University School of Chemical Technology

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

Sector-16C, Dwarka, New Delhi-78

Date: 29.11.2021

MINUTES OF BOS MEETING

Board of Studies (BOS), USCT meeting was held on 29th November 2021 at 11.00am in online mode to discuss the New Proposed Scheme and Syllabus of M.Tech. (Chemical Engineering) and (Biochemical Engineering) and B.Tech. (Chemical Engineering) and (Biochemical Engineering).

Following members were present:

1.	Prof. A.K. Jain	Dean, USCT, Chairman
2.	Prof. Rajesh Khanna, IIT Delhi	External Member
3.	Prof. T.R. Sreekrishnan, IIT Delhi,	External Member
4.	Prof. Ajay Bansal, NIT, Jalandhar,	External Member
5.	Prof. S.K. Jana, NIT, Jaipur,	External Member
6.	Prof. U.K. Mandal	Member
7.	Prof. Tapan Sarkar	Member
8.	Prof. S.K. Sharma	Member
9.	Prof.Biswajit Sarkar	Member
10.	Prof. Aradhana Srivastava	Member
11.	Prof. Neeru Anand	Member
12.	Dr. Rakesh Angira	Member
13.	Dr. Sanigdha Acharya	Member
14.	Mr. Azad Singh	Member
15.	Dr. Dinesh Kumar	Member
16.	Dr. Vinita Khandegar	Special Invitee

Prof. A.K. Shrivastava, External Member could not attend the meeting due to his prior commitments.

The agenda items were circulated to the BOS members in advance of the meeting. The agenda items were discussed and deliberated upon one by one. The following decisions were made during the meeting:

1. Scheme and Syllabus of B.Tech/M.Tech. (Chemical Engineering) dual degree:

Scheme and syllabus of B.Tech/M.Tech. (Chemical Engineering) dual degree was discussed and approved. The scheme and syllabus is enclosed as A-1 & A-2. These will be implemented from Academic session 2021-22. The M.Tech (Chemical Engineering) Scheme and syllabus as discussed above shall also be applicable for students admitted in academic year for B.Tech/M.Tech (Chemical Engineering) dual degree programme in 2017-18.

2. Scheme and Syllabus of B.Tech/M.Tech. (Biochemical Engineering) dual degree:

Scheme and syllabus of B.Tech/M.Tech. (Biochemical Engineering) dual degree was discussed and approved. The scheme and syllabus is enclosed as A-3 & A-4. These will be implemented from Academic session 2021-22. The M.Tech (Biochemical Engineering) Scheme and syllabus as discussed above shall also be applicable for students admitted in academic year for B.Tech/M.Tech (Biochemical Engineering) dual degree programme in 2017-18.

3. M.Tech. (Chemical Engineering) Regular

The scheme and Syllabus for M.Tech. (Chemical Engineering), Regular Students shall be same as in agenda item no. 1. This will be applicable for students admitted in the year 2021-22 and onwards.

4. Minor Degree in Emerging Areas

Further, Minor degrees in Emerging areas were discussed and it was decided to offer Minor degree along with Major B.Tech. degree in Chemical as well as in Biochemical Engineering. To award Minor degree in Chemical Engineering along with Major disciplines of other USS, few courses of Chemical Engineering have also been identified and approved. The details are annexed as [A-5]. The degree shall be named as B.Tech.(Chemical Engineering) with minor specialization in <name of minor specialization area>. For Biochemical Engineering students, B.Tech.(Biochemical Engineering) with minor specialization in <name of minor specialization area>.

Prof. Arinjay Kumar Jain	E-mail attached Prof. Rajesh Khanna	Prof. T.R. Sreekrishnan
E-mail attached Prof. Ajay Bansal	E-mail attached Prof. S.K. Jana	Prof. U.K. Mandal
Prof. Tapan Sarkar	Prof. S.K. Sharma	Prof. Biswajit Sarkar
Prof. Aradhana Srivastava	Prof. Neeru Anand	Dr. Rakesh Angira
Dr. Sanigdha Acharya	Mr. Azad Singh	Dr. Dinesh Kumar
Dr. Vinita Khandegar		

Plant

UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY
SCHEME OF EXAMINATION
M.TECH. (CHEMICAL ENGINEERING)

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

Duration – 2 Years (Full time)

Program Scheme and Syllabus
Applicable to

1st to 4th semester M. Tech Chemical Engineering
and
9th to 12th semester Dual degree M. Tech Chemical engineering

CHOICE BASED CREDIT SYSTEM

Effective from 2022

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

SECTOR-16C, DWARKA, NEW DELHI-110078

Entrepreneur hip | Employability | Skill Development

Approved in the Board of Studies of USCT held on 29th November, 2021

Guru Gobind Singh Indraprastha University

Vision

The University will stimulate both the hearts and minds of scholars, empower them to contribute to the welfare of society at large; train them to adopt themselves to the changing needs of the economy; advocate them for cultural leadership to ensure peace, harmony and prosperity for all.

Mission

Guru Gobind Singh Indraprastha University shall strive hard to provide a market oriented professional education to the student community of India in general and of Delhi in particular, with a view to serving the cause of higher education as well as to meet the needs of the Indian industries by promoting establishment of colleges and Schools of Studies as Centres of Excellence in emerging areas of education with focus on professional education in disciplines of engineering, technology, medicine, education, pharmacy, nursing, law, etc.

Quality Policy

Guru Gobind Singh Indraprastha University is committed to providing professional education with thrust on creativity, innovation, continuous change and motivating environment for knowledge creation and dissemination through its effective quality management system.‖ Rules & Regulations University administration functions while dealing with various issues of administrative and academic significance, within the provisions of the University Act, rules and regulations (Statutes & Ordinances) framed thereunder.

University School of Chemical Technology

The University School of Chemical Technology recognizes the importance of chemical industry and the need for trained manpower, since establishment of the University in 1999, THE UNIVERSITY has taken the bold and visionary decision to start the University School of Chemical Technology, the only one of its kind in this part of the country after IIT, DELHI. The founding fathers concerned with education required in chemical industry showed extraordinary vision 100 years ago to recognise that education to provide trained manpower could be provided under two broad areas namely Unit Operations and Unit Processes. This framework still holds although it has evolved, expanded and continuously tuned over the last 10 decades to progressively include thermodynamics, reaction engineering, process control, process economics, mathematical and numerical methods, computers, process engineering, separation processes, catalysis hazard and safety etc. each one advancing in its own right with extensive research work both in academia and in industry. The School was established with the twin objectives of generating effective trained professionals and to keep pace with the R & D activities of this fast-changing field of Chemical Technology. The B.Tech. and M.Tech. (Chemical and Biochemical) programme being offered by the school are based on the pattern of I.I.T.'s and other national and international institutions of repute. The well-structured programmes are meant to impart comprehensive knowledge of various core chemical and biochemical engineering subjects, interdisciplinary courses in Biotechnology, Information Technology, Environment Management, Management Studies through Electives, and industrial exposure through practical training in laboratories and Industrial Units.

Vision

Achieving excellence through active teaching, skill development and research in the areas of chemical and biochemical engineering and allied areas to become a recognized centre for education and research.

Mission

To generate new knowledge by offering graduate and post graduate programme and provide quality manpower with high employment potential in the present liberalised economic climate in the era of globalization.

- To generate new knowledge by offering graduate and post graduate programme.
- Impart quality teaching and train students in addressing the challenges in the Chemical and Biochemical Engineering and allied areas.
- Provide quality manpower with high employment to achieve proficiency in Chemical and Biochemical Engineering through innovative teaching and state of the art laboratories.
- Develop inclusive technologies with a focus on sustainability.
- Team up with industries and research institutes to cater community needs.

Master of Technology
(Chemical Engineering)

The school was established since the foundation of the university in 1999. It is now a centre for teaching and research in the modern field of chemical technology and biochemical engineering. Considering the dynamism of science and engineering, the school started the post graduate course in chemical engineering since the conception of the university. The purpose was creating well-trained human resources to fulfil the growing demand in the fields of chemical processes development. The course emphasized to synthesize and evolve chemical process technology towards sustainable development and trained work force for research and development. The curriculum has been designed in order to provide education to the students with background of Chemical Engineering/ Biochemical Engineering/ Chemical Technology/Biotechnology/Environmental Engineering or allied fields.

