SCHEME OF COURSES & SYLLABUS
3RD–8TH SEMESTER

B. Tech. 2019 Batch Onward

DEPARTMENT OF CHEMICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR, HAZRATBAL
JAMMU AND KASHMIR – 190006 (INDIA)

VISION OF THE DEPARTMENT

To be one of the leading chemical engineering departments in the Country, providing teaching, research and training to the students along with high moral values to solve the problems of chemical and allied industries and to meet the aspirations of the society.

MISSION OF THE DEPARTMENT

M1. To create and sustain strong foundation of chemical engineering education, research and innovation.

M2. To produce well qualified, innovative chemical engineers with entrepreneurial skills & leadership qualities to face and solve the problems of the industries, and the society at large.

M3. To make professional leaders, academicians and engineers with highest moral values and ethics.

PROGRAM EDUCATIONALOBJECTIVES

PEO1: Providing broad-based engineering education on the solid foundation of basic sciences, engineering sciences, humanities & social sciences and management through choice based credit systems.

PEO2: Enable the students to become future leaders in engineering practices for the overall betterment of society, and instil in them a work culture based on foundations of ethics, scientific temperament, and team work.

PEO3: Equip the students with knowledge, understanding and applications of chemical engineering tools that enable them to pursue innovative research.

PEO4: Attain excellence in engineering and design through education in the principles and practices of chemical engineering.

Consistency of PEOs with Mission of the Department

Mission→ PEOs↓	M1	M2	M3
PEO1	3	2	3
PEO2	2	2	3
PEO3	3	2	2
PEO4	3	2	2

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Chemical Engineering Graduates will be able to:

PSO 1. Apply the principles and practices of Chemical Engineering discipline along with the basic sciences and humanities to solve the complex engineering problems concerning the issues of environment, safety, economics, culture and society etc.

PSO 2. Acquire and apply the new knowledge with professional responsibility and ethics towards the advancement of academic and research pursuits in chemical and allied disciplines in the societal contexts.

PSO 3. Design, develop and modify the chemical processes and to analyze these by applying the physicochemical and biological techniques.

CURRICULAR COMPONENTS

(B.Tech Chemical Engineering 1st Semester to 8th Semester)

Course Component		Curriculum Content (% of total number of credits of the program)	Total number of contact hours	Total Number of credits
1	Mathematics	10	20	20
2	Basic Science	6.5	15	13
3	Basic Eng. Course	11	26	22
4	Computing	2.5	7	5
5	Humanities and Social Science	6	13	12
6	Professional Core	51	111	102
7	Electives (Department and open)	6	12	12
8	Projects/Training/Seminar	7	28	14
	Total	100	232	200

Scheme of Courses for B. Tech. Chemical Engineering (3rd to 8th Semester)
[2019 Batch onwards]

3rd Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	CET-201	Introduction to Chemical Engineering	3	1	0	4
2.	CET-202	Material and Energy Balance	3	1	0	4
3.	CET-203	Process Fluid Mechanics	3	1	0	4
4.	CET-204	Thermodynamics and Chemical Kinetics	3	1	0	4
5.	ECT-205	Basic Electronics Engineering	2	1	0	3
6.	HST-201	Ethics & Self Awareness	2	0	0	2
7	MAT-201	Chemical Engineering Mathematics-I	3	1	0	4
		TOTAL = 19 + 6 + 0 = 25	**19**	**6**	**0**	**25**

4th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	CET-250	Chemical Engineering Thermodynamics	2	1	0	3
2.	CET-251	Heat Transfer	3	1	0	4
3.	CET-252	Mechanical Operations	3	1	0	4
4.	CET-253	Material Science &Technology	3	1	0	4
5.	CET-254	Process Instrumentation	3	0	0	3
6.	MAT-250	Chemical Engineering Mathematics –II	3	1	0	4
7.	CEL-255	Fluid Mechanics &Mechanical Operations Lab.	0	0	4	2
8.	ECL-256	Basic Electronics Engineering Lab.	0	0	2	1
		TOTAL = 17 + 5 +6 = 28	**17**	**5**	**6**	**25**

5th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	CET-305	Process Equipment Design– I	3	1	0	4
2.	CET-306	Chemical Reaction Engineering	3	2	0	5
3.	CET-307	Mass Transfer-I	3	1	0	4
4.	CET-308	Chemical Technology – I	3	0	0	3
5.	HST-309	Basic Management Principles	3	0	0	3
6.	MAT-310	Numerical Methods	3	1	0	4
7.	CEL-311	Heat Transfer Lab	0	0	2	1
8.	CEL-312	Computer Simulation Lab	0	0	2	1
		TOTAL = 18 +5 + 4 = 27	**18**	**5**	**4**	**25**

