]
5.	Explain in detail the effective steps to be taken to implement safety procedure [CO1]
6.	Proper selection and treatment of equipment is vital for safe operation - Discuss in detail giving suitable examples [CO2]
7.	Write in detail the fire fighting equipment and extinguishing agents used in industries[CO1]
8.	What are the reasons for industrial accidents? Discuss on accident costs [CO3]
9.	Explain the salient features of Factory Act and Workers Compensation Act [CO2]
10.	Explain the role of safety organizations, management and trade unions in maintaining industrial safety [CO3]
11.	Explain the importance of Industrial Hygiene & discuss the Identification & Evaluation of Industrial hygiene?
12.	Describe Evaluation procedure for Exposures to Volatile Toxicants
13.	Discuss the importance of MSDS in industrial safety?
14.	How will you estimate the worker exposure to toxic vapors?
15.	Explain different Control techniques for Industrial Hygiene?
16.	Elaborate the importance of Industrial Hygiene?
17.	Discuss the importance of MSDS in industrial safety?
18.	Outline the OSHA process safety management process
19.	What are the reasons for industrial accidents? Discuss on accident cost?
20.	Give steps involved in accident process
21.	Estimate in detail worker exposures to toxic vapors, dust and Noise?
	UNIT-III
	Discuss in detail the psychological attitude towards safety programs [CO2]
1.	Write in detail about social environmental setup with a suitable case study [CO2]
2.	Briefly explain the safety features of high pressure vessels in Chemical industry[CO2]
3.	What are the safety precautions to be adopted while doing the plant layout? [CO2]
4.	What is meant by personal protective equipment? Discuss the importance of personal protective equipments in the chemical industries [CO2]
5.	Discuss the various effective steps to be followed for the implementation of safety procedures in a chemical plant [CO3]

6.	Discuss the various fire prevention methods in detail[CO3]
7.	Briefly explain the various remedial measures that are to be taken after an industrial accident
8.	Discuss the occupational hazards with suitable examples [CO2]
9.	Discuss about the role of trade union in promoting industrial safety [CO3]
	UNIT-IV
1.	Discuss the importance of safety consciousness in chemical industries [CO2]
2.	Discuss the psychological attitude towards safety programs [CO3]
3.	Discuss the safety measures to be adopted in an explosives manufacturing plant [CO3]
4.	Discuss the various highly radioactive materials with suitable examples [CO3]
5.	Discuss the importance of periodic advice and checking to follow safety procedures [CO2]
6.	How will you use and maintain the personal protective equipment in an industry? [CO2]
7.	Discuss the various fire prevention methods to be adopted in a chemical industry[CO2]
8.	What are the remedial measures that are to be taken after an accident in an industry? Explain with suitable examples [CO2]
9.	Discuss the various health hazards in a chemical plant [CO2]
10.	. What are the legal aspects to be followed to start a chemical plant? [CO2]
	UNIT-V
1.	Discuss the importance of training at various levels of production and operation [CO2]
2.	Why safety is a must in an industry? Discuss. How will you create safety awareness among the workers? [CO2]
3.	Discuss the chemical and physical job safety analysis [CO2]
4.	Discuss the safe handling of dangerous and toxic chemicals [CO3]
5.	Discuss the importance of proper selection and replacement of handling equipments
6.	What are the factors to be considered while designing a plant layout? [CO]
7.	Discuss the various industrial accidents in detail with suitable examples [CO2]
8.	What is fire triangle? Discuss the causes for fire in a chemical industry [CO]
9.	Discuss about Workmen Compensation Act [CO3]
10.	Explain in detail the parliamentary and labor welfare legislations [CO2]
11.	Explain confined and unconfined explosions [CO2]

	UNIT-VI
1.	Explain relief systems in hazards prevention. [CO2]
2.	Explain in detail hazard model and risk data [CO2]
3.	Discuss probability theory in risk assessment (CO3)
4.	Discuss in detail confined and unconfined explosion [CO2]
5.	Discuss ventilation systems in preventing hazards [CO1]
6.	Describe sprinkler systems for hazards prevention and minimization of loss due to hazards [CO3]
7.	Explain miscellaneous design to prevent fire and explosion [CO2]
8.	. Discuss fire prevention in detail [CO2]
9.	Explain runway reactions [CO2]
10.	Explain toxicity control to prevent hazards [CO2]
11.	. Define and explain hazard, toxicity, threshold limit value and accident [CO2]
12.	. Explain the process of accident and its prevention measures [CO3]

Course: 04

Petrochemical Engineering

(409352A)

[Theory]

Chemical Engineering Department

Course Syllabus

Petrochemical Engineering (409352A)

Unit I: **(6h)**

Introduction to petrochemical, petrochemical industry in India, basic raw material for petrochemical synthesis and their sources, preparation of feedstock for petrochemical production, main building blocks of petrochemical industry

Unit II: **(7h)**

First generation raw material like olefins, aromatics, naphthenes. Production of aromatics, naphthenes and other hydrocarbon feedstock, aromatic separation into B, T, X.

