Academic Program: UG

Academic Year 2020-21

Syllabus

VII & VIII Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for VII & VIII semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2020-21 till further revision.

Principal   Chairman BoS & HoD

SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs):

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs):

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):

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for VII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC700	Process Dynamics and Control	4-0-0	4	50	100	3		
15UCHC701	Chemical Technology	4-0-0	4	50	100	3		
15UCHC702	Biochemical Engineering	3-0-0	3	50	100	3		
15UCHL703	Major Project-1	0-0-6	4	50			50	3
15UCHL704	Process Control Laboratory	0-0-3	1.5	50			50	3
15UCHL705	Computer Applications in Chemical Engineering and Simulation Laboratory	0-0-3	1.5	50			50	3
15UCHE70X	Elective – 5	4-0-0	4	50	100	3		
15UCHE70X	Elective – 6	4-0-0	4	50	100	3		
Total		**19-0-12**	**26**	**400**	**500**		**150**	
Electives								
15UCHE706	Pilot Plant and Scale up Methods	4-0-0	4	50	100	3		
15UCHE707	Transport Phenomena	4-0-0	4	50	100	3		
15UCHE708	Process Modeling and Simulation in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE709	Novel Separation Techniques	4-0-0	4	50	100	3		
15UCHE710	Wastewater Treatment and Engineering	4-0-0	4	50	100	3		

Scheme for VIII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC800	Process Engineering Economics and Management	4-0-0	4	50	100	3		
15UCHL801	Seminar	0-0-3	2	50				
15UCHL802	Major Project-2	0-0-12	10	50			50	3
15UCHE80X	Elective – 7	4-0-0	4	50	100	3		
15UCHE80X	Elective – 8	4-0-0	4	50	100	3		
Total		**12-0-15**	**24**	**250**	**300**		**50**	
Electives								
15UCHE803	Solid Waste Management	4-0-0	4	50	100	3		
15UCHE804	Instrumental Methods of Analysis**	4-0-0	4	50	100	3		
15UCHE805	Sugar Technology	4-0-0	4	50	100	3		
15UCHE806	Bioprocess Engineering	4-0-0	4	50	100	3		
15UCHE807	Unit Processes in Organic Synthesis**	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

* SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

**** To be handled by the Chemistry department faculty

Total credits offered for the Fourth year: 50

Interdisciplinary Elective open for all Engineering Branches:

15UMAE875 Applied Numerical Methods (VIII Sem)

15UPHE876 Nanotechnology (VIII Sem)

VII Semester B.E.

15UCHC700	Process Dynamics and Control	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Outline the basic principles and importance of process control in industrial process plants.	13	1	-
CO-2	Formulation of dynamic models based on fundamental laws and analytically solve linear dynamic models of first and second order system.	-	2,3	13
CO-3	Predict the closed-loop behavior using block diagram and control valves.	-	2,10	13
CO-4	Predict closed loop behavior using block diagram and analyze control valves.	-	2	13
CO-5	Analyze controllers and determine the stability of a closed-loop feed-back control system.	-	2,3	13

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	2.0	2.0	2.0	-	-	-	-	-	-	2.0	-	-	1.4	-	-

Course Content:

Unit-I

Introduction: Classification of variables, control configuration, classification of control systems. Laplace Transform, types of inputs- step, impulse, linear and sinusoidal. **09 Hrs.**

Unit-II

Process Dynamics: First order systems, transfer functions - mercury in glass thermometer, level, mixing tanks, stirred tank reactors, Response of first order system in series: Interacting and non-interacting systems, Linearization of non-linear first order systems. **12 Hrs.**

Unit-III

Second Order Systems: U-tube manometer, damped oscillator, response equations, terms of second order under damped system, Transportation lag **09 Hrs.**

Unit-IV

Block Diagram: Importance, reduction rules, steps, servo and regulator problem, overall transfer function for set-point change and load change.

Final Control Element: control valves, types, actuators, positioners, valve characteristics. **10 Hrs.**

Unit-V

Controllers: Transfer functions for two position, proportional, Proportional +Reset (P+I), Proportional + Rate (P+D), Proportional + Reset +Rate controller (P+I+D), servo and regulator control system.

Stability: Concept of Stability, Stability criterion, Routh Herwitz test for stability, Root Locus method. Stability of linear control system, Routh –Hurwitz, Root Locus methods. **12 Hrs.**

Reference Books:

1) Coughanour and Koppel, “Process System Analysis and Control”, 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2) Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2/e, McGraw Hill, 1990.
3) Coulson and Richardson, “Chemical Engineering” Vol, III, 3/e, Pengeman Press.
4) George Stephanopoules, “Chemical Process Control” An Introduction to Theory and Practical, Prentice Hall, New Delhi, 1998.

