PRAVARA RURAL EDUCATION SOCIETY
PRAVARA RURAL ENGINEERING COLLEGE
LONI

CHEMICAL ENGINEERING

ACADEMIC BOOK

T.E. CHEMICAL

SEMESTER-I

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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.

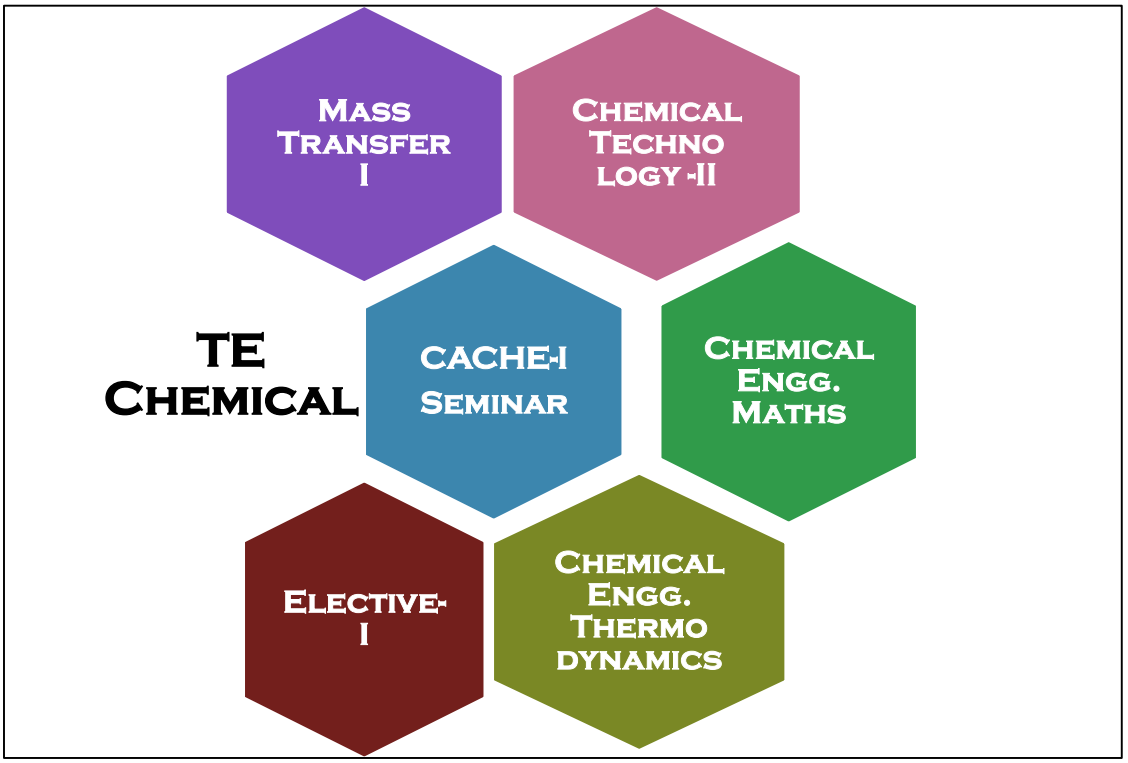
Program Educational Objectives (PEOs)

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	
Third Year						
309341	**Mass Transfer-I**	03	-	04	07	**05**
309342	**Chemical Technology -II**	03	-	04	07	**05**
309343	**Chemical Engineering Mathematics**	03	-	-	03	**03**
309344	**Chemical Engineering Thermodynamics**	03	-	-	03	**03**
309345	**Elective-I**	03	-	-	03	**03**
309346	**Computer Aided Chemical Engineering- I**	-	-	02	02	**01**
309347	**Seminar**	-	01	-	01	**01**
	Total	**15**	**01**	**10**	**25**	**21**



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

Mass Transfer - I

(309341)

T.E. Chemical (2019 Pattern)

[Theory & Practical]

Chemical Engineering Department

Course Syllabus

Mass Transfer - I (309341)

Unit 1: Introduction **7 Hrs**

General principles of Mass Transfer, classification of Mass Transfer Operations, choice of separation method, methods of conducting mass transfer operations, design principles. Diffusion Mass Transfer, Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, diffusion in solids, unsteady state mass transfer.

Unit 2: Inter-Phase Mass Transfer **7 Hrs**

Mass transfer coefficients in laminar flow and turbulent flow, theories of mass transfer, mass, heat and momentum transfer analogies. Inter-phase mass transfer, equilibrium in mass transfer, the two resistance theory, continuous co-current, countercurrent and crosscurrent processes, cascades.

Unit 3: Gas Absorption **7 Hrs**

Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculations of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction.

Unit 4: Humidification and Dehumidification- **7 Hrs**

Principles, vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.

Unit 5: Equipment for gas liquid operation **7 Hrs**

Types of columns, Types of trays, types of packing, Gas dispersal equipment – bubble columns, mechanically agitated vessels, tray towers. Liquid dispersal equipment – Venturi scrubbers, wetted wall columns, spray towers, packed columns

Unit 6: Drying **7 Hrs**

Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, design principles of tray dryer, rotary dryer, drum dryer, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

References:

1. Mass Transfer Operations – Robert E.Treybal , McGraw Hill
2. Chemical Engineering, Vol. I & II – Coulson J.M. and |Richardson J.F., McGraw Hill
3. Principles of Unit Operations in Chemical Engineering, Foust A.S.
4. Separation Techniques – King C.J. Design of Equilibrium Stage Processes - Smith B.D.
5. Transport Processes & Separation Process Principles – Christie John Geankoplis

Chemical Engineering Department
TE Chemical

309341: Mass Transfer - I

Teaching Scheme: Lectures: 3 Hrs/ Week Practical: 4 Hrs/ Week	**Examination Scheme:** Paper: (30+70) 100 Marks In semester Assessment: 30 Marks End Semester Assessment: 70 Marks. PR :50 Marks **Credits:** Theory: 3 Practical: 2 Total: **5** Credits

Course Outcomes (COs Mass Transfer–I)

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

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
CO341.1	**Remember** the general principle & classification of Mass Transfer,, Methods of conducting Mass Transfer, Diffusion Mass Transfer operation,etc.	**1**	**Remember**
CO341.2	**Understand** IMTC and different Theories of Mass Transfer.	**2**	**Understand**
CO341.3	**Apply** mechanism of Gas Absorption,HETP,NTU,HTU concept.	**3**	**Apply**
CO341.4	**Understand** Vapour-Liquid equilibra,basic definitions of Humidification terms, Psychrometric chart ,calculation of height of cooling tower, etc.	**2**	**Understand**
CO341.5	**Remember** different Gas-Liquid contacting devices..	**1**	**Remember**
CO341.6	**Understand** basic drying principles, types of moisture binding, mechanism of moisture movement in solid, rate of drying curve,etc..	**2**	**Understand**

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX															
COs	PROGRAM OUTCOMES (POs)												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO 10	PO11	PO 12	PSO1	PSO2	PSO 3
1	3	1	1	1						1		1	3	1	
2	3	2	1	1						1		1	3	1	
3	3	2	1	1	1					1		1	3	1	1
4	3	2	1	1						1		1	3	1	
5	2			1						1		1	3	1	
6	3	2	3	1	1					1		1	2	1	1
Total	17	9	7	6	2					6		6	17	6	2
Total Wt	18	18	15	18	6					18		18	18	18	6
% Mapping	94.44	60	46.67	33.33	33.33					33.33		33.33	94.44	33.33	33.33
C341	3	3	2	1	1					1		1	3	1	1

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
C341.1	√			√	√	√	√	
C341.2	√			√	√	√	√	
C341.3		√		√	√		√	√
C341.4		√		√	√		√	√
C341.5			√	√	√		√	√
C341.6			√	√	√		√	√

Chemical Engineering Department

Teaching Plan

Mass Transfer-I (309341)

Teaching Scheme:
Theory: 03 hrs/week

Practical: 4hrs / week

Examination Scheme:
Insem: 30
Endsem: 70 Credit = 3
PR: 50 Credit = 2

Lect No.	Topics / Sub- Topics	CO mapped
1	Vision,Mission,CO-PO, Subject Orientation	
2	**Introduction**:- General principles of M.T.	CO1
3	Methods of conducting M.T. operation	CO1
4	Diffusion ,molecular & eddy diffusion	CO1
5	Ficks law,molecular diffusion in gases & liquids	CO1
6	Diffusivities of gases & liquids	CO1
7	Maxwells law of diffusion, Numericals	CO1
8	**Inter-Phase Mass Transfer:-**Mass transfer coefficient in laminar & turbulent flow.	CO2
9	Theories of mass transfer	CO2
10	Mass, heat & momentum transfer analogies	CO2
11	Equilibrium in mass transfer, Concentration profile in IMT	CO2
12	Continuous co-current, countercurrent and crosscurrent processes	CO2
13	Cascades, MT using film MTC & IMTC	CO2
14	overall MTC	CO2
15	Numerical	CO2
16	**Gas Absorption: -** Mechanism of gas absorption, equilibrium in gas absorption	CO3
17	Absorption in wetted wall columns	CO3
18	Absorption in packed tower and spray tower	CO3
19	Calculation of HETP, HTU, NTU, calculations of height of packed and spray tower	CO3
20	Absorption in tray towers, absorption and stripping factors	CO3
21	Tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction	CO3
22	Numerical	CO3
23	**Humidification and Dehumidification:-** Principles, vapour-liquid equilibria	CO4
24	Basic definition of all humidification terms	CO4
25	Wet bulb temperature relation, Lewis relation	CO4
26	Equipment like cooling towers, tray towers, spray chambers, spray ponds	CO4
27	Cooling tower design – HTU, NTU concept	CO4

28	Calculation of height of cooling tower.	CO4
29	Numerical	CO4
30	**Equipment for gas liquid operation:-** Types of columns, trays, & packing	CO5
31	Gas dispersal equipment – bubble columns	CO5
32	Mechanically agitated vessels	CO5
33	Tray towers.	CO5
34	Liquid dispersal equipment–Venturi scrubbers	CO5
35	Wetted wall columns	CO5
36	Spray towers, packed columns.	CO5
37	**Drying:-** Principles, equilibrium in drying.	CO6
38	Type of moisture binding, mechanism of batch drying, continuous drying.	CO6
39	Time required for drying	CO6
40	Mechanism of moisture movement in solid	CO6
41	Design principles of tray dryer, rotary dryer	CO6
42	Spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.	CO6
43	Numerical	CO6
44	University Paper	

Question Bank

Mass Transfer-I (309341)