Unit III: **(7h)**

Production of low molecular weight olefins by hydrocarbon cracking, furnaces, separation techniques and purification.

Unit IV: **(7h)**

Combining olefins and aromatics to produce second generation intermediates such as glycols, amines, acids, ketones that can be used also as solvents and formulating agents.

Unit V: **(7h)**

Polymers: bulk, engineering and specialty, types of polymerization such as bulk, emulsion and suspension etc, at least two polymeric products and manufacture from each class, few examples (flow sheet, applications) of polymers like polyester, nylon, etc

Unit VI: **(6h)**

Integration of refinery and petrochemical plants with power generation, pollution control – norms and methods of elimination, brief description on safety considerations

Reference Books:

1. Modern Petroleum Technology, Hobson and Pohl, Vol. I & II, John Wiley and Sons, New York.
2. Introduction to petrochemical industry and refinery by Speight, Encyclopedia of Life Support systems.
3. Dryden's Outline of chemical industry, M Gopal Rao, M Sittig, East –West press.
4. Petrochemical Process Technology, ID Mall, Macmillan India Ltd., New Delhi
5. Modern Pertoleum Refinery Engineering, Bhaskar Rao, published by Aman Dhanani.

Chemical Engineering Department

409352A: Petrochemical Engineering

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Course Outcomes (CO's) : Petrochemical Engineering

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

CO1	Analyse status of petrochemical industries and its necessity in India
CO2	Get acquainted and interpret the first generation petrochemicals and its basic raw materials
CO3	Evaluate and recognize process and methodology for separation and purification techniques in petrochemical complexes
CO4	Analyze and Differentiate between First generation and second generation petrochemicals and its feedstock and different types of polymers and its preparation methodologies along with its use in industries.
CO5	Evaluate the different safety norms and aspects in petrochemical industry and pollution control norms and methods of elimination.

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

CO/PO	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C452.1	3	2	3	3	1	-	-	-	-	-	-	-	3	2	1
C452.2	3	2	3	2	1	-	-	-	-	-	-	-	3	2	1
C452.3	2	2	1	2	1	-	-	-	-	-	-	-	3	3	1
C452.4	2	2	1	2	1	-	-	-	-	-	-	-	2	2	1
C452.5	2	2	2	3	1	-	-	-	-	-	-	-	2	2	1
Sum	2	2	2	2	1	-	-	-	-	-	-	-	3	2	1
Total Wt	14	12	12	14	6								16	13	6
% Mapping	100	91.7	58.3	58.3	91.7	-	-	-	-	-	-	66.7	100	58.3	58.3
C452	3	2	2	3	1	-	-	-	-	-	-	-	3	2	1

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

Chemical Engineering Department

CO Assessment Tools

Course Outcomes (COs)	Assessment Tools								
	Continuous Internal Evaluation					Semester End Exam (SEE) conducted by SPPU Pune			
	T1	T2	T3	Assignment	CIE-Pr	OR	TW	Insem	Endsem
C452.1	√			√	--	--	--	√	
C452.2	√	√		√	--	--	--	√	√
C452.3			√	√	--	--	--		√
C452.4			√	√	--	--	--		√
C452.5					--	--	--		

Chemical Engineering Department
Petrochemical Engineering (409352A)