15UCHC701	Chemical Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the industry protocols used in the manufacture of chemicals both inorganic and organic with the use of reference flow sheets.
2. Identify major engineering problems associated with manufacturing processes.
3. Overcoming bottlenecks and trouble shooting.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the impetus of Chemical Industry globally and summarize production process of industrial gases.	6,7	12	1
CO-2	Apply the concepts of unit operations and processes, reaction kinetics to Chlor-Alkali and acids production.	12,13,1	9,10, 14	3
CO-3	Illustrate the technology of manufacturing fertilizers and phosphorous compounds.	14	9, 12	--
CO-4	Interpret the concept of operation, process reactions and unit operation to pulp and paper and fermentation industries.	14	3, 6, 7	--
CO-5	Prioritize trouble shooting to overcome the bottlenecks in a process and develop the technology within realistic constraints of oils and fats and soap industries.	13,14	12	---

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	2.0	-	1.5	-	-	2.5	2.5	-	2.0	2.0	-	2.25	3.0	2.75	-

Course contents:

Unit-I

Introduction to Chemical Process Industries: Chemical Industry in this millennium, Scenario of Indian and World chemical industry.

Industrial and Fuel Gases: H_2, O_2, N_2, CO_2, Water gas, Producer gas. **10 Hrs.**

Unit-II

Chlor-Alkali Industry: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder

Acids: Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **12 Hrs.**

Unit-III

Fertilizer Industry: Ammonia, Urea, Ammonium Nitrate, Ammonium Sulfate, DAP, Potash fertilizers, Bio-fertilizers.

Phosphorous Industry: Red and White phosphorous, Phosphorous pentoxide, Phosphate fertilizers, Super phosphate and Triple super phosphate.

10 Hrs.

Unit-IV

Pulp and Paper Industry: Raw materials, manufacture of pulp and paper, recovery of chemicals.

Fermentation and Distillery: Manufacture of alcohol, beer, wine, vinegar.

10 Hrs.

Unit-V

Oils and Fats Industry: Manufacture of oils (vegetable and industrial) processing and refining, essential oils and uses,

Soaps Industry: Types of soaps and fatty acid, manufacturing process and uses

10 Hrs.

Reference Books:

1) George T Austin: Shreves, "Chemical Process Industries", Mc Graw Hill International ltd.
2) Gopal Rao and Marshall, "Dryden's Outlines of Chemical Technology", East-West Press.
3) S.D. Shukla and G.N. Pandey, "Text book of Chemical Technology" Vol.1 and 2, Vikas Publishing House Pvt. Ltd. New Delhi.
4) S.C. Bhatia, "Chemical Process Industries", Vol.1 and 2, CBS Publishers, New Delhi

15UCHC702	Biochemical Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide the forum to understand the principles and concepts of microbiology, cell biology and biochemistry and thereby apply chemical engineering principles to asses and evaluate the cell as a reactor.
2. To incorporate the principles of chemical engineering in understanding the upstream and downstream processing techniques in a biochemical industry.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the microorganisms in the context of industrial and environmental microbiology and explain the chemicals of life with the properties and their derivates.		7	2
CO-2	Interpret and evaluate the enzyme kinetic parameters with different effects of the reactors.	13	3	2
CO-3	Analyze cell growth kinetics and solve problems of upstream bio processing.	13	3	2
CO-4	Explain the various configurations of bioreactors along with fermentation technology	12,13	3	2
CO-5	Identify and explain the methods involved in product recovery and purification	12,14	3	2

POs/PSOs	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-13	PSO-14	PSO-15
Mapping Level	-	1.0	2.0	-	-	-	2.0	-	-	-	-	3.0	3.0	3.0	-

Course content:

Unit-I

Microbiology: Scope, structure of cells: Prokaryotic and Eukaryotic, characterization and classification of microorganisms - Taxonomy and Whitaker's 5-Kingdom concept, environmental and industrial microbiology, control of microorganisms.

Biochemistry: Chemicals of life - Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids and their derivatives. **08 Hrs.**

Unit-II

Enzyme Catalyzed Reactions: Enzyme Nomenclature and classification, enzyme kinetics, Mechanism and kinetics of enzymatic reactions, evaluation of kinetic parameters, factors affecting enzyme activity, Inhibitors and inhibition kinetics, Industrial enzymes and applications, methods of immobilization of enzymes. **08 Hrs.**

Unit-III

Biomass Production in Cell Cultures: Ideal reactors for kinetic measurements - batch and continuous reactors, Monod’s growth kinetics, Transient growth kinetics, Cell growth and kinetic patterns, Reactors and their configurations. **09 Hrs.**

Unit-IV

Fermentation Technology: Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **07 Hrs.**

Unit-V

Downstream Processing: Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **07 Hrs.**

Reference Books:

1) Jay Bailey, James Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill, 1986.
2) Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering - Basic Concepts", 2/e, Prentice Hall of India (2003).
3) Michael J. Pelczar, E. C.S. Chan and Noel R. Krieg, "Microbiology Concepts and Applications", 5/e, McGraw Hill reprint 2001.
4) Syed Tanveer Ahmed Inamdar, “Biochemical Engg: Principles and Concepts” 3/e, Prentice Hall of India Learning Pvt. Ltd. (2012), New Delhi.