	Unit-I	CO
Q.1	What is the Principle of Mass Transfer? Explain the importance of Mass Transfer and methods of conducting the Mass-Transfer?	CO1
Q.2	How Mass-Transfer operations are classified? List the general design Principles for Mass-Transfer operation?	CO1
Q.3	Differentiate between Molecular & Eddy Diffusion? Explain Flicks law for molecular diffusion?	CO1
Q.4	State and explain Maxwell's law of diffusion?	CO1
Q.5	Explain the importance of Mass Transfer and Classification of the Mass-Transfer Operations?	CO1
Q.6	Explain diffusion in solids and Unsteady state mass transfer?	CO1
Q.7	What are the types of diffusion? Explain?	CO1
Q.8	Calculate diffusivity of dry Hydrogen in Air at 303^{o} K & 1 atm. The molecular volume of Air & Hydrogen is 29.9 cm^3/gm.mole & 14.3 cm^3/gm.mole respectively.	CO1
	Unit-II	
Q.1	What are the different theories of Mass Transfer? Explain any one?	CO2
Q.2	What are the different theories of Mass Transfer? Explain Whitman's Two-Film theory?	CO2
Q.3	Explain Heat, Mass and Momentum transfer analogies?	CO2
Q.4	Derive relation between overall and individual mass transfer resistance in term of mass transfer coefficients?	CO2
Q.5	Derive the equation for Mass transfer coefficient for steady state diffusion of A through stagnant B	CO2
Q.6	A tube 1 cm in inside diameter that is 20 cm long is filled with CO2 (A) & H2 (B) at 2 atm total pressure at 0 ^{o} C. The diffusion coefficient of the CO2 - H2 (AB) system under these conditions is 0.275 Cm^2/sec. If the partial pressure of CO2 is 1.5 atm at one end & 0.5 atm at the other end. Find the rate of diffusion for :- i) Steady state equimolar counter diffusion. ii) Steady state counter diffusion where NB= -0.75 NA iii) Steady state diffusion of Co2 through stagnant H2.	CO2
Q.7	Ammonia gas (A) is diffusing through a uniform tube 0.10 m long containing Nitrogen gas (B) at $1.0132X10^5$ Pa pressure & 298 K.At point one P_{A1} = $1.013X10^4$ Pa & at point two P_{A2} = $0.507X10^4$ Pa. The diffusivity D_{AB} = $0.23X10^{-4}$ m^2/sec. Calculate the flux at steady state.? (R=8.314 kg m^2/sec^2kgmol.K)	CO2
Q.8	A volatile organic compound Benzene costing Rs. 45 per Kg is stored in a tank 10 m diameter & open at top. A stagnant air film 10mm thick is covering the surface of the compound beyond which the compound is absent. If the atmospheric temperature is 25 ^{0} C, vapour pressure of the compound is 150	CO2

	mmHg & its molar diffusivity is 0.02 m^2/hr. Calculate the loss of Benzene in Rs/day. (R=0.082058 m^3atm/Kmol.K).	
Q.9	In an Oxygen-Nitrogen mixture at 10 atm. & 25^0 C the concentration of Oxygen at two places of 0.2 cm apart are 10 & 20 volume % respectively. Calculate the rate of diffusion of oxygen expressed as gm/cm^2.hr for the case of unicomponent diffusion (Nitrogen is non-diffusing). Value of diffusivity is 0.181 cm^2/sec.	CO2
Q.10	In a transfer operation operating at 1 atm. the individual mass transfer coefficients in liquid and gas phases have the following values respectively, k_x = 22 kgmol/m^2h ,k_y = 1.07 kgmol/m^2h. The equilibrium composition of gaseous and liquid phases are characterized by Henry's law $P_A = 0.08 \times 10^6\ x_A$. i) Determine the overall mass transfer coefficients. ii) Determine the resistance of liquid and gas phase	CO2
Q.11	A stream of air at 100Kpa pressure and 300 K is flowing on the top surface of thin flat sheet of solid Naphthalene of length 0.2 m with a velocity of 20 m /s. Data : Mass Diffusivity of Naphthalene vapour in air = 6 x 10^{-6} m^2 / s Kinematic viscosity of air = 1.5 x 10^{-5} m^2/sec. Concentration of naphthalene at the air- solid Naphthalene interface = 1 x 10^{-5} kmole /m^3 Calculate : a) The average mass transfer coefficient over the flat plate b) The rate of loss of Naphthalene from the surface For heat transfer over a flat plate, convective heat transfer coefficient for laminar flow can be calculated by the equation, $Nu = 0.664\ Re_L^{1/2}\ Pr^{1/3}$ You may use heat and mass transfer analogy.	CO2
Q.12	Air flows at velocity of 5 m/s through the cylindrical tube of Naphthalene. The diameter of the tube is 0.1 m and the temperature of the air is 293 k. Calculate the mass transfer coefficient for transfer of naphthalene to air using expression proposed by Gilliand and Sherwood, $Sh_M = 0.023\ (Re)^{0.83} . (Sc)^{0.33}$ Data: Viscosity of air = μ = 1.8 x 10^{-5} kg/m.sec Density of air = ρ = 1.2 kg/m^3 Diffusivity of Naphthalene in air = D_{AB} = 4.24 x 10^{-6} m^2/sec	CO2
	Unit-III	
Q.1	Explain in detail Absorption & Stripping?	CO3
Q.2	Explain Choice of solvent for Absorption?	CO3
Q.3	Explain the process for determination of number of theoretical plates for counter current absorption process?	CO3
Q.4	Explain minimum Liquid / Gas (L/G) ratio for Absorption?	CO3
Q.5	Explain in detail Equilibrium in Gas Absorption?	CO3
Q.6	Explain mechanism of Gas Absorption & Desorption? Explain absorption in wetted wall column?	CO3

Q.7	Describe absorption with Chemical reaction?	CO3
Q.8	What is Tray efficiency? Explain types of Tray efficiencies?	CO3
Q.9	5000 kg /hr of a SO_2 – air mixture containing 5% by volume SO_2 is to be scrubbed with 200000 kg / hr of water in a packed tower. The exit concentration of SO_2 is reduced to 0.15%. The tower operates at 1 atm.The equilibrium relationship is given by **Y=30X** Where, Y = Mole SO_2/Mole air X = Mole SO_2/Mole water. If the packed height of the tower is 420 cm, estimate the height of transfer unit (HTU)	CO3
Q.10	10,000 kg /hr of a SO_2 – air mixture containing 5% by volume SO_2 is to be scrubbed with 4,00,000 kg / hr of water in a packed tower. The exit concentration of SO_2 is reduced to 0.15%. The tower operates at 1 atm. The equilibrium relationship is given by **Y = 20X** Where, Y = Mole SO_2/Mole air X = Mole SO_2/Mole water. If the packed height of the tower is 420 cm, estimate the height of transfer unit (HTU)	CO3
Q.11	A packed tower is designed to recover 98% CO2 from a gas mixture containing 10% CO2 & 90% air using water The equilibrium relation is given as **Y= 14X**. Where Y= KgCO2/Kg dry air & X= Kg CO2/Kg water The water to gas rate is kept 30% more than the minimum value. Calculate the height of tower if (HTU) OG = 1m	CO3
	Unit-IV	
Q.1	Define following terms 1. Absolute Humidity 2. Saturation Humidity 3. Percentage Humidity 4. Percentage relative Humidity 5. Dew point temperature 6. Humid Heat 7. Humid Volume	CO4
Q.2	Explain the Phase diagram for water & Psychometric Chart?	CO4
Q.3	Explain Adiabatic Saturation temperature? Derive Lewis Relation?	CO4
Q.4	Explain the Vapor pressure of water & physical states?	CO4
Q.5	Explain the following 1. Cooling tower & calculation of height of cooling tower. 2.Tray tower 3.Spray chambers 4.Spray ponds	CO4
Q.6	Explain design of cooling tower-HTU, NTU concept?	CO4
Q.7	Air entering a dryer has a temperature (DBT) of 60 ^oC & a dew point of 26.7 ^oC.Using the Humidity chart; determine the actual humidity, Percentage humidity, humid heat & the Humid volume?	CO4
Q.8	The air in a room is at 26.7 ^0C & a pressure of 101.325KPa & contains water vapor with a partial pressure 2.76 KPa. Calculate 1) Absolute Humidity 2) Saturation humidity. 3) Percentage humidity 4) Relative humidity.	CO4

	Data: Vapor pressure of water at 26.7 ^{0}C is 3.5 KPa	
Q.9	A gas (B) - Benzene (A) mixture is saturated at 1 std.atm 50 ^{0}C.Calculate the absolute humidity if B is i) Nitrogen and ii) Carbon dioxide. (**Data:** PA= 0.362 std.atm.)	CO4
	Unit-V	
Q.1	Explain mechanically agitated vessels with different types of impellers?	CO5
Q.2	What are the different Gas dispersal equipment's? Explain bubble column?	CO5
Q.3	What are the various equipment's used for gas-liquid contact. With neat sketch explain Venturi Scrubber & Spray Towers?	CO5
Q.4	What are the different types of Column? Explain?	CO5
Q.5	Explain various types packing's used in separation towers and their classification?	CO5
Q.6	Differentiate between tray columns and packed columns.	CO5
Q.7	What are the different types of trays? Explain?	CO5
Q.8	What are the different liquid dispersal equipment's? Explain	CO5
	Unit-VI	
Q.1	Explain how to plot the Rate of drying curve?	CO6
Q.2	What is drying? Explain mechanism of moisture movement within solid?	CO6
Q.3	Explain time required for Drying? Derive the equation to calculate total time for Drying?	CO6
Q.4	Draw and explain with neat sketch (Principle, working and construction) 1. Rotary Dryer 2. Fluidized Bed Dryer 3. Tray Dryer 4. Spray Dryer	CO6
Q.5	What are factors affecting rate of drying? Draw and Explain drying rate curve.	CO6
Q.6	Explain experimental determination of Rate of drying curve?	CO6
Q.7	A batch of solid for which the following table of data applies is to be dried from 25% to 6% (wet basis) moisture under conditions identical to those for which the data were tabulated. The initial weight of the wet solid is 300 kg & the drying surface is 1 m^2/8 kg dry weight. Determine the time for drying?	CO6
Q.8	A porous dry solid was dried under constant drying conditions in a batch dryer. It took 6 hrs. to reduce the moisture from 50% to 10%.All the moisture content on dry basis .How long will it take to dry a sample of the above solid to dry from 66% to 6% under the same drying conditions?	CO6
Q.9	A slab of paper pulp 1.5 m × 1.5 m × 5 mm is to be dried under constant drying conditions from 65 to 30% moisture (wet basis) and the critical moisture is 1.67 kg free water / kg dry pulp. The drying rate at the critical point has been estimated to be 1.40 kg/m^2.hr. The dry weight of each slab is 2.5 kg. Assuming drying to	CO6

X kgmoisture/kg dry solid	0.35	0.25	0.2	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.064
R Kg moist./hr.m^2	0.3	0.3	0.3	0.266	0.239	0.208	0.18	0.15	0.097	0.07	0.025

	takes place from two large faces only, Calculate the drying time to be provided. (Equilibrium moisture content is zero).	
Q.10	A porous dry solid was dried under constant drying conditions in a batch dryer. It took 5 hrs. to reduce the moisture from 30% to 10%. The critical moisture content is 16%, equilibrium moisture content is 2%.All the moisture content on dry basis. How long will it take to dry a sample of the above solid to dry from 36% to 6% under the same drying conditions?	CO6

Mass Transfer-I (309341)

List of Practical:

Expt. No.	Name of Experiment	CO Mapped
1	Winkelmann's method – To find the diffusion Coefficient of vapour in still air	CO1
2	Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system	CO1
3	Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column	CO2
4	Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction	CO3
5	Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower	CO3
6	Humidifier and Dehumidifier – To study the Characteristics	CO4
7	Tray Dryer – To calculate rate of Drying	CO6
8	Rotary Dryer – To study the Characteristics of Rotary Dryer	CO6
9	Spray Dryer – To study the design and Operating Principles of Spray Dryer	CO6
10	Fluidized Bed Dryer – To study the characteristics of Fluidized bed Dryer	CO6

Course: 02

Chemical Technology-II

(309342)

T.E. Chemical (2019 Pattern)

[Theory & Practical]

Course Syllabus

Chemical Technology-II (309342)

Unit I: Sulfur and Sulfuric Acid Industries: 7 Hrs.