Program Educational Objectives (PEO)

PEO1	Pursue successful industrial/academic/research careers in chemical engineering and allied fields.
PEO2	Apply the knowledge of advanced topics in chemical engineering to meet contemporary needs of industry and research.
PEO3	Exhibit project management skills with the multifaceted aspects of using modern software, equipment/ analytical instrument, and ability to work in collaborative environment.
PEO4	To make professionals to apply principles of chemical engineering in solving practical problems related to safety, energy and environment.
PEO5	Pursue self-learning to remain abreast with latest developments for continuous technical and professional growth.

Programme Outcomes (POs)

At the end of the program the student will be able to:

PO1	Identify, formulates, and solve engineering problems by applying knowledge of mathematics/science/engineering.
PO2	Apply the state-of-the-art computational and simulation tools for solving problems in chemical and allied engineering industries.
PO3	Design and conduct experiments, as well as to analyse and interpret data.
PO4	Communicate professionally to express views and to publish technical articles.
PO5	Function on multidisciplinary team or to lead a technical group.
PO6	Understand of professional and ethical responsibility for development of the society.
PO7	Work as an independent consultant/entrepreneur.
PO8	Pursue life-long learning, updating knowledge and skills for technical, professional and societal development.

Programme specific outcomes (PSOs)

PSO1	The students will be familiar with the concepts of chemical engineering to identify, analyse and solve complex problems encountered in chemical and other allied industries, by applying the principles of process engineering and using modern engineering tools such as ASPEN PLUS, MATLAB, ANSYS, DESIGN-EXPERT etc.
PSO2	The students acquire the ability to design and optimize the biochemical process engineering systems, chemical plants and chemical production considering public health, safety and welfare, as well as global, social, environmental and economic aspects.
PSO3	The students will comprehend to play an important role in the diversified area of chemical engineering (Industries, Academia and R&D) and professional environment, and able to carry out multidisciplinary research in the field of chemical process engineering, environmental engineering, catalysis development and reactor design, nano-science and technology, and material engineering etc.
PSO4	The students will be expertise to synthesising the information of recent advancement in chemical engineering for conducting research in the wider fields of theoretical development, current issues and strategies planning.

SCHEME OF EXAMINATION

M.TECH
2-years Full Time/Dual Degree in Chemical Engineering

Credit distribution

	Sem MTech Chemical Engineering 2 years (Full Time/Dual degree Chemical)			
	I (IX)	II (X)	III (XI)	VI (XII)
AC (Audit Course)	-	2	2	-
PC (Programme Core)	20	7	-	-
PP (Programme Practical/Minor Project)	4	4	-	-
OE (Open Electives)	-	3	-	-
PE (Programme Electives)	-	9	3	-
PD(Programme Dissertation)	-	-	12	15
Total	**24**	**25**	**17**	**15**
Sum of all semester	**81**			

Note:
Student must earn minimum 75 credits for the Award of M.Tech. Degree. However, Student has to appear in all the courses as per scheme, and can drop credits from elective courses only.

Marking Scheme of Examination

For Theory
1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

For Practical/Viva
1. Teachers Continuous Evaluation: 40 marks
2. End Term Practical/Viva: 60 marks

First semester (or IX Sem Dual degree)

Paper ID	Paper Code	Tile	L	T	P	Credit
Theory Papers						
14501	CT-501	Advanced Transport Phenomena	3	1	0	4
14503	CT-503	Advanced Separation Engineering	3	1	0	4
14505	CT-505	Advanced System Engineering	3	1	0	4
14507	CT-507	Advanced Chemical Engineering Thermodynamics	3	1	0	4
14509	CT-509	Advanced Reaction Engineering	3	1	0	4
Practical/Viva Voce						
14551	CT-551	Advanced Computational Lab	0	0	3	2
14553	CT-553	Advanced Reaction Engineering Lab	0	0	3	2
		Total	**15**	**5**	**6**	**24**

Second semester (or X Sem Dual degree)

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14502	CT-502	Statistical Analysis and Research Methodology	3	1	0	4
14504	CT-504	Analytical Techniques	3	0	0	3
	HVE-102*	Human Values & Ethics	2	0	0	2
Elective Course (opt any **three** from following)						
14510	CT-510	Membrane Science & Technology	3	0	0	3
14512	CT-512	Process Design for Wastewater Treatment	3	0	0	3
14514	CT-514	Design & Analysis of Biological Reactors	3	0	0	3
14516	CT-516	Fuels and Combustion Technology	3	0	0	3
14518	CT-518	Process Plant Utilities	3	0	0	3
14520	CT-520	Biomass for Energy and Chemicals	3	0	0	3
14522	CT-522	Chemical Process Quantitative Risk Analysis	3	0	0	3
14524	CT-524	Application of Nanotechnology in Chemical Engineering	3	0	0	3
Open Electives (opt any **one** from following)						
14526	CT-526	Renewable Energy Technologies	3	0	0	3
XX-XXX	XX-XXX	MOOCs (as per list provided by USCT)				
XX-XXX	XX-XXX	Open elective course offered at PG level by other USS				
Practical/Viva Voce						
14552	CT-552	Minor Project	0	0	8	4
		Total	**20**	**1**	**8**	**25**

*NUES

Third semester (or XI Sem Dual degree)

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14601	CT-601*	Stress Management by Yoga	1	0	2	2
Elective Course (opt any **one** from following)						
14603	CT-603	Membrane Technology for Water and Wastewater Treatment	3	0	0	3
14605	CT-605	Advanced Petroleum Refining	3	0	0	3
14607	CT-607	Air Quality Management	3	0	0	3
Practical/Viva Voce						
14651	CT-651	Dissertation Part-I	0	0	24	12
		Total	**4**	**0**	**26**	**17**

*NUES

.

Fourth Semester (or XII Sem Dual degree)

Practical/Viva Voce						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14652	CT-652	Dissertation Part- II	0	0	30	15
		Total	**0**	**0**	**30**	**15**

CT-501 Advanced Transport Phenomena	3 L	1 T	0 P	4 Credit

Course Objectives:

1. To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
2. To enable students to understand the equations of change for isothermal and non-isothermal flow.
3. To introduce details of equations of change for multi component systems.
4. To give insight into properties of two-dimensional flows and aspects of dimensional analysis.

Course Outcomes:

1. Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
2. Perform momentum, energy and mass balances for a given system at macro and microscopic scale.
3. Solve the governing equations to obtain velocity, temperature and concentration profiles.
4. Model the momentum, heat and mass transport under turbulent conditions.
5. Develop analogies among momentum, energy and mass transport.

Course Content:

UNIT 1 **(6 Hrs)**

Philosophy And Fundamentals of Three Transport Phenomena: Importance of transport phenomena; analogous nature of transfer process; basic concepts, conversation laws. Summary of vector and tensor Notation: Vector operations from a geometrical view point. Vector operation from an analytical view point, the vector differential operations, second order tensors, vector and tensor components in curvilinear coordinates, differential operations in curvilinear coordinates. Momentum Transport: Viscosity and the mechanism of momentum transport, Newton's law of viscosity Energy Transport: Thermal Conductivity and the Mechanism of Energy Transport: Fourier's Law of heat conduction. Mass Transport: Definition of concentrations, velocities and mass fluxes, Fick's law of diffusion, theory of ordinary diffusion in gases at low density, theory of ordinary diffusion in liquids.

UNIT 2 **(17 Hrs)**

Equations of change for isothermal systems: Conversation laws and equations of change: development of equations of continuity, motion and energy in single component systems in rectangular coordinates and the forms in curvilinear coordinates; simplified forms of equations for special cases, solutions of momentum, mass and heat transfer problems discussed under shell balance by applications of equation of change. Time-dependent flow of Newtonian fluids; solving flow problems using a stream function; flow of inviscid fluids by use of the velovity potential.

UNIT 3 **(17 Hrs)**

Transport in turbulent and boundary layer flow: Introduction to turbulent flows, comparisons of laminar and turbulent flows in simple systems such as circular tube, flat plate. Concept of Boundary Layer Flow.

UNIT 4 **(16 Hrs)**

Equations of change for non-isothermal systems: The Energy Equation; special forms of the Energy Equation; use of the Equations of Change to solve steady-state problems; dimensional analysis of the Equation of Change for nonisothermal systems.