15UCHL703	Major Project – 1	(0-0-6) 4

Contact Hours: 72

Course Learning Objectives (CLOs):

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical			

	engineering or integrated problems (allied fields).	2,10	8, 12	6, 7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VII semester or project of VI semester can also be extended here. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VII semester. After getting the approval from DUGC, the project work should be carried out in VII and VIII semester. The project report should be submitted in VII semester which includes literature survey, plan of work and any progress of the work. The final project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:

Literature survey- 20%

Synopsis (plan of work and PERT charts)-10%

Project Topic/Work-35%

Presentation-15%

Conclusion and Final report-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

Books in the area of chemical engineering and its related fie

15UCHL704	Process Control Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. The purpose of this laboratory is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply fundamentals of industrial processes, process measurement and process control theory.	4, 15	9,10	-
CO-2	Analyse transient behavior of simple systems.	4, 15	9,10	-
CO-3	Analyse data from experiments and prepare well organized laboratory report.	4, 15	9,10	-

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	-	2.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Step response of first order systems (Thermometer).
2. Step response for Single Tank System - first order System.
3. Step & Impulse response for two first order systems arranged in Non - Interacting mode.
4. Step & Impulse response for first order systems arranged in Interacting mode.
5. Level Control Trainer– P, PI, PD, PID action.
6. Temperature Control Trainer– ON/OFF, P, PI, PD, PID action.
7. Control Valve Characteristics.
8. Temperature sensors characteristics – RTD , Thermocouple, Thermistor.
9. Characteristics of Temperature Transmitter.
10. Characteristics of I/P and P/I converters.
11. Analysis of Flapper-Nozzle system.

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Coughanour and Koppel, “Process System Analysis and Control”, 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2) Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2/e, McGraw Hill, 1990.

15UCHL705 Computer Applications in Chemical Engineering and Simulation Laboratory (0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To make the students understand physical systems in chemical engineering and using C program to develop models and solutions for these models.
2. The students will also learn to use the commercial process simulations using simulation software.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve Chemical Engineering problems using the analytical methods and programming.	4, 5,15	10	9
CO-2	Compute the chemical engineering problems with nonlinear-algebraic equations.	4, 5,15	10	9
CO-3	Compute the chemical engineering problems with Numerical Integration	4, 5,15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	3.0	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – Simpson’s1/3 rule.
6. Curve fitting – Least square method
7. Double pipe heat exchanger (Area, Length)
8. Bubble and dew point calculation.
9. Introduction to Unisim design Software
10. Simulation studies of flash drum
11. Simulation studies of CSTR
12. Simulation studies of Heat Exchanger.
13. Simulation studies of Mixer

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jenson, V.J. and Jeffereys, G.V., "Mathematical Methods in Chemical Engineering", Academic Press, London and New York, 1977.
2) Mickley, H.S., Thomas. K. Sherwood and Road, C.E., "Applied Mathematics in Chemical Engineering", Tata McGraw-Hill Publications, 1957.
3) S. Pushpavanam, "Mathematical Methods in Chemical Engineering", PHI
4) E. Balagurusamy, "Programming in ANSI C", 6/e, TMH 2012.
5) Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.
6) William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.

15UCHE706	Pilot Plant and Scale up Methods	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.
2. To study proper designs, modeling and processing and the importance of the process geometry.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and explain the need for pilot plant and its demonstration with economic evaluation.	3	-	14
CO-2	Identify and develop different models and similarity studies for scale up methods.	5	2	13
CO-3	Explain and compare the different concepts of regime in scale up studies.	3	2	13
CO-4	Interpret and analyse different approaches for scale up studies in chemical engineering mixing system.	2, 3	5	13, 14
CO-5	Interpret and analyse different approaches for scale up studies in heat and mass transfer system.	2, 3	5	13, 14

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	2.5	3.0	-	2.3	-	-	-	-	-	-	-	1.0	1.0	-

Course contents:

Unit-I

Introduction: Process development, Need for pilot plants, Scale-up procedures, basic terminologies- prototypes, models, scale ratios and elements. Major issues, fundamental principles, Demonstration, Economic evaluation of scaling up. **10 Hrs.**

Unit-II

Dimensional Analysis and Principles of Similarity: Significance of Dimensionless Numbers**,** Generalized dimensionless equations from Differential equation for static systems, flow systems, thermal systems, mass transfer processes, Homogeneous and heterogeneous chemical processes. **Principles of Similarity:** Geometric similarity, Distorted similarity, Static, dynamic, kinematics, thermal and chemical similarity with examples. **12 Hrs.**

Unit-III

Regime: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects. **10 Hrs.**

Unit-IV

Scale up of Mixing Process and Chemical Reactors: Mixing Processes: Scale-up relationships, Scale-up of polymerization units, Continuous stages gas liquid slurry processes. Fluid-fluid Reactors: Scale-up considerations in packed bed absorbers and bubble columns, Applicability of models to scale-up. **10 Hrs.**

Unit-V

Scale up of Mass and Heat Transfer Processes: Continuous Mass Transfer Process: Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units. Scale up of momentum and heat transfer systems.
10 Hrs.

Reference Books:

1) Attilio Bisio, Robert L. Kabel, "Scale up of Chemical Processes", John Wiley Interscience publication, 1985.
2) Ibrahim and Kuloor, "Pilot plant and Scale up Studies".
3) Johnstone and Thring, "Pilot Plants Models and scale up method in Chemical Engineering", McGraw Hill, 1962.
4) Marko Zlokarnik, "Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.

