DEPARTMENT OF CHEMICAL ENGINEERING

SCHOOL OF STUDIES OF ENGINEERING AND TECHNOLOGY

GURU GHASIDAS VISHWAVIDYALAYA, (A CENTRAL UNIVERSITY) BILASPUR (C.G.)

SCHEME

Pre-PhD Course Work

W.E.F. SESSION (2018-19)

S.N.	SUBJECT CODE	SUBJECT NAME	PERIODS /WEEK			ESE DURATION	ESE MARKS		CREDIT
			L	T	P		MAX	MIN	
1.	CHEPHDT01	Research Methodology in Engineering	3	1	0	3Hrs	100	40	4
2.		Elective-I	3	1	0	3Hrs	100	40	4
3.		Elective-II	3	1	0	3Hrs	100	40	4

S.N.	SUBJECT CODE	SUBJECT NAME	S.N.	SUBJECT CODE	SUBJECT NAME
1.	CHEPHDT 02	Advanced Heat Transfer	8.	CHEPHDT 09	Design and Development of Catalysts
2.	CHEPHDT 03	Chemical Reactor Design	9.	CHEPHDT 10	Advance Wastewater Treatment
3.	CHEPHDT 04	Fluidization Engineering	10.	CHEPHDT 11	Advanced Process Control
4.	CHEPHDT 05	Process Optimization			
5.	CHEPHDT 06	Chemical Process			
6.	CHEPHDT 07	Advanced Mass Transfer			
7.	CHEPHDT 08	Industrial Pollution Control Technologies			

ESE: End Semester Examination, **L**: Lecture, **T**: Theory, **P**: Practical
Max: Maximum Marks in ESE
Min: Minimum Pass Marks in each subject as 40%

- Duration of the semester will be 6 months.
- Candidate has to score minimum 55% of aggregate marks to qualify in ESE.
- Two subjects as Electives (4 credits each) can be taken from the list of Electives

DEPARTMENT OF CHEMICAL ENGINEERING
School of Studies, Engineering and Technology
GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (C.G.) 495009
(A Central University Established by Central University Ordinance 2009, No 3 of 2009)

Pre Ph.D. COURSE WORK (Effective from session 2018-19)

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT01	RESEARCH METHODOLOGY IN ENGINEERING	3:0:0	4

Course Objectives:

- To Understanding Research Principles
- To Research design
- To Data collection methods and data analysis ethical considerations
- To Literature Review, critical thinking, problem solving and practical application

Introduction and Design of Research

Meaning, objective, significance of research, types and parameters of research, research process, identification and definition of the research problem, definition of constants and variables, pure and applied research design, exploratory and descriptive design methodology, qualitative v/s quantitative research methodologies, field studies, field experiments v/s laboratory experiments, research design in social and physical sciences.

Data and Methods of Data Collection

Survey, assessment and analysis, data collection, primary and secondary sources of data collection, collection of primary data through questionnaire and schedules, collection of secondary data, processing and analysis of data, sample survey, simple random sampling, stratified random sampling, systematic sampling, cluster sampling, area sampling and multi stage sampling, pilot survey, scaling techniques validity and reliability.

Data Analysis

Procedure for testing of hypothesis, null hypothesis, determining level of significance, type-I and type-2 errors, grouped data distribution, measures of central tendency, measures of spread/dispersion, normal distribution, analysis of variance, one, two way, chi square test and its applications, students 'T' distribution, non-parametric statistical techniques, binomial test, correlation and regression analysis-discriminate analysis-factor analysis, cluster analysis, measures of relationship.

Simulation

Meaning of simulation, need of simulation; appropriateness of simulation, its advantages and disadvantages, its application in Engineering, methods of simulation.

Research Report Preparation and Presentation

Review of literature: historical survey and its necessity, layout of research plan, meaning, techniques and precautions of interpretation, types of report, mechanics of writing a research report, writing bibliography and references.