Teaching Plan

Teaching Scheme:
Theory: 03 h/week

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

Lect. No.	Topics / Sub- Topics	CO mapped
1	PO,PSO,CO & Subject orientation	-
2	**Introduction to petrochemical:** Introduction	1
3	Introduction to Petrochemical	1
4	Petrochemical industry in India	1
5	Basic raw material for petrochemical synthesis and their sources	1
6	Preparation of feedstock for petrochemical production	1
7	Main building blocks of petrochemical industry	1
8	Main building blocks of petrochemical industry	1
9	Question Papers	1
10	**First generation raw material:** Introduction	2
11	First generation raw material like olefins aromatics, naphthenes.	2
12	Production of aromatics	2
13	Production of naphthenes,	2
14	Production of other hydrocarbon feedstock	2
15	Aromatic separation into B, T, X.	2
16	Aromatic separation into B, T, X.	2
17	**Production of low molecular weight olefins:** Introduction,	2
18	Hydrocarbon cracking details	2
19	Hydrocarbon cracking examples	2
20	Furnaces	2
21	Furnaces Types	2
22	Separation techniques and purification.	2
23	Separation techniques and purification.	2
24	Separation techniques and purification.	2
25	Separation techniques and purification.	2
26	**Second generation Petrochemical: Introduction**	3
27	Introduction of Combining olefins and aromatics to produce second generation intermediates	3
28	Production of glycols	3
29	Production of amines	3

30	Production of acids	3
31	Production of ketones	3
32	Production of ketones	3
33	Question Papers	3
34	**Polymers:** Introduction	4
35	Engineering and specialty	4
36	Types of polymerization such as bulk, emulsion and suspension	4
37	Types of polymerization such as bulk, emulsion and suspension	4
38	Manufacture of Nylon	4
39	Manufacture of Nylon-6	4
40	Manufacture of polyester	4
41	**Integration of refinery and petrochemical:**	5
42	Integration of refinery and petrochemical plants with power generation: Introduction: Introduction	5
43	Safety Introduction	5
44	Integration of refinery	5
45	Power generation	5
46	Pollution control norms	5
47	Methods of elimination	1-2
48	Brief description on safety considerations	1-5

Question Bank

Petrochemical Engineering (409352A)

Unit-I

1. Write down the importance of Petrochemicals and status of Petrochemical industries in India.
2. What are the main basic building blocks of petrochemical industry explain with suitable examples? Give the details of petrochemical products that are produced from benzene?
3. What are basic principle sources of aromatics? Describe the BTX aromatic separation by suitable diagram.
4. Explain with neat diagram process for Benzene production and list out its derivatives.
5. With neat sketches explain in detail about production ethylene glycol as a second generation intermediates.
6. Write in details about the various separation and purification techniques used in Petrochemical industry?

UNIT-II

1. What are the basic raw material for petrochemical synthesis and write note on their sources.
2. What are the main basic building blocks of petrochemical industry explain with suitable examples?
3. What are basic principle sources of aromatics? Describe the BTX aromatic separation by suitable diagram.
4. What are olefins? Explain with neat diagram process for ethylene production and list out its derivatives.
5. Write in details about the various separation and purification techniques used in Petrochemical industry?
6. Write short note on Furnaces and its types.

UNIT-III

1. With neat sketches explain in detail about production Ethylene glycol as a second generation intermediates.
2. With neat sketches explain in detail about production Propylene glycol as a second generation intermediates.
3. Write short note on different types of furnaces used in petrochemical plants.
4. How the olefins and aromatics are used to produce second generation intermediates? Explain with example.
5. Write a note on Fluid Catalytic Cracking units.

Unit-IV

1. With neat sketches explain in detail about production of Acetic acid as a second generation intermediates.
2. Write note glycol ethers.
3. With neat sketches explain in detail about production of Hydrochloric acid as a second generation intermediates
4. Write in details about the various separation and purification techniques used in Petrochemical industry?
5. Explain Hydrocarbon cracking process in detail.
6. Define furnaces and write down its various types.
7. With neat sketches explain in detail about production Methylene glycol as a second generation intermediates.
8. With neat sketches explain in detail about production of Acetone as a second generation intermediates.
9. With neat sketches explain in detail about production of Amines as a second generation intermediates.
10. With neat sketches explain in detail about production of Acetone as a second generation intermediates.

Unit-V

1. Define polymerization. Describe the steps and mechanisms of condensation Polymerization.
2. With neat sketches explain in detail about production of Nylon6 along with its Engineering Problems.
3. With neat sketches explain in detail about production of Nylon 66 along with its Engineering Problems.
4. Explain in detail Bulk, Emulsion and Suspension.
5. With neat sketches explain in detail about production of Polyester.
6. Define polymerization. Describe the steps and mechanisms of addition Polymerization.
7. Describe in detail bulk, emulsion and suspension types of polymerization.
8. With neat sketches explain in detail about production of Teflon along with its Engineering Problems.
9. What is addition polymerization? Describe the steps and mechanisms of addition Polymerization.