15UCHE707	Transport Phenomena	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.	1	-	-
CO-2	Formulate velocity distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-3	Formulate temperature distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-4	Formulate concentration distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-5	Apply equations of change for isothermal systems and write analogies between momentum, heat and mass transport problems.	-	2, 3, 13	1

POs/PSOs	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-13	PSO-14	PSO-15
Mapping Level	1.4	2.0	2.0	-	-	-	-	-	-	-	-	-	2.0	-	-

Course content:

Unit-I

Introduction: Importance of transport phenomena in chemical engineering, Momentum, Energy and Mass transport, Newton's law of viscosity, Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all law. **10 Hrs.**

Unit-II

Velocity Distribution in Laminar Flow: Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow between parallel plates and slit. Numerical problems using the equation derived above. **11 Hrs.**

Unit-III

Temperature Distribution in Laminar Flow: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **11 Hrs.**

Unit-IV

Concentration Distribution in Laminar Flow: Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above. **10 Hrs.**

Unit-V

Equation of Change of Isothermal Systems: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **Analogies and Navier Stokes Equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **10 Hrs.**

Reference Books:

1) Bird, Stewart and Lightfoot, "Transport Phenomena", John Wiley, 2/e. 1994.
2) Robert Brodkey and Henry C. Hershey, "Transport Phenomena Unified Approach", International Edition- 1988. ISBN-10: 0070079633
3) Bennet and J. E., "Momentum Heat and Mass Transfer", Myer- McGraw Hill. 3/e. 1982.
4) Suryavanshi and Dongre, "Transport Phenomena", Nirali Prakashan. 7/e. 2012. ISBN: 978-81962-56-5.
5)

15UCHE708	**Process Modeling and Simulation in Chemical Engineering**
	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To study basic concepts of modeling and formulation of mass and energy balance relationships and thereby it helps for the development of complex models.
2. To understand the advanced technologies in simulation field and the

applicability in industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain and apply the different fundamentals to develop the models for chemical engineering system.	1,3	2	5
CO-2	Interpret and develop different mathematical methods for chemical engineering system.	3,13	1, 2	5
CO-3	Apply and assess different relevant software and models for solving chemical engineering problems.	5, 13	2,3	-
CO-4	Identify the different simulation tools and Ability to solve chemical engineering problems using numerical techniques	5, 13	2,3	-
CO-5	Demonstrate and analyse the different model solving ability for various chemical engineering process.	5, 13	2, 3	-

POs/PSOs	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-13	PSO-14	PSO-15
Mapping Level	2.5	2.0	2.4	-	2.2	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Modeling in Chemical Engineering: Introduction, Principles of Formulation, Fundamental laws; Continuity Equation, Energy Equation, Equation of motion, Transport Equations, Equation of States, Equilibrium, Chemical Kinetics, Classification of Mathematical models. **10 Hrs.**

Unit-II

Numerical Techniques: Iterative convergence methods like bisection and secant method, Newton raphson method, Numerical integration of ordinary differential equations like Euler and Runge Kutta method. Numerical solution of partial differential equations of first order approximation with examples. **12 Hrs.**

Unit-III

Models in Chemical Engineering: Introduction, Series of Isothermal, Constant-Holdup CSTRs, CSTRs with Variable Holdups, Two Heated Tanks, Gas-Phase, Pressurized CSTR, Non-isothermal CSTR, Single-Component Vaporizer, Multicomponent Flash Drum, Batch Reactor, Reactor With Mass Transfer, Ideal Binary Distillation Column, Multicomponent Non-ideal Distillation Column Batch Distillation With Holdup. **14 Hrs.**

Unit-IV

Computer Simulation: Introduction to Simulation, Role of Computers and Numerical Methods in simulation, Iterative convergence methods, Explicit Convergence methods, Explicit Numerical Integration algorithm, Implicit Methods, Numerical examples. **08 Hrs.**

Unit-V

Specific Simulation/ Model Development: Batch reactor, CSTR, Bioreactor, activity coefficient models, Distillation and equilibrium Flash vaporization. **08 Hrs.**

Reference Books:

1) William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.
2) Edger TF and Himmelblau D M, "Optimization of chem. Process" Mcgraw Hill, 1989.
3) Asghar Hussain, "Chemical process simulation", Wiley Eastern Ltd, 1986.
4) Roger G.E Franks, "Modeling and Simulation in Chemical Engineering" Wiley Inter science. New York, USA, 1972.

15UCHE709	Novel Separation Techniques	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide an understanding of novel/newer separations using mass transfer and thermodynamic considerations.
2. To provide an understanding of their applications at different levels in industry, viz. refineries, biochemical processing, pharmaceuticals, gaseous separations, metallurgical etc.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the use of separation factors and understand continuous adsorption processes with advanced chromatographic techniques.	4, 14	-	-
CO-2	Classify membrane based separations and explain their mass transfer and thermodynamic	-	4,12	-

	considerations with applications.			
CO-3	Explain the surfactants based micellar and foam separations with applications.	14	4, 12	-
CO-4	Describe Super Critical Fluid Extraction process with applications.	-	4, 12	14
CO-5	Explain the processes of gaseous diffusion, thermal diffusion, and electrophoresis.	4	-	14

POs/PSOs	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 -13	PSO-14	PSO -15
Mapping Level	-	-	-	2.4	-	-	-	-	-	-	-	2.0	-	2.0	-

Course content:

Unit-I

Introduction to separations: Importance, principles and separation factors, economic significance etc.

