KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Final Year Engineering

(Chemical Engineering)

Faculty of Science and Technology

B.E. Chemical Engineering Syllabus

W.E.F. 2020 – 21

Semester – VII

Syllabus Structure for Fourth Year Engineering (Semester – VII) Chemical Engineering (w.e.f. 2020 – 21)

Name of the Course	Group	Teaching Scheme				Evaluation Scheme					Credits
						Theory		Practical		Total	
		Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE	ESE	ICA	ESE		
Process Control	D	3	-	-	3	40	60	-	-	100	3
Professional Elective Course – III	E	3	-	-	3	40	60	-	-	100	3
Professional Elective Course – IV	E	3	-	-	3	40	60	-	-	100	3
Open Elective Course – III	F	3	-	-	3	40	60	-	-	100	3
Process Control Lab	D	-	-	2	2	-	-	25	25 (OR)	50	1
Instrumentation and Control Lab	D	1	-	2	3	-	-	25	25 (OR)	50	2
Project (Stage - I)	G	-	-	12	12	-	-	50	50 (OR)	100	6
Essence of Indian Traditional Knowledge		-	-	-	-	-	-	-	-	-	-
		13		**16**	**29**	**160**	**240**	**100**	**100**	**600**	**21**

ISE: Internal Sessional Examination **ESE: End Semester Examination** **ICA: Internal Continuous Assessment**

Professional Elective Course – III	Professional Elective Course – IV	Open Elective Course – III
Transport Phenomenon	Computer Aided Process Equipment Design	Plant Utility
Sustainability Engineering	Modeling & Simulation	Solar Power
Optimization Methods	Nanoscience and Nanotechnology	Enzyme Engineering
Safety Assessment for Chemical Processes	Computational Fluid Dynamics	Internet of Things

Syllabus Structure for Fourth Year Engineering (Semester – VIII) Chemical Engineering (w.e.f. 2020 – 21)

Name of the Course	Group	Teaching Scheme				Evaluation Scheme					Credits
						Theory		Practical		Total	
		Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE	ESE	ICA	ESE		
Process Technology and Economics	D	3	-	-	3	40	60	-	-	100	3
Professional Elective Course – V	E	3	-	-	3	40	60	-	-	100	3
Professional Elective Course – VI	E	3	-	-	3	40	60	-	-	100	3
Open Elective Course – IV	F	3	-	-	3	40	60	-	-	100	3
Process Technology and Economics Lab	D	-	-	2	2	-	-	25	25 (OR)	50	1
Design and Simulation Lab	D	2	-	2	4	-	-	25	25 (OR)	50	3
Project	G		-	6	6	-	-	50	50 (OR)	100	3
		14	**0**	**10**	**24**	**160**	**240**	**100**	**100**	**600**	**19**

ISE: Internal Sessional Examination **ESE: End Semester Examination** **ICA: Internal Continuous Assessment**

Professional Elective Course – V	Professional Elective Course – VI	Open Elective Course – IV
Chemical Plant Design and Project Engineering	Petrochemical Technology	Energy Conservation and Management
Piping Design	Environmental Pollution and Control	Material Technology
Advanced Separation Processes	Water Conservation and Management	Biostatistics
Research Methodology	Renewable Energy	Cyber Security

Process Control					
COURSE OUTLINE					
Course Title:	**Process Control**	**Short Title:**	**PC**	**Course Code:**	

Course description:

This course describes fundamental aspects of dynamic processes and the engineering tasks of process operations and control. The objective of the course is to apply the principles of science and chemical engineering to design static and dynamic model of processes, design of feedback and other control structures; and advanced control strategies.

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Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Fluid Mechanics, Material and Energy Balance Computations, Heat Transfer, Mass Transfer I & II, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To understand the importance of process control and role of process control engineers.
2. To develop input-output model of various processes by mathematical models and linearization concept.
3. To develop transfer functions and study the dynamic behavior of various systems.
4. To design a control system to meet desired needs of chemical engineering process.
5. To design and analyze block diagrams and dynamic behavior of feedback control from process information.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand process dynamics and various forms of mathematical models required to express them, including differential equations, transfer functions, and frequency response plots.
2. Understand the main ideas behind advanced multivariable control
3. Capable to analyze, design and tune various control systems.
4. To function along with multidisciplinary teams
5. To be capable of setting and complete team projects.

COURSE CONTENT

Process Control		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Characteristics of Chemical Process Control, Mathematical Modeling of Chemical Processes, State Variables and State Equation for Chemical Processes. Input –Output Model, Linearization of non linear systems. First order system and their transfer functions.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Dynamic behavior of first order system, Pure capacity process, First order system with variable Time constant and gain, Response of first order system in series: Interacting and Non-interacting. Second order system and their transfer function.		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Dynamic behavior of second order system: under damped and over damped and critically damped systems. Transportation lag. Higher order systems. Introduction to feedback control systems, Controllers and final control element. Block diagram of chemical reactant control systems.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Dynamic behavior of feedback control processes: P, PD, PI, and PID. Design of feedback controller: Performance criteria, selection of type of controller, Tuning of feedback controller. Stability analysis by Routh criteria, Root Locus Diagram.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Frequency response analysis of linear processes: Bode's diagram, Nyquist plots. Design of feedback control system using frequency response technique: Bode's stability criteria, gain and phase margin. Ziegler – Nichols tuning technique. Control Systems with Multiple Loops: Feed forward, Cascade, Ratio, selective, split range, Adaptive and Inferential control. Multi Variable Control.		
Text Books:		
1. George Stephanpolous, Chemical Process Control, Prentice Hall of India. 2. D.R. Coughnour, Process System Analysis and Control, McGraw-Hill. 3. R.P. Vyas, Process Control & Instrumentation (2nd edition). Central Techno publication, Nagpur.		
Reference Book:		
K. Krishnaswamy, Process Control, New age International Publication.		

Professional Elective Course – III

Transport Phenomenon

COURSE OUTLINE

Course Title:	**Transport Phenomenon**	**Short Title:**	**TP**	**Course Code:**	

Course description:

The main aim is to give a balanced overview of the field of transport phenomena, discussing the fundamental theories of the subject, and illustrating how to use them to solve transport problems and elaborate conceptual and mathematical models, from conservation principles.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Fluid Mechanics, Material and Energy Balance Computations, Heat Transfer, Mass Transfer I & II, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To develop an ability to apply knowledge of mathematics, interdisciplinary science, and engineering in the field of transport processes.
2. To study equilibrium and non equilibrium processes.
3. To study fundamental laws of conservation and apply to understand behavior of transport processes.
4. To formulate momentum, energy and mass balances in chemical processes.
5. To develop equation of motion using equation of continuity and equation of energy.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply engineering principles and analyze problems dealing with transport phenomena.
2. Apply mathematics, science, and engineering principles to analyze transport phenomena problems.
3. Implement and physically interpreting the transport mechanism.
4. Understanding various transport operations and collective effect of momentum, heat and mass transfer.
5. Display skill of various equation uses in momentum transfer.

COURSE CONTENT

Transport Phenomenon		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Introduction. Transport phenomenon and Unit Operation. Equilibrium and Rate Processes. Fundamental variables. The role of Intermolecular forces. Simple Balance: Material and Energy.

Molecular transport Mechanism: The Analogy. The Case of Heat Transfer. The Case of Mass Transfer. The Case of Momentum Transfer. The Analogues forms. Heat, Mass, Momentum Diffusivities. Thermal Conductivity. Diffusion Coefficient. Viscosity.		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Viscosity and Mechanism of Momentum Transport. Velocity Distribution in Laminar Flow.		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Thermal Conductivity and The Mechanism of Energy Transport. Temperature Distribution in Solids and in laminar Flow.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Diffusivity and Mechanism of mass Transport. Concentration Distribution in Solids and in Laminar Flow.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
The Equation of Change for Isothermal System. The Equation of Change for Non-Isothermal System.		
Text Books:		
1. R.B. Bird; W.E. Stewart; E.N. Lightfoot, Transport Phenomenon, John Wiley & Sons1994;Singapore 2. R.S. Brodsky & H.C. Hershey, Transport Phenomenon, McGraw-Hill (International edition)		
Reference Books:		
1. C.O. Bennett & J.E. Myers; Momentum, Heat & Mass Transfer; McGraw-Hill, 1982. 2. James R. Welly, Charles E. Wicks & Robert E. Wilson; Fundamentals of Momentum, Heat& Mass Transfer (3rd edition). John Wiley & Sons; Singapore.		

Professional Elective Course – III

Sustainability Engineering

COURSE OUTLINE

Course Title:	**Sustainability Engineering**	**Short Title:**	**SE**	**Course Code:**	

Course description:

This course is intended for the knowledge of students about the sustainable development and ways for achieving this. It will help in studying the methods about minimum degradation of environment .The students will also learn about waste minimization.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Fluid Mechanics, Material and Energy Balance Computations, Heat Transfer, Mass Transfer I & II, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To develop an increased awareness among students on issues in areas of sustainability
2. To make students understand the sustainable engineering design principles, economic, environmental and social indicators.
3. To aware the students the knowledge of environment-related legislation.
4. To establish in students an understanding environmental impact assessment of development projects and life cycle assessment.
5. To understand sustainable sources of energy; economic and social factors affecting sustainability.

Course outcomes:

After successful completion of this course the student will be able to:

1. Increased awareness on issues in the area of sustainability.
2. Understand the role of engineering and technology within sustainable development.
3. Aware about green chemistry and life cycle assessment.
4. Understand environmental impact assessment of development projects.
5. Understand the solid waste management.

COURSE CONTENT

Sustainability Engineering		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to the idea of sustainability and its relevance; magnitude of sustainability challenge, environment-related legislation; air and water pollution; towards sustainable future, pollution prevention, renewable resources, non renewable resources.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Solid waste management; collection and transportation systems, landfiling, combustion , resource recovery incineration technologies, pyrolysis, composting source reduction, recycling and reuse of plastic and glass bottles, integrated waste management, local and global environmental challenges.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Climate change; tools used to ensure sustainability in engineering activities, environmental management systems and environmental impact assessment; risk assessment, life cycle assessment, life cycle assessment tools, sustainable transportation.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Sustainable engineering design principles, economic, environmental and social indicators, green buildings; green chemistry; green sustainable materials, sustainable cities; sustainable transportation; waste minimization, case studies on waste minimization and cleaner technologies of chemical process industries.		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Sustainable sources of energy; economic and social factors affecting sustainability, cleaner technologies of industrial production, case studies such as biofuels for transportation, sustainable transportation, sustainable cities, green buildings.		
Text Books:		
1. R.T. Wright, B.J. Nebel "Environmental Science" Prentice Hall of India Private Limited, New Delhi 2. D.T. Allen , D.R. Shonnard,"Sustainable Engineering" Prentice Hall Limited, Boston 3. U. Rathore, "Energy Management"S. K. Kataria & sons, New Delhi.		
Reference Book:		
H.M. Neal, J.R. Schubel "Solid Waste Management and the Environment" Prentice Hall Inc., New Jersey, 1987.		

Professional Elective Course – III					
Optimization Methods					
COURSE OUTLINE					
Course Title:	**Optimization Methods**	**Short Title:**	**OMS**	**Course Code:**	

Course description:

This course describes how to use appropriate optimization methods for various application in designing of chemical engineering solutions. Computer aided process equipment design. It illustrates the application of unconstrained and constrained optimization techniques.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Applied Mathematics I, & II, Applied Physics I & II, Fluid Mechanics, Material and Energy Balance Computations, Heat Transfer, Mass Transfer I & II, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To learn optimization application in terms of optimizing recovery of waste heat, Optimizing Heat Exchanger and problem statement; design vector, design Constraints, constraints surface.
2. To apply knowhow for classical optimization single variable, multivariable optimization with no constraints, multivariable optimization with equality constraints.
3. To evaluate nonlinear programming, standard form of LPP, Solution of a system of linear simultaneous equation and simplex algorithm, LP Applications.
4. To understand the unconstrained optimization techniques, random search method, grid search, univariate method and constrained optimization techniques, characteristics of a constrained problem, complex method.
5. To demonstrate skill of the dynamic programming, multistage decision processes, concept of sub-optimization, principle of optimality and also genetic algorithm.

Course outcomes:

After successful completion of this course the student will be able to:

1. Exhibit skill of optimizing recovery of waste heat, Optimizing Heat Exchanger and problem statement; design vector, design constraints, constraints surface in a competitive manner how to optimize.
2. Demonstrate the ability to perform the task by identifying, formulating, and providing the solution to various chemical engineering problems associated with classical optimization single variable, multivariable optimization with no constraints, multivariable optimization with equality constraints.
3. Identify, formulate and provide the solution to various chemical engineering problems associate with the nonlinear programming, LPP, linear simultaneous equation.
4. Understand professional and ethical responsibilities formally and informally show the skill the unconstrained optimization techniques, random search method, grid search, univariate method and constrained optimization techniques.
5. Display the skill about dynamic programming, multistage decision processes, concept of sub-optimization and also genetic algorithm.