Texts/References:

- Kothari C.K., Research Methodology-Methods and Techniques, New Age International
- Panneerselvem, R., Research Methodology, Prentice Hall of India New Delhi, 2004

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Comprehend the ethical basis of the research and intellectual honesty.
- Analyze the different types of errors related to measurement techniques.
- Illustrate the data processing techniques.
- Demonstrate the writing skills and scientific presentations.
- Comprehend the ethics for research publication

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1		1	1		3	1	2		3	3	2	3
CO2	3	1	1		3	1		3	1	2		3	3	2	3
CO3	3	1	2		3	1		3	1	2		3	3	2	3
CO4	3	1	2		3	1		3	1	2		3	3	2	3
CO5	3	1	1		1	1		3	1	2		3	3	2	3

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 02	ADVANCED HEAT TRANSFER	3:0:0	4

Course Objectives:

- The course will deepen to understand of conduction, convection, radiation, phase change and dimensionless numbers.
- The course is design to learn the techniques for heat transfer enhancement and usage of numerical methods
- To understand for solving heat transfer problems such as heat exchangers and evaporators

General equation of heat conduction, Transient heat Conduction numerical and analytical methods for the solution of transient heat conduction problems, Critical radius and optimum thickness of insulation. Free convective heat transfer under different situation and application of dimensional analysis to estimate the convective heat transfer coefficients. Heat transfer factor Reynolds No. Plot, Analogy equation for heat momentum transfer. Boiling heat transfer with particular reference to Nucleate and film boiling and estimation of boiling heat transfer coefficient. Heat transfer from condensing vapors. Nusselt equation for film type condensation of vapors over vertical surfaces and inclined tubes. View factors and emissivity factors for different situation. Radiation shield and radiation error in pyrometry. Combined conduction, convection and radiation heat transfer.

Texts Books

- Hallman J. P., Heat Transfer Operation, McGRAW-Hill
- A Text Book on Heat Transfer, Universities Press; Fourth edition

Reference Books

- R.C.Sachdeva, Fundamentals of Engineering Heat & Mass Transfer.
- Bird, R. B., Steward, W.E. and Lightfoot E N., Transport Phenomena, Second edition, John Wiley and sons,
- Deen W. M. Analysis of Transport phenomena, Oxford University Press, 1998.
- Slattery J. C., Momentum Heat and Mass Transfer, Krieger Publishing, 1981

Course Outcomes: After learning the course, the students will be able to:

- To design and analyze the performance of heat exchangers and evaporators
- To Analyze the various analytical and numerical heat transfer problem.
- Understand the basic concepts of phase change and their coefficient, impact on heat transfer.

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3								3		
CO2	3	1	2	3	3								3		
CO3	3	3	3	3	3								3		
CO4	3	1	1	2	3								3		

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

Chandrakar 24/04/19 — 24/04/19 — 24/04/19. — Saha 24/4/19 — Amrijan 24/4/19

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 03	CHEMICAL REACTOR DESIGN	3:0:0	4

Course Objectives:

- This course introduces students to the application of kinetics and reaction engineering in chemical engineering processes.
- Understand the concepts such as standard states, chemical reaction rates, reaction mechanism mass balances and design equations for ideal reactors as well as non-ideal reactors

Review of Design of ideal isothermal homogeneous reactor for single and multiple reactions, RTD of Ideal reactor, interpretation of RTD data, Flow models for non-ideal reactors, dispersion model, N tanks in series, multi parameter model, diagnosing the ills of reactor , influence of RTD and micro mixing on conversion. Adiabatic and non adiabatic operations in batch and flow reactors, optimal temperature in progression. Hot spot in tubular reactor auto thermal operation and steady state multiple steady state introduction to bifurcation theory Catalytic reactors, effectiveness factor, selectivity, catalyst deactivation, Design of heterogeneous catalytic reactors.

Course Outcomes: At the end of the course, the student will be able to:

- Understand the Adiabatic and non-adiabatic operations in batch and flow reactors,
- Understand the reactor design involving Catalytic reactors, effectiveness factor,selectivity, catalyst deactivation,
- Understand the design of heterogeneous catalytic reactors.