Adsorptive Separations: Thermal swing adsorption, gradient chromatography, Ligand chromatography and unsteady state fixed bed adsorption etc. **11 Hrs.**

Unit-II

Membrane Separation Processes: Classification, structure and characteristics of membranes, membrane modules, concentration polarization and fouling of membranes, R.O., U.F, Pervaporation, and gaseous separations. **11 Hrs.**

Unit-III

Surfactant Based Separations: Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations. **10 Hrs.**

Unit-IV

Super Critical Fluid Extraction: Physicochemical principles, thermodynamics, process description. Applications and case study. **10 Hrs.**

Unit-V

Miscellaneous Separations: Gaseous diffusion, Thermal diffusion, electrophoresis and types. **10 Hrs.**

Reference Books:

1) P.C. Wankat, “Large scale adsorption chromatography” CRC Press,1986.

2) R.W. Rousseu, “Handbook of separation process technology”, John Wiley and sons 1987.
3) S.Sourirajan and T. Matsura, “Reverse osmosis and Ultra filtration process principle”, NRC publication Ottawa, 1985.
4) Richard Baker, “Membrane Technology and Applications”, 2/e, ,John Wiley and Sons Ltd.

15UCHE710	Wastewater Treatment and Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Cognize the different regulatory standards with design criteria for environmental parameters	-	14	3, 6, 7
CO-2	Understand the microbiology of waste water and determine the growth and kinetic constant	3, 6, 7	14	-
CO-3	Identify the physical treatment system and design the sewer system for the local region.	14	3, 6, 7	-
CO-4	Identify and Design the secondary treatment plant system for any Industry.	14	3, 6, 7	-
CO-5	Design the treatment plant for tertiary treatment system based on the fundamentals studies of waste water.	14	3, 6, 7	-

POs/PSOs	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-14	PSO-15	PSO-16
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	2.6	-	-

Course Content:

Unit-I

Objectives of Wastewater Treatment: Flow measurements and Composition. Characterization: properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. State and central standards for Effluent discharge to water bodies and land applications. **10 Hrs.**

Unit-II

Microbiology of Waste Treatment: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism and kinetics Manod's and Michaclis menton kinetics and their applications. Determination of kinetic coefficients. **11 Hrs.**

Unit-III

Sewerage System- Design of Sanitary Sewer: Sewerage System- Design of storm water sewers, Physical and Chemical treatment of wastewater, Screens, Commuters, Grit chambers, Sedimentation Chemical treatment. **10 Hrs**.

Unit-IV

Biological Treatment Process: Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. **11 Hrs.**

Unit-V

Advanced Waste Water Treatment: Introduction, Need of Advanced Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen & Phosphorus Nitrogen Removal: Nitrification, Denitrification Simultaneous nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane Module Submerged in the Bioreactor. Electro-coagulation: Factors affecting Electro coagulation, Electrode materials, Reactor configurations. **10 Hrs**.

Reference Books:

1) Metcalf and Eddy. "Waste water Engineering: Treatment and Reuse". McGrew Hill Publication. ISBN-10: 9780070495395. 4/e. 2017
2) A. F. Gaudy and E. T. Gaudy. "Microbiological for environmental Scientist and engineers". McGraw Hill 1/e. 1980.
3) T. McGhee. "Water Supply and Sewerage", McGraw Hill. 6/e. 1991. ISBN-10: 0070609381
4) G. S. Bridie and J.S. Brides. "Water Supply and Sanitary Engineering". Dhanpat Rai & Sons 2010. ISBN-10: 8187433795.

VIII Semester

15UCHC800 Process Engineering Economics and Management (4–0–0)4

Contact Hours: 52

Course Learning Objective (CLO):

1. Prepare the students to analyse cost/revenue data and carry out economic analysis in the decision-making process to justify alternatives/projects on an economic basis and prepare to function in the business and management side of professional engineering practice.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the concepts of plant location, layout, and feasibility survey and perform cost estimation.	-	9,10	12
CO-2	Apply economic concepts viz. depreciation, cash flow, profitability, replacement, breakeven analysis etc. in solving chemical engineering problems.	10,11	9,14	12
CO-3	Interpret production management with its virtues inclusive of automation, work study and method study applied to a chemical industry.	10,11	9,14	12
CO-4	Interpret material management with its virtues inclusive of value engineering applied to a chemical industry.	10,11	9	12
CO-5	Interpret marketing management with its virtues inclusive of product life cycle applied to a chemical industry.	10, 11	9	12

POs/PSOs	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-13	PSO-14	PSO-15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.8	3.0	1.0	-	2.0	-

Course content:

Unit-I

Introduction Importance of economics and management, plant location and plant layout, feasibility survey.

Cost Estimation Factors involved in project cost estimation, methods employed for the total cost estimation, Cost Index. **12 Hrs.**

Unit-II

Depreciation: Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagrams. Taxes and Insurance.

Profitability and Methods of Evaluation: Replacement and alternative investments. Break even analysis. Financial statements. **12 Hrs.**

Unit-III

Production Management: Types of production and planning, manufacturing planning, factory planning, production planning, schedule, work study, method study, incentives and bonus, Automation. Organization of production, planning and control department. **10 Hrs.**

Unit-IV

Material Management: Functions of purchasing. Quality standards and Inspection. Sources of supply, Inventory management. ABC analysis, EOQ model. Value analysis and engineering. **09 Hrs.**

Unit-V

Marketing Management: Functions of marketing, marketing and sales, marketing engineer, and Market research. Product life cycle, Promotion of sales. Pricing methods, advertisements etc. **09 Hrs.**

Reference Books:

1) Peters and Timmerhaus, "Plant design and Economics for Chemical Engineers", McGraw Hill, 1991.
2) Banga and Sharma, "Industrial Organization and Engineering Economics", Khanna Publications, 1999.
3) Tripathi and Reddy, "Principles of Management", 5/e, Tata McGraw-Hill Education, 2004.