<table>
<tr><td colspan="6" align="center">COURSE CONTENT</td></tr>
<tr><td colspan="3">Optimization Methods</td><td colspan="2">Semester:</td><td>VII</td></tr>
<tr><td colspan="3">Teaching Scheme:</td><td colspan="3">Examination scheme</td></tr>
<tr><td>Lectures:</td><td colspan="2">3 hours/week</td><td colspan="2">End semester exam (ESE):</td><td>60 marks</td></tr>
<tr><td colspan="3" rowspan="2"></td><td colspan="2">Duration of ESE:</td><td>03 hours</td></tr>
<tr><td colspan="2">Internal Sessional Exams (ISE):</td><td>40 marks</td></tr>
<tr><td colspan="2">Unit–I:</td><td colspan="2">No. of Lectures: 09 Hours</td><td colspan="2">Marks: 12</td></tr>
<tr><td colspan="6">Introduction to Optimization, Engineering application of optimization: Optimizing recovery of waste heat, Optimizing Heat Exchanger Design Network, problem statement: Design Vector, Design Constraints, Constraints surface, objective function, Objective function surface classification: based on existence of constraints and based on nature of the design variables, optimization techniques.</td></tr>
<tr><td colspan="2">Unit–II:</td><td colspan="2">No. of Lectures: 08 Hours</td><td colspan="2">Marks: 12</td></tr>
<tr><td colspan="6">Classical optimization single variable, multivariable optimization with no constraints, multivariable optimization with equality constraints: solution be direct substitution, by method of constrains variation, by method of Lagrange multipliers and multivariable optimization with inequality constraints.</td></tr>
<tr><td colspan="2">Unit–III:</td><td colspan="2">No. of Lectures: 09 Hours</td><td colspan="2">Marks: 12</td></tr>
<tr><td colspan="6">Introduction: Nonlinear programming, Standard form of LPP, Solution of a system of Linear Simultaneous equation, Simplex method, Two phases of simplex method, Simplex Algorithm, LP Applications.</td></tr>
<tr><td colspan="2">Unit–IV:</td><td colspan="2">No. of Lectures: 08 Hours</td><td colspan="2">Marks: 12</td></tr>
<tr><td colspan="6">Introduction: Unconstrained optimization techniques, Random search method, Grid search, Univariate method, conjugate search directions, Steepest Decent (Cauchy) method; Constrained optimization techniques: Characteristics of a constrained problem, Complex method.</td></tr>
<tr><td colspan="2">Unit–V:</td><td colspan="2">No. of Lectures: 08 Hours</td><td colspan="2">Marks: 12</td></tr>
<tr><td colspan="6">Dynamic programming, Multistage decision processes, Types of Multistage Decision Problems, Concept of Sub-optimization and Principle of Optimality; Introduction to genetic algorithm: Representation of design variables, representation of objective functions and constraints, genetic operators, Technique use in GA, Numerical Results.</td></tr>
<tr><td colspan="6">Text Book:</td></tr>
<tr><td colspan="6">S.S. Rao, Engineering Optimization Theory and Practice, New Age International (P) Limited, Delhi, Third Enlarged Edition.</td></tr>
<tr><td colspan="6">Reference Book:</td></tr>
<tr><td colspan="6">T.F. Edgar, D.M. Himmenblau, Optimization of Chemical Processes, McGraw – Hill International Editions, Chemical Engineering Series.</td></tr>
</table>

<table>
<tr><td colspan="6" align="center">Professional Elective Course – III</td></tr>
<tr><td colspan="6" align="center">Safety Assessment for Chemical Processes</td></tr>
<tr><td colspan="6" align="center">COURSE OUTLINE</td></tr>
<tr><td>Course Title:</td><td>Safety Assessment for Chemical Processes</td><td>Short Title:</td><td>SACP</td><td>Course Code:</td><td></td></tr>
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Course description:

This course describes how to use appropriate risk assessment methods for various application in chemical industry to provide designing of chemical engineering solutions taking consideration the identification of deviations and their assessment with plant safety.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Applied Physics I & II, Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Process Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To accustom basic terminology in loss prevention, procedure for process safety investigations and theoretical considerations for laboratory processes.
2. To understand basic assessment test methods for kg-scale processes and methods for the investigation and assessment of chemical reactions.
3. To learn investigation and assessment of normal operating conditions for safe normal operation of the cooled CSTR, PFTR, batch reactors and semibatch reactor.
4. To display skill about special problems in the assessment of normal operating conditions and investigation methods for the characterization of normal operating conditions.
5. To analysis use of methods for the identification of deviations and their assessment qualitative methods for the identification of deviations: checklists, Preliminary hazard analysis, what if' method, HAZOP analysis.

Course outcomes:

After successful completion of this course the student will be able to:

1. Demonstrate the basic terminology in loss prevention, procedure for process safety investigations and theoretical considerations for laboratory processes.
2. Analyze basic assessment test methods for kg-scale processes and methods for the investigation and assessment of chemical reactions.
3. Display the skill about investigation and assessment of normal operating conditions for safe normal operation of the cooled CSTR, PFTR, batch reactors and semibatch reactor.
4. Evaluate special problems in the assessment of normal operating conditions and investigation methods for the characterization of normal operating conditions.
5. Exhibit skill about methods for the identification of deviations and their assessment and plant technical safety concepts.

<table>
<tr><td colspan="4" align="center">COURSE CONTENT</td></tr>
<tr><td colspan="2">Safety Assessment for Chemical Processes</td><td>Semester:</td><td>VII</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="2">Examination scheme</td></tr>
<tr><td>Lectures:</td><td>3 hours/week</td><td>End semester exam (ESE):</td><td>60 marks</td></tr>
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	Duration of ESE:	**03 hours**
	Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Basic Terminology in Loss Prevention
General Safety Terms: Hazard Potential and Expectable Damage, Risk, Basic Terminology for Plant/Process Operation.
Procedure for Process Safety Investigations
Scope of Investigation in its Dependence on the antonym Process Development Stage, Definition of Significant Plant or Process Modifications, Types of investigations Corresponding to the Life Cycle Progress.
Test Methods For The Thermal Stability Assessment of Substances And Mixtures
Theoretical Considerations For Laboratory Processes, Screening -Methods For kg-Scale Processes: Difference Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC), The Carius Tube Test, The Miniautoclave Test, Open Cup Measuring Techniques.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Basic Assessment Test Methods For kg-Scale Processes: The Burning Test For Solids, Test on The Ignitability of Solids, Flash-point of Liquids, Ignition Temperature of Liquids Partial Testing for Explosion Risk,Deflagration Testing.
Methods for the Investigation and Assessment of Chemical Reactions
Reaction Engineering Fundamentals**:** Stoichiometry and Extent of Reaction, Reaction Rate, Ideal Reactor Models, Introduction of Characteristic Numbers, Mass Balances of the Ideal Reactors, Sample Solutions for Isothermal Operating Conditions, The General Heat Balance of Cooled Ideal Reactors.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Investigation And Assessment of Normal Operating Conditions
The Safety Technical Assessment of Normal Operating Conditions: Safe Normal Operation of The Cooled CSTR, Safe Normal Operation of the Cooled PFTR, Safe Normal Operation of Cooled Batch Reactors, Safe Normal Operation of the Cooled Semibatch Reactor.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Special Problems In The Assessment of Normal Operating Conditions:
Safe Normal Operation of Reactions Under Reflux, Safe Normal Operation of Polymerization Reactions.
Investigation Methods for the Characterization of Normal Operating Conditions: Fundamentals of Thermokinetics, Reaction Calorimetry, Thermokinetic Evaluation of Reaction Calorimetric Measurements.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Methods For The Identification of Deviations And Their Assessment
Qualitative Methods For The identification of Deviations: Checklists, Preliminary Hazard Analysis, What if' Method, HAZOP Analysis.
Quantitative Methods For The Identification Of Process Deviations
Fault-Tree Analysis, Event Tree Analysis, Special Methods.
Plant Technical Safety Concepts
Design of Emergency Relief Systems, General Fundamentals of Two-Phase Pressure Relief, Design According To Leung’s Equilibrium Model Design For Multi-Purpose Plants - A

Special Problem - The Concept of The Credible Worst Case, The Procedure.
Text Book:
Jorg Steinbach, Safety Assessment for Chemical Processes, Wiley – VCH, Publication.
Reference Book:
R.K. Jain, S.S. Rao, "Industrial Safety, Health and Environment Management Systems", Khanna Publishers, New Delhi.

Professional Elective Course – IV

Computer Aided Process Equipment Design

COURSE OUTLINE

Course Title:	**Computer Aided Process Equipment Design**	**Short Title:**	**CAPED**	**Course Code:**	

Course description:

This course describes how to use appropriate terminology for computer aided process equipment design. It illustrates the application of scientific principles associated with process equipment design.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Applied Physics I & II, Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To learn computer aided design of shell and tube heat exchanger and Batch Reactor - Isothermal and non-isothermal heating and Cooling medium.
2. To apply knowhow for computer aided design of the Single Effect Evaporator and Distillation Column.
3. To understand computer aided design of the absorption column and rotary dryer.
4. To evaluate the module for computer aided design of vessel under internal pressure, heads and closures and vessel under external pressure and rectangular storage tank.
5. To demonstrate skill of the module consideration for computer aided design of tall vessels, thick-walled high pressure vessel, Skirt support, Lug support and Saddle supports.

Course outcomes:

After successful completion of this course the student will be able to:

1. Exhibit computer aided design skills in a competitive manner how to design of shell and tube heat exchanger and batch reactor -isothermal and non-isothermal heating and cooling medium.
2. Demonstrate the ability to perform the task by identifying, formulating, designing and providing the solution to various chemical engineering problems associated with single effect evaporator and distillation column.
3. Identify, formulate, design and provide the solution to various chemical engineering problems associate with the absorption column and rotary dryer.
4. Understand professional and ethical responsibilities formally and informally show the capacity of designing requires the module for vessel under internal pressure, heads and closures and vessel under external pressure and rectangular storage tank product to meet economical and societal requirements.
5. Understand about computer aided design of tall vessels, thick-walled high pressure vessel, Skirt support, Lug support and Saddle supports along with the environmental issues and will provide solutions for green and clean technologies.

COURSE CONTENT			
Computer Aided Process Equipment Design		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 09 Hours	Marks: 12

Computer Aided Design:
Shell and Tube Heat Exchanger. Basic Theory, Types of heat exchanger its major characteristics and application. The rating and sizing method and various steps of design of heat exchanger. Flow sheet of optimal design of heat exchanger. Kern Methods of shell and tube side Design. Total pressure drop Delta P_T, shell side pressure drop, Baffles and Tube arrangement, standard coding and its layout, Fluids in a shell and tube Heat exchanger. Double pipe heat exchanger. LMTD and correction factor and writing of C ++Program.
Batch Reactor -Isothermal and non-isothermal Heating and Cooling medium.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Computer Aided Design:
Single Effect Evaporator. (SEE) Boiling point rise and duhring Rule, hydrostatic head effect, Use of vacuum in evaporator system. Types of evaporator- single effect evaporator. Assumption of evaporator. Numerical based on single effect evaporator with C++ programs, difference of SEE and Multiple effect evaporators MEE).
Distillation Column: Steps of distillation column , material and energy balance, dew point and bubble point, MESH equation, Ideal binary distillation column, multicomponent non ideal distillation column, batch distillation with hold up, Relative volatility, Smoker equation and MacCabe- Thiele diagram, q-line equations and numerical on C++ program.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Computer Aided Design:
Absorption Column: Introduction, steps of designing absorption column. Types of packing, Rate of absorption, Height of column based on liquid film conditions, pressure drop and flooding co relation. Numerical based on C++ program
Rotary Dryer: Classification types of rotary dryers, rates of drying, Material Balance and Energy Balance of continuous rotary dryer. Numerical based on C++ program.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Computer Aided Design Module: Design of vessel under internal pressure
Computer Aided Design Module: Heads and Closures
Computer Aided Design Module: Design of vessel under external pressure
Computer Aided Design:
Rectangular storage tank. Numerical based on C++ program.

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

Computer Aided Design Module: Design of tall vessels.
Computer Aided Design Module: Design of thick-walled high pressure vessel.

Computer Aided Design: Vertical supports for chemical process plant
Skirt support, Lug support. Numerical based on C++ program.
Computer Aided Design:
Saddle supports. Numerical based on C++ program.

Text Books:

1. W. L. Luyben , Process Modeling Simulation and Control for Chemical Engineers; McGraw Hill 1988.
2. B.C. Bhattacharya, C. M. Narayan, Computer Aided Design of Chemical Process Equipment: 1st Edition, 1992, New Central Book Agency (P) Ltd. Calcutta.

Reference Books:

1. S.D. Dawande, Process Equipment Design (Vol. I & II), Denett & Co., Nagpur.
2. V.V.Mahajani, S.B.Umarji, Joshi's Process Equipment Design, Trinity Press, Fifth Edition.
3. J.H. Perry, Chemical Engineer's Hand Book, McGrawhill, New Delhi.
4. Lloyed E. Brownell, Edwin H. Young, Process Equipment Design, John Wiley & Sons.
5. R.W.Gaikwad, Dr.Dhirendra, Process Modelling and Simulation, Central Techno Publication, Nagpur. First Edition.

Professional Elective Course – IV					
Modeling & Simulation					
COURSE OUTLINE					
Course Title:	**Modeling & Simulation**	**Short Title:**	**MS**	**Course Code:**	

Course description:

This course describes how to use appropriate model development to carry out the for process equipment design and simulate. It illustrates the application of scientific principles associated with process equipment design.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Applied Physics I & II, Material & Energy Balance Computation, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To learn conservation principle, model representation, types of modeling equations, types of mathematical models, computer simulation and use of simulated process model.
2. To apply knowhow the process and the model – Process description, mathematical model, application of control algorithm for batch reactor, semi batch reactor, CSTR and Bioreactor.
3. To understand the process and the model – Process description, mathematical model for compartmental distillation, ideal binary distillation and activity coefficient model.
4. To evaluate the module for binary batch distillation column, binary continuous distillation column and development of soft-sensor for distillation column.
5. To demonstrate skill of the module consideration for multi-component batch distillation column, equilibrium flash vaporization and adiabatic flash.

Course outcomes:

After successful completion of this course the student will be able to:

1. Exhibit use of model representation, types of modeling equations, types of mathematical models, simulated process.
2. Demonstrate the ability to perform the task by identifying, formulating, designing and providing the solution to various chemical engineering problems associated with batch reactor, semi batch reactor, CSTR and Bioreactor.
3. Identify, formulate, design and provide the solution to various chemical engineering problems associate with the compartmental distillation, ideal binary distillation and activity coefficient model.
4. Understand professional and ethical responsibilities formally and informally show the capacity of how to evaluate the module for binary batch distillation column, binary continuous distillation column and development of soft-sensor for distillation column.
5. Understand about the skill of the module consideration for multi-component batch distillation column, equilibrium flash vaporization and adiabatic flash.

COURSE CONTENT		
Modeling & Simulation	**Semester:**	**VII**

Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction of modeling and simulation:
Definition, conservation principle, model representation, types of modeling equations, types of mathematical models, computer simulation, use of simulated process model.
Numerical Methods:
Interative convergence methods – Bisection method (Interval halving), Secant method, Newton-Raphson Method , Muller method.