Elemental sulfur mining by Frasch process, Sulfur production by oxidation-reduction of H2S, Sulfur and sulfur dioxide from pyrites, Sulfuric acid. Contact process, Chamber process. Sea chemicals: Sodium-Magnesium compounds, different methods for different salt recovery. Electrolytic industry: Production of Aluminum, Magnesium.

Unit II: Sugar and Starch Industries: 7 Hrs.

Sucrose, ,Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar, Starch production from maize, Production of dextrin by starch hydrolysis in a fluidized bed. Pulp and Paper Industries: Sulfate pulp process, Chemical recovery from sulfate pulp digestion liquor, Types of paper products, Raw materials, Methods of production.

Unit III: Coal Chemicals: 7 Hrs.

Destructive distillation of coal, Types of carbonization, Coke oven – construction, working and applications. Cements: Introduction, types of cements, properties and applications. Manufacture of Portland cement. Beneficiation & Production of Hydrated lime. Iron and Steel: Production of steel, blast furnace detail.

Unit IV: Surface coating industries: 7 Hrs.

Types of surface coating; Paints, varnishes, distempers and enamels. Dyes and dye intermediates industry: Classification of dyes; Dye and dye intermediates; Production of some important dyes, lacquers and toners. Fuel and Industrial Gases: Technology options of producing producer gas, natural gas, water gas, nitrogen, oxygen and carbon dioxide.

Unit V: Pharmaceutical industries: 7 Hrs.

Classification of drugs; Drug production based on some selected unit processes. Bio Pharmaceutical Industry: Production of penicillin, antibiotics. Agrochemical industries: Manufacturing process of some important pesticides, insecticides, fungicides, fumigants, plant growth regulators, yield stimulators and herbicides.

Unit VI: Petrochemical Industry: 7 Hrs.

C1 Compounds: Production of Methanol, Formaldehyde, and Halogenated Hydrocarbons. C2 Compounds: Production of Ethylene and Acetylene- Steam Cracking of Hydrocarbons, Ethylene Dichloride, Vinyl Chloride. C3 Compounds: Production of Propylene by Indirect Hydration, Acetone, Cumene Aromatic Compounds: Production of Phenol, Phthalic Anhydride and Styrene.

Reference Books:

1. Chemical Technology- Venkatesh Waralu, Vol. I, II, III, IV Chemical Engg. IIT Madras
2. Outlines of Chemical Technology, Dryden
3. Unit Processes in Organic Synthesis, Groggins P., McGraw Hill.
4. Chemical Process Industries, Shreeve R.N., McGraw Hill.
5. Industrial Chemicals, Feith – Keys and Clerk.

TE Chemical

309342: Chemical Technology-II

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks
Practical: 4 Hrs/ Week	In semester Assessment: 30 Marks
	End Semester Assessment: 70 Marks.
	TW: 25 Marks Oral :50 Marks **Total- 175**
	Credits: Theory: 3 Practical: 2 Total: 5 Credits

Course Outcomes (COs Chemical Technology-II

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

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C342.1	Describe the basic principles and mfg. processes used in chemical process Industries.	**02**	**Understand**
C342.2	Draw and construct various industries process flow diagrams.	**03**	**Apply**
C342.3	Produce the various chemical components used in chemical process industry and evaluate their heat and mass balance and also describe the end use (application) of various chemical components.	**03**	**Apply**
C342.4	Analyse major engineering problems encountered in chemical processes.	**04**	**Analyze**

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												2		
2	2				2							2	2		2
3	2	2	1	2			2					2	2	2	
4	2	2	2				2						2	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	TW	OR	Endsem
C342.1	√	√		√	√	√	√	√	√
C342.2	√	√		√	√	√	√	√	√
C342.3			√	√	√	√	√	√	√
C342.4			√	√		√	√	√	√

Chemical Engineering Department

Teaching Plan

Chemical Technology-II (309342)

Teaching Scheme:
Theory: 03 hrs. /week

Practical: 04 hrs. /week

Examination Scheme:
Insem: 30
Endsem: 70 : Credit = 3
Tw: 25 OR: 50 : Credit = 2
Total: 175 : Total Credit = 5

Lect. No.	Topics / Sub- Topics	CO mapped
1	PO,PSO,CO & Subject orientation	-
2	**Sulfur and Sulfuric Acid Industries:** Elemental sulfur mining by Frasch process	1,2
3	Sulfur production by oxidation-reduction of H_2S, Sulfur and sulfur dioxide from pyrites	1,2,4
4	Sulfuric acid. Contact process	1,2,4
5	Sulfuric acid-Chamber process	1,2,4
6	Sea chemicals: Sodium-Magnesium compounds, different methods for different salt recovery	1,2
7	Electrolytic industry: Production of Aluminum, Magnesium.	1,2
8	**Sugar and Starch Industries:** Sucrose, Extraction of sugar cane to produce crystalline white sugar	1,2,3,4
9	Extraction of sugar cane to produce sugar	1,2,3,4
10	Starch production from maize	1,2
11	Production of dextrin by starch hydrolysis in a fluidized bed	1,2,3,4
12	Pulp and Paper Industries: Sulfate pulp process	1,2,4
13	Chemical recovery from sulfate pulp digestion liquor	1,2
14	Types of paper products, Raw materials, Methods of production	1,2,3
15	**Coal Chemicals:** Destructive distillation of coal, Types of carbonization	1,2
16	Coke oven – construction, working and applications	1,2
17	Cements: Introduction, types of cements, properties and applications	1,3
18	Manufacture of Portland cement	1,2
19	Beneficiation & Production of Hydrated lime	1,2
20	Iron and Steel: Production of steel	1,2
21	Blast furnace detail	1,2
22	**Surface coating industries:** Types of surface coating; Paints, varnishes, distempers and enamels.	1,3
23	Dyes and dye intermediates industry: Classification of dyes; Dye and dye intermediates.	1,3

24	Production of some important dyes, lacquers and toners	1,3
25	Fuel and Industrial Gases: Technology options of producing producer gas	1,2
26	Natural gas	1,2
27	Water gas	1,2
28	Nitrogen, oxygen and carbon dioxide	1,2
29	**Pharmaceutical industries:** Classification of drugs; Drug production based on some selected unit processes.	1,3
30	Bio Pharmaceutical Industry**:** Production of penicillin	1,2,4
31	Agrochemical industries: Manufacturing process of some important pesticides	1,2
32	Insecticides, fungicides,	1,2
33	Fumigants, plant growth regulators	1,2
34	Antibiotics, Yield stimulators and Herbicides	1,2
35	**Pharmaceutical industries:** Classification of drugs; Drug production based on some selected unit processes.	1,3
36	**Petrochemical Industry:** C1 Compounds: Production of Methanol	1,2,4
37	Production Formaldehyde and Halogenated HC	1,2,4
38	C2 Compounds: Production of Ethylene and Acetylene- Steam Cracking of Hydrocarbons	1,2,4
39	Ethylene Dichloride	1,2,4
40	Vinyl Chloride	1,2,4
41	C3 Compounds: Production of Propylene by Indirect Hydration, Acetone	1,2,4
42	Cumene Aromatic Compounds: Production of Phenol	1,2,4

Question Bank

Chemical Technology-II (309342)

	Unit-I	CO
Q.1	Describe in detail the contact process for Sulphuric acid mfg. Also describe the major Engineering problems associated in this process.	01+04
Q.2	Explain different methods for different salt recovery.	01
Q.3	With neat flow diagram and reactions, discuss manufacture of sulfur production by oxidation-reduction of H_2S.	01+02
Q.4	Discuss with neat sketch production of Aluminum.	01+02
Q.5	Elemental sulfur mining by Frasch process with neat diagram.	01+02
Q.6	Draw neat process flow diagram for sulfur and sulfur dioxide from pyrites.	01+02
Q.7	Describe the mfg. of sulfur and sulfur dioxide from pyrites with chemical reactions. Also describe the major engineering problems.	01+04
Q.8	Describe the mfg. of magnesium compound from sea.	01
Q.9	Differentiate between contact and chamber process for mfg. of sulfuric acid.	01
Q.10	State the end uses of 1. Sulphur 2. Sulfuric acid	04
Q.11	State the classification of fuel gases.	01
Q.12	Draw process flow diagram for production of magnesium compound from sea.	02
	Unit-II	
Q.1	Describe in detail extraction of sugar cane to produce crystalline white sugar with neat and labeled flow-sheet.	01+02
Q.2	Discuss the sulfate pulp process with neat flow-sheet and in detail explain chemical recoveries from sulfate pulp digestion liquor	01+02
Q.3	Describe the Chemical recovery from sulfate pulp digestion liquor with neat process flow diagram.	01+02
Q.4	Describe the method for paper production with neat process flow diagram.	01+02
Q.5	Describe the extraction of sugar cane to produce sugar (gur/dark brown sugar concentrate).	01
Q.6	Describe the starch production from maize with neat diagram.	01+02
Q.7	Describe the production of dextrin by starch hydrolysis in a fluidized bed with neat diagram.	01+02
Q. 8	State types of paper products and raw material for paper making.	01
Q.9	Describe the major engineering problems associated with production of sugar.	04
Q.10	State the end use of starch.	03
Q.11	Describe the sulfate pulp process with neat diagram.	01+02
Q.12	Describe the Chemical recovery from neutral pulp digestion liquor with	01+02

	neat process flow diagram.	
	Unit-III	
Q.1	What is destructive distillation? State Process for destructive distillation.	01
Q.2	What is carbonization of coal? Explain types of carbonization. Effect of temperature on product obtained.	01
Q.3	Describe the manufacture process for Portland cement with neat flow sheet.	01+02
Q.4	Explain the types of cements.	01
Q.5	Describe the properties of cement with applications.	01+03
Q.6	Explain the beneficiation & Production of Hydrated lime with neat process flow diagram. Also explain major engineering problems.	01+03+04
Q.7	Explain production of cock with major engineering problems.	04
Q. 8	Draw and explain coke oven construction with its applications.	01+02
Q. 9	Explain construction and working of blast furnace.	02
Q.10	Describe the pyrolysis of coal with neat diagram and steps.	03
Q.11	Explain types of steel in detail with their applications.	03
Q.12	Describe the production of steel with neat diagram.	01+02
	Unit-IV	
Q.1	Describe the manufacture process for producer gas with neat flow sheet.	01+02
Q.2	Explain the types of surface coating. Also explain types of dyes.	01
Q.3	Describe the manufacture process for water gas with neat process flow sheet. 1. By using Regenerative Process. 2. By using Continuous process.	01+02
Q.4	Describe the production of oxygen and nitrogen with neat diagram.	01+02
Q.5	Explain the production of dyes with unit operations and processes involved in it.	01+02
Q.6	Describe the major engineering problems for the production of oxygen and nitrogen with end use.	01+02
Q.7	Explain the preparation of paints with typical formulations, mention the functions of each ingredients.	01+02
Q.8	Give the classification of dyes based on various parameters.	01+02
Q. 9	State the major unit operations used for production of various types of surface coating industries with its applications.	01+03
Q.10	Describe the major engineering problems for the production of water gas and producer gas.	04
Q.11	Explain the properties and applications of varnishes.	01+03
Q.12	Describe the manufacture process for natural gas and LPG with neat flow sheet.	01+02
	Unit-V	
Q.1	Describe in detail the Production of Penicillin.	01
Q.2	Explain classification of drugs.	01
Q.3	Describe in detail the Production of DDT (dichloro-diphenyl-	01+02