Unit-VI

1. Discuss about recent advances in petrochemical plants & refineries in India.
2. Describe in detail with example the Integration of refinery and petrochemical plants with power generation.
3. MPCB and CPCB norms in Petrochemical industries
4. Safety consideration in petrochemical plants
5. Write in detail about pollution control – norms and methods of elimination in petrochemical industries.

Course: 05

Project Stage-II

(409353)

[Practical]

Chemical Engineering Department

Project Stage-II (409353)

University Guidelines

During the second term the students are required to:

1. Carry out detailed experimental work on previously defined (Phase I) research problem.
2. Write a *Project Report*, which should be broadly divided into the following sections –
    a. Abstract
    b. Introduction
    c. Experimental
    d. Results and Discussion
    e. Conclusion
    f. Plant layout and costing
    g. References

Students should submit a neatly typed and spiral bound *Project Report* at the end of the 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:

2. Guo J. X. and Gray D. G., Chiroptical behavior of (acetyl) (ethyl) cellulose liquid crystalline Solutions in chloroform, *Macromolecules, 22*, (1989), 2086.

(Reference numbers should be mentioned in the main text as a superscript) The *Project Report* should contain:

1. The cover page –must mention: Project title, Name of the student(s), Name of the guide, Exam seat number and Year.
2. Certificate from guide
3. Certificate from industry (if any)
4. Index
5. Detailed *Project Report* having sections ‘a’ to ‘g’ from above.

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.

Each student is required give **presentation** of his work for 10 minutes using 10-12 slides. The presentation will be followed by question answer session of 5 min. Every student will be examined orally for 50 marks based on the topic of his/her project and relevant area to evaluate his understanding of the problem. Term work assessment for 100 marks will be based on student's workup, performance and progress (depth and quality of work) during the term.

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.

409353: Project Stage-II

Teaching Scheme:	**Examination Scheme:**
Lectures : 12 Hours / Week	Term Work: 100 Oral: 50 **Total: 150** **Credits: 6**

Course Outcomes (CO's) : Project Stage - II

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

Course Outcomes	Statements	Bloom's Taxonomy	
		Level	Descriptor
C453.1	Conduct the research literature survey and to identify and formulate the engineering problem.	**6**	**Formulate**
C453.2	Apply the mathematical concepts, science concepts, engineering concepts, management principles and engineering tools necessary to solve the identified engineering problem.	**3**	**Apply**
C453.3	Analyse and interpret results of experiments conducted on the designed solution(s) to arrive at valid conclusions	**4**	**Analyse**
C453.4	Demonstrate professionalism with ethics; present effective communication skills, writing skills and relate engineering issues to broader societal context	**3**	**Demonstrate**
C453.5	Apply the ethical principles, social benefits, environmental, health and safety issues, individual and team work and leadership knowledge.	**3**	**Apply**

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C453.1	3	2	2	2	3	2	2	2	3	3	2	3	3	2	3
C453.2	3	3	2	2	3	2	2	2	3	3	2	3	3	3	3
C453.3	3	3	3	3	3	2	2	2	3	3	2	3	3	3	3
C453.4	3	3	3	2	3	2	2	2	3	3	3	3	3	3	3
C453.5	3	3	3	2	2	3	2	3	3	3	3	3	3	3	3
Total	15	14	13	11	14	11	10	11	15	15	12	15	15	14	15
Total Wt	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
% Mapping	100	93.3	86.7	73.3	93.3	73.3	66.6	73.3	100	100	80	100	100	93.33	100
C453	3	3	3	2	3	2	2	2	3	3	3	3	3	3	3

Project Stage -II Evaluation

The Project stage- II carrying 100 marks term work and 50 marks for oral in VIII semester. The rubrics are defined for evaluation of 50 marks which is converted to 100 marks term work shown below:

Rubrics for evaluation of Project Stage-II

Sr. No.	Rubrics	Marks
1	Review-III: Project Implementation A. Detailed Design B. Experimentation/ Manufacturing C. Innovation / outcomes	10
2	Review-IV: Final Project report presentation A. Detailed Results B. Report Preparation C. Participation / publication	10
3	Weekly evaluation of the guide	20
4	Phase-II Final Report submission and papers	10
5	Examination : Evaluation by an external & internal examiner appointed by SPPU, Pune [Oral (OR) & Term Work (TW)]	OR:50 TW:100