Texts Books

- James J Carberry: Chemical and Catalytic Reaction Engineering McGraw Hill
- J M Smith " Chemical Engineering Kinetics", McHill

Reference Books

- O. Levenspiel, " Chemical Reaction Engineering", Wiley Eastern, 2nd ed. 1972
- Frinebt G. F. Bischoff K. B; " Chemical Reactor Analyzer and design" John Wiley & Sons.
- H. S. Foggler; Elements of Chemical Reaction Engineering

Course Outcomes and their mapping with programme Outcomes

COs	PROGRAM OUTCOMES (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	I	II	III
CO1	3	1	2	2	3	2							2	1	
CO2	3	2	2	2	2	3							2	2	
CO3	3	3	2	3	3	3							2	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

Chandrakar 24/04/19 — 24/04/19 — 24/04/19. — Salaha 24/4/19 — Asmajani 24/4/19

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 04	FLUIDIZATION ENGINEERING	3:0:0	4

Course Objectives:

- To study the phenomenon of fluidization with industrial processing objective
- To study the various regimes of fluidization and their mapping.
- To study the design of equipments based on fluidization technique

Phenomenon of Fluidization, Industrial applications of fluidized beds, Gross behavior of fluidized beds- Minimum fluidizing velocity and pressure drops; Voidage, Transport disengaging height; Bubbles in dense beds-Davidson Model, stream of bubbles, Bubbling bed models, Emulsion phase, Turn-over rate of solids, Residence Time Distribution of Solids, Diffusion model of solids movement, Interchange coefficient of solid into and out of wake; Flow Pattern of Gas through fluidized beds, diffusion model for gas flow; two region models, evaluation of interchange coefficients, Mass and heat transfer between fluids and solid- from bubbling bed models; Catalytic conversion from bubbling bed model; contacting efficiency; application to successive reactions; Theories and bed wall heat transfer; comparison of theories; Entrainment and elutriation, Circulation rates of solids, flow of high and low bulk density mixtures; Design for catalytic reactors; Design for non-catalytic gas-solid reactors.

Text/References:

1. Kuinl D. and Levenpiel O., Fluidization Engineering, John Wiley, 1969
2. Davidson J. F. and Harrison D., Fluidization, Academic Press 1971
3. Zenz F.A. and Othmer D. F., Fluidization and Fluid Particles Systems, Reinhold Publishing, 1960

Course Outcomes: At the end of the course, the student will be able to:

1. Performing and understanding the behavior fluidization in fluidized bed
2. Evaluate the characterization of particles and power consumption in fluidization regimes
3. Understanding the applicability of the fluidized beds in chemical industries

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	2	3	2							2	1	
CO2	3	2	1	2	2	3							2	2	
CO3	3	2	2	2	2	2							2	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 05	PROCESS OPTIMIZATION	3:0:0	4

Course Objectives:

To study and apply optimization techniques in the chemical process industry.

Introduction to optimization; Formulation of objective function; Basic concepts-functions, regions, necessary and sufficient conditions for an extreme of an unconstrained function.

One dimensional Search: Scanning and bracketing; Newton, quasi-Newton and secant methods; Region elimination method; Polynomial approximation methods.

Unconstrained multivariable optimization: Direct methods-random search, grid search, univariate search, simplex method, conjugates search direction and Powell's method; indirect method- gradient and conjugate gradient methods, Newton's method, movement in search direction, secant method.

Linear programming: Basic concepts in linear programming; Graphical solution; Simplex method; Standard LP from; Obtaining first feasible solution; Sensitivity analysis.

Non-linear programming: Lagrange multiplier method; Quadratic programming; Penalty function and augmented Lagrangian methods.

Texts/References:

- Edgar T.F. and Himmelblau D.M., Lasdon, Optimization of Chemical Processes, McGraw Hill, 2001
- Urbaniec K. and McDermott C., Optimal Design of Process Equipment. John Wiley, 1986

Course Outcomes:

Upon completion of this course, the students will be able to:

- Formulate the objective functions for constrained and unconstrained optimization problems;
- Use different optimization strategies;
- Solve problems using non-traditional optimization techniques;
- Use of different optimization techniques for problem solving

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	2	1								2	2	2
CO2	1	2	1	2	2								1	2	2
CO3	2	2	3	2	2								2	2	1
CO4	2	2	2	2	2								2	2	2

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

Chandrakar 24/04/19 24/04/19 24/04/19. Saha 24/4/19 Banerjee 24/4/19

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 06	CHEMICAL PROCESS MODELING	3:0:0	4

Course Objective:

- To understand the systematic approaches for the development of modelling.
- To understand the mathematical modeling of chemical processes.