Text and Reference Books:

[1] R.B. Bird, W.E. Stewart and E.W. Lightfoot, Transport Phenomena, 2nd Edition. John Wiley, 2002.
[2] J.R. Wilty, R.W. Wilson, and C.W. Wicks, Fundamentals of Momentum Heat and Mass Transfer, 5th Edition, John Wiley, New York, 2010.
[3] C. John Geankoplis, Transport Processes and Separation Process Principles, 4th Edition. Prentice-Hall, 2003.
[4] R.S. Brodkey, and H.C. Hershey, "Transport Phenomena - A Unified Approach", McGraw Hill, 1988.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	2	1	2	2	3
CO2	3	2	3	2	1	2	2	3
CO3	3	2	2	2	1	2	2	2
CO4	3	2	2	2	1	2	2	2
CO5	3	2	2	2	1	2	2	2

CT-503 Advanced Separation Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:
1. To gain an understanding of the basic principles and applications of multicomponent distillation.
2. To enable students to understand the various calculation procedures for multicomponent distillation.
3. To describe enhanced-distillation with their applications.

Course Outcomes:
At the end of the course, the student should be able to:
1. Understand the principles, vapour-liquid relationship, distillation curve maps of multicomponent distillation.
2. Understand the approximate method and rigorous methods of distillation calculation.
3. Understand the working principles on enhanced-distillation method and their applications, and the differences from ordinary distillation.

Course Content:

UNIT 1 **(15 Hrs)**

Multicomponent diffusion: Multicomponent diffusion equation, Estimation of multicomponent diffusion coefficient and its application.
Multicomponent distillation: Introduction to multicomponent distillation, Degree of freedom analysis, Formulation of vapor-liquid equilibrium relationship, Use of Triangular graph, Residual-curve maps, Distillation-curve maps, Calculation of bubble point and dew point. Multicomponent flash distillation; Multicomponent differential distillation.

UNIT 2 **(15 Hrs)**

Approximate method for multicomponent distillation: Fenske-Underwood-Gilliland method, Minimum equilibrium stages, Minimum reflux, Actual reflux ratio and theoretical stage, Feed stage location. Equilibrium-based method for multicomponent distillation: Theoretical model for an equilibrium stage; General strategy of mathematical solution; Matrix method of solution.

UNIT 3 **(13 Hrs)**

Rate-Based Models for distillation: Rate-based models, Transport-rate expression, Estimation of transport coefficient.

UNIT 4 **(13 Hrs)**

Enhanced distillation: Salt distillation, Pressure swing-distillation, Azeotropic distillation, Extractive distillation, Reactive distillation.
Multicomponent adsorption: Adsorption isotherm and its application.

Text and Reference Books:

[1] Seader J.D. and Henley J.E., Separation Process Principles, 2nd Edition, John Wiley & Sons, 2006.
[2] Taylor R and Krishna R., Multicomponent Mass Transfer, John Wiley & Sons, 1993.
[3] Wankat P.C., Separation Process Engineering, Pearson, 3rd Edition, 2014.
[4] Stichlmair J.G and Fair J.R., Distillation Principles and Practice, Wiley-VCH,1998.
[5] Dutta B.K., Principles of Mass Transfer and Separation Processes, PHI, 2007.
[6] Treybal R.E., Mass-Transfer Operation, McGraw-Hill, 3rd Edition, 1981.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	3	1	1	2	2
CO2	3	3	3	3	1	1	2	2
CO3	3	3	3	3	1	1	2	2
CO4	3	3	3	3	1	1	2	2

CT-505 Advanced System Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:
1. Introduction to various optimization techniques of linear and non-linear problems to the students.
2. Introduction to various emerging tools e.g., Neural Network in optimizing the problems in process industries.

Course Outcomes:
1. Students would be able to represent physical problem in mathematical terms.
2. Students would be able to optimize chemical process
3. Students would be able to apply neural networks in industrial applications

Course Content:

UNIT 1 **(15 Hrs)**

Introduction to process engineering and optimization, Formulation of various process optimization problems and their classification, Basic concepts of optimization - convex and concave function, necessary and sufficient conditions for stationary points, optimization of one-dimensional problems.

UNIT 2 **(15 Hrs)**

Unconstrained multi variable optimization - direct search methods, indirect first and second order methods; linear programming and its application: Simplex, Big M & Two Phase methods.

UNIT 3 **(16 Hrs)**

Constrained multi level optimization - necessary and sufficient for constrained optimum, quadratic programming (Wolfe's Method and Beale's Method), Generalized Reduced gradient method, optimization of stage and discrete processes, Dynamics Programming, Integer and Mixed Integer Programming (Gomory's algorithm and Branch & Bound technique)

UNIT 4 **(10 Hrs)**

Network: Fundamentals of Neural Network, Back Propagation Network, Simulated annealing. Use of Neural networking in industries, Genetic Algorithm: Fundamentals of genetic algorithm, Genetic Modeling.

Text and Reference Books:

[1] T.F. Edgar and D.M. Himmelblau "Optimization of Chemical Proceses", McGraw Hill International editions.
[2] Rao S S, "Engineering Optimization"
[3] Sharma JK. "Operations Research", Macmillian.
[4] Rajasekaran R. and Vijaylakshmi GA, "Neural Networks, Fuzzy systems and Genetic algorithm", Eastern Economy Edition.
[5] G.S. Beveridge and R.S. Schekhter "Optimization theory and practice, McGraw Hill New York.
[6] James A Anderson, "An Introduction to Neural Networks", Eastern Economy Edition.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	2	1	1	2	2	3
CO2	3	3	2	1	1	2	2	3
CO3	3	3	2	1	1	2	2	3

CT-507 Advanced Chemical Engineering Thermodynamics	3 L	1 T	0 P	4 Credit

Course Objectives:

1. To introduce the fundamentals of statistical thermodynamics and to give students a foundation for molecular simulation of chemical engineering processes.
2. To train students to apply this fundamental body of knowledge in thermodynamics to the solution of practical problems.

Course Outcomes:

1. Ability to implement statistical analysis and interpret molecular data, formulation and solve engineering problems.
2. Ability to evaluate the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients etc.) of pure fluid and fluid mixtures using statistical thermodynamics.
3. Ability to do molecular prediction of equilibrium composition of mixtures under phase and chemical-reaction equilibria.
4. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Content:

UNIT 1 **(15 Hrs)**

Fundamentals of Statistical Thermodynamics: Quantum energy levels and degeneracy, Boltzmann statistics, Maxwell statistics and thermodynamics properties,

UNIT 2 **(15 Hrs)**

Thermodynamics equilibrium of process, Molecular theory of ideal gases, Dense gases and liquids, Phase transitions and phase equilibrium.

UNIT 3 **(15 Hrs)**

Irreversible Thermodynamics: Definition, Entropy production and flow, Thermodynamics forces, Onsager's reciprocal relation and application to chemical processes.

UNIT 4 **(11 Hrs)**

Molecular Simulation: Thermodynamics modeling and molecular simulation of equilibrium separation processes.

Text and Reference Books:

[1] J M Prausnitz, R N Lichtenthaler, E G de Azevedo, Molecular Thermodynamics of Fluid Phase Equilibrium, 3rd Edition., Prentice-Hall, 1999.
[2] V P Carey, Statistical Thermodynamics and Microscale Thermophysics, Cambridge University Press, 1999.
[3] T L Hill, An Introduction to Statistical Thermodynamics, Dover Publications, New York.
[4] J M Haile, Molecular Dynamics Simulations-Elementary Methods, J Wiley & Sons.
[5] Introduction to Chemical Engineering Thermodynamics, Smith J.M, Van Ness H.C., Abbott M.M. The McGraw Hill Companies, Inc., USA, 5th Edition, 1996.
[6] Chemical and Engineering Thermodynamics, Sandler S.I. John Wiley and Sons, Inc., New York, 3rd Edition, 1999.
[7] Introductory Chemical Engineering Thermodynamics, Elliot J.R and Lira C.T., Prentice Hall, 1999.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	3	2	1	3
CO2	3	3	3	3	2	2	2	3
CO3	3	3	3	3	2	2	2	3
CO4	3	3	3	3	2	2	3	3

CT-509 Advanced Reaction Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:
To understand and develop the concepts of heterogenous catalysts their synthesis and characterization with an understanding of fixed and fluidized bed modelling.