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Batch reactor: The process and the model – Process description, mathematical model, application of control algorithm.
Semi-batch rector: Mathematical model.
Continuous stirred tank react: The process and the model – Process description, mathematical model.
Multi steady states: Representative process, steady state solution, Multi steady states behavior
pH Neutralization rector: Process description, mathematical model.
Bioreactor: Chemical engineering in bioprocess industry, operation stages in a bioprocess, Biochemical reactor, Continuous stirred tank bio reactor: Process description, mathematical model.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Compartmental distillation model: Introduction, an overview, Process description, mathematical model.
Ideal binary distillation column: Introduction, the process and the model – Process description, mathematical model.
Activity coefficient models: Introduction, Activity coefficient models for liquid mixtures – The Margules model, The Van Laar model, The Wilson model.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Binary batch distillation column: Introduction, features of batch distillation column, start up procedure of a batch column – simulation procedure for the initial filling.
An example of process and model ; Material and energy balance equations, entahlphy calculation, tray hydraulics, murphree vapour-phase tray efficiency, molecular weight and density of the tray liquid and vapour-liquid equilibrium.
Software sensor : Development of soft-sensor for distillation column.
Binary continuous distillation column: Introduction, The process and the model – Material and energy balance.

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Multicomponent batch distillation column: Introduction, The process and the model, Material and energy balance equations, Enthalpy calculation, molecular weight and density of the tray liquid and equilibrium relationship.
Equilibrium flash vaporization: Introduction, isothermal flash, ideal mixtures.

Adiabatic flash: First set of problem, second set of problem.
Text Book:
Amiya K.Jana, Chemical process modeling and simulation, PHI Learning Private Limited, Delhi Second Edition.
Reference Books:
1. W. L. Luyben , Process Modeling Simulation and Control for Chemical Engineers; McGraw Hill 1988. 2. B.C. Bhattacharya, C. M. Narayan, Computer Aided Design of Chemical Process Equipment: 1st Edition, 1992, New Central Book Agency (P) Ltd. Calcutta. 3. R.W.Gaikwad, Dr.Dhirendra, Process Modelling and Simulation, Central Techno Publication, Nagpur. First Edition.

Professional Elective Course – IV

Nanoscience and Nanotechnology

COURSE OUTLINE

Course Title:	**Nanoscience and Nanotechnology**	**Short Title:**	**NSNT**	**Course Code:**	

Course description:

This course is designed to equip the students with the basics of nanoscience and nanotechnology, through nanomaterial preparation, nanomaterial characterization and identifying the nanomaterial for specific applications.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Applied Physics I & II, Applied Chemistry I & II.

Course objectives:

1. To learn the preliminaries of nanoscience and nanotechnology.
2. To understand the synthesis of nanomaterials by physical methods.
3. To understand the synthesis of nanomaterials by chemical methods.
4. To study the characterization techniques for nanomaterials.
5. To apply knowledge for recognizing the nanomaterial for specific applications.

Course outcomes: After successful completion of this course the student will be able to:

1. Understand the basic aspects of nanoscience and nanotechnology.
2. Learn synthesis of nanomaterials by physical methods.
3. Learn synthesis of nanomaterials by chemical methods.
4. Analyze the characterization techniques for nanomaterials.
5. Demonstrate the ability in selecting the nanomaterial for specific applications.

COURSE CONTENT

<table>
<tr><td colspan="2">Computer Aided Process Equipment Design</td><td>Semester:</td><td>VII</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="2">Examination scheme</td></tr>
<tr><td>Lectures:</td><td>3 hours/week</td><td>End semester exam (ESE):</td><td>60 marks</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Duration of ESE:</td><td>03 hours</td></tr>
<tr><td>Internal Sessional Exams (ISE):</td><td>40 marks</td></tr>
</table>

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction; history and scope of nanomaterials, classification on nanostructured materials, clustrers, type of clusters, properties of nanomaterials: mechanical properties, structural properties, melting of nanoparticles, electrical conductivity, optical properties, applications of nanomaterials.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Synthesis of nanomaterials by physical methods: high energy ball milling, melt mixing, physical vapour deposition, laser pyrolysis, sputter deposition, chemical vapour deposition, electric arc deposition, molecular beam epitaxy.

Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Synthesis of nanomaterials by chemical methods: colloid and colloids in solution, synthesis of colloids, growth of nanoparticles, metal nanoparticles by colloidal route, Langmuir-Blodgett method, microemulsions, sol-gel method, sonochemical synthesis, microwave synthesis, lab-on –chip.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Nanoscale measurement and characterization;: X-Ray Diffraction (XRD), Small Angle X-ray Scattering(SAXS), Scanning Electron Microscopy(SEM), Transmission Electron Microscopy(TEM), Atomic Force Microscopy(AFM), Scanning Tunneling Microscopy(STM), Field Ion Microscope(FIM),Three Dimensional Atom Probe(3DAP), Nanoindentation.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Special nanomaterials: Carboneous nanomaterials: Fullerenes. Carbon Nanotubes (CNTs): types and synthesis, Graphene, Porous silicon: preparation, mechanism and properties, Aerogels: Types and properties, Zeolites: synthesis and properties.		
Text Book:		
B.S.Murty, P Shankar, Baldev Raj, B B Rath, James Murday., “Textbook of Nanoscience and Nanotechnology,”,University Press (India) Pvt. Ltd. 2012		
Reference Book:		
Sulabha K. Kulkarni, “Nanotechnology: Principles and Practices” , Capital Publishing Compony, New Delhi, 2011		

Professional Elective Course – IV					
Computational Fluid Dynamics					
COURSE OUTLINE					
Course Title:	**Computational Fluid Dynamics**	**Short Title:**	**CFD**	**Course Code:**	

Course description:

The incorporation of CFD (Computational Fluid Dynamics) as a possible solution to modern day fluid mechanic problems has become part of the daily lives of many engineers along with the companies they work for. Usually, the main objective is to quantitatively estimate forces produced by flows around a specific structural component or to optimize the design of an individual part responding to forces originating from fluid dynamics.

These skills imply a high degree of multidisciplinary competence in order to accurately define and resolve specific problems. A profound knowledge is needed in different key areas such as CAD to properly discretize the problem, fluid mechanics to properly understand the governing phenomena behind the problem, numerical methods to understand how these fluid dynamic problems are numerically solved and finally, experimental techniques in fluid mechanics to understand the underlying errors in reference values used for validation.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Fluid Mechanics, Applied Physics I & II, Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To understand the philosophy of computational fluid dynamics and conservation principles and classification of flows & characteristics of simple turbulent flows, free turbulent flows.
2. To study different models such as turbulence models, mixing length model, the k-e model and their algebraic stress equations and Grid Generation.
3. To understand discretization of ordinary and partial differential equations.
4. To study approximation of first, second and mixed derivatives & its implementation on boundary conditions.
5. To understand heat transfer in a complex tubes and channels.

Course outcomes:

After successful completion of this course the student will be able to:

1. Accustom the philosophy of computational fluid dynamics and conservation principles and classification of flows & characteristics of simple turbulent flows, free turbulent flows.
2. Understand different models such as turbulence models, mixing length model, the k-e model and their algebraic stress equations and Grid Generation.
3. Display the skill about discretization of ordinary and partial differential equations.
4. Analyze approximation of first, second and mixed derivatives & its implementation on boundary conditions.
5. Demonstrate use of heat transfer in a complex tubes and channels.

<table>
<tr><th colspan="4">COURSE CONTENT</th></tr>
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<tr><td>Lectures:</td><td>3 hours/week</td><td>End semester exam (ESE):</td><td>60 marks</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Duration of ESE:</td><td>03 hours</td></tr>
<tr><td>Internal Sessional Exams (ISE):</td><td>40 marks</td></tr>
</table>

Unit–I:	No. of Lectures: 09 Hours	Marks: 12

Philosophy of computational fluid dynamics, conservation principles of mass, energy, and momentum, simplified flow models such as incompressible, potential and creeping flows, classification of flows.
Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Turbulence models, Mixing length model, The k-e model, Algebraic stress equation models. Grid Generation: Structured and unstructured grids, choice of grid, general transformation of equations, some modern developments in grid generation in solving the engineering problems. Finite Difference Method.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Discretization of ordinary and partial differential equations, approximation of first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Discretisation methods, approximations of surface integrals and volume integrals, interpolation and differentiation practices, implementation of boundary conditions, applications to the engineering problems. One-dimensional unsteady heat conduction.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Flow in a sudden pipe contraction / expansion, flow and heat transfer in a complex tubes and channels, reactive flow, multiphase flow, and turbulent flow processes.

Text Books:

1. Anderson Jr J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill. 1995.
2. Muralidhar K. and Sundararajan T. "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, 2003.
3. H. K. Versteeg and W. Malalasekera, "An introduction to computational fluid dynamics: the finite volume method", Longman scientific & technical publishers, 2007.
4. Ranade V. V, "Computation Flow Modeling for Chemical Reactor Engineering", Academic Press. 2002.

Reference Book:

Ferziger J. H. and Peric M., "Computational Methods for Fluid Dynamics", Third Edition, Springer, 2002.

Open Elective Course – III					
Plant Utility					
COURSE OUTLINE					
Course Title:	**Plant Utility**	**Short Title:**	**PU**	**Course Code:**	

Course description:

This course covers the requirement of different utilities for the process plant, along with its generation and its effective utilization. Main utilities required for processes are water, steam, air and refrigeration. Steam and non- steam heating media are important for conversion of raw material to products in reactors and to elevate the temperature in the chemical processes. Refrigeration is important to maintain the temperature in the process plant. Compressed air, process air is used in processes & in instrument air is used in pneumatic devices & controls.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Fluid Mechanics, Applied Physics I & II, Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II.

Course objectives:

1. To learn steam generation and its application in chemical process plants.
2. To accustom with types of compressors and vacuum pumps & method of vacuum development.
3. To understand characteristics of refrigeration system& production of liquid N_2 and O_2.
4. To understand insulation for meeting the process equipment requirement.
5. To study Properties, use, Sources and methods of generation of inert gases.

Course outcomes:

After successful completion of this course the student will be able to:

1. Display the skill of steam generation and its application in chemical process plants.
2. Exhibit the knowhow about types of compressors and vacuum pumps & method of vacuum development.
3. Analyzed characteristics of refrigeration system& production of liquid N_2 and O_2.
4. Demonstrate use of insulation for meeting the process equipment requirement.
5. Identify formulating, designing and providing the various properties, use, sources and methods of generation of inert gases.

COURSE CONTENT

Plant Utility		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 09 Hours	Marks: 12

Steam: Steam generation and its application in chemical process plants, Design of efficient

steam heating systems, Steam economy, condensate utilization, steam traps, Selection and application, waste heat utilization.		
Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**
Compressors And Vacuum Pumps: Types of compressors and vacuum pumps, Methods of vacuum development and their limitations, Materials handling under vacuum, piping systems, Lubrication in compressors and pumps.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Refrigeration Systems: Refrigeration system and their characteristics, cryogenics, the characteristics and production of liquid N_2 and O_2. Load calculation, humidification and de-humidification equipments. Drying and cooling tower.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Insulation: Importance of insulation for meeting for the process equipment .Fitting and valves Insulation for high, intermediate, low temperatures .Determination of optimum insulation thickness.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Inert Gases: Properties of inert gases & their use, Sources and methods of generation. Comparison of nitro generation routes .Operational, maintenance and safety aspects.		

Text Books:

1. Jack Broughton, Process utility systems, Institution of Chemical Engineers U.K.
2. Reid, Prausnitz Poling; The properties of gases & liquids, Fourth edition, McGraw Hill international edition.
3. S.C. Arora& S. Domkumdwar; A course in refrigeration and air conditioning; Dhanpat Rai & Co. (P) Ltd.
4. Stoccker, W.F., Refrigeration and Air Conditioning, Mc-Graw Hill, 1983.
5. Jorgenson, R., Fan Engineering, Buffalo Rorge Co., 1983.

Reference Book:

Lyle, O., Efficient Use of Steam, HMSO, 1974.

Open Elective Course – III

Solar Power

COURSE OUTLINE

Course Title:	**Solar Power**	**Short Title:**	**SP**	**Course Code:**	

Course description:

This course describes the photovoltaic (PV) systems, Solar energy potential for PV, Solar cell arrays, PV modules, PV generators, Energy storage alternatives for PV systems. It also covers Power conditioning and maximum power point tracking (MPPT) algorithms and Feasible operating region of inverter at different power factor values for grid-connected systems.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Fluid Mechanics, Applied Physics I & II, Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. Provide an introduction to various PV systems and their components.
2. Explain operation of modules and electrical characteristics.
3. Describe common installation methods on various surfaces.
4. Explain the theory of both grid-connected and off-grid systems.
5. Size and design multiple grid-connected PV systems.

Course outcomes:

After successful completion of this course the student will be able to:

1. Demonstrate the feasibility of PV systems as an alternative to the fossil fuels.
2. Exhibit the knowledge of applying modules in solar power generation.
3. Analyze grid-connected and off-grid systems.
4. Apply design parameters in various photovoltaic systems.
5. Work in a team to develop projects involving complete design and construction of a stand-alone PV system.

COURSE CONTENT

Solar Power		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to photovoltaic (PV) systems. Historical development of PV systems. Overview of PV usage in the world, Solar energy potential for PV, irradiance, solar radiation and spectrum of sun, geometric and atmospheric effects on sunlight, Photovoltaic effect, conversion of solar energy into electrical energy, behavior of solar cells, Solar cells, basic structure and characteristics: Single-crystalline, multicrystalline, thin film silicon solar cells, emerging new technologies.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Electrical characteristics of the solar cell, equivalent circuit, modeling of solar cells including the effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current, Solar cell arrays, PV modules, PV generators, shadow effects and bypass diodes, hot spot problem in a PV module and safe operating area. Terrestrial PV module modeling, Interfacing PV modules to loads, direct connection of loads to PV modules, connection of PV modules to a battery and load together.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Energy storage alternatives for PV systems. Storage batteries, lead-acid, nickel-cadmium, nickel-metal-hydride and lithium type batteries. Small storage systems employing ultracapacitors, charging and discharging properties and modeling of batteries.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Power conditioning and maximum power point tracking (MPPT) algorithms based on buck- and boost-converter topologies Maximum power point tracking (MPPT) algorithms, Inverter control topologies for stand-alone and grid-connected operation. Analysis of inverter at fundamental frequency and at switching frequency.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Feasible operating region of inverter at different power factor values for grid-connected systems, Stand-alone PV systems. Consumer applications, residential systems, PV water pumping, PV powered lighting, rural electrification, etc., Grid-connected (utility interactive) PV systems. Active power filtering with real power injection, Modeling and simulation of stand-alone and grid-connected PV systems.