	trichloroethane) with neat process flow sheet.	
Q.4	Draw and explain the process flow sheet for production of 2, 4-D.	01+02
Q.5	Describe the detail about plant growth regulators and yield simulators.	01
Q.6	Describe the manufacturing of BHC with major engineering problems.	01+04
Q.7	Discuss different types of agrochemicals and explain process for mfg. of pesticides.	01
Q.8	Describe the major engineering problems for production of Penicillin.	04
Q. 9	Describe the major engineering problems for production of DDT and 2,4-D.	04
Q.10	Explain classification of pesticide, insecticide and fungicides.	01
Q.11	Draw the process flow diagram for production of penicillin.	02
Q.12	State the consumption of pesticide by groups and applications in agriculture.	03
	Unit-VI	
Q.1	Describe in detail the Production of Methanol with neat process flow sheet.	01
Q.2	Describe in detail the Production of Formaldehyde with neat process flow sheet with major engineering problems.	01+04
Q.3	Draw and describe the process flow sheet for production of Ethylene Dichloride	02
Q.4	Draw and describe the process flow sheet for production of Vinyl Chloride.	01+02
Q.5	Explain production of phenol by cumen process with neat process flow diagram with major engineering problems.	01+04
Q.6	Explain production of acetone with neat process flow diagram.	01
Q.7	Explain in detail hydrogenated hydrocarbons.	01
Q.8	Explain production of phenol by toluene oxidation process with neat process flow diagram.	01
Q.9	Describe the raschig process for phenol mfg. with neat process flow sheet.	01
Q.10	Explain production of Phthalic Anhydride with neat process flow diagram.	02
Q.11	Explain production of Styrene with neat process flow diagram.	02
Q.12	Draw and describe the Production of ethylene and acetylene-steam cracking of hydrocarbons with neat process flow diagram.	02
Q.13	State the end use for Methanol, Formaldehyde, acetone and Styrene.	03

Chemical Technology-II (309342)

List of Practical:

Expt. No.	Name of Experiment	CO Mapped
1	Study of Unit operations and unit processes	01
2	Study recycle operations	01
3	Introduction to Chem CAD software	02
4	Process flow diagram (PFD) using software C1/C2 Compounds	02
5	Process flow diagram (PFD) using software Sulfuric Acid/Sugar/(Other)	02
6	Mfg./production of Soap	03
7	Mfg./production of Detergents	03
8	Mass balance calculations of any two processes using process calculation approach	03
9	Heat balance calculations of any two processes using process calculation approach.	03
10	Industrial Visit	-

Course: 03

Chemical Engineering Mathematics

(309343)

T.E. Chemical (2019 Pattern)

[Theory]

Course Syllabus

CHEMICAL ENGINEERING MATHEMATICS (309343)

Unit 1: Error and Roots of Equation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Error Definition, Round of Error, Error Propagation, Total Numerical Error. Bracketing method: Graphical, Bisection, False-Position. Open Method: Single variable Newton Raphson, Secant method, multiple roots. Roots of Polynomial: Mullers Method. Caley Hamilton method.

Unit 2: Linear Algebraic Equation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods :Gauss Elimination, Gauss-Jordon Elimination, LU Decomposition, Tridiagonal Systems (Thomas Algorithm), Gauss Seidel and Relaxation Method. Eigen values and Eigen Vectors of Matrices.

Unit 3: Regression Analysis and Interpolation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods. Statistical Data Analysis: Least square method, curve fitting and regression. Linear Regression, Polynomial Regression, Multiple Linear regression, Non-linear regression, Newton's Interpolation, Newton's Divided Difference Interpolation, Polynomial, Lagrangian Interpolation. Numerical Integration: Trapezoidal method, Simpson 1/3rd rule, Simpson 3/8th rule

Unit 4: Ordinary Differential Equation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods. Euler's method, Modified Euler's method, 2nd order Runge-Kutta Method, 4th order Runge-Kutta method, Systems Equations. Picards method of successive approximations. Ordinary Differential Equation: Boundary Value Problems, Taylor series method.

Unit 5: Finite Difference Methods **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods .Introduction to finite difference method. Boundry value problems of exact differential equations up to second order. Hyperbolic equations, Finite difference approximations to derivatives. Elliptical Equation, Control Volume Approach, Heat Conduction Equation.

Unit 6: Optimization **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Basic concept of optimization and formulation, Nature of optimization. Linear programming by simplex method. Applications of optimization based on simplex method. Golden search method and its application.

Reference Books:

1. Steven C Chapra, Raymond P Canale, 'Numerical Methods for Engineers', 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Dehli, 2007

2. Santosh K Gupta, 'Numerical Methods for Engineers', New Age International Publishers Limited, 1995

3. Thomas F Edgar, David M Himmeblau, Leon S Lason, 'Optimization of Chemical Processes', 2nd Edition, Mc-Graw Hill Publication, 2002

4. S. Balgurusamy, 'Numerical methods', Tata McGraw Hill Publication, New Delhi, 2008

5. Curtise F Gerald, Patrick O Wheatley, 'Applied Numerical Analysis', 6th Edition, Pearson Education Asia, 2002.

309343: CHEMICAL ENGINEERING MATHEMATICS

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

Course Outcomes (COs) CHEMICAL ENGINEERING MATHEMATICS

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

Course Outcomes	Statements	Bloom's Taxonomy	
		Level	Descriptor
C343.1	Apply the different numerical methods for evaluate error and roots of equations	3	**Apply**
C343.2	Apply numerical methods to solve linear algebraic equations.	3	**Apply**
C343.3	Analyze the regression and interpolation methods to solve numerical.	3	**Apply**
C343.4	Evaluate ordinary differential equation by applying the different numerical methods	4	**Evaluate**
C343.5	Apply numerical methods to solve Finite Difference Methods	3	**Apply**
C343.6	Formulate the optimization process and evaluate the numerical on optimization.	4	**Formulate & 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	3	3	2	2									2	2	1
2	2	3	2	2									2	2	1
3	2	2	1	2									2	2	1
4	3	2	2	2									2	2	1
5	2	2	1	1									1	1	2
6	2	2	2	2									2	1	1

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	OR	Endsem
C343.1	√		--	√	-	√	-	
C343.2	√		--	√	-	√	-	
C343.3	--	√	--	√	-		-	√
C343.4	--	√		√	-		-	√
C343.5			√	√				√
C343.6			√	√				√

Chemical Engineering Department

Teaching Plan

Chemical Engineering Mathematics (309343)

Teaching Scheme:
Theory: 03 h/week

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

Lect No.	Topics / Sub- Topics	CO mapped
1	Vision, Mission,PO,PSO,CO & Subject orientation	
	Introduction to Error and Roots of Equation	CO1
2	Problems based on Process Calculation, Fluid Flow operation and Heat Transfer	CO1
3	Error Definition, Round of Error	CO1
4	Error Propagation, Total Numerical Error. Bracketing method:	CO1
5	Bisection, False-Position. Open Method	CO1
6	Single variable Newton Raphson, Secant method, multiple roots.	CO1
7	Mullers Method, Caley Hamilton method	CO1
8	Innovative teaching methods- Quiz	CO1
	Linear Algebraic Equation	CO2
9	Gauss Elimination	CO2
10	Gauss-Jordon Elimination	CO2
11	L U Decomposition	CO2
12	Gauss Seidal Method	CO2
13	Gauss Relaxation Method	CO2
14	Tridiagonal Systems (Thomas Algorithm)	CO2
15	Innovative teaching methods- Quiz	CO2
	Regression Analysis and Interpolation	CO3
16	Statistical Data Analysis: Least square method, curve fitting and regression.	CO3
17	Linear Regression, Polynomial Regression	CO3
18	Multiple Linear regression, Non-linear regression	CO3
19	Newton's Interpolation, Newton's Divided Difference Interpolation	CO3
20	Polynomial, Lagrangian Interpolation	CO3
21	Numerical Integration: Trapezoidal method	CO3
22	Innovative teaching methods- Quiz	CO3
	Ordinary Differential Equation	CO4
23	Modified Euler's method	CO4
24	2nd order Runge-Kutta Method	CO4
25	4^{th} Runge-Kutta method	CO4
26	Picards method of successive approximations.	CO4
27	Ordinary Differential Equation: Boundary Value Problems	CO4
28	Taylor series method.	CO4
29	Innovative teaching methods- Quiz	CO4

	Finite Difference Methods	CO5
30	Boundry value problems of exact differential equations up to second order	CO5
31	Hyperbolic equations	CO5
32	Finite difference approximations to derivatives	CO5
33	Elliptical Equation,	CO5
34	Control Volume Approach	CO5
35	Heat Conduction Equation	CO5
36	Innovative teaching methods- Quiz	CO5
	Optimization	CO6
37	Basic concept of optimization and formulation	CO6
38	Nature of optimization.	CO6
39	Linear programming by simplex method	CO6
40	Applications of optimization based on simplex method	CO6
41	Golden search method and its application.	CO6
42	Innovative teaching methods- Quiz	CO6

Question Bank

Chemical Engineering Mathematics (309343)

	Unit-I	CO
Q.1	Calculate the volume for a Real gas using vandar walls equation at following conditions. Pressure = 1 KN/$m^{2,}$ R = 0.082 KJ/kg.k, T= 300K, a = 3.82, b= 0.06 Use Newton –Raphsons method. Assume initial volume= 20 m^3/kg.	CO1
Q.2	Explain different types of error associated with numerical methods.	CO1
Q.3	Using three iterations of Bi-section method, determine root of equation. Initial guesses are x_1 =2.8 and x_2= 3, f(x)= -0.9 x^2 +1.7x+2.5	CO1
Q.4	Enlist the categories and various methods to solve linear algebraic equation.	CO1
Q.5	Find the root of cosx-x=0 by Regula Falsi Method . Take x_1= 0.6 and x_2= 1. Find valve of x for 3 iterations.	CO1
Q.6	Explain Convergence and Divergence in case of Newton- Rapson method.	CO1
Q.7	Find root of equation $2x^3 + 4x^2 - 8 = 0$ using bi-section method. Do three iterations.	CO1
Q.8	Explain Graphical Representation of Bisection Method.	CO1
Q.9	Using Newton Raphsons Method and initial guess as zero, Find x^3-5x +3=0. Do 3 iterations only	CO1
	Unit-II	
Q.1	Explain Partial pivoting in case of Elimination method with suitable example.	CO2
Q.2	State and explain drawbacks of Elimination method used in pitfall technique.	CO2
Q.3	Enlist the categories and various methods to solve linear algebraic equation	CO2
Q.4	Solve the following equations using Gauss Elimination methods 5x + 13y+ 7z = 14 3x+ 6y+3z= 9 7x+2y+4z= 5	CO2
Q.5	Solve the following equations using LU Decomposition methods 2x+3y+z= 9 X+2y+3z= 6 3x+y+2z =8	CO2
Q.6	Solve the following equations using Relaxation methods. Perform 3 iterations 10 X_1+ X_2+ X3 = 12 2X1 +10X2+X3= 13 2X1+2X2+10X3= 14	CO2
Q.7	Solve the following system of equations using Gauss Relaxation method. 10 x_1 -2x_2- 2x_3 = 6 -x_1 +10 x_2- 2x_3 = 7 -x_1 - x_2+10 x_3 = 8	CO2
Q.8	Solve the following equations using Thomas Algorithm X+2y= 3	CO2