Course Outcomes:

1. Students will be able to understand concepts of heterogeneous catalysts and their characterization.
2. Students will be able to outline aspects and utilization of fixed and fluidized bed reactors.
3. To learn and understand other multiphase reactors e.g. slurry and trickle bed reactors.
4. Students will be able to use mathematical tools by using Population Balance Equations for reactor modeling

Course Contents:

UNIT 1 **(8 Hrs)**

Introduction: Phenomenon of catalysis, mode of action of catalyst, Classification of catalysts, homogenous and heterogenous catalysts, Catalysts concepts of heterogeneous catalysts : energy aspects of catalytic activity, stearic effects, electronic factors, isolators, supported catalysts, promotors, inhibitors, catalyst deactivation and regeneration, poisoning and sintering, Reaction mechanisms of catalysts: adsorption, chemisorption, Langmuir-Hinshelwood Mechanism and Eley-Rideal Mechanism

Catalysts preparation bulk catalyst: precipitation, gelation and flocculation, hydrothermal transformation, drying, calcination, granule formulation, extrusions, Supported catalysts: precipitation and impregnation, Characterization techniques of catalyst e.g. BET, Pore volume & pore size, FTIR, XRD, TPD, TPR, SEM etc

UNIT 2 **(16 Hrs)**

Fixed bed catalytic reactor: Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multibed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models

Fluidized bed catalytic reactor: Introduction, fluidization, two phase model, Bubble property model, non bubbling beds, character and quality of fluidization, fluid bed reactor modeling; Davidson Harrison model, Kunii - Levenspiel model, anatomy of overall rate coefficient, Olsons's fluid bed reactor analysis.

UNIT 3 **(11 hrs)**

Multiphase reactors: Design models for multiphase flow reactors, Specific design aspects of absorption absorbers, trickle bed reactor, down flow and upflow bubble reactors, plate columns, stirred vessel reactors,

UNIT 4 **(11 hrs)**

Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate.

Text and Reference Books:

[1] Jens hagen, İndustrial catalyst: A practical approach, Wiley VCH, 2006.
[2] Chorkendroff I., Niemantsvedriet J.W., Concepts of modern catalysis and kinetics, Wiley VCH, 2003.
[3] Froment G.F., Bischoff K.B., Chemical reactor: Analysis and Design, John Wiley & sons, 1979.
[4] Perego C., Villa P., Catalysts preparation method, Chapter 4Catalysis today 34 (1997)281-305.
[5] Lee, H.D., Heterogeneous Reactor Design, Butterworth Publishers, 1985.
[6] NPTEL Chemical Engineering - Catalyst Science and Technology, module 1,2 & 3.
[7] Rawling J.B., Ekerdt J.G., Chemical Reactor Analysis and Dsign : Fundamentals, Nob Hill Publishing, 2002.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	3	2	3	1	2	3
CO2	3	1	2	2	1	2	2	2
CO3	3	1	2	2	1	2	2	2
CO4	3	3	1	2	2	2	2	2

CT-551 Advanced Computational Lab	0 L	0 T	3 P	2 Credit

Laboratory Objectives:

To solve problems involving in fluid flow operations, reaction engineering, thermodynamics, mechanical operations, heat and mass transfer operation using commercially available software.

Laboratory Outcomes:

1. To solve problem on linear algebraic equation and nonlinear algebraic equation using MATLAB.
2. To solve problem on ordinary differential equation and partial differential equation using MATLAB.

List of problems to be solved:

1. To understand various features, commands, functions, codes etc. used in MATLAB.
2. To solve single variable and multivariable linear algebraic equation, nonlinear algebraic equation using MATLAB.
3. To solve ordinary differential equation (initial value and boundary value problems) and simultaneous differential equation using MATLAB.
4. To solve partial differential equation using MATLAB.
5. To solve advance problems in chemical indusries involving fluid flow operations, reaction engineering, thermodynamics, mechanical operations, heat and mass transfer operation etc. using MATLAB.

CT-553 Advanced Reaction Engineering Lab	0 L	0 T	3 P	2 Credit

Laboratory Objective:
1. To provide through understanding of Reaction Engineering.
2. To design reactor and identity type of reactor by suiting chemical kinetics and using information from thermodynamics, heat and mass transfer economics.
3. Characteristics of a fluidized bed reactor.
4. Understanding of heterogeneous and homogeneous catalytic reactions

Laboratory Outcomes:
1. Students will able to know the solid-liquid, liquid -liquid reactions.
2. Students will be able to know RTD of different reactors
3. Students will be able to know the monolithic catalytic reactors applications.

List of experiments:
1. RTD Studies of Tank in series model
2. RTD Study of type of packing in trickle bed reactor
3. Study of plastic conversion to hydrogen in a packed bed catalytic reactor
4. Reactions on Monolithic Catalytic Reactors
5. High pressure reactions for biomass conversion to liquid fuels
6. Analyze the characteristics of a fluidized bed reactor
7. Studies on homogeneous catalytic reaction: Kinetics of a esterification of bio oil to bio-diesel in a batch reactor
8. Catalyst synthesis using different approaches e.g. EISA, Hydrothermal, sol gel etc

CT-502 Statistical Analysis and Research Methodology	3 L	1 T	0 P	4 Credit

Course Objective:
To develop an understanding of various experimental designs techniques and research methodologies.
Course outcomes:
At the end of the course, students should be able to:
1. List the different types of formal experimental design techniques.
2. Describe the six factors affecting significance, "p-values" and ANOVA.
3. Understand research problem formulation, literature review and research ethics.

Course content:

UNIT 1 **(15 Hrs)**

Introduction to Statistics: Statistical concept, Statistical Inference, Statistical Hypotheses, Statistical Estimation, Point Estimates, Interval Estimates, Quantitative Data Graphs.
Qualitative Data Graphs, Graphical Depiction of Two-Variable. Numerical Data: Scatter Plots
Graphical methods of model selection from experimental data. Two variable empirical equations. Liner, logarithmic and semi logarithmic plots. Modified linear, logarithmic and semilogarithmic plots. Reciprocal plots.

UNIT 2 **(15 Hrs)**

Equations for lumped data. Elongated "s" curves. Three variables empirical equations. Sterns methods. Multivariable empirical equations. Dimensionless numbers. Nomography: Introduction. Logarithmic charts. Equations of the form F1(x)+F2(y)=F3(z), F1(x)+F2(y)=F3(z), 1/ F1(x)+1/F2(y)=1/F3(z) and line coordinate charts.

UNIT 3 **(15 Hrs)**

Statistical Analysis: Tests for Fluctuations in process variables. Test for deviation of the variables from standard conditions. Selection of theoretical model to fit the data.
Descriptive Statistics: Measures of Central Tendency- mean, median and mode, Measures of Variability-Data range, variance and standard deviation, Measures of shape of distribution of data, Tests and estimates on statistical variance.

UNIT 4 **(6 Hrs)**

Design of experiments: Factorial design of experiments. Detection of significant variables in the absence of and in the presence experimental errors. 2k factorial design. Fractional factorial design. Box-Wilson method. Estimation of quantitative significance of the variables. Response surface analysis: Interpretation of results. Reduction of equations to canonic form. Steepest ascent along response surface.

UNIT 5 **(5 Hrs)**

Research Ethics: Research honesty and integrity, Authorship, Acknowledgement and citation, Funding agencies and sponsorship, Sources of data, sensitive materials and safety, Patents and copyright, Confidentiality and privacy, Human rights, Environmental laws, Fabrication of data and misrepresentation, Plagiarism.

Text and Reference Books:

[1] Mokhtar S. Bazara & C.M.Shetty; Non linear Programming, Theory & Algorithums; John Wiley & Sons.
2. Stephan G.N., Ariela Sofer; Linear & nonlinear programming, McGraw Hill.
[2] T.F. Edgar and D.M.Himmelblan " Optimization of Chemical Processes", McGraw Hill International Ed.
[3] G.S.Beveridge and R.S.Schekhter " Optimization theory and practice, McGraw Hill, New York.
[4] G.V. Rekhlaitis, A.Ravindran and K.M. Ragidell "Engineering Optimization Methods & applications, John Wiley, New York.
[5] Stuart Melville and Wayne Goddard, "Research Methodology: an introduction for science & engineering students"'.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	1	1	2	3
CO2	3	3	3	2	1	1	2	3
CO3	3	3	3	2	1	1	2	2

CT-504 Analytical Techniques	3 L	0 T	0 P	3 Credit

Course Objective:

1. To develop the skills to understand the theory and practice of analytical techniques
2. To provide scientific understanding of analytical techniques and detail interpretation of results.