15UCHL801	Seminar	(0-0-3)2

Contact Hours: 40

Course Learning Objectives (CLOs):

1. To provide platform to focus on knowledge of technical data collection, communication skills and report writing.
2. To develop intellectual and professional competence and work on the chosen topic to improve skills in writing and oral presentation.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review and acquire knowledge on the chemical engineering topic outside the scope of curriculum	14	6,7,8,9,12	4, 5
CO-2	Outline and consolidate the required information on chosen topic	9	6,7,8	-
CO-3	Organize the technical matter in the required format and compile the same	12	9	-
CO-4	Interpret and communicate the topic with proper justification and conclusion	9, 10	-	-

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	-	-	1.0	1.0	2.0	2.0	2.0	2.5	3.0	-	2.5	-	3.0	-

Course content:

Seminar should be based on a detailed study of any topic related to Chemical Engineering (preferably the advanced areas / application) and the topic should preferably be relevant to the curriculum. Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. It is expected that the student collect information from reference books, standard journals. 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.

The seminar shall be evaluated with due weightage on:

Topic-10%

Literature survey-25%

Report-20%

Presentation-25%

Conclusion and querries-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

Books in the area of chemical engineering and its related field.

15UCHL802	Major Project – 2	(0-0-12)10

Contact Hours: 100

Course Learning Objectives (CLOs):

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) /PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical engineering or integrated problems (allied fields).	2,10	8, 12	6, 7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

Course Content:

The project has been assigned at the beginning of the VII semester. The project group would have carried out the preliminary literature survey, plan of project and submitted the synopsis in the VII semester. After the approval from DUGC, the left project work should be carried out and completed in the VIII semester. The detailed project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHE803	Solid Waste Management	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide students with a comprehensive understanding of integrated solid waste management from an environmental and public health perspective.
2. To study the detailed engineered system of solid waste management system.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the components and characteristics of a solid waste management system.	6	7	3
CO-2	Identify the various collection, transfer and transport mechanisms of municipal solid waste management.	6	3,7	-
CO-3	Explain various processing, material and energy recovery facilities.	14	3	
CO-4	Describe different methods and safety precautions used in disposal of MSW.	6,7	14	
CO-5	Explain types of hazardous solid waste and Discuss safe methods of disposal of hazardous waste & their management principles.	6,7	14	3

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	-	1.5	-	-	3.0	2.5	-	-	-	-	-	-	2.3	-

Course content:

Unit I

Introduction to Solid Wastes: Definition, Characteristics, Types of solid waste, Physical, Chemical and Biological properties of Municipal Solid Waste, Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies. **10 Hrs.**

Unit II

Engineered Systems for Solid Waste Management: Generation of solid waste, Quantities of solid Waste, Methods to measure solid waste quantities, Solid waste generation and collection, Factors affecting solid waste generation rate, Onsite handling, Storage and Processing, Transfer and transport, Collection system and devices. **12 Hrs.**

Unit III

Processing Techniques and Recovery of Energy: Objectives of waste processing, component separation and volume reduction, various processing technologies — biological and chemical conversion methods, Composting, Factors affecting composting, Aerobic composting and anaerobic Digestion, Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). Municipal incinerators, Grates, Furnances of solid waste. Recovery, Material and Energy recovery operations. **12 Hrs.**

Unit IV

Disposal of Solid Wastes: Various disposal methods, landfills — site selection, site infrastructure, essential components of landfill; types of landfilling methods, landfill planning –leachate management and gas control; Environmental monitoring systems for landfill sites, closure and post-closure plans for landfills, landfill site rehabilitation, reclamation and remediation. **10 Hrs.**

Unit V

Hazardous Wastes: Definition, identification and classification of hazardous solid waste, Origin and reduction at source, Collection and handling, Management issues and planning methods, Environmental Act, E-waste handling and disposal.

Industrial Solid Waste Management: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units. **10 Hrs.**

Reference Books:

1) George Tchobanoglous, “Integrated Solid waste Management-Engineering Principles and Management issues”, McGraw Hill, 1993.
2) Howard Peavy, “Environmental Engineering”, McGraw Hill,1986.

3) Dutta, "Industrial Solid waste Management and landfilling practice", Narose Publication, 1999.