	2x+3y+z= 4 2y-z =1	
Q.9	Solve the following equation by using Thomas Algorithm $x_1+ 2x_2= 4$ $-x_1+x_2+2x_3= 1$ $x_2+3x_3 + x_4= 7$ $2x_3+2x_4 = 8$	CO2
Q.10	Find the solution of following system of equation using Gauss Seidal Iterative method perform 3 iterations 10 x1 -5x2-2x3 = 3 -4x1+10x2-3x3= 3 -x1-6x2+10x3 =3	CO2
Q.11	Solve the following system of equation by Gauss Jordon Elimination Method 2x +y+4z = 12 8x-3y+2z = 20 4x+11y-z = 33	CO2
	Unit-III	
Q.1	Explain Polynomial regression with example.	CO3
Q.2	Determine the valves of a and b so that q= a h^b best fits the following data by method of least squares	CO3
Q.3	The velocity distribution of a fluid near a flat surface is given below	CO3
Q.4	Use the method of group averages and find a curve of the form y= mx^n that fits following data	CO3
Q.5	Show that the sum of the squares of the residuals is minimum for least square method.	CO3
Q.6	The equation of best fit curve is of the type y = a b^x Find valve of constants a and b . Fitting the curve through the points.	CO3
Q.7	What is regression? Explain the following a) Polynomial Regression b) Linear Regression	CO3
Q.8	Use **least square** regression to fit a straight line to the data given below.	CO3

H	25	20	12	9	7	5
Q	0.22	0.2	0.15	0.13	0.12	0.1

x	0.1	0.3	0.6	0.8
V= y	0.72	1.81	2.73	3.47

Where , x is distance from the surface (mm) and V is the velocity (mm/sec). Use Lagrange's interpolation polynomial to obtain the velocity at x= 0.4

X	10	20	30	40	50	60	70	80
Y	1.06	1.33	1.52	1.68	1.81	1.91	2.01	2.11

x	2.1	2.5	3.1	3.5	4.1
y	5.14	6.78	10.29	13.58	20.57

X	1	2	3	4	5	6	7
y	0.5	2.5	2.0	4.0	3.5	6.0	5.5

<table>
<tr><td>Q.9</td><td>Using least square technique, fit a curve y = a x^b for a set of points given below and find the valves of constants a and b.

<table><tr><td>x</td><td>0.5</td><td>1.5</td><td>2</td><td>2.5</td><td>3.0</td></tr><tr><td>y</td><td>0.7425</td><td>3.8579</td><td>5.9397</td><td>8.301</td><td>10.912</td></tr></table></td><td>CO3</td></tr>
<tr><td>Q.10</td><td>Growth of bacteria (N) in a culture after t hours is given in following table. Fit a curve of the form N= ab^t And Estimate N when t= 4.5 and t=7

<table><tr><td>T</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>N</td><td>32</td><td>47</td><td>65</td><td>92</td><td>132</td><td>190</td><td>275</td></tr></table></td><td>CO3</td></tr>
<tr><td>Q.11</td><td>The outflow of chemical concentration from a completely mixed reactor is measured as
<table><tr><td>t, min</td><td>0</td><td>2</td><td>4</td><td>6</td><td>8</td><td>12</td><td>16</td><td>20</td></tr><tr><td>C, mg/m^3</td><td>10</td><td>20</td><td>30</td><td>40</td><td>60</td><td>72</td><td>70</td><td>50</td></tr></table>
For an outflow of Q= 12 m$^{3/}$ min., Estimate the mass of chemical that exits the reactor from t= 0 to 20 min. Use Trapezoidal Rule.</td><td>CO3</td></tr>
<tr><td>Q.12</td><td>Fit a Second order polynomial of the type ax^2 + bx +c using least square technique.
<table><tr><td>X</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>Y</td><td>3.5</td><td>5.5</td><td>7.5</td><td>9.5</td><td>11.5</td></tr></table></td><td>CO3</td></tr>
<tr><td>Q.13</td><td>A missile is launched from a ground station. The acceleration during its first 80 sec of flight , as recorded is given by following table

<table><tr><td>t(sec)</td><td>0</td><td>10</td><td>20</td><td>30</td><td>40</td><td>50</td><td>60</td><td>70</td><td>80</td></tr><tr><td>a (m/s^2)</td><td>30</td><td>31.63</td><td>33.34</td><td>35.47</td><td>37.75</td><td>40.33</td><td>43.25</td><td>46.69</td><td>50.67</td></tr></table>Compute the velocity of the missile when t = 80 sec., Using Simpsons 1/3 rule.</td><td>CO3</td></tr>
<tr><td>Q.14</td><td>Explain Linear Regression with example</td><td>CO3</td></tr>
<tr><td></td><td>Unit-IV</td><td></td></tr>
<tr><td>Q.1</td><td>State and explain graphical interpretation of Eulers method.</td><td>CO4</td></tr>
<tr><td>Q.2</td><td>Discuss the errors induced by Eulers method.</td><td>CO4</td></tr>
<tr><td>Q.3</td><td>Solve the following differential equation using Modified Eulers method for the given boundary condition dy/dx = x/4 +y y(1)= 0.1.Find valve of y at x= 1.2 upto accuracy =0.001</td><td>CO4</td></tr>
<tr><td>Q.4</td><td>An object having surface area of 0.1 m^2 is initially at 0 ^{0}C is dipped in a hot water bath. Water is initially at 95^{0}C . Find the temperature of object after 10 seconds, taking dt = 2 seconds</td><td>CO4</td></tr>
<tr><td>Q.5</td><td>The concentration of salt x in a homemade soap maker is given as a function of time by dx/dt = 37.5 - 3.5x. At the initial time, t = o the salt concentration in the tank is 50 g/L. Using Eulers method and a step size of h= 1.5 minutes, What is the salt concentration after 3 minutes?</td><td>CO4</td></tr>
<tr><td>Q.6</td><td>Solve the following equation by Runge-Kutta 4 th order method at x= 0.8. dy/dx= y-x
Take $x_{0=0,}$ y(0)= 2, h =0.2</td><td>CO4</td></tr>
<tr><td>Q.7</td><td>Apply Euler’s method to solve y’= -xy^2 ,y(0)=2 computing upto x=1 with h =0.1 (Given x_0 = 0, y_0 = 2, h= 0.1, x_g =1)</td><td>CO4</td></tr>
<tr><td>Q.8</td><td>Use Modified Euler’s method to solve</td><td>CO4</td></tr>
</table>

	$\frac{dy}{dx} = x^2 + y$ with the condition y(0)=1 . Find the valve of y at x=0.1., $x_0 = 0$ (n=2 and Accuracy= 0.0001)	
Q.9	Using Runge-Kutta Method of fourth order to obtain the numerical solution of $\frac{dy}{dx} = x^2 + y^2$, $x_0 = 0$, $y_0 = 0$, h= 0.2, $x_g = 0.4$ Estimate y (0.2) and y(0.4)	CO4
	Unit-V	
Q.1	Difference between Explicit and Implicit method.	CO5
Q.2	Explain applications of elliptic and parabolic equation in chemical engineering.	CO5
Q.3	A non insulated metallic bar 1 m long is held in air which is at temperature 20^0C. one end of the bar is maintained at 100^0C while other is at 40^0 C. The temperature distribution along the length at steady state may be assumed to be $d^2T/dX^2 + h(Ta-T)=0$, where T is temp. in degree Celsius, X is distance measured fro hot end, Ta is atmospheric temp. in ^{0}C and h= 0.01. Calculate the rod temp.at a distance 250,500,700 mm from hot end.	CO5
Q.4	Using the difference method solve the boundary valve problem $x^2 d^2y/dx^2 + x\, dy/dx = 1$ with y(1) =0, y(1.4)= 0.0566. Find y (1.1) ,y(1.2), y(1.3).	CO5
Q.5	Solve the boundary value problem $d^2y/dx^2 + y = 0$ with boundary conditions y=0 when x=0 y=0 when x=1 . Find y at x =0.5. step size = 0.25	CO5
Q.6	Solve the boundary valve problem, $d^2y/dx^2 - 64y + 10 = 0$ with y(0) =y(1)=0. Using finite difference method calculate y(0.5), taking step size h=0.25	CO5
Q.7	Solve $\partial u/dt = \partial^2 u/dx^2$ for the following condition using explicit finite difference method at x=1 and x=4, u=0 for all values of t at t = 0 $u = e^x + \cos x$ for $1< x< 4$. Take dh=1, dk=0.1. Find all valve of u for t= o to t = 0.5	CO5
Q.8	A steel plate 750x 750 mm has its two adjacent sides maintained at 100 degree C . while the two other sides are maintained at 0 degree C. What will be the steady state temperature at interior points assuming a grid size of 250mm?	CO5
Q.9	Solve $\partial u/dt = \partial^2 u/dx^2$, for the following condition using using Crank- Nicolson method . At x=0 and x=3, u=0 for all values of t . At t = 0, $u = x^2$ for $0< x< 3$. Take increment in x as 1 and increment in t as 0.1.Find all valve of u for t = o to t = 0.3	CO5
Q.10	Evaluate the pivotal valves of the equation uu =16 taking Δx =1 upto t= 1.25. The boundary conditions are u(0,t) =u(5,t)= u(x,0) and u(x,0)= x2(5-x).	CO5
Q.11	Use Crank- Nicolson method to determine temperature distribution of a long thin rod with a length of 10 cm and following valves k= 0.49 cal/s.cm.^{0}C), Δx = 2 cm and Δt = 0.1 sec. At t=0 the temperature of the rod is zero and boundary conditions are fixed for all times at T (0) =50 deg C and T(10) = 100 deg C. Note that the rod is of	CO5