Introduction to process modeling, types of models, the basic modeling approaches, the transport phenomena models, population balance models, parameter estimation.

Texts/References:

- Denn M. M., Process Modelling, John Wiley, 1987
- Baughman R.D. and Liu Y.A., Neural Networks in Bioprocessing and Chemical Engineering, Academic Press, 1996
- Rutherford Aris, Mathematical Modeling. Vol.1, A Chemical Engineer's Perspective (Process Systems Engineering), Academic Press, 1999

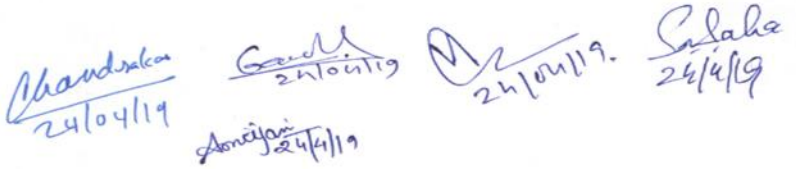
Course Outcome: After learning the course, the students will be able to:

- To apply the suitable modelling approach for given problem.
- Analyze the terminology of mathematical models.
- Develop a mathematical model based on transport phenomenon and population balance for chemical process.

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	2	3	2							2	1	
CO2	3	2	2	2	2	3							2	2	
CO3	3	3	3	3	3	3							2	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly



SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 07	ADVANCED MASS TRANSFER	3:0:0	4

Course Objectives:

- To provide basic knowledge of fundamental mass transfer operations and mechanisms.
- To understand the mass transfer in LLE, leaching, drying, crystallization, adsorption and humidification operation

Qualitative behavior of the vapour-liquid equilibria (VLE). Simple models for vapour-liquid equilibria: Raoult's and Henry's laws. Dew point and bubble point calculations. VLE by modified Raoult's law and K-value correlations. Flash calculations.

Ternary and multicomponent system, fractionation. Theories and design, number of plates, Lewis Sorel's method, minimum reflux ratio, Underwood's equation, Colburn's equation.

Unsteady state mass transfer, multicomponent Gas-Phase systems, effective diffusivity, Maxwell's law, Regular and Random surface renewal, Harriot Model, Danckwerts model.

Mass Transfer across a phase boundary — the film-penetration theory, other theories of mass transfer. Interfacial turbulence, Mass Transfer coefficient, Applications of theories of interphase transfer. Mass Transfer and chemical reaction — steady state and unsteady state

Universal velocity profile- The laminar sub-layer, the buffer layer, Reynolds analogy, Taylor-Prandt, Modifications.

Text / References :

- Seader J.D., Henley E. J., Chemical Engineering Principles.
- Coulson J.M. and Richardson J.F., Chemical Engineering

Course Outcomes:

Students would be able to

- Explain the basics of humidification, drying, leaching, crystallization and adsorption.
- Identify the mechanisms of mass transfer, formulate rate equations.
- Solve problems related to humidification, drying, leaching and crystallization.
- Design equipment for humidification, drying, leaching and crystallization.

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	1							3	2	
CO2	3	3	2	2	2	2							3	2	
CO3	3	2	2	1	1	1							3	2	
CO4	3	2	3	1	2	1							3	2	
CO5	3	2	2	1	1	1							3	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

24/04/19 24/04/19 24/04/19. 24/4/19 24/4/19

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 08	INDUSTRIAL POLLUTION CONTROL TECHNOLOGIES	3:0:0	4

Course Objectives:

- To Understanding Industrial Pollution
- To Introduce students to a range of pollution control technologies
- To Regulatory Framework
- To Best Practices and Sustainable Solutions
- To Techno-economic Analysis and Emerging Technologies and Innovations

Brief review of industrial, municipal and natural pollution sources, dynamics of pollutants from point, non-point, line and area sources; generation, transport and decay of air pollutants; sampling and monitoring methods.