15UCHE804	Instrumental Methods of Analysis	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the principles and concepts behind the qualitative and quantitative analysis of molecules and compounds using instrumental methods with their applications.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain and analyse Flame photometry and AAS techniques and its application.	-	2	1
CO-2	Explain and analyse the electrochemical techniques and its application	-	2	1
CO-3	Identify the concepts for analysis of molecules and compounds using instrumental methods.	1	-	-
CO-4	Interpret and analyse the different spectroscopic techniques.	1	-	-
CO-5	Explain and analyse the chromatography technique and its applications	1	-	-

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	2.2	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Chemistry and Fundamentals

Course content:

Unit-I

Introduction to Flame Photometry and Atomic Absorption Spectroscopy: Introduction, Principle, Flame and flame spectra, variation of emission intensity with flame, Metallic spectra in flame, flame ground, Role of temperature on absorption emission and fluorescence. Comparative study of Flame Emission ectroscopy (FES) and Atomic Absorption Spectroscopy (AAS) Instrumentation and Applications. Qualitative and titative determination of alkali and alkaline earth metals. **11 Hrs.**

Unit-II

Electrochemical Techniques: Introduction to Electrochemistry, Electrode Potential, Measurement, sign convention, Standard electrode potential, Cell Potential: Liquid junction potential, Effect of current. Polarization: Sources, over voltage, concentration polarization, Mechanism of mass transport. Potentiometric Methods: reference Electrodes- calomel electrode Ag- Agcl (s) electrode, Hydrogen electrode, Potentiometric titrations and applications. Membrane Electrodes: Classification of properties, Principle design, theory of ion selective electrodes Membrane potential, Selectivity, Crystalline liquid membrane and electrodes. **11 Hrs.**

Unit-III

Nuclear Magnetic Spectroscopy: Introduction, Chemical shifts, Mechanism of shielding and deshielding. Types of nuclei, Theory of population of nuclear magnetic energy levels, Spin –spin coupling, Rules of governing the interpretation of first order spectra, Low and high resolution NMR, Instrumentation and application to structure elucidation of simple organic molecules. **10 Hrs.**

Unit-IV

Mass Spectroscopy: Introduction, theory, Instrumentation of mass spectrometer, Methods of generation of positively charged ions, Mass analyzers, Resolving power, Molecular ion peak, Base peak, Metastable peak, Modes of fragmentations, Application of mass spectrometry in Qualitative and Quantitative analysis. Structural elucidation of simple organic molecules **10 Hrs.**

Unit-V

Chromatography: Introduction to chromatographic techniques, General descriptions, definitions, terms and parameters used in chromatography. Classification of chromatographic methods, working principles, Instrumentation and applications of Thin layer chromatography (TLC), Gas chromatography(GC), High pressure liquid chromatography (HPLC). **10 Hrs.**

Reference Books:

1) Jaffery, G.H., Basset, J., et. al., “Vogel’s Text book of Quantitative Inorganic Analysis”, 5/e, ELBX, 1998.
2) Skoog, D.A., “Principles of Instrumental Analysis”, 3/e, Saunders College publishing, 1985.
3) W.H. Willard, “Instrumental Methods of analysis”, 7/e, L.L., Merritt and J.A. Dean, 1988.

4) B.K. Sharma ,"Instrumental Methods of Chemical Analysis", Goel Publishing House Meerut, 2000.

15UCHE805	Sugar Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the different processing methods practiced for production of sugar. Learn about the extraction and production of sugar, learn different unit operation and unit process application with practical difficulties encountering during process along with its remedies.

Course Outcomes (COs):

Description of the course outcomes: At the end of the course student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Relate the Indian Sugar industry and World scenario	-	6	7, 14
CO-2	Analyze Working, operation and performance of sugar production process.	-	2	1
CO-3	Identify various equipments for sugar production.	-	14	-
CO-4	Formulate a system to meet the needs considering the constraints of economics, safety and environmental problems associated with sugar industry.	3, 14, 6	7	-
CO-5	Identify the various means of cogeneration and its importance on economy of sugar industry.		2	13, 14

POs/PSOs	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-13	PSO-14	PSO-15
Mapping Level	1.0	2.0	3.0	-	-	2.5	1.5	-	-	-	-	-	1.0	1.75	-

Course content:

Unit- I

Sugar Industry in India: Chemical and physical properties of sucrose and reducing sugars. Sources of sucrose, formation of sucrose plants, non sugar compounds of sugarcane, inorganic constituents of sugar cane juices and sugars analytical used in sugar industry. **10 Hrs.**

Unit- II

Purification: Technology of the purification process, fundamental reactions and physical chemistry aspects of clarification, liming, Sulphitation and carbonation process, filtration of sugar juices. **10 Hrs.**

Unit- III

Unit Operations: Evaporation of sugar juice, heat transfer in evaporators, evaporation equipment and auxiliaries. Crystallography: solubility of sucrose, theoretical aspects of crystal growth, factors influencing rate of crystallization, control methods and equipment in sugar crystallization, technology of sugar crystallization, boiling scheme of crystallization Centrifugation: theory of the centrifugal process, centrifugal operation, engineering principles of sugar centrifugals, and the centrifugal equipment and auxiliaries, grading of sugar.

12 Hrs.

Unit- IV

Distillery: Production of final molasses and molasses's utilization and storage. Molasses characteristics for alcohol. Fermentation methodology for alcohol production, factors influencing the production. Distillation methods used in separation process, Design consideration for distillation column. **10 Hrs.**

Unit- V

Co-generation: Types of co-generation methods, quality of bagasse used, different types of boilers used and efficiency, factors influencing the operation, methods of obtaining steam, and quality of steam

Environmental Management Plan: Pollution control measures for water, air, solid waste, noise in sugar industries. **10 Hrs.**

Reference Books:

1) Honing P (Ed), "Principles of Sugar Technology", Vol I to III, Elsevier publishing company, 1953.
2) Jenkinos. G.H., "Introduction to cane sugar Technology", Elsevier, 1966.
3) Mathur.R.B.L, "Handbook of cane Sugar Technology", 2/e, Oxford and I.B.H. Publishing Co., 1997.
4) R.K. Rajputh, "A text book on Power Plant Engineering", 2/e, Laxmi publications (p) Ltd., New Delhi, 2001.