Text Books:

1. R. Messenger, J. Ventre, Photovoltaic Systems Engineering, 2nd ed., CRC Press, 2004.
2. M. R. Patel, Wind and Solar Power Systems, CRC Press, 1999.

Reference Books:

1. A. Goetzberger, V. U. Hoffmann, Photovoltaic Solar Energy Generation, Springer-Verlag, 2005.
2. L. Castaner, S. Silvestre, Modeling Photovoltaic Systems Using PSpice, John Wiley & Sons, 2002.
3. R. J. Komp, Practical photovoltaics: electricity from solar cells, 3rd ed., Aatec Publications, 2001.
4. R. H. Bube, Photovoltaic Materials, Imperial College Press, 1998.
5. T. Markvart, Solar Electricity, John Wiley & Sons, 1994.

Open Elective Course – III					
Enzyme Engineering					
COURSE OUTLINE					
Course Title:	**Enzyme Engineering**	**Short Title:**	**ENZE**	**Course Code:**	

Course description:

This course is introduced for learning the basic fundamentals of Enzyme Engineering to undergraduate students. The goals of the course are to understand the basic knowledge of Enzymes, their classification, production, purification and Immobilization to be use in different areas

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. Get knowledge of enzyme & its classification & its role in metabolic pathway of living systems.
2. Will get knowledge of enzyme kinetics and its application in production of desired products.
3. Ability to design and conduct experiments to analyze and interpret enzyme kinetic data for the design of enzyme reactor for production of value added products.
4. Get knowledge of various analytical techniques for characterization of enzymes.
5. Get knowledge of application of enzymes in various industries used for the manufacturing of Bioproducts for the welfare of society.

Course outcomes:

After successful completion of this course the student will be able to:

1. Classify enzymes on the basis of their working mechanism.
2. Calculate the enzyme kinetics and activity by performing various assays.
3. Characterize the enzymes by using modern equipments.
4. Immobilize enzyme by various immobilization techniques for better stability and activity as well as to reduce their losses during use.
5. Apply molecular mechanism of various enzymes in different metabolic pathways.

COURSE CONTENT			
Enzyme Engineering		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Enzymes:

Classification, nomenclature, International units and types of enzymes, General characters of enzymes: characters such as specificity, catalysis and regulation and localization of enzymes in the cell, Structure of enzymes: Primary, secondary and tertiary structure of enzyme, Models of enzyme activity: Lock and key model, Induced fit, Substrate Strain model. Isoenzyme, with example and its application.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Enzyme Kinetics:
Introduction to kinetics: activation energy, transition state theory and energy, consideration, Enzyme kinetics, rate equation, Rate of reaction, First order and second order reaction, Michaelis – menten equation (Steady state kinetics) and Haldane relationship, Significance of Km, Lineweaver – Burk or Double – reciprocal plot, Eadie- Hofstee plot, Hanes plot, Turnover number, Specificity constant, Bisubstrate reaction.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Enzyme inhibition, its kinetics and Catalysis:
Types of inhibition- Reversible and irreversible inhibition, Kinetics of inhibition. Catalytic efficiency- proximity and orientation effects, distortion or strain, Different mechanisms of enzyme catalysis, acid base and covalent catalysis and metal-ion catalysis, Molecular mechanism of action of chymotrypsin, Lysozyme, Chemical modification of enzymes, Bisubstrate or Multisubstrate reaction: Ping – Pong mechanism, sequential mechanism.

Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**

Allosteric and regulatory enzyme, enzyme production and purification:
Binding of ligands to Protein, Co-operativity models- MWC and KNF model, Regulations by allosteric enzymes, other mechanisms of enzyme regulation-enzyme induction and repression and covalent modification. Sources of enzymes-animal plant and microbial sources, large scale production of enzymes- basic methodology of production, extraction and purification of enzymes, Enzyme production and recombinant DNA technology.

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Enzyme immobilization and Enzyme applications:
Methods of immobilization - ionic bonding, adsorption, covalent bonding (based on R groups of amino acids), and microencapsulation and gel entrapment, Properties of immobilized enzymes, Applications of immobilized enzymes. Applications of enzymes in food, sugar, leather, detergent industries etc., Uses of enzymes in drug, medicine, industries, Uses of enzymes to make amino acids and peptides, Legislative and safety aspects.

Text Books:

1. Lehninger, Nelson and cox. Principles of Biochemistry –Macmillan publishers.
2. Palmer, Enzymes, Oxford University press.

Reference Books:

1. Voet and Voet, Biochemistry, Wiley publisher.
2. Biotol series, Principles of Cell energetics , Butterworth- Heinemann Ltd, Jordan Hill, Oxford.
3. Biotol Series, Principles of enzymology and its application, Butterworth- Heinemann Ltd,Jordan Hill, Oxford.
4. Murray moo-young, Comprehensive Biotechnology Pergemon Press(Vol 2)

5. Nicholascprice and Tewis stereous, Fundamentals of Enzymology, Oxford University press.
6. Michael L. Shuler, Fikret Kargi, Bioprocess Engineering, Basic concepts, Prentice Hall India Pvt. Ltd., New Delhi.

Open Elective Course – III
Internet of Things
COURSE OUTLINE

Course Title:	**Internet of Things**	**Short Title:**	**IOT**	**Course Code:**	

Course description:

This course develops a foundation of concepts and solutions that supports the project planning & management concepts. Describe how to managing development of project by applying project management concepts. Project risk management provides students with an organized approach for managing the uncertainties that can lead to undesirable project outcomes. Course topics include: Project procurement management and post project analysis.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Introduction to Computer Programming.

Course objectives:

1. Understand about internet of things and design principles for connected devices.
2. Learn the design principles for web connectivity and internet connectivity principles.
3. Accustom about data acquiring, organizing, processing and analytics and data collection, storage and computing using cloud platform.
4. Display the skill about sensors, participatory sensing, RCIDs, and wireless sensor networks and prototyping the embedded devices for IoT and M2M.
5. Identify formulating, providing the prototyping and designing the software for LoT applications and LoT privacy, security and vulnerabilities solutions.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the design principles for connected devices.
2. Understand the design principles of Internet connectivity.
3. Analyze the concepts of knowledge acquiring, managing and storing.
4. Understand the wide variety of sensors.
5. Design the software for IoT applications.

COURSE CONTENT

Internet of Things		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Internet of Things: An Overview: Internet of Things, IoT Conceptual Framework, IoT Architectural View, Technology Behind IoT, Sources of IoT, M2M Communication, Examples of IoT.

Design Principles for Connected Devices: IoT/M2M Systems Layers and Designs Standardization, Communication Technologies, Data Enrichment, Data Consolidation and Device Management at Gateway, Ease of Designing and Affordability.		
Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**
Design Principles for Web Connectivity: Web Communication Protocols for Connected Devices, Message Communication Protocols for Connected Devices, Web Connectivity for Connected-Device a Network using Gateway, SOAP, REST, HTTP RESTful and Web Sockets. **Internet Connectivity Principles**: Internet Connectivity, Internet-Based Communication, IP Addressing in the IoT, Media Access Control, Application Layer Protocols: HTTP, HTTPS, FTP, Telnet and Others.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Data Acquiring, Organizing, Processing and Analytics: Data Acquiring and Storage, Organizing the Data, Transactions, Business Processes, Integration and Enterprise System, Analytics, Knowledge Acquiring, Managing and Storing Processes. **Data Collection, Storage and Computing Using Cloud Platform:** Cloud Computing Paradigm for Data Collection, Storage and Computing, Everything as a Service and Cloud service Models, IoT Cloud-Based Services using the Xively, Nimbits and Other Platforms.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Sensors, Participatory Sensing, RCIDs, and Wireless Sensor networks: Sensor Technology, Participatory Sensing, Industrial IoT and Automotive IoT, Actuator, Sensor Data Communication Protocols, Radio Frequency Identification Technology, Wireless Sensor Networks Technology. **Prototyping the Embedded Devices for IoT and M2M:** Embedded Computing Basics, Embedded Platforms for Prototyping, Things Always Connected to the Internet/Cloud.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Prototyping and Designing the software for IoT Applications: Prototyping Embedded Device Software, Devices, Gateways, Internet and Web/Cloud Services Software-Development, Prototyping Online Component APIs and Web APIs. **IoT Privacy, Security and Vulnerabilities Solutions:** Vulnerabilities, Security Requirements and Threat Analysis, Use Cases and Misuse Cases, IoT Security Tomography and Layered Attacker Model, Identity Management and Establishment, Access Control and Secure Message Communication, Security Models, Profiles and Protocols for IoT.		
Text Book:		
Raj Kamal, “Internet of Things: Architecture and Design”, McGraw Hill.		
Reference Book:		
Jeeva Jose, “Internet of Things”, Khanna Publishing House, Delhi.		

Process Control Lab					
LAB COURSE OUTLINE					
Course Title:	**Process Control Lab**	**Short Title:**	**PC Lab**	**Course Code:**	
Course description:					
This course illustrates practical aspect of process control and its application to chemical engineering. It describes various systems used in process control.					

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	2	14	28	1

End Semester Exam (ESE) Pattern:	**Practical (PR)**

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To study the dynamic behavior of first order system.
2. To study the dynamic behavior of second order system.
3. .To understands various controllers.
4. To provide the students with fundamental theoretical concepts and practical analysis skills associated with process control devices.
5. To understand closed loop control system.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Apply the knowledge of control theory for understanding the various processes, carried out in the Chemical Engineering Industry.
2. Demonstrate their ability of understanding the process control and its application by virtue of experimentation.
3. Apply the knowledge of first order control system.
4. Apply the knowledge of second order control system.
5. Apply the knowledge of Final Control Element system.

LAB COURSE CONTENT

Process Control Lab		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. Dynamic behavior of Mercury Thermometer.
2. Dynamic behavior of Single Tank system.
3. Dynamic behavior of C.S.T.R.
4. Dynamic behavior of two tank non-interacting system.
5. Dynamic behavior of two tank interacting system.
6. Dynamic behavior of Mercury Manometer Second order system.

7. Dynamic behavior of Final Control Element.
8. Study of Controllers.
9. Study of closed loop control system.
10. Study of flow, temperature and pressure control systems.

Text Books:

1. George Stephanpolous, Chemical Process Control, Prentice Hall of India.
2. D.R. Coughnour, Process System Analysis and Control, McGraw-Hill.
3. R.P. Vyas, Process Control & Instrumentation (2nd edition). Central Techno publication, Nagpur.

Reference Book:

Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.

Guidelines for ESE: End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

<table>
<tr><td colspan="6">Instrumentation and Control Lab</td></tr>
<tr><td colspan="6">LAB COURSE OUTLINE</td></tr>
<tr><td>Course Title:</td><td>Instrumentation and Control Lab</td><td>Short Title:</td><td>IC Lab</td><td>Course Code:</td><td></td></tr>
<tr><td colspan="6">Course description:</td></tr>
<tr><td colspan="6">This course describes the importance of instrumentation in the field of chemical engineering. By instrumental analysis, different materials and their properties can be studied and measured which provides characterization of raw materials and finished products from the industry.</td></tr>
</table>

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	2	14	28	1

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To expertise the students in handling laboratory instruments with due care & precautions.
2. To train the students in calibration of instruments.
3. To develop analytical skills in students through instrumental techniques.
4. To understand use chromatography.
5. To accustom refractive index.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Develop expertise in handling laboratory instruments with due care & precautions.
2. Deliver the skill in calibration of instruments.
3. Demonstrate analytical skills in students through instrumental techniques.
4. Understand use chromatography.
5. Evaluate refractive index.

LAB COURSE CONTENT

Instrumentation and Control Lab		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed)

1. To study the response of bimetallic thermometer.
2. To study the response of thermocouple.
3. To measure the pH of given solution.
4. To measure the conductance of given solution.
5. To investigate the conductometric titration of strong acid and strong base.
6. To determine concentration of given solution by colorimeter.
7. To study separation of components present in given mixture by thin layer chromatography.
8. To study separation of components present in given sample by paper chromatography.

9. To determine refractive index of liquids by Abbey's refractometer.
10. To identify the given sample by FTIR.

Text Book:

Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Book:

Patranabis D. Industrial Instrumentation, Tata – McGraw Hill Publications, New Delhi.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal.

Guidelines for ESE:

End Semester Examination shall be based on practical / oral evaluation of student performance and practical / assignments submitted by the student in the form of journal.

Project (Stage - I)

LAB COURSE OUTLINE

Course Title:	**Project (Stage – I)**	**Short Title:**	**PROJ-SI**	**Course Code:**	

Course description:

Project (Stage-I) represent the culmination of study towards the Bachelor of Engineering degree. The project (Stage-I) offers the opportunity to apply and extend material learned throughout the program. The emphasis is necessarily on facilitating student learning in technical, project management and presentation spheres.

Laboratory	Hours/week	No. of weeks	Total hours	Semester credits
	12	**14**	**168**	**6**

End Semester Exam (ESE) Pattern:	**ORAL (OR)**

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To understand the basic concepts & broad principles of projects.
2. To understand the value of achieving perfection in project implementation & completion.
3. To apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach.
4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.
5. To develop ability of extracting the material from the different sources and writing comprehensively and exhaustive report on an allotted topic.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate a sound technical knowledge of their selected project topic.
2. Undertake problem identification, formulation and solution.
3. Design engineering solutions to complex problems utilizing a systems approach.
4. Conduct an engineering project.
5. Demonstrate the knowledge, skills and attitudes of a professional engineer.

LAB COURSE CONTENT

Project (Stage – I)		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme:**	
		End semester exam (ESE):	**50 marks**
Practical:	**12 hours/week**	**Internal Continuous Assessment (ICA):**	**50 marks**

At final year the students shall carry out a project (Stage-I) in a group of maximum up to 5 students. The project work spans both the semesters. By the end of Semester – VII the students shall complete the partial work, and by the end of Semester – VIII the students shall complete remaining part of the project. Assessment for the project shall also include presentation by the students. Each teacher can guide maximum 04 groups of projects.