Strategies and methods for removal of gaseous pollutants and particulates from process exhaust streams; air pollution abatement technology; detail design of particulates and gaseous emission control equipment; air pollution indices; air pollution survey; costs of air pollution control, air pollution legislation and regulations.

Case studies of a few industrial pollution control system

Waste water characteristics. Wastewater treatment 'objectives, methods and implementation considerations liquid hazardous waste treatment such as chemical, biological, and thermal oxidation, carbon adsorption, ion exchange.

Design of facilities for physical and chemical treatment; design of facilities for treatment and disposal of sludge; effluent disposal

Water pollution legislation and regulation

Text / References :

- Schnelle K.B. and Brown C.A., Air Pollution Control Technology Handbook, CRC Press
- Peavy H.S., Rowe D. R. and Tchobanoglous George, Environment Engineering, McGraw-Hill
- Triwedi R.K. and Goel P.K., An Introduction to Air Pollution, Technoscience Pub.
- Sengar D.S., Environmental Law, PHI

Course Outcomes:

- Understand the sources, types, and impacts of industrial pollution.
- Identify and evaluate pollution control technologies for industrial applications.
- Analyze and apply regulatory frameworks and environmental standards in industrial pollution control.
- Promote best practices and sustainable solutions for industrial pollution control.
- Conduct techno-economic analysis of pollution control technologies.

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	2	1							3	2	
CO2	3	1	2	2	1	2							3	2	
CO3	3	2	1	1	1	1							3	2	
CO4	3	2	3	1	2	1							3	2	
CO5	3	2	2	1	1	1							3	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

24/04/19 24/04/19 24/04/19. 24/4/19 24/4/19

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 09	DESIGN & DEVELOPMENT OF CATALYST	3:0:0	4

Course Objective:

- To give the students insight into advances in catalytic reaction engineering
- To understand the mechanisms involved in catalytic reactions
- To study the catalyst characterization techniques
- To study the advanced industrial applications in catalysis
- To understand the principles behind catalyst deactivation and study their models

Course Contents:

Structure of solid surfaces; Chemisorption and Physisorption; Thermodynamics and kinetics of surface processes; Principles of heterogeneous catalysis; Preparation, characterization and classification; Structure and activity; Lattice imperfection; Geometric and electronic factors Preparation and characterization of catalysts. Kinetics of heterogeneous reactions. Physical, Chemical and mathematical description of catalyst deactivation; Deactivation by fouling, poisoning and sintering. Deactivation and regeneration of catalyst pellets. Deactivation and regeneration of fixed beds. Dynamics of polyfunctional catalysts. Electrocatalysis and photocatalysis. Mechanism and kinetics of some typical heterogeneous catalytic reactions. Applications in fertilizer, petroleum, petrochemical industries and pollution control.

Texts Books

- G. Poncelet, J. Martens, B. Delmon; Preparation of Catalyst VI : Scientific bases for thepreparation of Haterogeneous Catalysts; Elseveir
- John Regalbuto; Catalyst Preparation : Science and Engineering; CRC Press

Reference Books

- Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954
- Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971
- Thomas and Thomas - "Introduction to Heterogeneous Catalysts ", Academic Press,London 1964
- Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004
- Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-stability deactivation, Wiley, VCH, 2011

Course Outcomes: At the end of the course, the student will be able to:

- To understand the concepts of homogenous and heterogeneous catalysis, with specific examples.
- To study reaction mechanisms and kinetics of homogenous and heterogeneouscatalytic reactions.
- To familiarize with the characterization of catalysts
- To understand the application and mechanisms of several types of catalysts inchemical industry

Course Outcomes and their mapping with programme Outcomes

COs	PROGRAM OUTCOMES (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	I	II	III
CO1	3	1	2	2	3	2							2	2	
CO2	2	2	3	2	2	2							3	2	
CO3	2	1	3	2	2	2							2	2	
CO4	3	2	1	2	1	2							2	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 10	ADVANCE WASTEWATER TREATMENT	3:0:0	4

Course Objectives:

- To understanding Advanced Wastewater Treatment Processes
- To advanced Treatment Technologies
- To water Reuse and Resource Recovery
- To advanced Monitoring and Control
- To process Modeling and Simulation
- To treatment Plant Design and Optimization

Introduction, health and environment concern in wastewater management. Water quality: definitions, characteristics and perspectives. The hydraulic cycle, water quality, physical, chemical and biological water quality parameters. Measurement of organic concentration, BOD, COD and TOC test, reaction between BOD, COD, & TOC, Most probable number (MPN), measurement of biological characteristics, toxicity test. Reactor used for transient of wastewater mass balance analysis, modeling of ideal flow in reactor, modeling of treatment process, kinetics of processes, process selection. Physical unit operations: screening, mixing, gravity separation, primary sedimentation, coagulation, secondary treatment of waste water, adsorption. Biological waste water treatment, micro-organism growth kinetics, modeling of suspended froth treatment process, aerobic biological oxidation, anaerobic process, heavy metal pollution remedies

Texts/References:

- M$_{etc}$alf and Eddy, Wastewater Engineering: Treatment and Reuse, Tata McGraw Hill publication, India
- P$_{eavy}$ H.S. and Rowe D.R., Environment Engineering, McGraw Hill Book Company, New Delhi
- Levenspiel 0., Chemical Reaction Engineering, John Wiley and Sons publication
- Treybal R.E., Mass Transfer Operations, McGraw-Hill publication
- Coulson and Richardson Vol..-II, Butterworth Heinemann Publication, New Delhi

Course Outcomes:

- Understand the principles and theories of advanced wastewater treatment processes.
- Apply advanced treatment technologies and processes for wastewater treatment.
- Evaluate and design advanced wastewater treatment systems.
- Implement monitoring and control strategies to optimize wastewater treatment plant performance.
- Demonstrate knowledge of water reuse and resource recovery practices.

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	1							3	2	
CO2	3	3	2	2	2	2							3	2	
CO3	3	2	2	1	1	1							3	2	
CO4	3	2	3	1	2	1							3	2	
CO5	3	2	2	1	1	1							3	2	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly

SUBJECT CODE	SUBJECT NAME	L:T:P	Credit
CHEPHDT 11	ADVANCED PROCESS CONTROL	3:0:0	4

Course Objectives:

- To provide fundamental knowledge on process control strategies.
- To impart knowledge on a theoretical analysis of open loop and closed loop systems

A brief review on the preliminary concepts of process control, modeling of few complicated system understanding of first and second order system and PID controls, state space and transfer function matrix models, stability criterion of transfer function matrix models, development of empirical model for process data, identifying discrete-time models from experimental data, design of feed forward and ration control, study of cascade control system, digital sampling, filtering, and control: sampling period, along and digital filters, Z-transforms use of SIMULINK design of digital control, multi loop control: calculation of extent of interaction and pairing of control and manipulated variable implementation of real time optimization in computer control. Study of model predictive control (MPC), concepts of statistical process control, Study of Kalman filter.

Texts/References:

- Seborg Dale E., Edgon Thomas F. and Mellichamp D.C.A., Process Dynamics and Control, WILEY Publication
- Luyben M. L. and Luyben W.L., Essential of Process Control, McGraw-Hill
- Ogunnaike B.A. and Ray W.H., Process Dynamics, Modeling and Control Oxford University Press
- Coughnowr D.R. and Kopple L.B., Process System Analysis and Control, McGraw-Hill
- Stephanopolous G., Chemical Process Control- An Introduction Theory and Practice, Prentice Hall of India

Course Outcomes:

Students would be able to

- Evaluate dynamic behavior of first and second order system.
- Determine the process stability in Laplace domain.
- Analyze open-loop systems and linear closed loop systems.
- Develop working knowledge of control system by frequency response.

Course Outcomes and their mapping with programme Outcomes

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1		1						2	1	
CO2	2	2	1	1	1		1						2	1	
CO3	2	2	1	1	1		1						2	1	
CO4	2	2	1	1	1		1						2	1	

Weightage: 1-Slightly; 2-Moderate; 3-Strongly