<table>
<tr><td></td><td>Aluminum with C = 0.2174 cal/ (g.^{0}C) and p = 2.7 gms/ cm^3. k= 0.835 cm^2/sec. and λ = 0.020875 .</td><td></td></tr>
<tr><td></td><td>Unit-VI</td><td></td></tr>
<tr><td>Q.1</td><td>What are the six steps of optimization?</td><td>CO6</td></tr>
<tr><td>Q.2</td><td>Explain salient features of Golden search method.</td><td>CO6</td></tr>
<tr><td>Q.3</td><td>Maximize Z= 1600x + 1500y Constraints are
5x+4y ≤ 500
15x+16y≤ 1800 x≥ 0, y≥ 0 By Simplex method</td><td>CO6</td></tr>
<tr><td>Q.4</td><td>Explain scanning and bracketing procedure for optimization of unconstrained functions of one dimensional search.</td><td>CO6</td></tr>
<tr><td>Q.5</td><td>What are various steps in optimization problems?</td><td>CO6</td></tr>
<tr><td>Q.6</td><td>A company is manufacturing two different types of product A and B. Each product has to be processed on two machines M_1 and M_2 . Product A requires 2 hours on machine M_1 and 1 hour on machine M_2. Product B requires 1 hour on machine M_1 and 2 hours on machine M_2 . The available capacity of M_1 is 104 hours and that of M_2 is 76 hours . Maximize Profit per unit for product A is Rs. 6 and that for product B is Rs. 11
Formulate the problem. Use Simplex Method</td><td>CO6</td></tr>
<tr><td>Q.7</td><td>What is optimization and discuss its application in detail</td><td>CO6</td></tr>
<tr><td>Q.8</td><td>What are the limitations of linear programming</td><td>CO6</td></tr>
<tr><td>Q.9</td><td>Explain numerical methods for optimizing a function of one variable.</td><td>CO6</td></tr>
<tr><td></td><td>Define following terms
i) Feasible solution
ii) Basic solution
iii) Optimum solution
iv) Degenerate solution</td><td>CO6</td></tr>
<tr><td></td><td>A firm uses lathes, milling machines and grinding machines to produce two machine parts. Table represents the machining times required for each part, the machines times available on different machines and the profit on each machine part.
<table>
<tr><td rowspan="2">Type of machine</td><td colspan="2">Machine time required for the machine part(minutes)</td><td rowspan="2">Maximum time available per week(minutes)</td></tr>
<tr><td>I</td><td>II</td></tr>
<tr><td>Lathes</td><td>12</td><td>6</td><td>3000</td></tr>
<tr><td>Milling machines</td><td>4</td><td>10</td><td>2000</td></tr>
<tr><td>Grinding machines</td><td>2</td><td>3</td><td>900</td></tr>
<tr><td>Profit per unit</td><td>Rs.40</td><td>Rs.100</td><td></td></tr>
</table></td><td>CO6</td></tr>
</table>

<table>
<tr><td></td><td>Find the number of part I and II to be manufactured per week to maximize the profit.</td><td></td></tr>
<tr><td></td><td>11 Using Simplex method
Maximize $Z = 5x_1 + 3x_2$
Subject to $x_1 + x_2 \leq 2$
$5x_1 + 2x_2 \leq 10$
$3x_1 + 8x_2 \leq 12$
$x_1, x_2 \geq 0$</td><td>CO6</td></tr>
<tr><td></td><td>A firm produces three products which are processed on three machines. The relevent data is given below:
<table>
<tr><td rowspan="2">Machine</td><td colspan="3">Time per unit (minutes)</td><td rowspan="2">Machine capacity(minutes/day)</td></tr>
<tr><td>Product A</td><td>Product B</td><td>Product C</td></tr>
<tr><td>M1</td><td>2</td><td>3</td><td>2</td><td>440</td></tr>
<tr><td>M2</td><td>4</td><td>--</td><td>3</td><td>470</td></tr>
<tr><td>M3</td><td>2</td><td>5</td><td>--</td><td>430</td></tr>
</table>
The profit per unit for products A, B and C is Rs.4, Rs.3 and Rs.6 respectively. Determine the daily number of units to be manufactured for each product. Assume that all the units produced are consumed in the market.</td><td>CO6</td></tr>
<tr><td></td><td>A company is manufacturing two different types of products A and B .Each product has to be processed on two machines M1 and M2. Product A requires 2 hours on machines M1and 1hour on machines M2. Product B requires 1 hour on machines M1 and 2 hours on machines M2. The available capacity of machineM1 is 104 hours and that of M2 is 76 hours. Profit per unit for product A is Rs.6 and that for product B is Rs. 11
i) Formulate the problem.
ii) Find the optimal solution by Simplex method.</td><td>CO6</td></tr>
</table>

Course: 04

Chemical Engineering Thermodynamics

(309344)

T.E. Chemical (2019 Pattern)

[Theory]

Course Syllabus

Chemical Engineering Thermodynamics (309344)

Unit I: Solution Thermodynamics (7 h)

State and path functions, intensive and extensive properties, Fundamental property relations for closed systems, Maxwell relationships, residual properties, chemical potential, effect of T and P on chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, Pointing factor, for species in solution, generalized correlations, ideal solutions.

Unit II: Solution Thermodynamic applications (7 h)

Excess properties, VLE data, fugacity, activity coefficients, excess Gibb's energy, Margules equation, van Laar equation, property changes of mixing.

Unit III: Vapor-liquid equilibrium (7 h)

The nature of equilibrium, criteria of equilibrium, effect of T and P on VLE, zoetrope's, the phase rule, Duhem's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, VLE from Kvalue correlations, Flash calculations, Henry's law.

Unit IV: Phase Equilibria (7 h)

Equilibrium and stability, liquid-liquid equilibrium, solid-liquid equilibrium, osmotic equilibrium and osmotic pressure, thermodynamic consistency.

Unit V: Chemical Reaction Equilibria (7 h)

The reaction coordinates, Application of the criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of the equilibrium constant.

Unit VI: Equilibrium constant (7 h)

Equilibrium constant 7Hrs Relation of equilibrium constant to composition, calculation of equilibrium conversion for single reactions, The phase rule and Duhem's theorem for reacting systems, multireaction equilibria, Introduction to fuel cells.

Reference Books:

1. Introduction to Chemical Eng. Thermodynamics: J. M. Smith, H. C. Van Ness & M. M.Abbott.
2. Principles of Chemical Equilibrium: Kenneth Denbigh
3. Chemical Engineering Thermodynamics: B. F. Dodge
4. Chemical Engineering Thermodynamics: T. E. DauTErt
5. Thermodynamics for Chemists: Glasstone S.
6. Thermodynamics for Chemical Engineers: WeTEr and Meissner
7. Chemical and Process Thermodynamics: B. G. Kyle
8. Molecular Thermodynamic: Praunitz
9. Chemical Engineering Thermodynamics: Narayanan
10. Chemical Engineering thermodynamics: Y.V.C. Rao

309344: Chemical Engineering Thermodynamics

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

Course Outcomes (COs Chemical Engineering Thermodynamics

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

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C344.1	Apply the basic parameters of solution & concept of chemical potential , fugacity and partial molar properties	3	Apply
C344.2	Calculate engineering problems related to solution using different equations.	3	Apply
C344.3	Evaluate bubble point, Dew point and flash calculation.	4	Determine
C344.4	Estimate the thermodynamics consistency of VLE data.	4	Determine
C344.5	Determine the equilibrium constant	4	Determine
C344.6	Determine the equilibrium composition of more than one chemical reaction occurs simultaneously.	3	Estimate

Mapping of Course Outcomes to POs and PSOs

CO-PO CORRELATION MATRIX															
COs	PROGRAM OUTCOMES (POs)												PSO		
	PO1	PO2	PO3	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	3	2	1	1									3	2	
3	3	2	2	1									3	2	
4	3	2	2	1									3	2	
5	3	2	2	1									3	3	
6	3	2		2									3	3	
Total	**18**	**11**	**8**	**6**									**18**	**12**	
Total Wt.	**18**	**18**	**15**	**15**									**18**	**15**	
% Mapping	**100**	**61.11**	**53.3**	**40**									**100**	**80**	
C344	**3**	**3**	**2**	**2**									**3**	**3**	

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		Insem	Endsem
C344.1	√			√		√	
C344.2	√			√		√	
C344.3		√		√			√
C344.4		√		√			√
C344.5			√	√			√
C344.6			√	√			√

Chemical Engineering Department

Teaching Plan

Chemical Engineering Thermodynamics (309344)

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.	Fundamental Property Relation, Chemical Potential.	1
3.	Criteria for Phase Equilibrium , Partial Molar Properties	1
4.	Fugacity & Fugacity Coefficients for pure species.	1
5.	For Species in Solution & Generalized Correlations.	1
6.	Gibbs Duhem Equation & its Various Forms	1
7.	Ideal Gas Mixture, Gibbs Theorem.	1
8.	Innovative teaching methods- Cross word puzzle	-
9.	Excess properties	2
10.	Property Changes of Mixing	2
11.	Fugacity	2
12.	Activity & Activity Coefficients	2
13.	Margules Equation, Van Laar Equation.	2
14.	Excess Gibbs energy	2
15.	Innovative teaching methods- Quiz	-
16.	Phase Equilibrium in Single and Multi component System	3
17.	The Phase Rule	3
18.	Duhem's Theorem	3
19.	The Nature of Equilibrium , Criteria of Equilibrium	3
20.	Constant Pressure VLE Data	3
21.	Roults Law , VLE by Modified Roults Law	3
22.	Dew point Calculation	3
23.	Bubble point calculation	3
24.	Azeotropes	3
25.	Activity coefficient equation using Gibbs Duhem Equation	3
26.	Innovative teaching methods- Cross word puzzle	-
27.	Equilibrium and Stability	4
28.	Binary Liquid - Liquid Equilibrium	4
29.	Ternary Liquid - Liquid Equilibrium	4
30.	Solid - Liquid Equilibrium	4
31.	Solid - Liquid Equilibrium	4
32.	Thermodynamic Consistency	4
33.	Chemical Reaction Equilibria	4
34.	Innovative teaching methods- quiz	-
35.	Application of Criterion of Equilibrium to Chemical Reaction	5
36.	The Standard Gibbs free Energy change	5

37.	The Equilibrium Constant	5
38.	Equilibrium Constant & Effect of Temperature on Equilibrium Constant	5
39.	Evaluations of Equilibrium Constant	5
40.	Innovative teaching methods- Cross word puzzle	-
41.	Relation of Equilibrium Constant to Composition	6
42.	Calculation of Equilibrium Conversion for Single Reaction	6
43.	The Phase Rule & Duhems Theorem for Reacting Systems.	6
44.	Multireaction Equilibria	6
45.	Introduction to fuel cells	6
46.	Fuel cells applications	6
47.	Numerical	6
48.	Innovative teaching methods- Quiz	-

Question Bank

Chemical Engineering Thermodynamics (309344)

	Unit-I	CO
Q.1	Obtain the relation: $d(nG) = (nV)dP - (nS)dT + \sum_i dn_i$	CO1
Q.2	Determine the fugacity of steam at 623K and 1000kPa using enthalpy and entropy values provided here. Assume that the steam behaves ideally at 101.3 kPa. Given: At 1000 kPa and 623 K: H = 3159 kJ/kg; S = 7.3 kJ/kg.K At 101.3 kPa and 623 K: H = 3176 kJ/kg; S = 8.38 kJ/kg.K	CO1
Q.3	Explain the concept of fugacity and fugacity coefficient for species in ideal solution.	CO1
Q.4	Show that the fugacity of a gas obeying Van der Waal's equation	CO1
Q.5	Describe the effect of temperature and pressure on fugacity.	CO1
Q.6	The volume of a mixture of 2 organic liquids 1 & 2 is given by $V=110-17x_1-2.5x_1^2$, where V is volume in m^3/mol at 1 bar & 300K. Find expressions for $V_1, V_2, \Delta V$ and partial molar volumes for 1 and 2	CO1
Q.7	Calculate the mean heat capacity of 20mole% ethanol water solution at 298K. Heat capacity of water is $4.18*10^3$ J/kg.K. Heat capacity of alcohol is $2.18*10^3$ J/kg.K. The enthalpy of mixing Ethanol & water at 298K is -758J/mol and that at 323K is -441J/mol.	CO1
Q.8	What is partial molar property? Explain with an example.	CO1
Q.9	Describe the effect of temperature and pressure on activity coefficients.	CO1
	Unit-II	
Q.1	Two suffix Margule's equation is the simplest equation for excess Gibb, s free energy. $G^E=Ax_1x_2$, where A is an empirical constant independent of composition. Derive the expressions for the activity coefficients that result from this expression.	CO2
Q.2	Explain the VLE diagram.	CO2
Q.3	Derive the equation for excess Gibb's free energy in terms of activity coefficient.	CO2
Q.4	What are the various equations for finding out activity coefficients	CO2
Q.5	Explain Dalton's law with its applicability in the context of VLE.	CO2
Q.6	The excess Gibb's free energy is given by $G^E/RT=-3x_1x_2(0.4x_1+0.5x_2)$. Find activity coefficients.	CO2
Q.7	Prove that if Henry's law is obeyed by component 1 in a binary solution over a certain concentration range, LR rule will be obeyed by component 2 over the same range.	CO2