Course Outcomes:

1. Student will understand the fundamentals of various useful analytical techniques.
2. Students will acquire the basic knowledge/strategies for evaluation/quantification of material properties using those techniques.

Course Content:

UNIT 1 **(15 Hrs)**

Spectroscopic techniques: Fundamentals of UV-Vis, Atomic Absorption Spectroscopy (AAS) and Fourier-transform Infrared Spectroscopy (FTIR); methods for quantification of various target compounds using these techniques.

UNIT 2 **(12 Hrs)**

Chromatographic techniques: Fundamentals of Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC); methods for identification of the target compound(s) and/or separation of the target compound from a mixture using chromatographic techniques. GC analysis of liquids and gases

UNIT 3 **(15 Hrs)**

Surface and particle characterization techniques: Fundamentals of and working principles of Goniometric methods for contact angle measurement and surface characterization; Dynamic Light Scattering (DLS) techniques for particle size and surface charge measurement, and Atomic Force Microscopy (AFM) for surface morphology. BET analysis for surface area and pore diameter, acidity of catalysts and TPR/TPD studies

Text and Reference Books:

[1] Handbook of Spectroscopy, edited by Gunter Gauglitz, Tuan Vo-D, John Wiley, 2003.
[2] Analytical Techniques, edited by T.P. Mommsen, Peter W. Hochachka, Elsavier, 1994
[3] Chromatography: Fundamentals and applications of chromatography and related different migration methods, edited by E. Heftmann, Elsavier, 1994.
[4] Chemical Reaction and Reactor Design edited by J J Carberry & A. Verma; Marcel Dekker Inc, New York and Base.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	1	1	2	3
CO2	3	3	3	3	1	1	2	3

HVE-102 Human Values and Ethics*	2 L	0 T	0 P	2 Credit

Course Objective:

1. To develop a universal approach towards human values.
2. To be able to strike a balance between aspirations and happiness.
3. To understand that humans are a part of nature and how being close to nature bring in joy and satisfaction
4. Select classical short stories from Indian context will expose the students.
5. to diverse and multifaceted subsections in Indian society.

Course Outcomes:

1. The students will get sensitized about the role of value education and learn to balance ambition & happiness.
2. The students will be able to understand the importance of living in harmony with nature.
3. The students will be able to see the relevance of Professional behavior and ethics
4. They will draw inspiration from the classical Indian literature narrated to them in the form of select short stories.

Course Contents

UNIT 1 **(7 Hrs)**

The Problem and Paradox of Happiness: Twin goals: happiness and just order; role of value education. Concept of good life-quality of life and subjective well-being; happiness, life satisfaction and positive affect; studying quality of life through surveys; and findings of quality-of-life surveys. Moral and Institutional approaches; and the inherent conflict between the two. Man, and Society.

UNIT 2 **(7 Hrs)**

Happiness and Nature: Biophilia hypothesis- connections with nature and co-existence with other forms of life, Deep Ecology, Importance of meaningful contact with the natural world, solutions for a healthier, greener tomorrow, Indigenous and traditional knowledge system and its intellectual roots.

UNIT 3 **(7 Hrs)**

Basics of Professional Ethics, Ethical Human Conduct: Human Conduct- based on acceptance of basics Human Values, Humanistic Constitution and Universal Human Order-skills, sincerity and fidelity. To identify the scope and characteristics of people-friendly and eco-friendly production systems..

UNIT 4 **(7 Hrs)**

Encompassing Different Stories/ narratives on Human Values from Indian Context.

Text and Reference Books:

[1] Gaur, R.R., Sangal, S.and Bagaria, G., "A Foundation Course in Human Values and Professional Ethics", New Delhi: Excel Books, 2010.

[2] Mike, W. Martin, "Paradoxes of Happiness", Journal of Happiness Studies, 2008, pp. 171-184.

[3] Giddens, Anthony, "Sociology", 5th edition, Cambridge: Polity Press, 2006.

[4] Ambedkar, B.R., Buddha and his dhamma, http://www.scrubd.com/doc/16634512/Buddha-and-His-Dhamma-by-B-R-Ambedkar-Full [accessed on 21 October, 2010]

[5] Beteille Andre, "Antinomies of Society: Essays on Ideologies & Institutions", New Delhi: Oxford University Press, 2000.

[6] Fikret Berkes, "Sacred Ecology", Second Edition Routledge Taylor & Francis Group, 2008.

[7] Richard Louv, "Last Child in the Woods", Algonquin Books, 2008.

[8] Ramakrishnan, E.V., "Indian Short Stories": (18700-200). Sahitya Akademi, 2012.

[9] Davidar, David., "Cluch of Indian Masterpieces", Aleph Book Company, 2016.

[10] "Contemporary Indian Short Stories", Sahitya Akademi, 2014.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	1	1	2	3	3	3	3	3
CO2	1	1	2	3	3	3	3	3
CO3	1	1	2	3	3	3	3	3
CO4	1	1	2	3	3	3	3	3

CT-510 Membrane Science & Technology	3 L	0 T	0 P	3 Credit

Course Objective:
1. To provide a general overview of synthesis of polymeric membrane, mixed matrix membrane, thin film composite membrane and adsorptive membrane with their characterization.
2. To enable students to understand various membrane modules and process design aspects

Course Outcomes:
At the end of the course, the student should be able to:
1. Understand various techniques for synthesis of polymeric membrane, mixed matrix membrane and composite membrane.
2. Know about all kinds of characterization techniques, for both porous and non-porous membrane, and the effects of various parameters on membrane morphology.
3. Understand various membrane modules and their applications.

Course Content:

UNIT 1 **(12 Hrs)**
Basic concept of membrane separation processes: Pressure-driven membrane process, Concentration-driven membrane process, Electric-driven membrane process, Ion exchange membrane and its application. Membrane module and applications: Plate-and-frame module, tubular module, hollow fibre module etc. Comparison of module configuration. Dead-end filtration cell and cross-flow filtration cell.

UNIT 2 **(10 Hrs)**
Synthesis of polymeric membrane: Porous and non-porous membrane; Selection of polymer and solvent; Phase inversion membranes; Thermodynamic aspects; Mechanism of membrane formation; Effects of various parameters on membrane morphology

UNIT 3 **(10 Hrs)**
Characterization of membrane: Permeability, Molecular weight cut-off, Porosity and pore size, Surface hydrophilicity, Surface charge, and Solute rejection etc.

UNIT 4 **(10 Hrs)**
Fabrication and characterization of mixed matrix nanocomposite membrane and thin film nanocomposite membrane; Basic principles of adsorptive membrane. pH-responsive and thermo-responsive membrane.

Text and Reference Books:
[1] Marcel Mulder, Basic Principle of Membrane Technology, second Edition, Kluwer Academic Publishers, 1996.
[2] Leos J. Zeman and Andrew L. Zydney, Microfiltration and Ultrafiltration; Principles and Applications, Marcel Dekker, 2016.
[3] Munir Cheryan, Ultrafiltration and Microfiltration Handbook, CRC Press, 2016.
[4] Peter M. Bungay, Harold K. Lonsdale, Maria Norbertade Pinho, Synthetic Membranes: Science, Engineering and Applications, D. Reidal Publishing Company, Holland, 1986.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	3	1	-	1	2	2
CO2	3	1	3	1	-	1	2	2
CO3	3	1	3	1	-	1	2	2
CO4	3	1	3	1	-	1	2	2

CT-512 Process Design for Wastewater Treatment	3 L	0 T	0 P	3 Credit

Course Objective:
Basic concepts and design of Physico-Chemical and biological Process for wastewater treatment.
Course Outcomes:
1. Students will learn
2. About the availability and distribution of water,
3. Different methods of treating water to make it potable, and Mathematical models for some of the processes.