15UCHE806 Bioprocess Engineering (4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide the students with the basics of bioreactor engineering.
2. To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts and cell lines and other process criteria.	-	3, 7	2
CO-2	Design and analyse the scale up criteria for the different bioreactors.	5	2, 3, 7	-
CO-3	Understand the enzyme kinetics and design the immobilized enzyme bioreactors.	13	3, 7	-
CO-4	Apply modeling and simulation of bioprocesses so as to reduce costs and to enhance the quality of products and systems.	5	3, 7	-
CO-5	Identify the different cell cultivation system to apply in the different bioreactors.	13	3, 7	-

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	-	1.5	2.0	-	3.0	-	2.0	-	-	-	-	-	3.0	-	

Prerequisite: Biochemical Engineering

Course content:

Unit-I

Operational Modes of Bioreactors: Fed batch cultivation, Cell recycle cultivation, Cell recycle cultivation in waste water treatment, two stage cultivation. Packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor. **10 Hrs**.

Unit-II

Bioreactor Scale-Up: Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. **12 Hrs.**

Unit-III

Bioreactor Consideration in Enzyme Systems: Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors. **10 Hrs.**

Unit-IV

Modeling and Simulation of Bioprocesses: Study of structured models for analysis of various bioprocess – compartmental models, models of cellular energetic and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism. **10 Hrs**

Unit-V

Recombinant Cell Cultivation: Different host vector system for recombinant cell cultivation strategies and advantages. E.coli, yeast Pichia pastoris/ Saccharomyces cereviseae, Animal cell cultivation, plant cell cultivation, Insect cell cultivation. High cell density cultivation, process strategies, reactor considerations in the above system. **10 Hrs.**

Reference Books:

1) Jens Nielson, John Villadsen and Gunnar Liden, "Bioreaction engineering principles", 2/e, Kulwer Academic, 2002
2) Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, 2/e, CRC press, London. 1995.
3) James E. Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill. Singapore. 1986
4) Atkinson, B, Mavituna, F, "Biochemical Engineering and Biotechnology Handbook" 2/e, Macmillan Publishers Ltd, New York, 1992.

15UCHE807	Unit Processing in Organic Synthesis	4-0-0(4)

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To study the fundamental concepts of Industrial Chemistry and theirapplications.
2. To have knowledge on various reaction mechanisms, preparation of organiccompounds, classification of the compounds etc

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	To apply basic knowledge of chemical processes and equations to	1	2	-

	solve numerical problems.			
CO-2	To converge the concepts of chemical processes of sulphonation for industrial products	1	-	-
CO-3	To elaborate halogenations its process, kinetics and interpret it for modern industrial processes.	1	-	-
CO-4	To correlate oxidation and analyze various unit processes of many organic compounds for improvement of existing techniques for the preparation of better yield and quality	1	-	-
CO-5	To evaluate hydrogenation reaction and processes with mechanisms for innovative industrial products	-	2	-

POs/PSOs	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 -13	PSO -14	PSO -15
Mapping Level	3.0	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Basic Chemistry
Course content:

Unit-I

Introduction: Unit processes and principles of thermodynamics and kinetics related to unit processes. Nitration: Introduction, nitrating agents, aromatic nitration, thermodynamics, kinetics and mechanism, nitration of paraffin hydrocarbon, Mixed acid for nitration, process equipment for technical nitration typical industrial nitration processes (nitrobenzene). **11 Hrs.**

Unit-II

Sulfonation: Introduction, sulfonating agents and their application, chemical and physical factors, kinetics mechanism and thermodynamics of sulfonation, industrial equipments for batch and continuous processes industrial processes (Monosulphonation of benzene, detergent alkylate). **11 Hrs.**

Unit-III

Halogenation: Introduction survey of halogenation processes thermodynamics and kinetics, chlorination in presence of catalyst, photo halogenation, industrial equipment for halogenation, typical processes (Chlorobenzene). **10 Hrs.**

Unit-IV

Oxidation: Types of oxidative reactions, oxidizing agents. Typical liquid phase oxidation processes, vapor phase oxidation of aromatic compounds. Industrial processes (styrene from ethyl benzene, acetaldehyde to acetic acid.) **10 Hrs.**

Unit-V

Hydrogenation: Introduction, methods of hydrogen production, general principles relating to hydrogenation catalysts, kinetics and thermodynamics, industrial apparatus for hydrogenation and typical examples of hydrogenation processes (Hydrogenation of oils and fats). **10 Hrs.**

Reference Books:

1) P. H. Groggins. “Unit Processes in Organic Synthesis “, 5/e, Tata Mc Graw Hill, 1995.
2) Kirk R. E. Othmer D. F. “Encyclopedia of Chemical Technology”, Inter Science Publishers.
3) Bahl and Bahl, “Organic Chemistry”, Chand Publications, New Delhi.