Q.8	A container is divided into 2 compartments one containing 3 moles of hydrogen at 298K and 1 bar and the other containing 1 mole of nitrogen at 298K and 3 bar. Calculate the free energy of mixing when the partition is removed.	CO2
	Unit-III	
Q.1	Explain the VLE diagram.	CO3
Q.2	Explain minimum and maximum boiling azeotropes.	CO3
Q.3	The azeotrope of ethanol-benzene system has a composition of 44.8% by mole ethanol with a boiling point of 341.4K at 101.3kPa. At this temperature, vapor pressure of ethanol is 67.4kPa. and that for benzene is 68.9kPa. What are the activity coefficients in a solution containing 10% by mole ethanol?	CO3
Q.4	Draw and explain the 3 types of constant pressure liquid-liquid solubility diagram.	CO3
Q.5	Describe the solid liquid equilibrium mechanism in crystallization process.	CO3
Q.6	Note the criteria for phase equilibria.	CO3
Q.7	Describe the 3 suffix Margules equation.	CO3
Q.8	Explain the phase rule and Duhem's equation for reacting systems.	CO3
	Unit-IV	
Q.1	Explain the following two methods of consistency tests for VLE data: a. Using co-existence equation b. Using partial pressure data	CO4
Q.2	Explain triple point and eutectic temperature with neat diagram.	CO4
Q.3	A gas mixture consisting of 60% hydrogen, 20% nitrogen and rest inerts is passed over a catalyst for the production of ammonia at 50 bar($Kp=1.25*10^{-2}$). Assuming ideal gas behavior determine the composition of the gases leaving the reactor.	CO4
Q.4	Write a note on osmotic equilibrium.	CO4
Q.5	Verify if the following data are consistent:	CO4
Q.6	Explain the Redlich-Kister method and mid point method for testing consistency of data.	CO4
Q.7	Using the criterion of phase equilibrium show that the change in entropy during phase change can be calculated from the latent heat of phase change and the absolute temperature.	CO4
Q.8	What is the stability criteria of phase equilibrium?	CO4
	Unit-V	
Q.1	Derive the expression for reaction equilibrium constant	CO5

X1	0	0.2	0.4	0.6	0.8	1.0
ɤ1	0.576	0.655	0.748	0.856	0.95	1.0
ɤ2	1.0	0.985	0.930	0.814	0.626	0.379

Q.2	Give the criteria of feasibility of a reaction.	CO5
Q.3	Describe the effect of temperature on equilibrium constant.	CO5
Q.4	Calculate the equilibrium constant for the reaction $N_2O_4 \rightarrow 2NO_2$ if the free energy of formation at 298K for N_2O_4 is 97540J/mol and that for NO_2 is 51310 J/mol.	CO5
Q.5	Describe the equation: $\Delta G^0 – RT \ln K$	CO5
Q.6	Describe the application of equilibrium criteria to chemical reactions.	CO5
Q.7	Acetic acid is esterified in liquid with ethanol at 100^0C to produce ethyl acetate. If initially here is one mole each of acetic acid and ethanol estimate the mole fraction of ethyl acetate in the mixture	CO5
	Unit-VI	
Q.1	For gas and liquid phase reactions, explain the relation of equilibrium constant to composition.	CO6
Q.2	Explain the phase rule for reacting systems.	CO6
Q.3	Evaluate the equilibrium constant	CO6
Q.4	A gas mixture containing 25% CO, 55% H_2 and 20% inerts is to be used for methanol synthesis: $CO + 2H_2 \Longrightarrow CH_3OH$. The gas mixture leaving the reactor is in equilibrium at 300 bar and 625K. Assume that the equilibrium mixture forms an ideal solution and Kf &KΦ are $4.9*10^{-9}$ And 0.35 resp. What is the % conversion of CO?	CO6
Q.5	What is the relation between Gibb's free energy change and equilibrium constant?	CO6
Q.6	Explain the equilibrium constant.	CO6
Q.7	How to calculate equilibrium conversion for single reactions?	CO6
Q.8	Determine the number of degrees of freedom: I. A system of 2 immiscible non reacting species which exists as an azeotrope in VLE II. A system prepared by partially decomposing $CaCO_3$ into evacuated space III. A system consisting of gases CO, CO_2, H_2, H_2O and CH_4 in equilibrium	CO6

Course: 05

Chemical Industry Management

(309345: Elective-I)

T.E. Chemical (2019 Pattern)

[Theory]

Course Syllabus

CHEMICAL INDUSTRY MANAGEMENT (309345)

Unit 1: Management Science **7 Hrs**

A. Management, its growth, concepts of administration and management of organization. Definition of management, functions, authority and responsibility, unity of command and direction decision making in management by objectives.

B. Personality: Physical appearance, body language, voice, communication style, content of communication, enriched communication through Sensory Specific Language. Business style and professional image: Dress codes, Guidelines for appropriate business attire.

C. Business organization: Different forms of organization, their formation and working, different organization structure- line organization, functional organization, line and staff organization.

Unit 2: Personnel Management **7 Hrs**

Manpower planning, sources of recruitment, selection and training of staff, job evaluation, merit rating, performance appraisal, wage administration and system of wage payment, incentive, motivations, industrial fatigue, trade unions – industrial relations. Introduction to personal selling & salesmanship: Defining personal selling and salesmanship, Selling as a profession, Objectives and importance of personal selling, Essentials of personal selling, traditional & modern selling approach, ethics in Selling, role of selling in marketing, types of selling, qualities of winning sales Professionals-physical, mental, social and character traits.

Unit 3: Purchase and stores management **7 Hrs**

Concepts of quotation, tenders and comparative statement, inspection and quality control, inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, stores management, functions of storekeeper, methods of inventory : LIFO, FIFO. Credit analysis and appraisal principles of credit management: Principles of lending –evaluation of borrower – sanction limit-principles of good lending.

Unit 4: Marketing management **7 Hrs**

Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion. Introduction to product management: Product management as a basis of marketing organization structure. Role of product manager, skills required for product management. Product management in consumer product industry vs industrial product industry. Overview of product level marketing plans.

Unit 5: Export and import management **7 Hrs**

Concepts of international trade, duties, antidumping duty, cost involved in exporting a product, pricing of export product. Government aids for export promotion, export houses, export promotion counsel, MODVAT, patent, inflation, causes, effects, control of inflation, value of money, index numbers, construction, utility, limitations, business cycles, phases of business cycles.

Unit 6: Management Laws **7 Hrs**

Concepts of contract act, offer, and acceptance, types of contracts, void contract, concept of guarantee and warranty. Introduction of MRTP and FERA. Work study: Work measurement, motion and time study flow process chart, flow diagram, silo chart, string chart, therbligs. Patent law: Patent cooperation treaty, patent act 1970, procedure for filing patent applications, patent granting procedures, revocation.

Reference Books:

1. Stonier, A. W. and Hague, D. C., "A Text Book of Economic Theory", Longman.
2. Bach, George Leland, "Economics -Analysis, Decision Making and policy", Prentice Hall Inc. Englewood Cliffs N. J.
3. Bonham F, "Economics", Sir Isaac Pitman and Sons Ltd., London.
4. Seth, M. L., "Principles of Economics", Lakshmi Narayan Agarwal, Agra.
5. Agarwal, A. N., "Indian Economy", Vikas Publishing House Pvt. Ltd., New Delhi.
6. Datta R. and Sundharam, K. P. M., "Indian Economy" S. Chand & Co. Ltd., New Delhi
7. Peter F. Drucker, "The Practice of Management", Allied publishers pvt. ltd., Bombay.
8. Barat, Nikhil, "Production management & Control", Academic Publishers, Calcutta.
9. Garrett, Leonard J. & Silver, Milton, "Production Management Analysis", Harcourt Brace Jovanovich, Inc. New York.
10. Kuchhal, S. C., "Financial Management: An- Analytical & Conceptual Approach", Chaitanya Publishing House, Allahabad.
11. Pandey, L. M., "Financial Management", Vikas Publishing House Pvt. Ltd., New Delhi.
12. Kotlel, Philip, "Marketing Management: Analysis, Planning & Control", Prentice – Hall of India Pvt. Ltd: New Delhi
13. Sinha, J. C., "Marketing and Salesmanship", S. Chand & Co., Delhi. 14. H.L. Ahuja, "Modern economics", S. Chand and co. ltd., New Delhi.
14. Management for Business and Industry-C. S. George Jr. Principles of management-Knoots and O. Donnell.

Chemical Engineering Department

TE Chemical

309345: CHEMICAL INDUSTRY MANAGEMENT

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

Course Outcomes (Cos) CHEMICAL INDUSTRY MANAGEMENT

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

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
CO1	Identify critically assess planning function, strategic planning, organizing function	**2**	Identify
CO2	Identify economic and operations management concepts useful in the production process.	**2**	Identify
CO3	Apply the project management tools in effective development and implementation of the business activities.	**3**	Apply
CO4	Apply the entrepreneurial spirit and plan to start their own enterprise.	**3**	Apply
CO5	Apply basic management principles.	**3**	Apply
CO6	Apply basic management Law	**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	2	2	2			2		1	2	1	1	1			2
2	2	1	1			2		1	2	1	1	1			2
3	2	2	2			2	1	1	2	1	1	1			2
4	2	1	1			2	1	1	2	1	1	1			2
5	2	1	1			1		1	1	1	1	1			2
6	2	2	2			2	1	2	1	1	1	1			2

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

CO AssessmentTools

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
C345.1	√		--	√	-	√	-	
C345.2	√		--	√	-	√	-	
C345.3	--	√	--	√	-		-	√
C345.4	--	√		√	-		-	√
C345.5			√	√				√
C345.6			√	√				√

Chemical Engineering Department

Teaching Plan

CHEMICAL INDUSTRY MANAGEMENT (309345)