Course Content:

UNIT 1 **(10 Hrs)**

Water Quality-Physical, chemical and biological parameters of water- Water Quality requirement - Potable water standards -Wastewater Effluent standards -Water quality indices. Fundamentals of Process Kinetics, Bio reactors classification – Design principles.

UNIT 2 **(10 Hrs)**

Physico chemical process: Theory and design of Clarification, Sedimentation, Coagulation, flocculation, Filtration, flotation, and neutralization.

UNIT 3 **(12 Hrs)**

Evaluation of kinetic Parameters- Activated Sludge biological process, New biological process- passive immobilization in packed and fluidized bed, biological nitrification, and denitrification.

Attached Growth Biological Treatment Systems Trickling Filters- Rotating Biological Contactors- Activated Biofilters etc.

Waste stabilization Ponds and Lagoons: Aerobic and anaerobic pond, facultative pond, and aerated Lagoons.

Anaerobic filters-Expanded fluidized bed reactors-Upflow anaerobic sludge blanket reactors, - Expanded granular bed reactors- Two stage/phase anaerobic reactors. Complete waste treatment case studies for typical wastes- poultry industry waste, food industry, fermentation industry waste (alcohol, beer, and wine) cheese and dairy industry waste.

UNIT 4 **(10 Hrs)**

Filters: Bag filters, drum and disc filters, Disinfecting- Chlorine treatment, Ultraviolet light treatment, Ozone treatment, advanced oxidation process, electrohemical process.

Text and Reference Books:

[1] Weber, W.J. Physicochemical processes for water quality control, John Wiley and sons, Newyork, 1983.
[2] Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.
[3] Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.
[4] Benefield, L.D. and Randall C.W. Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs, 1982.
[5] Grady Jr. C.P.L and Lin H.C. Biological wastewater treatment: Theory and Applications, Marcel Dekker, Inc New York, 1980.
[6] Metcalf & Eddy, Inc. Wastewater Engineering, Treatment and Reuse. 3rd Edition, Tata McGraw-Hill, New Delhi, 2003.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2

CT-514 Design & Analysis of Biological Reactors	3 L	0 T	0 P	3 Credit

Course Objective:

The main objective of the module is to perform advanced analysis and design of different types of reactors. The fundamental concepts of chemical engineering will be applied to the different biological and catalytic reactors with particular emphasis on reactors with immobilized biological catalysts. The module proposes to integrate kinetics, thermodynamics, transport phenomena and numerical methods to solve the models corresponding to the reactors. Likewise, simulation studies will be conducted to understand the sensitivity of the design parameters and to understand the operation of chemical and biochemical reactors.

Course Outcomes:

1. Apply engineering concepts to the design and operation of non-ideal, catalytic heterogeneous reactors.
2. Apply specific methodologies, techniques, and resources to conduct research and produce innovative.
3. Solve problems in new or situations (multidisciplinary) contexts related to the field of study.
4. Use IT tools to acquire further knowledge in the field of biological and environmental engineering.
5. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
6. Work in a multidisciplinary team

Course Content:

UNIT 1 **(10 Hrs)**

Ideal Bioreactors: Fed-Batch Reactor, Enzyme-catalyzed reactions in CSTRs, CSTR reactors with recycle and wall growth, The ideal plug-flow and tubular reactor.

Reactor Dynamics: Dynamics model, Stability

UNIT 2 **(12 Hrs)**

Reactors with non-ideal mixing: Mixing time in agitated tanks, Resident time distributions, Models for no-ideal reactors, Mixing-Bio reaction interactions, reactors in series.

Sterilization Reactors: Batch Sterilization, Continuous Sterilization, Axial flow with dispersion (continuous sterilization)

Immobilized Bio Catalysis: Formulation and characterization of immobilized cell bio catalysts, Application of immobilized cell biocatalysts

UNIT 3 **(10 Hrs)**

Multiphase Bio reactors: Conversion of heterogeneous substrates, Packed bed reactors, Bubble column Bio-reactors, Fluidised bed Bio-reactors, Trickle bed reactors

Fermentation Technology: Medium formulation, Design and operation of a typical aseptic, aerobic fermentation process, Alternate bioreactor configurations, air-lift bioreactor, bubble column bio reactor.

UNIT 4 **(10 Hrs)**

Plant and Animal Cell culture Technology: Reactor types and controls, hollow fiber reactor, perfusion reactor medium requirements for animal cell cultivation, Reactor for large-scale production using animal cells.

Case study on a plant and animal cell products - alkaloids, steroids, proteins, erythropoietin factor-VIII protein etc.

Text and Reference Books:

[1] Biochemical Engineering Fundamentals by James E. Bailey & David F.Ollis, Publishers: McGrew-Hill.
[2] Bioprocess Engineering by Shuler & Kargi, Prentice Hall
[3] Encyclopedia of Chemical Engineering by Kirk & Othmer.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	1	1	2	2	2
CO2	3	3	3	1	1	2	2	2
CO3	3	3	3	1	1	2	2	2
CO4	3	3	3	1	1	2	2	2
CO5	3	3	3	1	1	2	2	2
CO6	3	3	3	1	1	2	2	2

CT-516 Fuels and Combustion Technology	3 L	0 T	0 P	3 Credit

Course Objective:
1. Knowledge about types of fuel, in-depth evaluation of combustion principles.
2. To study various modern technologies, industrial furnaces

Course Outcomes:
1. Understanding of types of fuel and their characteristics
2. In-depth evaluation of combustion principles and processes
3. Understanding of combustion equipment's and furnaces used industrially and the importance of energy conservation.

Course Content:

UNIT 1 **(10 Hrs)**

Introduction to fuels (solid, liquid and gaseous fuels) -types and characteristics of fuels, determination of various properties of fuels

Solid fuels, proximate and ultimate analysis, moisture determination, calorific value, gross & net calorific values.

UNIT 2 **(10 Hrs)**

Liquid and gaseous fuels, constituents, characteristics, properties, processing

UNIT 3 **(10 Hrs)**

Combustion principles, stoichiometry, theoretical & actual combustion processes combustion thermodynamics, combustion processes, flame propagation, solid, liquid & gaseous fuels combustion, flame temperature -theoretical, adiabatic & actual, limits of inflammability.

UNIT 4 **(12 Hrs)**

Combustion equipment's and furnaces, waste heat recovery in furnaces, heat transfer in furnaces. Burners for solid. Liquid and gaseous fuels. Factors affecting burners & combustion, Fuel economy/ energy conservation in industrial plants

Text and Reference Books:

[1] Samir Sarkar, Fuels and Combustion, CRC Press; 3rd edition, 2010.
[2] O.P.Gupta, Elements of Fuel and Combustion Technology, Khanna publishers, 2018.
[3] S.P Sharma, Chander Mohan, Fuels & Combustion, Tata Mcgraw Hill, 1984.
[4] M. Lackner, A. Palotas, F. Winter, Combustion: From Basics to Applications, Wiley, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2

CT-518 Process Plant Utilities	3 L	0 T	0 P	3 Credit

Course Objective:
This course consists of lectures, question and answer sessions designed to educate the student in the process plant utilities in chemical Enginerring.

Course Outcomes: The students will be able to:
1. Exhibit the ability to understand the application of various process plant utilities.
2. Understand the Importance of steam economy and refrigeration systems.
3. Understand the importance of insulation for the process equipment

Course Content:

UNIT 1 **(10 Hrs)**
Various process utilities, their role and importance in chemical plants.
Water sources: sources of water, their characteristics, storage and distribution of water, water for boiler use, cooling purposes, drinking and process water treatment reuse and conservation of water, water resources management.

UNIT 2 **(11 Hrs)**
Steam: Steam generation and its application in chemical process plants, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps, their characteristics, selection and application, waste heat utilization.
Compressors and Vacuum Pumps: Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum development and their limitations, materials handling under vacuum, piping systems, lubrication and oil removal in compressors in pumps.

UNIT 3 **(10 Hrs)**
Refrigeration Systems: Refrigeration system and their characteristics, load calculation and load calculation and humidification and de humidification equipment's, drying and cooling tower, air blending, exhaust, ventilation, cryogenics, their characteristics and production of liquid N_2 and O_2

UNIT 4 **(11 Hrs)**
Insulation: Importance of insulation for the process equipment, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and sub zero temperatures including cryogenic insulation, determination of optimum insulation thickness.
Inert Gases: Introduction, properties of inert gases & their use, sources and methods of generation, comparison of nitro generation routes, general arrangement for inerting system, operational, maintenance and safety aspects.