The students should take project work, as specified in the curriculum, based on the knowledge acquired by the students during the degree course till Semester – VI. The project may be either fully theoretical / practical or involving both theoretical and practical work to be assigned by the Department. The work may also be Study / Survey / Design.

Project (Stage – I) may involve literature survey, problem identification, design methodology, collection of data etc. The project work shall involve sufficient work so that students get acquainted with different aspects of design and analysis. Approximately more than 50% work should be completed by the end of Semester – VII. Each student group should submit partial project report in the form of thermal bound at the end of Semester –VII.

Each student group is required to maintain separate log book for documenting various activities of the project.

Suggestive outline for the partial project report is as follows.

Abstract

Chapter 1. Introduction

Chapter 2. Literature Survey

Chapter 3. Methodology

Chapter 4. Results & Discussion

Chapter 5. Conclusion

Bibliography/ References

Index

Appendix

Guide lines for ICA:

The Internal Continuous Assessment (ICA) for project shall be based on continuous evaluation of students' performance, active participation, knowledge / skill acquired throughout semester and presentation by the students. The assessment shall be done jointly by the guide and departmental committee. A three-member departmental committee including guide, appointed by Head of the department, shall be constituted for the assessment. The assessment for Project (stage – I) in Semester – VII shall be as per the guidelines given in Table – A.

Table – A

		Assessment by Guide					Assessment by Departmental Committee		
Sr. No.	Name of the Student	Attendance / Participation	Problem Identification / Project Objectives	Literature Survey	Methodology / Design	Report	Depth of Understanding	Presentation	Total
	Marks	5	5	5	5	5	10	15	50

Guidelines for ESE:

In End Semester Examination (ESE), the student may be asked for presentation / demonstration and questions on Project. Evaluation will be based on answers given by students in oral examination.

Essence of Indian Traditional Knowledge

Course objective:
The course aims at imparting basic principles of thought process, reasoning and inferencing, sustainability is at the core of Indian traditional knowledge system connecting society and nature. Holistic life style of yogic science and wisdom capsules in Sanskrit literature are also important in modern society with rapid technological advancements and societal disruptions. The course focuses on introduction to Indian knowledge systems, Indian perspective of modern scientific world-view, and basic principles of yoga and holistic health care system, Indian artistic tradition.

Outcomes:
Ability to understand, connect up and explain basics of Indian traditional knowledge in modern scientific perspective.

Course Contents:
Introduction to:
1. Ayurveda, Charaka Samhita, Sushruta Samhita
   Principles and Terminology: Vatha, Pitha, Kapha, Ether, Earth, Water, fire and Air Tatva, Influence of these on human health.
2. Architecture: Temple Architecture, Indo – Islamic Architecture, Mughal Architecture, Indian Rock Cut Architecture, Vastu Shastra.
3. Importance of Yoga for Physical and Mental health, Yoga Sutras of Patanjali, Meditation, International day of Yoga.
4. Indian Classical Music, Hindustani and Carnatic Music, Raga, Tala, Dhrupad, Khyal, Tarana and Thumri, Sangitaratnakara, Work of Tansen, Purandara Dasa, Bhimsen Joshi, Ustad Bismillah Khan, Bal Gandharva etc.
   Folk Music and Dances such as Rajasthani, Marathi, Gujrati, Punjabi etc.
5. Indian Classical Dances: Shastriya Nritya, Natya Shastra, Bharatanatyam, Kathak, Kuchipudi, Odissi, Kathakali, Sattriya, Manipuri, Mohiniyattam and Chhau dance forms.

References:

1. Amit Jha, “Traditional knowledge system in India”, Atlantic Publisher, ISBN 978812691223
2. Basanta Kumar Malhotra, “Traditional Knowledge System and Technology in India”, Pratibha Prakashan, ISBN 8177-023101
3. Nitin Singhania, “Indian Art and Culture”, McGraw Will Publication.
4. Dr. Bramhand Tripathi, “Charak Sanhita”, Chaukhambha Surbharti Prakashan, ISBN: 9381-4847-59
5. Dr. Anantram Sharma, “Sushrut Samhita”
6. Valiatham M.S., “An Introduction to Ayurveda” Orient Bkackswan Publication.
7. Valiathan M.S., “The legacy of Charaka” University Press.
8. Valiathan M.S., “The legacy of Susruta” University Press.
9. Garg Maheshwari, “Ancient Indian Architecture”, CBS Publisher and Distributors
10. Sharmin Khan, “History of Indian Architecture”, CBS Publisher and Distributors.
11. Bindia Thapar, Surat ku. Manto, Suparana Bhalla, “Introduction to Indian

Architecture”, Periplus Editions Ltd.
12. Vijay Prakash Singh, “An Introduction to Hindustani Classical Music”, Lotus Publisher
13. Leeta Venkataraman, Avinash Pasricha, “Indian Classical Dance” Lustre Publisher
14. Shovana Narayan, “Indian Classical Dances” New Dawn Press
15. Kapila Vatsyayan, “Indian Classical Dance”, Ministry of Information and Broadcasting, Govt of India.
16. Mahadevan Ramesh, “A Gentle introduction to Carnatic Music”, Oxygen books Publisher.

KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Final Year Engineering

(Chemical Engineering)

Faculty of Science and Technology

कवयित्री बहिणाबाई चौधरी उत्तर महाराष्ट्र विद्यापीठ

अंतरी पेटवू ज्ञानज्योत

1990

'A' Grade

NAAC Re-Accredited

3rd Cycle

B.E. Chemical Engineering Syllabus

W.E.F. 2020 – 21

Semester – VIII

Process Technology and Economics					
COURSE OUTLINE					
Course Title:	**Process Technology and Economics**	**Short Title:**	**PTE**	**Course Code:**	

Course description:

The purpose of this course is to equip the students with fundamental concepts and principles of manufacturing, through the economical and environmental friendly conversion of raw materials into industrially important chemical products.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
Lecture	03	14	42	04

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To familiarize students with manufacturing aspects of industrially relevant chemicals.
2. To know the basics of manufacturing of useful inorganic chemical products.
3. To identify the engineering problems encountered during production of chemicals with achievable best appropriate solutions.
4. To learn the various components of cost of production and their estimation.
5. To develop the knowledge of students about Analysis of Projects.

Course outcomes:

After successful completion of this course the student will be able to:

1. Describe sources and processes of manufacture of various industrially important chemicals.
2. Draw block diagrams/ process flow diagrams of the processes used for manufacture of industrially important inorganic chemicals.
3. Identify the major engineering problems involved in manufacturing and provide best possible solutions for the same.
4. Explain and calculate economic aspects of Projects involved in manufacturing of Chemical
5. Analyze the projects through economical evaluation of manufacturing practices.

COURSE CONTENT

Process Technology and Economics		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for the manufacture of important chemicals from chlor-alkali industries: Soda ash, Sodium bicarbonate ,caustic soda, Chlorine , Bleaching powder, calcium hypochlorite, sodium hypochlorite, sodium chlorite

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Nitrogen industries & inorganic acids: Synthetic ammonia process for ammonia production, Nitric acid, Ammonium nitrate, Urea, Hydrochloric acid manufacture. Sulfur industries: Manufacture of elemental sulfur by Frasch & Finnisch process, production of sulfuric acid.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Phosphorous Industries: Elemental phosphorous, Wet process & electric furnace process for phosphoric acid production, Manufacturing of ammonium phosphate, Baking powder, Manufacturing of Superphosphate & Triple Superphosphate, Notrophosphates, sodium phosphate, Fire retardant chemicals		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Coal & Coal Chemicals: coal as energy source, nature & occurrence of coal, mining , uses of coal, Coking of coal, gasification of coal, hydrogenation of coal, distillation of coal tar:, methods & products of distillation, Uses of coal tar, Fuel Cells: Principle& Efficiency of Fuel cells, Kinds of Fuel cells & advantages of Fuel cells.		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to project cost and cost of production, Various components of cost of production and their estimation, Various components of project cost and their estimation. Estimation of working capital. Analysis of working results project: Balance sheets, Project financing, concept of interest, time value of money, depreciation. Profitability Analysis of Projects		

Text Books:

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984.
2. M. Gopala Rao, Marshall Sittig, Dryden's Outlines of Chemical Technology, , East West Press, 1997.
3. Mahajani V. V. and Mokashi S M., Chemical Project Economics, MacMillan India Ltd. 2005.
4. Max Peters, Klaus Timmerhaus, Plant Design and Economics for Chemical Engineers, Ronald West, McGraw Hill International Edition, 2013.

Reference Book:

Chemical Process Technology, Moulijn, M. and van Dippen, Wiley, 2013.

Professional Elective Course – V					
Chemical Plant Design and Project Engineering					
COURSE OUTLINE					
Course Title:	**Chemical Plant Design and Project Engineering**	**Short Title:**	**CPDPE**	**Course Code:**	

Course description:

This course describes to use appropriate terminology of chemical plant design and project engineering for possible commercialization of chemical plant. It illustrates role of chemical engineer in chemical plant design aspects with the project engineering.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Process Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To learn the role of Chemical Engineer in Chemical Plant Design and Development of the project.
2. To understand the Process Design : Choice of process continuous Vs. Batch processing Process Equipments and Materials Selection Scale up method and development of process flow sheet.
3. To display skill of the Plant Layout and Location of Chemical Plant.
4. To study the Site preparations and Structures and New Development in Management techniques (PERT & CPM).
5. To comply requirement of the Process Auxiliaries.

Course outcomes:

After successful completion of this course the student will be able to:

1. Exhibit the role of Chemical Engineer in Chemical Plant Design and Development of the project.
2. Apply requisite skill of the Process Design: Choice of process continuous Vs. Batch processing Process Equipments and Materials Selection Scale up method and development of process flow sheet.
3. Develop the Plant Layout and understand about Location of Chemical Plant.
4. Understand the Site Preparations and Structures requires in the chemical industry and adopting the tool of management for planning, scheduling and controlling like PERT and CPM network analysis
5. Demonstrate use of the Process Auxiliaries for reducing the cost of piping with overall safety for the sustainable plant design.

COURSE CONTENT			
Chemical Plant Design and Project Engineering		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**

		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to Chemical Engineering Plant Design and Project Engineering. The role of Chemical Engineer in Chemical Plant Design. Chemical Engineering Design, need for Plant Design, Process Design.
Development of the project: Evaluation of a process, process research, research evaluation, process development, preliminary engineering studies, pilot plant, semi-commercial plant, commercial plant and commercial plant design factors.
Technical factors, economic factor, safety considerations, legal phases, sources of information.

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Process Design: Choice of process continuous Vs. Batch processing.
Process Equipments and Materials: Selection of Materials, Plan for Selection of Materials.
Selection of Process Equipments, Equipment selection procedures, standard versus special equipment. Scale up method, types of flow sheet, development of process flow sheet from process information.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Plant Layout : Introduction, planning-layout, factors in planning-layout, methods of layout planning, area concept, two dimensional layouts, scale models, principles of plant layout, safety, utilities & material handling equipments , railroads and roads, etc. Plant layout for Benzene Hexachloride process.
Locating the Chemical Plant: Introduction, summary of factors in plant location. Economic location, plant location factors, raw material supply, market and transportation, power and fuel, water supply, temperature, plant measures for conservation of water, legal restriction, federal pollution act, climate, labour, community and site characteristics and waste disposal.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Site preparations and Structures: Introduction, Site Preparation, Surface Evaluation, Foundation and Shape of Foundation, Machinery and Equipment Foundations, Supports, Outdoor Plants, Selection Building types, Building design principles, Flooring , walls, Roof, safety and higher protection conditioning , heating and ventilation. Cost Consideration for Plant Sites and Structures
New Development in Management techniques (PERT & CPM).

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Process Auxiliaries : Introduction, Piping, Explanation of CODES, Selection of Piping, Pipe strength, Wall thickness, Nominal Pipe Size (NPS), Criteria for Selection of Materials, Pipe sizing by ID, Choosing the final pipe size, Process steam piping, piping layout, piping insulation, methods of providing flexibility for piping.

Text Books:

1. F.C. Vilbrandt and C.E. Dryden, “Chemical Engineering Plant Design”, McGraw Hill, New Delhi.
2. Peter M. S. and K.D. Timmerhaus, “Plant Design and Economics for Chemical Engineers”, McGraw Hill.

3. Modes J. and Philips, Rheinhold, Project Engineering with CPM and PERT, Van Nostrand Reinhold Co., 1970
Reference Book:
Perry's Chemical Engineer's handbook, McGraw-Hill: New York, 2008

Professional Elective Course – V					
Piping Design					
COURSE OUTLINE					
Course Title:	**Piping Design**	**Short Title:**	**PIPD**	**Course Code:**	

Course description:

Piping design course is structured to raise the level of expertise in piping engineering and to improve the competitiveness in the present scenario of industries. This course provides various know how of piping system designs, development skills and knowledge of current trends of plant layout.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To accustom the role of piping engineer and the scope of piping engineering.
2. To understand criteria for selection of pipe joints.
3. To learn the types of valves, the constructional features criteria for selection and pressure relieving devices.
4. To develop the skill about the pipe rack spacing, drawing and the piping systems for plant utilities.
5. To display skill about the PFD, P&ID and utility flow diagram.

Course outcomes:

After successful completion of this course the student will be able to:

1. Demonstrate of the role of chemical engineer as piping engineer, the scope.
2. Exhibit skill of selection of the various pipes joint.
3. Apply requisite skill of the Design calculations involved like frictional losses and pressure drops, various valves to be used.
4. Develop piping system with their construction features, piping supports for utilities pipeline.
5. Demonstrate skill of how to draw drawings like PFD, P&ID and Utility flow diagram.