Teaching Scheme:
Theory: 03 h/week

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

Lect No.	Topics / Sub- Topics	CO mapped
1	Vision, Mission, PO,PSO,CO & Subject orientation	
	Unit I Managemet Science	CO1
2	Management, its growth, concepts of administration and management of organization	CO1
3	Definition of management, functions, authority and responsibility	CO1
4	Unity of command and direction decision making in management by objectives , Personality	CO1
5	Content of communication, enriched communication through sensory specific language	CO1
6	Business style and professional image, Dress codes, Guidelines for appropriate business attire	CO1
7	Business organization, Different forms of organization	CO1
8	Functional organization, line and staff organization	CO1
	Unit 2 Personnel Management	CO2
9	Manpower planning, sources of recruitment, job evaluation	CO2
10	Merit rating, performance appraisal, Wage administration and system of wage payment	CO2
11	Incentive, motivations, industrial fatigue, trade unions	CO2
12	Introduction to personal selling & salesmanship, Objectives and importance of personal selling	CO2
13	Essentials of personal selling, traditional & modern selling approach	CO2
14	Ethics in Selling, role of selling in marketing, types of selling, qualities of winning sales professionals	CO2
	Unit III Purchase and stores management	CO3
15	Concepts of quotation, tenders and comparative statement	CO3
16	Inspection and quality control, inventory	CO3
17	Carrying cost and fixed cost of inventory Examples of cost of Inventory	CO3
18	Stores management Functions of storekeeper	CO3
19	Methods of inventory, Credit analysis	CO3
20	Appraisal principles of credit management, Principles of lending	CO3
21	Sanction limit-principles of good lending	CO3

	Unit IV Marketing management	CO4
22	Concepts of selling, marketing, definition of marketing	CO4
23	Market research and of pricing, penetration	CO4
24	Pricing, skimming pricing, distribution of product	CO4
25	Advertising and promotion, product management	CO4
26	Product management as a basis of marketing organization structure	CO4
27	Role of product manager , skills required for product management	CO4
28	Product management in consumer product industry vs. industrial product industry	CO4
	Unit V Export and import management	CO5
29	Concepts of international trade, duties	CO5
30	Antidumping duty, cost involved in exporting a product, pricing of export product	CO5
31	Government aids for export promotion, export houses	CO5
32	Export promotion counsel, patent and patent rights	CO5
33	Quality Management , quality circles, ISO systems	CO5
34	Inflation, types of inflation, causes, effects, control of inflation	CO5
35	Value of money, index numbers, construction, utility	CO5
36	Business cycles, phases of business cycles	CO5
	Management Laws	CO6
37	Concepts of contract act, offer, and acceptance, types of contracts	CO6
38	Void contract, concept of guarantee and warranty	CO6
39	Work study, Motion and time study flow process chart	CO6
40	Flow diagram, silo chart, string chart	CO6
41	Patent law, procedure for filing patent applications	CO6
42	Patent granting procedures, revocation	CO6
43	Discussion on University Question Papers	CO6

Question Bank

CHEMICAL INDUSTRY MANAGEMENT (309345)

	Unit-I	CO
Q.1	What is Joint Stock Company? Enlist the characteristics and advantages of such organizations	CO1
Q.2	Write an explanatory note on Partnership Organization.	CO1
Q.3	Explain with a neat sketch the Line and Staff Organization	CO1
Q.4	Explain in detail scientific management given by FW Taylor.	CO1
Q.5	Define Management and state importance and characteristics of management	CO1
Q.6	State and explain in detail the various function of Management	CO1
Q.7	Explain Partnership with advantages and disadvantages	CO1
	Unit-II	
Q.1	Explain in detail selection process.	CO2
Q.2	Define Manpower Planning. Enlist various objective and requirements of Manpower Planning.	CO2
Q.3	Explain different types of Wages	CO2
Q.4	Explain in detail Job Evaluation	CO2
Q.5	Explain in detail Sales Promotion.	CO2
Q.6	Write a note on Merit rating	CO2
Q.7	Explain in detail Recruitment.	CO2
Q.8	What is Industrial Fatigue? Write down various causes and effects of Industrial fatigue.	CO2
Q.9	Write note on Trade unions.	CO2
Q.10	What is Motivation? How it is important for industry prospective?	CO2
	Unit-III	
Q.1	Explain in detail the various types of Purchasing	CO3
Q.2	Write a note on comparative statement	CO3
Q.3	Explain the types of Tenders.	CO3
Q.4	Write short note on i) VED Analysis ii) MNG Analysis	CO3
Q.5	Explain the objective and benefits of Inventory Control.	CO3
Q.6	Write short note on i) LIFO ii) FIFO	CO3
Q.7	Write a notes on Stores and Stores location	CO3
Q.8	Enlist various functions of store keeper.	CO3
	Unit-IV	

Q.1	What is market research? Explain with suitable example	CO4
Q.2	Explain any two Pricing strategies in detail.	CO4
Q.3	What is sales forecasting? Explain the two types of sales forecasting in detail.	CO4
Q.4	Write an explanatory note on Marketing mix	CO4
Q.5	What is sales promotion? explain sales promotion technique	CO4
Q.6	What is Advertising? Explain its importance in product selling	CO4
Q.7	Define advertisement. Discuss the various method of advertisement	CO4
	Unit-V	
Q.1	Explain in detail Quality circle	CO5
Q.2	Discuss the benefits and objectives of Quality circles	CO5
Q.3	Explain the role of Quality circles for quality management of a process industry	CO5
Q.4	Explain Total Quality Management of a process industry	CO5
Q.5	What is ISO? Explain any three ISO standards.	CO5
Q.6	Explain in detail the procedure to export a product to a foreign customer	CO5
Q.7	Write a short note on i) Antidumping duty ii) ISO	CO5
Q.8	Explain in detail various factors affecting International trade	CO5
Q.9	Write a short note on i) Antidumping duty ii) MODVAT	CO5
Q.10	Write a short note on i) Customer duty and VAT ii) International trade.	CO5
Q.11	What are the various methods used for effective marketing? Explain	CO5
	Unit-VI	
Q.1	Write a note on FERA and FEMA	CO6
Q.2	Explain the term Agreement in contract Act. Explain the various types of contract according to enforceability, formation and performance	CO6
Q.3	Write short notes on a) MRTP b) Flow chart and flow diagram	CO6
Q.4	Write note on Patent and patent rights.	CO6
Q.5	Write short notes on the following i) Work measurement ii) MRTP iii) Therbligs	CO6
Q.6	Write short notes on the following i)FEMA ii)contract and its types iii)Guarantee and Warrantee	CO6
Q.7	Discuss Flow chart and flow diagram	CO6

Course: 06

Computer Aided Chemical Engineering -I

(309346)

T.E. Chemical (2019 Pattern)

[Practical]

Course Syllabus

Computer Aided Chemical Engineering-I (309346)

Minimum 10 practical and a compulsory home paper.
Applications of numerical Techniques in chemical engineering to be evaluated by following methods: Topics may include but are not restricted to:

1. Eigen values and Eigen vector computations for Level Control Applications.
2. Applications of Vectors to problems in Fluid Mechanics, Continuity equations, Stream lines, Equations of motion, Bernoulli's equations.
3. Numerical interpolation
4. Numerical integration.
5. Integration of ODE – Equation for Batch Reactions.
6. Numerical differentiation.
7. Root-finding method – two nonlinear equations.
8. Linear programming for solving Liquid Level in Tank model.
9. Data fitting.
10. Process calculation using MS-EXCEL.
11. Application of neural networks.
12. Fuzzy logic applications.
13. Application of support vector machines.
14. Design Algorithms
15. Non-linear optimization methods-Interacting and non-interacting systems
16. Regression Analysis.

Home paper for each student or group of students is compulsory. (A paper written by a student may be five to six pages in double spacing, a few figures may get added.)

309346: Computer Aided Chemical Engineering -I

Teaching Scheme: Practical: 2 Hrs/ Week	**Examination Scheme:** Term Work (TW): 25 Marks **Credits: 1** Credit.

Course Outcomes (Cos) Computer Aided Chemical Engineering -I

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

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C346.1	Analyze the engineering problem by using process software.	**L4**	Analysis
C346.2	Evaluate the engineering problem by interpreting the experimental data by using process software.	**L5**	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	PS O1	PS O2	PS O 3
1	**3**	**3**	**2**	**2**	**3**								**3**	**3**	**3**
2	**3**	**3**	**3**	**2**	**3**								**3**	**3**	**3**

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	TW	Endsem
C346.1							√	
C346.2							√	

Chemical Engineering Department

309346: Computer Aided Chemical Engineering -I
List of Practical:

SN	Name of Experiment	CO Mapped
1	Program in "C" for integration of function by using Trapezoidal Rule	1
2	Program in "C" for integration of function by using Simpsons 1/3rd rule	1
3	Program in "C" for integration of function by using Simpsons 3/8th Rule	1
4	Program in "C" for calculation of Volume by Using Van-Derr Waals equation of State	1
5	Program in "SCILAB" for calculation of Volume by Using Van-Derr Waals equation of State	1
6	Program in "C" to find the length of Double pipe Heat Exchanger	1
7	Program in "SCILAB" to find out roots of Quadratic equation	2
8	Program in "SCILAB" for Dew and Bubble point calculation with Bubble point Diagram	2
9	Integration of Function by using SCILAB	2
10	Integration of Function by using MATLAB	2
11	Home paper on design algorithm	1,2

Course: 7

Seminar

(309347)

T.E. Chemical (2019 Pattern)

[Term Work]

Course Syllabus

Seminar (309347)

The seminar may be a review of literature of specific phenomena/new process. Working model to demonstrate the principle, alternatively a small experimentation to investigate chemical engineering. Data/unit process/ unit operation. Based on this study focused report should be submitted. It is expected that the student collect information from reference books, journals and Internet. The report submitted should reveal the student's internalization of the collected information. Mere compilation from the net and other resources is discouraged.

Format of the Seminar report and TW assessment:

1. The Seminar report should be based on a detailed study of any relevant topic to Chemical Engineering, be neatly written or typed on white paper. The typing shall be with normal spacing and on one side of the paper [A-4 size].
2. The report should be submitted with front and back cover of card paper neatly cut and bound or spirally together with the text.
3. Front cover: This shall have the following details.
    a. Title of the seminar report.
    b. The name of the candidate with roll number examination seat number at the middle.
    c. Name of the guide below the candidate's details.
    d. The name of the institute and year of submission on separate lines at the bottom.
4. Seminar approval sheet.

5. The format of the text of the seminar reports:

The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text. They should be followed by nomenclature and symbols used followed by acknowledgement. The bibliography should be at the end. References should be written in the standard format. The total number of typed pages, excluding cover shall be about 25 to 30 only. All the pages should be numbered. This includes figures and diagrams. Two copies of the seminar report shall be submitted to the college. The candidate shall present the Seminar before the examiners. The total duration of presentation and after-discussion should be about 30 minutes max. [25 min + 5 min]. Audience can ask questions only if the examiner permits. [Such questions will not have any bearing on marks].

The assessment for the subject shall be based on

1. Report submitted.
2. Presentation.
3. Discussion

309347: Seminar

Teaching Scheme: Tutorial : 1 Hrs./Week	**Examination Scheme:** Term Work (TW): 50 Marks **Credits:** 1 Credit

Course Outcomes (Cos) Seminar

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

Course Outcome	Statements	Bloom's Taxonomy	
		Level	Descriptor
C347.1	Conduct the literature survey and to identify and formulate the engineering problem.	**L2**	Understand
C347.2	Apply the mathematical concepts, science concepts, engineering concepts, management principles and engineering tools necessary to solve the identified engineering problem.	**L3**	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		2	1	2	2	2	3	1	2	3	3	2
2	3	2	1		2	1	2	2	2	3	2	2	3	3	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	TW	Endsem
C347.1							√	
C347.2							√	