Text and Reference Books:
[1] Jack Broughton; Process utility systems; Institution of Chem. Engineers U.K.
[2] Reid, Prausnitz poling; The properties of gases & liquids, IV ed. McGraw Hill international ed.
[3] S.C.Arora & S. Domkumdwar; A course in refrigeration and air conditioning; Dhanpat Rai & Co.(P) ltd.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2

CT-520 Biomass for Energy and Chemicals	3 L	0 T	0 P	3 Credit

Course Objective:
Study of utilization of biomass to meet energy demand in various sectors.

Course Outcomes:
1. Ability to have a good understanding on fundamentals for the conversion of biomass resources for harnessing and generating bioenergy.
2. Ability to understand various analytical techniques to characterize biomass and products from biomass.
3. Ability to understand the biochemical conversion technologies of biomass into various bio-products.
4. Ability to understand the applications of biomass conversions into biogas, alcohols and other products.

Course Content:

UNIT 1 **(10 Hrs)**
Introduction to biomass, Sources of biomass and Biomass and other solid wastes.
Biochemical conversion of biomass into biogas, alcohols and other products

UNIT 2 **(10 Hrs)**
Biomass wastes Compositions, Characteristics, Properties, Structural Components, Production of Biomass and Biomass wastes, Photosynthesis.

UNIT 3 **(10 Hrs)**
Biomass characterization. Solid, liquid and gaseous products from biomass.

UNIT 4 **(12 Hrs)**
Overview of conversion technologies - Pre-processing techniques and separation of components for feed stocks preparation, thermo chemical conversion of biomass. Combustion, pyrolysis and gasification of biomass. Design of gasifier for biomass conversion, Electricity generation and charcoal production from biomass. Useful chemicals and energy from rice husk.

Text and Reference Books:

[1] S.Samir, R.Zaborsky, Biomass Conversion Processes for Energy and Fuels, New York, Plenum Press, 1981.
[2] Nicholas P. Cheremisinoff, Paul N. Cheremisinoff, Fred Ellerbusch, Biomass Application, Technology and Production, Marcel Dekker, inc. NY.
[3] A.V. Bridgwater and D.G.B. Boocock, Developments in Thermochemical Biomass Conversion, , Editors, Vol I & II , Blackie Academic and Professional Publisher, London, ed.1997.
[4] Samir Kumar Khana, Bioenergy and Biofuel from Biowastes and Biomass, ASCE publications, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	3	2	2	3	2	3
CO2	3	2	3	3	3	2	2	3
CO3	3	3	2	2	3	3	3	3
CO4	3	1	2	3	3	3	2	3

CT-522 Chemical Process Quantitative Risk Analysis	3 L	0 T	0 P	3 Credit

Course Objective:
1. To understand various techniques for identifying hazards leading to fire, explosion or toxic release
2. To determine the consequences of an accident including the rate of material release and the physical state of the material.
3. To determine the failure probabilities of components which contribute to the failure of a process using event and fault trees.
4. To explain the importance of pressure protection and relief design procedure,

Course Outcomes:
The students will be able to
1. Identify the potential hazards involved in the chemical process industries.
2. Perform consequence analysis of chemical process industries.
3. Determine the potential damage.
4. Determine failure frequencies of the entire system.
5. Estimate Individual risk and societal risk

Course Content:

UNIT 1 **(12 Hrs)**
Techniques of CPQRA: Scope of CPQRA Studies, Application of CPQRA and Limitations of CPQRA
Consequence Analysis: Source Models, Explosion & Fires, Effect Models

UNIT 2 **(10 Hrs)**
Dispersion Models: Dispersion and the parameters required to describe dispersion, the neutrally buoyant plume and puff models
Relief Systems Relief design code requirements, Relief types and their characteristics, Relief installation practices,
Chemical Reactivity: Reactive Chemical Hazards, Reactive Chemicals Testing and estimating kinetic parameters

UNIT 3 **(10 Hrs)**
Event Probability and Failure Frequency Analysis: - Incident Frequencies from Historical Record and Frequency Modeling Techniques including event tree and fault tree.

UNIT 4 **(10 Hrs)**
Measurement, Calculation & Presentation of Risk Estimates: - Risk Measures, Risk Presentation, Risk Calculations, Risk Uncertainty, Sensitivity & Importance.

Text and Reference Books:
[1] Daniel A Crowl, Joseph F. Lovvar, Chemical Process Safety Fundamentals with Applicat.: Prentice Hall
[2] Loss Prevention in Process Industries, Lees, F.P.
[3] Guidelines for Chemical Process Quantitative Risk Analysis, CCPS of AIChE
[4] Risk Analysis for Process Plant, Pipelines & Transport; J.R. Taylor.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2
CO4	3	3	3	2	2	1	2	3
CO5	3	3	3	2	2	1	2	2

CT-524 Application of Nanotechnology in Chemical Engineering	3 L	0 T	0 P	3 Credit

Course Objective:

1. To understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.
2. To gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials and characterization methods in nanotechnology
3. To give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

Course Outcomes:

1. Understanding the different top down and bottom-up approaches for nanoparticles
2. Get to know the different applications of nanoparticles in chemical engineering field.
3. Learning the characterization techniques for nanoparticles.

Course Content:

UNIT 1 **(14 Hrs)**

Introduction: Introduction to nanotechnology, Feynman's Vision-There's Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

Semiconductors and Quantum dots: Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

UNIT 2 **(10 Hrs)**

Approaches to Synthesis of Nanoscale Materials and characterization: Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nano-emulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modelling methods. Size, shape, crystallinity, topology, chemistry analysis using X-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA.

UNIT 3 **(10 Hrs)**

Polymer-based and Polymer-filled Nanocomposites: Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

UNIT 4 **(8 Hrs)**

Applications to Safety, Environment and Others: Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self-cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Societal, Health and Environmental Impacts.

Text and Reference Books:

[1] Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., “Introduction to Nanoscience”, (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805

[2] Ajayan P. M., Schadler L. S., Braun P. V., “Nanocomposite Science and Technology”, Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.

[3] Kelsall Robert W., Hamley Ian W., Geoghegan Mark, “Nanoscale Science and Technology”, John Wiley & Sons, Ltd, 2006.

[4] Kal Ranganathan Sharma, “Nanostructuring Operations in Nanoscale Science and Engineering”, McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.

[5] “Organic and inorganic nanostructures”.-(Artech House MEMS series), Nabok, Alexei, ISBN 1-58053-818-5, 2005.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	3	3	2	3
CO2	3	3	3	2	3	3	2	3
CO3	3	3	3	2	3	3	2	3

CT-526 Renewable Energy Technologies	3 L	0 T	0 P	3 Credit

Course Objective:
The course will introduce students with nonconventional energy resources and their uses.

Course Outcomes:
1. Students will be able to understand the nonconventional energy resources.
2. Applications in various fields.

Course Content:

UNIT 1 **(12 Hrs)**
Introduction: Indian and global energy crisis, alternative energy sources management, renewable energy sources, remedial measures to energy crisis.
Wind Energy: Basic principles, wind energy conversion, site selection, basic components of wind energy conversion systems (WECS), classification of WECS, wind energy collectors, applications of wind energy.

UNIT 2 **(10 Hrs)**
Geothermal Energy: Introduction, applications of geothermal energy, Geothermal resource types, Classification and types of geothermal power plants.
Hydro Energy: Hydrology & Hydro - Electric Power Plants- Hydrographs - Flow duration curve - Mass curve & storage. Site selection for hydroelectric power plants. Operation Of Hydro-Electric Power Plants-Components -Advantages & Disadvantage of underground power station.

UNIT 3 **(10 Hrs)**
Energy From Oceans: Energy from Tides, Methods of utilization of tidal energy, storage, components of tidal power plants, ocean waves, wave energy conversion devices.