COURSE CONTENT

Piping Design		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Role of piping engineer, Scope of piping engineering, Responsibilities of piping engineer, Inputs received by piping engineers and output given by them, Interactions of piping engineers with other disciplines such as process engineering, instrumentation engineering etc.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Pipes and pipe fittings – standards and specification, steel pipes, steel pipe fittings, cast iron pipes, cast iron fittings, joining of cast iron pipes, tubes of other materials, design of flanges and flange joints.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Types of Valves, Control Valves, Safety Valves, Constructional features, Criteria for selection, Piping components, Safety valves and other pressure relieving devices, Constructional features, Selection criteria.

Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**

Pipe Rack Spacing, Drawing pipe in the rack, Pipe insulation shoes, Pipe guides, Pipe Flexibility, Pipe Supports, Field supports, Dummy supports, Hanger rods, Spring hangers, Pick-up pipe supports, Plant utilities, Control valve manifolds, Utility stations, Sewer and underground piping system**.**

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Introduction to PFD, P&ID, Utility flow diagrams, Piping symbols, Line symbols, Valve symbols, Equipment Symbols, Plant layout.

Text Books:

1. Design of Piping system, M.W. Kellogg Co. 1976 (2ndEdition).
2. G. K. Sahu, Handbook of Piping Design.
3. Sam Kannapan, P.E. Pipe Stress Analysis, Willey-Interscience Publications.
4. Roy A. Parisher, Robert A. Rhea, Pipe Drafting and Design, Gulf Professional Publishing, 3rd Edition.
5. Thakore, Bhatt, Introduction to Process Engineering and Design, Tata McGraw-Hill Education, 2007
6. D. J. Deutsch, Process piping systems, Chemical Engineering Magazine. McGraw Hill.

Reference Books:

1. M. L. Nayyar, P.E , Piping Handbook, 6 th edition, McGraw-Hill, Inc
2. Johan J McKetta, Piping Design Handbook , CRC Press, 1992.

Professional Elective Course – V					
Advanced Separation Processes					
COURSE OUTLINE					
Course Title:	**Advanced Separation Processes**	**Short Title:**	**ASP**	**Course Code:**	

Course description:

The objective of the course is to give a thorough understanding of the strategies employed for developing safe separation methods for the chemical analysis. The intention behind the course is to transmit the essential knowledge for critically evaluating the performance of an analytical procedure during chemical separations.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To introduce basics of separation processes and Mechanism of Separation.
2. To learn Azeotropic Distillation, Extractive Distillation and Reactive distillation.
3. To understand concept in super critical fluid extraction and Phase equilibria.
4. To accustom about Ultra filtration, Microfiltrations and Gas- Separations membranes.
5. To study Biochemical separation processes.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the basis of analytical separation process in terms of equilibrium and thermodynamic driving forces, and other physical chemical aspects of separations.
2. Apply distillation, extraction, and solid phase extraction for sample cleanup prior to chromatographic methods.
3. Display practical knowledge skill of experimental methods and analytical instrumentation for carrying out analytical separations using gas and liquid chromatography.
4. Exhibit appropriate skill of separation methods to the analysis of real world problems.
5. Demonstrate the use Biochemical separation processes.

COURSE CONTENT			
Advanced Separation Processes		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 09 Hours	Marks: 12

Separation Processes: Industrial Chemical Processes, Mechanism of Separation.
Separation by phase addition or creation. Separation by barrier. Separation by solid agent. Separation by external field or gradient. Component Recoveries and product purities.

Separation power. Selection of feasible separation processes.
Crystallization from the melt: Introduction.
Progressive freezing: component Separation by progressive freezing, Pertinent variables in progressive freezing. Applications.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Enhanced distillation: Introduction. Azeotropism.
Azeotropic distillation: Introduction, exploitation of homogeneous azeotropes, exploitation of pressure sensitivity, exploitation of boundary curvature, Exploitation of azeotropy and liquid
Extractive distillation: Introduction, solvent effect in extractive distillation, extractive distillation, design and optimization, solvent screening and selection extractive distillation by salt effects.
Reactive distillation: Introduction, simulation, modeling and design feasibility, Mechanical design and implementation issues, process applications.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Supercritical fluid separation processes: Introduction. Physical properties of pure supercritical fluids; thermodynamic properties and transport properties. Process concept in super critical fluid extraction. Phase equilibria: Liquid- Fluid equilibria, Solid- Fluid equilibria, Polymer-Fluid equilibria and the Glass Transition, Cosolvents and surfactants, phase equilibria models.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Ultra filtration: Process description, UF membranes, membrane characterization, process limitations, process configurations, Energy requirements, Design and economics.
Microfiltrations: process description, Examples, MF membranes, membrane characterization, process limitations, Equipments configurations, process Applications and Economics.
Gas- Separations membranes: Process descriptions, examples, Basic principles of operations, selectivity and permeability, Gas- Separation membranes, membrane system design features, energy requirements and economics.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Biochemical separation processes: Introduction.
Initial product harvest and concentration: centrifugation, Filtration, Selection of cell separation, Unit operation, Cell disruption, protein refolding.
Initial purification: Precipitation, Extraction, Adsorption, Membrane processes.
Final Purification and product formulation: Chromatography, Lyophilization and drying.
Integration of fermentation and downstream processing operations.

Text Book:

Richardson and Coulson, Chemical Engineering, Vol. II, Butterworth-Heinmann (Elsevier) (Fifth Edition).

Reference Books:

1. Perry Robert H. and Green Don W. Perry’s chemical Engineers Handbook 7th edition. McGraw Hill Publication, New York.
2. Seader J. D. and Henley Ernest J, Separation Process Principles. John Wiley and Sons, Inc,New York.
3. Ladisch Michael R., Bioseparations Engineering, Principles, Practice and Economics,

Wiley. Interscience, John Wiley and Sons, Inc. Publications New York.
4. Long Robert B. Separation Process in Waste Minimization .Marcel Dekker, Inc, New York.

Professional Elective Course – V					
Research Methodology					
COURSE OUTLINE					
Course Title:	**Research Methodology**	**Short Title:**	**RM**	**Course Code:**	
Course description:					
This course describes the fundamental of research, formulation of problem, research development. Use of mathematics and statics, and know of sampling / data collection methods. Demonstration of role of computer and research writing skills.					

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Applied Mathematics I and II.

Course objectives:

1. To understand fundamental of research and formulation of research problem.
2. To develop research design and formulation of hypothesis skills.
3. To learn the fundamental of mathematics and statics.
4. To display the skill of Sampling methods and methods of data collection.
5. To apply the Role of computer in Research and Research writing skills.

Course outcomes:

After successful completion of this course the student will be able to:

1. Demonstrate formulation of research problem on the basis fundamental of research.
2. Display about performing the task with multidisciplinary teams by identifying, formulating, designing of research and formulation of hypothesis skills.
3. Understand professional and ethical responsibilities formally and informally show the capacity of designing to meet economical and societal requirements on the basis of the fundamental of mathematics and statics.
4. Demonstrate the ability of using the skill of Sampling methods and methods of data collection.
5. Exhibit the Role of computer in Research and Research writing skills.

COURSE CONTENT			
Research Methodology		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Fundamental of Research and Formulation of research problem: Research Concept: Concept, meaning, objectives, motivation; Types of research, Research Process, Formulation of Research Task: Research problem, importance, sources, considerations, literature Review, Development of Theoretical and Conceptual framework, the formulation of objectives, Difficulties in research, Linking research to practice, Steps in research Process, Research Ethics.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Research Design and formulation of Hypothesis: Research Design: meaning, need, features of good design, Concepts relating to research design, Types of research designs (Exploratory, Descriptive, diagnostic, Experimental), Basic Principles of experimental Designs, Factors affecting research Design.
Formulation of Hypothesis: Introduction, Basic concept, procedure for Hypothesis testing, Flow diagram for Hypothesis testing, Limitations of the test of Hypotheses.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Fundamental of mathematics and Statics: Introduction, Types of Averages: The Arithmetic mean, weighted arithmetic mean, Median, Mode, geometric mean, harmonic mean, conclusion, Methods of Measuring Dispersion: the range, Mean Average deviation, standard deviation, coefficient of variation
Measurement and Scaling techniques: Measurement in Research, Scales, Source of error in Research, technique of Developing, Measurement tools, Scaling: Meaning, Classification basis for scales, Important Scaling Techniques.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Sampling methods and methods of data collection :Sampling design,: survey, implications of a sample design, Steps in Sampling design, Criteria of selecting a sampling procedure, Characteristics of a good sample design, Types of sample design,
Methods of data Collection: Collection of Primary data, Observation methods, interview methods, collection of data through questionnaires, and schedules, Case study method, social survey method, Field Study, selection of appropriate method for data collection.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Research writing in general: Report Writing: Significance, Different steps in writing report, Layout, types, Mechanics of writing a research report, Precautions, interpretation of results, Referencing, writing a bibliography, Developing an Outlines,Writing about a variable, tables, figures, conclusions, appendices.
Role of computer in Research: The computer and computer technology, important characteristics, Computer applications, Computers and researchers Software for paper formatting like LaTeX/ MS Office

Text Books:

1. Ranjit Kumar, Research Methodology: A Step-by-step Guide for Beginners", Pearson, Second Edition
2. C.R. Kothari, Research Methodology: Methods and Techniques", New age International publishers.
3. Dr. Prasant Sarangi, Research Methodology, Taxmann Publication

Reference Book:

P.L. Bhandarkar, T.S. Wilkinson, Methodology and Techniques of Social Research, Himalaya Publishing House

Professional Elective Course – VI					
Petrochemical Technology					
COURSE OUTLINE					
Course Title:	**Petrochemical Technology**	**Short Title:**	**PCT**	**Course Code:**	

Course description:

This course describes the unit operations and unit processes involved in the manufacturing various industrially important petrochemicals.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To study current status of petroleum refinery worldwide.
2. To develop knowledge of different refining processes.
3. To understand safety and pollution control aspects in the refining industries.
4. To learn general characteristics and production of ethane- ethylene-Acetylene and their derivatives.
5. To study Synthesis gas and synthetic chemicals and their applications.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the current status and challenges of petroleum refinery worldwide and in India.
2. Apply the knowledge for refining of crude oil through fractionation.
3. Display the knowledge for controlling pollution in the petrochemical refineries.
4. Understand the significance of unit operations and unit processes in manufacturing of chemicals.
5. Demonstrate techniques for the economical manufacturing of commercially important petrochemicals.

COURSE CONTENT			
Petrochemical Technology		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Petrochemical Industry in India. Feed stocks for petrochemicals, separation of aromatics.

Chemicals from methane: Manufacture of methanol, formaldehyde, acetic acid, ethylene glycol, CS2, liquid fuels from methanol, manufacture of ethanol.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12
Chemicals from ethane- ethylene-Acetylene. Ethane: Occurrence, halides of ethane, Nitroethane and oxidation of ethane. Ethylene production, production of ethylene derivatives like vinyl acetate monomer, ethylene oxide, ethylene diamine, ethanol and acetaldehyde. Chemicals from acetylene: acrylic acid, vinyl chloride, vinyl acetate and Acetonitrile.		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Chemicals from C_3, C_4 and higher carbon atoms: Products from propane. Dehydrogenation of propane and higher paraffin's. Chemicals from propylene: Isopropyl alcohol, acetone, propylene glycol, acrylic acid and ester, Phenol. Dehydrogenation of butanes. Production of Iso and n- butanol. Production of methyl –tert-butyl ether [MTBE], Adipic acid. Derivatives from hydrocarbons higher than butane.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Synthesis gas and chemicals: Synthesis gas. Steam reforming of hydrocarbons. Production of synthesis gas. Chemicals from synthesis gas. Oxo synthesis, vinyl acetate, acetic acid. Fischor- Tropsch synthesis: catalysts and the products. LPG: sources, properties grades of LPG. Supply of LPG to consumers, the storage and use of LPG.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Petroleum aromatics: Production of BTX. Benzene derivatives like Aniline, phenol, alkylation of benzene. Products from toluene: Chlorotoluenes, O- Cresols, Dinitrotoluenes, Benzaldehyde, caprolactum, Terephthalic acid.		

Text Books:

1. Bhaskararao B.K. "A Text on Petrochemicals", Khanna Publishers, New Delhi
2. Sarkar G.N. "Advanced Petrochemicals" Khanna Publishers, New Delhi

Reference Book:

Maiti Sukumar [editor],"Introduction to Petrochemicals", Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi

Professional Elective Course – VI					
Environmental Pollution and Control					
COURSE OUTLINE					
Course Title:	**Environmental Pollution and Control**	**Short Title:**	**EPC**	**Course Code:**	

Course description:

This course describes Industrial Pollution and its control by various methods such as physical, chemical and biological. It also includes information regarding Water (Prevention and Control of Pollution) Act, 1997, Air (Prevention and control of Pollution) Act, 1981.The design of water and air pollution control equipment is included in this course

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Material & Energy Balance Computations, Applied Chemistry I & II, Mass Transfer I & II, Heat Transfer, Thermodynamics I & II, Chemical Reaction Engineering-I & II.

Course objectives:

1. To study types of environmental pollution & pollution control aspects.
2. To study Water (Prevention and Control of Pollution) Act, 1997, Air (Prevention and control of Pollution) Act, 1981.
3. To study Waste Water Treatment Processes.
4. To learn about air pollution preventive and control measures.
5. To understand pollution control in chemical process industry.

Course outcomes:

After successful completion of this course the student will be able to:

1. Demonstrate the processes of pollution prevention and waste management techniques which is used in industry.
2. Display the types of processes that take place in industry and review the types of emissions that can occur.
3. Demonstrate the methods by which, water and air pollution is controlled.
4. Display solid waste management techniques.
5. Display pollution control techniques in chemical process industry.

COURSE CONTENT			
Environmental Pollution and Control		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 09 Hours	Marks: 12

Introduction ,types of pollution, water standards for potable and agricultural streams, air Standards, Environmental Legislation: Water (Prevention and Control of Pollution) Act,1997, Air (Prevention and control of Pollution) Act, 1981. Industrial Waste Water Analysis.

Industrial Gaseous Effluent Analysis.		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Air pollution - air pollutants and interaction products, preventive and control measures; Removal of particulate matter: Introduction to removal of particulate matter, Gravity settling chamber, solid traps, cyclone separators, fibre filters, fabric filters, liquid scrubbers and ESP. cyclone separators, fiber filter and ESP.		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Water pollution-waste water sampling and analysis, primary, secondary and tertiary treatment methods; Introduction to removal of BOD, Biological oxidation units: Activated Sludge Process; Trickling Biological Filters; Waste Stabilisation Ponds. Anaerobic Treatment. Numerical Examples based on removal of BOD. Removal of Chromium. Introduction to removal of Chromium. Control Methods, Reduction precipitation, Ion Exchange, Reverse Osmosis, Lime coagulation and adsorption.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Solid waste management- collection, storage and transport, processing and transformation, incineration, composting and sanitary landfilling; Removal of Mercury: Introduction of removal of mercury, Measurement of Mercury, Ventron mercury removal process. Removal of ammonia/urea: Introduction to removal of ammonia/urea, Methods for removal of nitrogen, Physico-chemical processes, Biological methods.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Pollution control in chemical process industry. Introduction to pollution control, Pollution control aspects of fertilizer industry: Introduction to pollution control in fertilizer industry. Removal of carbon in ammonia plant effluents by scrubbing with liquids using vacuum filtration, Removal of oil in ammonia plant effluents, Removal of hydrogen sulphide in ammonia plant effluents. Pollution control in petroleum and petrochemical units: Introduction Refinery Liquid based treatment methods: Oxidation pond treatment, disposal of sludges. Treatment of liquid effluents from petrochemical industries.		
Text Book:		
S.P.Mahajan "Pollution Control in Process Industries" McGraw Hill Education (India), Pvt. Ltd. New Delhi.		
Reference Books:		
M.N.Rao, H.N.Rao, Air Pollution, Tata McGraw Hill Publication.		

Professional Elective Course – VI

Water Conservation and Management

COURSE OUTLINE

Course Title:	**Water Conservation and Management**	**Short Title:**	**WCM**	**Course Code:**	

Course description:

This course will teach how to conserve this precious resource in various situations from the home environment to industry.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Applied Chemistry I & II, Introduction to Civil Engineering and Mechanics and Fluid Mechanics.

Course objectives:

1. To understand terminology used in water conservation & management.
2. To understand water flow, quality control.
3. To know about testing water and preserving water quality.
4. To learn measures for reshaping local water balance.
5. To understand treatment of water.

Course outcomes:

After successful completion of this course the student will be able to:

1. Display the knowhow of water cycle, water storage and water quality.
2. Understand methods of water conservation & management.
3. Understand analysis of water.
4. Apply skill about water flow measurement, water quality control and preventive methods
5. Display skill of treatment of water.

COURSE CONTENT

		Semester:	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction: water cycle, water storage, water quality; quantity of water, need to protect water supplies, importance of water supply, water conservation in buildings ; sources of water, water requirement for buildings ,treatment of water ,conveyance of water, water pollution control and management, water softening

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Water management-water quality, controlling use and quality of water, water flow measurement, water quality control, preventive methods, impurities in water, reasons for the analysis of water, analysis of water, physical tests, chemical tests, bacteriological test, water

borne diseases		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Testing water salinity, preserving water quality, minimising evaporation, water sanitation, suitability of water for trade purposes, drinking water standards, maintainance of purity of water, water audits; ,types of hardness, purpose of water softening, removal of temporary and permanent hardness.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Measures for reshaping local water balance, use and conservation of water resources, water conservation in agriculture,; water conservation in process industry; water conservation in construction industry; water conservation in service industry		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Treatment of water, screens, presedimentation, coagulation of water, flocculation, ,filtration of water, theories of filtration, filter sand, classification of filters, double filtration, disinfection of water, methods		
Text Book:		
S.C. Rangwala, “Water Supply and Sanitary Engineering” Charotar Publishing House Pvt. Ltd. Anand.		
Reference Book:		
Madireddi V., Subba Rao Water Conservation, Management and Analysis **,** Readworthy Publications Pvt Ltd.		

<table>
<tr><td colspan="6">Professional Elective Course – VI</td></tr>
<tr><td colspan="6">Renewable Energy</td></tr>
<tr><td colspan="6">COURSE OUTLINE</td></tr>
<tr><td>Course Title:</td><td>Renewable Energy</td><td>Short Title:</td><td>RE</td><td>Course Code:</td><td></td></tr>
<tr><td colspan="6">Course description:</td></tr>
<tr><td colspan="6">This course describes the various renewable energy sources such as solar energy, wind energy, biomass energy etc. and their applications.</td></tr>
</table>

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	14	42	3

Prerequisite course(s):

Heat transfer, Mass transfer-I and II , Applied Chemistry I & II, Applied physics I and II, Applied Mathematics I and II, Introduction to Electrical Engineering.

Course objectives:

1. To accustom concept of various forms of renewable energy.
2. To understand renewable energy sources for both domestics and industrial applications.
3. To learn the environmental and cost economics of using renewable energy sources compared to fossil fuels.
4. To identify biomass resources and energy.
5. To understand biomass conversion technologies Tidal energy; geothermal energy.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the commercial energy and renewable energy sources.
2. Analyze the working principle of various energy systems.
3 Apply tidal energy; geothermal energy knowledge.
4. Understand biomass resources and energy.
5. Demonstrate the ability for providing solutions for problems of renewable energy.

COURSE CONTENT

<table>
<tr><td colspan="2">Renewable Energy</td><td>Semester:</td><td>VIII</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="2">Examination scheme</td></tr>
<tr><td>Lectures:</td><td>3 hours/week</td><td>End semester exam (ESE):</td><td>60 marks</td></tr>
<tr><td colspan="2"></td><td>Duration of ESE:</td><td>03 hours</td></tr>
<tr><td colspan="2"></td><td>Internal Sessional Exams (ISE):</td><td>40 marks</td></tr>
</table>

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction, world energy status, current energy scenario in India, environmental aspects of energy utilization, energy and sustainable development , various forms of renewable energy, uses

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Solar energy ,basic concepts, flat plate and concentrating collectors, types, solar desalination plant design and working ,solar pumping and its applications, solar photo voltaic conversion principles and applications, solar cells and types

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Wind energy ,availability, wind power plants, wind energy conversion systems, site characteristics, types of wind turbines, applications		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Energy from biomass, biomass resources, biomass conversion technologies - direction combustion, pyrolysis, gasification, anaerobic digestion: principle and applications		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Bioethanol and biodiesel production , commercial applications ,Other Renewable Sources , Tidal energy: principle and applications, geothermal energy: principle and applications, hydroelectric energy: principle, design and applications		
Text Books:		
1. S. Rao ,Dr. B.B. Parulekar "Energy Technology" Khanna Publishers, New Delhi 2. G.D. Rai" Energy Sources" Khanna Publishers, New Delhi		
Reference Book:		
Kishore V.V.N., "Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012.		

<table>
<tr><td colspan="6">Open Elective Course – IV</td></tr>
<tr><td colspan="6">Energy Conservation and Management</td></tr>
<tr><td colspan="6">COURSE OUTLINE</td></tr>
<tr><td>Course Title:</td><td>Energy Conservation and Management</td><td>Short Title:</td><td>ECM</td><td>Course Code:</td><td></td></tr>
<tr><td colspan="6">Course description:</td></tr>
<tr><td colspan="6">This course describes the various Energy Conservation and Management methods and energy audit. The objective of the course is to apply the principles of science and engineering to understand various energy conservation acts, design waste heat recovery systems.</td></tr>
</table>

<table>
<tr><td rowspan="2">Lecture</td><td>Hours/week</td><td>No. of weeks</td><td>Total hours</td><td>Semester credits</td></tr>
<tr><td>3</td><td>14</td><td>42</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite course(s):</td></tr>
<tr><td colspan="5">Heat transfer, Mass transfer-I and II, Applied Chemistry I & II, Applied physics I and II, Applied Mathematics I and II, Introduction to Electrical Engineering.</td></tr>
<tr><td colspan="5">Course objectives:</td></tr>
<tr><td colspan="5">1. To impart basic knowledge to students about energy Conservation ,management and audit
2. To understand Indian energy conservation act, Electricity Act.
3. To learn energy index, cost index.
4. To understand material and energy balance.
5. To learn waste heat recovery.</td></tr>
<tr><td colspan="5">Course outcomes:</td></tr>
<tr><td colspan="5">After successful completion of this course the student will be able to:</td></tr>
<tr><td colspan="5">1. Learn energy conservation, management and audit.
2. Understand Indian energy conservation act.
3. Understand economics of efficient energy use and energy efficient technology.
4. Accustom waste heat recovery.
5. Demonstrate energy saving techniques.</td></tr>
</table>

<table>
<tr><td colspan="4">COURSE CONTENT</td></tr>
<tr><td colspan="2">Energy Conservation and Management</td><td>Semester:</td><td>VIII</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="2">Examination scheme</td></tr>
<tr><td>Lectures:</td><td>3 hours/week</td><td>End semester exam (ESE):</td><td>60 marks</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Duration of ESE:</td><td>03 hours</td></tr>
<tr><td>Internal Sessional Exams (ISE):</td><td>40 marks</td></tr>
</table>

<table>
<tr><td>Unit–I:</td><td>No. of Lectures: 09 Hours</td><td>Marks: 12</td></tr>
<tr><td colspan="3">Energy Conservation and Energy Management, Scope of Energy management, necessary steps of Energy Management programme, general l principles of Energy management, economy interactions, energy conservation plan.</td></tr>
<tr><td>Unit–II:</td><td>No. of Lectures: 08 Hours</td><td>Marks: 12</td></tr>
<tr><td colspan="3">Introduction, objectives of energy audit, control of energy, uses of energy, energy conservation schemes, energy index, cost index,pie chart, types of energy audit,general energy audit, sample questionnaire energy audit case studies.</td></tr>
</table>

Unit–III:	No. of Lectures: 09 Hours	Marks: 12
Energy conservation, Indian energy conservation act 2001, Electricity Act 2003, rules for efficiency, energy conservation of energy and materials, Technology for energy conservation ,design of energy conservation,energy flow network, critical assessment of energy use, formulation of objectives and constraints.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Energy management, material and energy balance, basic concepts of material and energy balance,economics of efficient energy use and energy efficient technology.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Energy management in industrial sectors, energy saving techniques, waste heat recovery, advantages of recuperators, air preheaters and economizers, microwave heating,process automation, laser beam and electron beam welding.		

Text Books:

1. U. Rathore, Energy Management, S.K.Kataria and Sons New Delhi.
2. K.V. Sharma and P. Venkataseshaiah I.K, Energy Management and Conservation, International Publishing House Ltd, New Delhi.

Reference Books:

Kishore V.V.N., “Renewable Energy Engineering and Technology”, Teri Press, New Delhi, 2012

Open Elective Course – IV					
Material Technology					
COURSE OUTLINE					
Course Title:	**Material Technology**	**Short Title:**	**MT**	**Course Code:**	

Course description:

This course provides an overview of materials science and technology as a basis for understanding how structural properties are developed and used for different types of materials.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Materials Science, Applied Chemistry I & II, Applied physics I and II.

Course objectives:

1. To review physics and chemistry in the context of materials science & engineering.
2. To describe the different types of bonding in solids, and the physical implications of these differences.
3. Give an introduction to metals, ceramics, polymers, and electronic materials in the context of a molecular level understanding of bonding.
4. Give an introduction to the relation between processing, structure, and physical properties.
5. To appraise the students about recent developments in materials science & engineering within the framework of this course.

Course outcomes:

After successful completion of this course the student will be able to:

1. Identify various crystal imperfections, deformation mechanisms, and strengthening mechanisms.
2. Demonstrate understanding of metallurgical properties of materials.
3. Interpret Iron-Iron carbide phase diagram, and different phases in microstructures of materials at different conditions.
4. Select appropriate heat treatment process for specific applications.
5. Identify effect of alloying elements on properties of steels.

COURSE CONTENT			
Material Technology		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Structure of Materials:

Introduction-classification of materials, selection of materials, imperfections properties of materials, x-ray crystallography, Bragg's law, x-ray diffraction, electron diffraction, neutron

diffraction, structure of NaCl and diamond, Crystal defects, alloy formation, solid solution types, solidification of castings, structural examination using microscopy		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Metallurgical Properties of Materials: Phase diagrams - isomorphism, eutectic, eutectoid and paratactic system. Diffusion - Fick's laws. Mechanical properties - tension test, hardness test - brinnel, vickers, rockwell, micro hardness test - shore scleroscope. Impact test, fracture - grifiths' theory, fracture toughness, embrittlement phenomena. Fatigue and creep. Strengthening mechanisms		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Types of Materials : Classification of steel, Fe-C phase diagram, heat treatment, TTT curves, ausforming, marforming, annealing types, normalizing, tempering, hardening, effect of alloying elements, tool steels, stainless steel, cast iron - malleable and ductile types and properties. Copper and its alloys - brass, bronze, copper – nickel. Aluminum and its alloys, hardening treatment. Al cladding nickel and its alloys, titanium and its alloys, cermets, welding electric and magnetic materials, nano particles and nano structures		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Physical Characteristics of Materials : Metals, semiconductors, insulators, electron theory, band theory, types of magnetism, domain structures, anisotrophy of materials, and application. Soft and hard magnets. Conductivity of materials, zone refining, crystal growth techniques		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Non-Metallic Materials : Ceramic materials - oxides, silicates. Refractories, abrasives, cement and concrete materials. Polymers – classification, reaction, types, mechanisms, deformation of polymers, mechanical, thermal, electrical and chemical behavior. Rubber, silicones, fluorocarbons, composites - FRP, particulates, and laminates		

Text Books:

1. V.Raghavan, "Materials Science and Engineering: A first course", V Edition, Prentice Hall of India, 2004.
2. Van Vlack L. H, "Elements of Materials Science and Engineering" (Addision Wesley series in metallurgy and materials engineering), VI Edition, Prentice Hall, 6th Edition, 1989.

Reference Books:

1. WF.Hosford, "Material Science", Cambridge Univ. Press, New York, 2006.
2. C.Srinivasan, "Science of Engineering Materials", John Wiley, New York, 1987.