UNIT 4 **(10 Hrs)**
Nuclear Energy: Fission, fuel for nuclear fission reactor, Nuclear Fuel Cycle, different types of reactor Current Generation power reactors- Pressurized water reactors - Boiling water reactors - Gas-cooled reactors, reactor control, nuclear reactor power plants, nuclear waste management

Text and Reference Books:
[1] Mathew S., Wind Energy-Fundamentals, Resource Analysis and Economics, SpringerVerlag Berlin Heidelberg 2006.
[2] S.Rao&Dr.B.B. Parulekar, “Energy Technology”, Third Edition, Khanna Publishers.
[3] Heinloth K., Energy Technologies: Renewable Energy, Springer-Verlag Berlin Heidelberg 2006.
[4] Gasification, C. Higman, M. Burgt, Gulf Professional Publishing, 2003, Elsevier Science (USA).
[5] Begamudre R. D. Energy Conversion Systems, New Age International Ltd. 2000.
[6] Twidell J. & Weir T. Renewable Energy Resources, 2nd Ed, Taylor & Francis, 2000.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	3	3	2	3
CO2	3	3	3	2	3	3	2	3

CT-552 Minor Project	0 L	0 T	8 P	4 Credit

The student is required to study and present a comprehensive report on a process/a lab equipment/an analytical instrument/ Application of software in chemical engineering.

CT-601* Stress Management by Yoga	1 L	0 T	2 P	2 Credit

Course Objective:
1. To achieve overall health of body and mind
2. To overcome stress

Course Outcomes:
Students will be able to:
1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Course Content:

UNIT 1 **(9 Hrs)**
Definitions of Eight parts of yog. (Ashtanga)

UNIT 2 **(10 Hrs)**
I. Yam and Niyam.
II. Do`s and Don't's in life
III. Ahinsa, satya, astheya, bramhacharya and aparigraha
IV. Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT 3 **(9 Hrs)**
Asan and Pranayama
I. Various yog poses and their benefits for mind & body
II. Regularization of breathing techniques and its effects
III. Types of pranayama

Text and Reference Books:

[1] Janardan Swami Yogabhyasi Mandal, Yogic Asanas for Group Tarining-Part-I Nagpur.
[2] Swami Vivekananda, Advaita Ashrama Rajayoga or conquering the Internal Nature (Publication Department), Kolkata.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3

CT-603 Membrane Technology for Water and Wastewater Treatment	3 L	0 T	0 P	3 Credit

Course Objective:
1. To provide a general overview of membrane processes, membrane modules, transport modelling, and process engineering fundamentals.
2. To enable students to understand the application of membrane processes for treatment of water and wastewater.

Course Outcomes:

At the end of the course, the student should be able to:
1. Understand the various membrane processes, principles, separation mechanisms, selection criteria and their industrial applications.
2. Understand the various transport models, different types membrane fouling and their control, and the effects of process parameters on system performance.
3. Understand the basic principles and applications of micellar enhanced ultrafiltration.
4. Understand the application of membrane to various industrial effluents such textile, paper and pulp, and electroplating.

Course Content:

UNIT 1 **(10 Hrs)**

Membrane processes: Microfiltration, Ultrafiltration, Nanofiltration and Reverse osmosis; Membrane configuration; Criterion of selection of suitable membrane; Membrane fouling, Factors affecting membrane fouling; Flux enhancement techniques; Membrane cleaning and compaction; Concept of integrated membrane process; Process design and energy requirement

UNIT 2 **(15 Hrs)**

Solute and solvent transport modeling: Pore blocking model, Concentration polarization model, Resistance- in-series model, Gel layer model, Osmotic pressure model, Combined fouling model etc. Estimation of various fouling resistances.

UNIT 3 **(7 Hrs)**

Micellar enhanced ultrafiltration (MEUF): Basic principles, Micellization and critical micelle concentration, Evaluation of MEUF process. Effects of various parameters on permeate flux and rejection.

UNIT 4 **(10 Hrs)**

Applications: Water treatment, Treatment of textile effluent, pulp and paper effluent, electroplating effluent etc.

Text and Reference Books:

[1] Leos J. Zeman and Andrew L. Zydney, Microfiltration and Ultrafiltration; Principles and Applications, Marcel Dekker, 2016.
[2] Munir Cheryan, Ultrafiltration and Microfiltration Handbook, CRC Press, 2016.
[3] Marcel Mulder, Basic Principle of Membrane Technology, second Edition, Kluwer Academic Publishers, 1996.
[4] R. Rautenbach and R. Albrecht, Membrane Processes, John Wiley & Sons Ltd. 1994.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	-	-	1	1	2
CO2	3	3	3	-	-	1	1	2
CO3	3	3	3	-	-	1	1	2
CO4	3	2	3	-	-	1	1	2

CT-605 Advanced Petroleum Refining	3 L	0 T	0 P	3 Credit

Course Objective:

1. Knowledge about chemical composition, in-depth characterization and evaluation of crude oil.
2. To study various modern technologies, processes of refinery processes to obtain

Course Outcomes:

1. Understanding of petroleum characterization
2. Understanding of modern manufacturing practices in refinery
3. Understanding Supporting processes for finished products

Course Content:

UNIT 1 **(10 Hrs)**

Composition and properties of crude oil.
Distillation methods: atmospheric distillation, vacuum distillation.

UNIT 2 **(12 Hrs)**

Thermal cracking processes, thermal, visbreaking and different type of coking.
Catalytic cracking processes, catalytic hydrocracking, different type of catalysts used.

UNIT 3 **(10 Hrs)**

Reforming-type of catalysts,
Alkylation, polymerization and isomerization

UNIT 4 **(10 Hrs)**

Supporting processes: solvent extraction processes for deasphalting of gasoline, kerosene and diesel oil.
Wax separation and preparation as a finished product.

Text and Reference Books:

[1] Petroleum Refining Technology, by Dr. Ram Prasad, Khanna publisher,(2018 reprint)
[2] Petroleum Refining Technology, by I.D Mall, CBS publisher(2017 reprint)
[3] Petroleum refining technology and economics, fourth edition, J.H.Gary, G.E..handiwerk, Marcel and Dekker INC., New york,.6th edition 2019.
[4] The chemistry and technology of petroleum, second edition, revised and expanded. By James G. Speight, Marcel Dekker, New York, 1991.
[5] Modern petroleum refining processes, B.k. Bhaskarrao oxford and ibm pub. Co. Pvt ltd, New delhi, 1990.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	1	1	2	3
CO2	3	3	3	2	1	1	2	3
CO3	3	3	3	2	1	1	2	2

CT-607 Air Quality Management	3 L	0 T	0 P	3 Credit

Course Objective:
To teach students basic air pollutants, standards of air quality, and control technology.

Course Outcomes:
1.Students will be able to understand air pollution sources
2.Design system for control of air pollution.

Course Content:

UNIT 1 **(12 Hrs)**
Air pollutants - Sources and classification of pollutants and their effect on human health vegetation and property- Effects - Reactions of pollutants and their effects-Smoke, smog and ozone layer disturbance - Greenhouse effect - Ambient and stack sampling.

UNIT 2 **(10 Hrs)**
Atmospheric diffusion of pollutants - Transport, transformation and deposition of air contaminants - Air sampling & pollution measurement methods - Ambient air quality and emission standards - Air pollution indices - Air Act.

UNIT 3 **(10 Hrs)**
Principle methods for controlling mixture of pollutants (wall collecting devices)
Gravity settlers, baffle chambers, cyclone separators, electrostatic precipitators

UNIT 4 **(10 Hrs)**
Principle methods for controlling mixture of pollutants (dividing collection devices)
Adsorption, absorption, wet collectors, fabric filters, precipitation. Biological air pollution control technologies - bioscrubers, biofilters, and Indoor air quality.

Text and Reference Books:

[1] Wark Kenneth and Warner C.F, Air pollution its origin and control. Harper and Row Publishers, New York, 1981.
[2] Rao C.S., Environmental pollution control Engineering, New age international Ltd, New Delhi, 1995.
[3] Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3

CT-651 Dissertation Part -I	**0 L**	**0 T**	**24 P**	**12 Credit**

The student is required to work on a research topic related to Chemical Engineering. Candidate would prepare a detailed report and present the work before the Internal/external expert committee.

CT-652 Dissertation Part -II	0 L	0 T	30 P	15 Credit

The student is required to work on a research topic related to Chemical Engineering. Candidate would prepare a detailed report and present (at least twice in a semester) the work before the Internal/external expert committee.