Open Elective Course – IV

Biostatistics

COURSE OUTLINE

Course Title:	**Biostatistics**	**Short Title:**	**BST**	**Course Code:**	

Course description:

This course is a combination of both elementary probability and basic statistics with a strong emphasis on Biotechnology applications. The course coverage explores the probability; probability distributions; probability densities; curve fitting; correlation and regression; sampling distributions; inferences concerning means; inferences concerning variances; inferences concerning proportions; analysis of variance; factorial experimentation.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	14	42	3

Prerequisite course(s):

Applied Mathematics I and II.

Course objectives:

1. Students will understand the Probability distribution. Namely, Binomial, Poisson and Normal distribution are discussed which will allow them to apply to engineering problems.
2. Students will understand what is meaning of bi-variate data and correlation between them and also learn various tests, for large sample and small sample.
3. Students will learn how to fit a curve to given data and also understand meaning of sampling.
4. Students will earn to test a hypothesis based on a sample.
5. Students will learn Experimental design and 2^2 ,2^3designs.

Course outcomes:

After successful completion of this course the student will be able to:

1. Will be able to use Probability distributions effectively. Also will be able to know a given set of data will follow which distribution.
2. Will be able to calculate the mean and variance of a probability distribution.
3. Can use sampling for performing any real experiment which is otherwise very expensive
4. Will be able to use t-test, F-test and chi square test etc. for Goodness of fit to test hypothesis.
5. Able to apply Randomization to avoid confounding the variable under investigation with other uncontrollable variables.

COURSE CONTENT

Biostatistics		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Probability Distributions.

Random variables, The mean and variance of a Probability distribution, The Binomial and Poisson distributions, The Poisson's approximation to the Binomial Distribution. Continuous random variable, and Normal Distribution, Normal approximation to the Binomial Distribution.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Curve Fitting, Correlation and Regression.

The method of Least Square, Curvilinear regression (quadratic, exponential), Correlation coefficient and its properties .Regression coefficient, line of regression.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Sampling: Definitions of (population, sample, statistic, parameter, hypothesis, null hypothesis, alternative hypothesis, critical region, level of significance), Interval estimation, Confidence interval, confidence limit, Sampling, types of sampling, type-I error, type-II error. Test of sampling for single mean, two means. Hypothesis concerning one proportion, Hypothesis concerning two proportions

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Small sample test and Chi-square test

Small sample test(1.Student t-test for an assumed mean and equality of means of two populations when sample observations are independent, 2.F-test for comparison of variances of two populations,)Chi-square test for independence of attributes, Goodness of fit and homogeneity of samples

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Experimental Designs

Principles of experimental designs, Completely randomized, Randomized block and Latin square designs, Simple factorial experiments of 22,23,24,Confounding in factorial experiments (mathematical derivations not required);Analysis of variance(ANOVA)and it' s use in the analysis of RBD.

Text Books:

1. N.P. Bali and Manish Goyal, A Text Book of Engineering Mathematics
2. Gupta S. C. Fundamentals of Statistics. Himalaya Publishing House, NewDelhi
3. Khan, Biostatistics. Tata Mc Graw Hill Publishers

Reference Books:

1. Richard A. Johnson, Miller& Freund's Probability and Statistics for Engineers (Sixth Edition).
2. Jay L. Devore, Probability and Statistics for Engineers (India Edition).
3. Norman T .J .Bailey, Statistical methods in biology by (3rdEdition), Cambridge University Press (1995).
4. Daniel W.W.(9th Edn. 2009).Biostatistics: A Foundation for Analysis in the Health Sciences

Open Elective Course – IV					
Cyber Security					
COURSE OUTLINE					
Course Title:	**Cyber Security**	**Short Title:**	**CS**	**Course Code:**	

Course description:

Cyber Security course focuses on cyber threats and cyber security that provides the much needed awareness in the times of growing cybercrime episodes.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	3	**14**	**42**	**3**

Prerequisite course(s):

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Course objectives:

1. To understand Cybercrime and Cyber offenses.
2. To understand Cybercrime through portable devices.
3. To understand tools and methods used in Cybercrime.
4. To understand Phishing and Identity theft.
5. To understand Computer Forensics.

Course outcomes:

After successful completion of this course the student will be able to:

1. Determine the act of Cyber offenses.
2. Determine the Cybercrime through portable devices.
3. Determine the methods used in Cybercrime.
4. Determine Phishing and Identity theft.
5. Describe Computer Forensics.

COURSE CONTENT

Cyber Security		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme:**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to Cybercrime: Introduction, Cybercrime: Definition and Origins of the Word, Cybercrime and Information Security, Who are Cybercriminals?, Classifications of Cybercrimes

Cyber offenses: How Criminals Plan Them: Introduction, How Criminals Plan the Attacks, Social Engineering, Cyberstalking, Cybercafe and Cybercrimes, Botnets: The Fuel for Cybercrime, Attack Vector, Cloud Computing.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Cybercrime: Mobile and Wireless Devices: Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices,

Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile device related security issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Tools and Methods Used in Cybercrime: Introduction, Proxy Servers and Anonymizers,, Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Trojan Horses and Backdoors, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Overflow, Attacks on Wireless Networks		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Phishing and Identity Theft: Introduction, Phishing, Identity Theft (ID Theft) **Understanding Computer Forensics:** Introduction, Historical Background of Cyberforensics, Digital Forensics Science, The Need for Computer Forensics, Cyberforensics and Digital Evidence, Forensics Analysis of E-Mail		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Computer Forensics: Digital Forensics Life Cycle, Chain of Custody Concept, Network Forensics, Approaching a Computer Forensics Investigation, Computer Forensics and Steganography, Relevance of the OSI 7 Layer Model to Computer Forensics, Forensics and Social Networking Sites: The Security/Privacy Threats, Challenges in Computer Forensics, Special Tools and Techniques, Forensics Auditing, Antiforensics		
Text Book:		
Nina Godbole and Sunil Belapure, “Cyber Security”, Wiley India Publication, 2014		
Reference Books:		
1. Nina Godbole , Information Systems Security , Wiley India Publication 2. V.K. Pachghare, Cryptography and Information security, PHI, Second edition		

<table>
<tr><td colspan="6">Process Technology and Economics Lab</td></tr>
<tr><td colspan="6">LAB COURSE OUTLINE</td></tr>
<tr><td>Course Title:</td><td>Process Technology and Economics Lab</td><td>Short Title:</td><td>PTE Lab</td><td>Course Code:</td><td></td></tr>
<tr><td colspan="6">Course description:</td></tr>
<tr><td colspan="6">This course educates and trains the students about the fundamental aspects of process technology and economics parameters useful for them in chemical process industries.</td></tr>
</table>

<table>
<tr><td rowspan="2">Laboratory</td><td>Hours/week</td><td>No. of weeks</td><td>Total hours</td><td>Semester credits</td></tr>
<tr><td>2</td><td>14</td><td>28</td><td>1</td></tr>
<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="3">Practical (PR)</td></tr>
<tr><td colspan="5">Prerequisite course(s):</td></tr>
<tr><td colspan="5">Chemical Engineering Lab-II, Chemical Engineering Lab -III, Industrial Chemistry.</td></tr>
</table>

Course objectives:

1. To understand general design considerations involving in chemical process design and development.
2. Acquire basic understanding of design parameters, knowledge of design procedures for manufacturing of commercially important chemical products.
3. To draw process flow sheet of chemical products
4. To identify major engineering problems involved during manufacturing.
5. Learn basic concepts of economic analysis for process, involving equipment cost, and profitability.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. State the basic concepts of process design development and general design considerations.
2. Understand importance of unit processes and symbols of unit operations.
2. Draw the process flow sheet for the manufacturing of specific chemical products.
3. Identify and thereby solve major engineering problems encountered during manufacturing
4. Perform economic analysis for process to calculate equipment cost, and profitability for process.

<table>
<tr><td colspan="4">LAB COURSE CONTENT</td></tr>
<tr><td colspan="2">Process Technology and Economics Lab</td><td>Semester:</td><td>VI</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="2">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td>End semester exam (ESE):</td><td>25 marks</td></tr>
<tr><td colspan="2"></td><td>Internal Continuous Assessment (ICA):</td><td>25 marks</td></tr>
</table>

(Amongst the following any eight experiments / assignments are to be performed)

1. Drawing of symbols of unit operations and important unit processes.
2. Drawing of process flowsheets for the manufacturing of chemical products with major engineering problems involved (any four).
3. Location of a chemical plant.
4. Indian Chemical industry.
5. Cost Estimation.

6. Interest and Investment costs.
7. Depreciation.
8. Profitability and Replacement.

Text Book:

Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Books:

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984.
2. M. Gopala Rao, Marshall Sittig, Dryden's Outlines of Chemical Technology, , East West Press, 1997.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal

Guidelines for ESE:

End Semester Examinationshall be based on practical / oral evaluation of student performance and practical / assignments submitted by the student in the form of journal.

Design and Simulation Lab					
LAB COURSE OUTLINE					
Course Title:	**Design and Simulation Lab**	**Short Title:**	**D&S Lab**	**Course Code:**	

Course description:

This course describes how to use appropriate terminology of CAD process equipments/processes. It illustrates the application of scientific principles associated with process equipment design. The intent of this course is to help to understand concepts in simulation.

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	2	14	28	1

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):

Heat transfer, Mass transfer-I and II , Applied Chemistry I & II, Applied physics I and II, Applied Mathematics I and II, Elements of Electrical & Electronics Engineering

Course objectives:

1. To accustom CAD of the Shell and tube heat exchanger.
2. To learn CAD of the Single Effect Evaporator.
3. To study CAD of the rotary dryer.
4. To learn CAD of absorber.
5. To accustom simulation of ammonia production system, catalyst temperature by Newton Raphson method, Reactor Design etc

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate the ability of using Chemical Engineering concepts in designing and providing computer aided solutions to various unit operations and unit processes with the help of C/C++.
2. Display performing the task with multidisciplinary teams by identifying, formulating, designing.
3. Understand professional and ethical responsibilities formally and informally show the capacity of designing to meet economical and societal requirements.
4. Understand about computer aided design along with the environmental issues and will provide solutions for green and clean technologies.
5. Exhibit the computational skills using simulation.

LAB COURSE CONTENT			
Design and Simulation Lab		**Semester:**	**IV**
Teaching Scheme:		**Examination scheme**	
Theory	**2 hours/week**	**End semester exam (ESE):**	**25 marks**
Practical	**2 hours/week**	**Internal Continuous Assessment (ICA):**	**25 marks**

(Amongst the following any eight experiments / assignments are to be performed or any eight experiments / assignments based on Use of C/C++ , Open Source Software / Tool / Technology are to be performed)

List of Experiments/Assignments:

1. Computer aided design of shell & tube heat exchanger.
2. Computer aided design of single effect evaporator.
3. Computer aided design of rotary dryer.
4. Simulation of ammonia production system.
5. Simulation of catalyst temperature by Newton Raphson method.
6. Simulation of Reactor Design.
7. Development of the model equations for a double pipe heat exchanger.
8. Computer Aided Design of absorber.
9. Computer Aided Design of tall vessels.
10. Computer Aided Design of Design of thick-walled high pressure vessel.
11. Computer Aided Design: of Vertical supports for chemical process plant.
12. Computer Aided Design of Design of vessel under internal pressure.

Text Book:

Designed Standard College Laboratory Manual and Instruction Manuals of the Laboratory Equipment Suppliers.

Reference Book:

R.W.Gaikwad, Dr. Dhirendra, Process Modelling and Simulation, Central Techno Publication, Nagpur. First Edition.

Guide lines for ICA:

Internal Continuous Assessment shall be based on continuous evaluation of Student performance throughout semester and practical / assignments submitted by the student in the form of journal

Guidelines for ESE:

End Semester Examination shall be based on practical / oral evaluation of Student performance and practical / assignments submitted by the student in the form of journal.

Project

LAB COURSE OUTLINE

Course Title:	**Project**	**Short Title:**	**PROJ**	**Course Code:**	

Course description:

Project represents the culmination of study towards the Bachelor of Engineering degree. The project offers the opportunity to apply and extend material learned throughout the program. The emphasis is necessarily on facilitating student learning in technical, project management and presentation spheres.

Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	6	**14**	**84**	**3**

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):

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Course objectives:

1. To understand the basic concepts & broad principles of projects.
2. To understand the value of achieving perfection in project implementation & completion.
3. To apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach.
4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.
5. To develop ability of extracting the material from the different sources and writing comprehensively and exhaustive report on an allotted topic.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Demonstrate a sound technical knowledge of their selected project topic.
2. Undertake problem identification, formulation and solution.
3. Design engineering solutions to complex problems utilizing a systems approach.
4. Conduct an engineering project
5. Demonstrate the knowledge, skills and attitudes of a professional engineer.

LAB COURSE CONTENT

Project		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme:**	
		End semester exam (ESE):	**50 marks**
Practical:	**6 hours/week**	**Internal Continuous Assessment (ICA):**	**50 marks**

In continuation with Project (Stage – I) at Semester – VII, by the end of Semester – VIII, the

student should complete implementation of ideas as formulated in Project (Stage – I). By the end of Semester – VIII the students shall complete the project. Assessment for the project shall also include presentation by the students.
Each student group should submit partial project report in the form of thermal bound at the end of Semester –V

Each student group is required to maintain separate log book for documenting various activities of the project.

Suggestive outline for the project report is as follows.

Abstract

Chapter 1. Introduction

Chapter 2. Literature Survey

Chapter 3. Methodology

Chapter 4. Results & Discussion

Chapter 5. Conclusion

Bibliography

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Appendix

Guide lines for ICA:

The Internal Continuous Assessment (ICA) for project shall be based on continuous evaluation of students' performance, active participation, knowledge / skill acquired throughout semester and presentation by the students. The assessment shall be done jointly by the guide and departmental committee. A three-member departmental committee including guide, appointed by Head of the department, shall be constituted for the assessment. The assessment for Project in Semester – VIII shall be as per the guidelines given in Table – B.

Table – B

		Assessment by Guide					Assessment by Departmental Committee		
Sr. No.	Name of the Student	Attendance / Participation	Problem Identification / Project Objectives	Literature Survey	Methodology / Design	Report	Depth of Understanding	Presentation	Total
	Marks	5	5	5	5	5	10	15	50

Guidelines for ESE:

In End Semester Examination (ESE), the student may be asked for presentation / demonstration and questions on Project. Evaluation will be based on answers given by students in oral examination.