6th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	CET-355	Process Equipment Design -II	3	1	0	4
2.	CET-356	Mass Transfer – II	3	1	0	4
3.	CET-357	Chemical Technology – II	3	0	0	3
4.	CET-358	Energy Technology	3	1	0	4
5.	CET-359	Chemical Process Safety	3	0	0	3
6.	CET-360	Transport Phenomena	3	1	0	4
7.	CEL-361	Energy Technology Lab	0	0	2	1
8.	CEL-362	Thermodynamics & Reaction Engineering Lab	0	0	2	1
9.	CEI-363	Industrial Training & Presentation	0	0	2	1
		TOTAL = 18 +4+6 = 28	**18**	**4**	**6**	**25**

7th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	CEP-413	Pre-project work	0	0	4	2
2.	CES-414	Seminar	0	0	2	1
3.	CET-415	Process Dynamics & Control	3	1	0	4
4.	CET-416	Process Economics & Plant Design	3	1	0	4
5.	CET-417	Biochemical Engineering	3	1	0	4
6.	CEL-418	Process Dynamics & Control Lab	0	0	2	1
7.	CEL-419	Mass Transfer Lab	0	0	4	2
8.	CET-020-24	Elective – I	3	1	0	4
9.	CET-025-29	Elective – II	3	0	0	3
		TOTAL = 15 + 4 + 12 = 31	**15**	**4**	**12**	**25**

8th Semester						
S. No.	Course No.	Subjects	L	T	P	Credits
1.	CEP-464	Project Work	0	0	16	8
2.	CET-465	Bioresource Technology	3	1	0	4
3.	CEL-466	Biochemical Engineering Lab	0	0	2	1
4.	CET-467	Modeling & Simulation of Chemical Process Systems	3	0	0	3
5.	CET-468	Industrial Pollution Abatement	3	0	0	3
7.	CET-069-72	Elective – III	3	0	0	3
8.	CET-073-76	Elective – IV	3	0	0	3
		TOTAL = 15 + 1 +18 = 34	**15**	**1**	**18**	**25**

E-I: Any one of the following electives

S. No.	E-1	Elective courses	L	T	P	Credit
1.	CET-020	Polymer Science and Engineering	3	1	0	4
2.	CET-021	Computational Fluid Dynamics	3	1	0	4
3.	CET-022	Advanced Separation Processes	3	1	0	4
4.	MAT-023	Operations Research	3	1	0	4
5.	CET-024	Process Heat Integration	3	1	0	4

E-II: Any one of the following electives

S. No.	E-II	Elective courses	L	T	P	Credit
1.	CET-025	Cement Technology	3	0	0	3
2.	HST-026	Managerial Economics for Engineers	3	0	0	3
3.	CET-027	Multi-component Distillation	3	0	0	3
4.	CET-028	Optimization Techniques in Chemical Engineering	3	0	0	3
5.	CET-029	Heterogeneous Catalysis & Catalytic Processes	3	0	0	3

E-III: Any one of the following online electives

S. No.	E-III	Elective courses	L	T	P	Credit
1.	CET-069	Petroleum Refining/Online course (SWAYAM Etc.)	3	0	0	3
2.	CET-070	Clean Technology in Process Industries/ Online course SWAYAM Etc.)	3	0	0	3
3.	CET-071	Online course SWAYAM Etc	3	0	0	3
4.	CET-072	Online course SWAYAM Etc	3	0	0	3

E-IV: Any one of the following online electives

S. No.	E-IV	Elective Courses	L	T	P	Credit
1.	CET-073	Food Technology/ Online course SWAYAM Etc	3	0	0	3
2.	CET-074	Instrumental Methods of Analysis/ Online course SWAYAM Etc	3	0	0	3
3.	CET-075	Nano science and Technology/ Online course SWAYAM Etc	3	0	0	3
4.	CET-076	Online course SWAYAM Etc	3	0	0	3

Nomenclature

CE	Chemical Engineering
MT	Mathematics Department subject
HS	Humanities and Social Sciences Department subject
EC	Electronics and Communication Engineering Department subject
T	Theory
L	Lab. course
P	Project/Dissertation
S	Seminar
I	Industrial Training & Presentation
First Numeral	Year of course, Except for Elective courses assigned as “0”.
2nd& 3rd Num.	Unique Course Number

***Online courses SWAYAM Etc. will be floated before the start of semester to be managed by a faculty mentor.**

3^{rd} Semester

Introduction to Chemical Engineering (CET-201)

<table>
<tr><td rowspan="3">Subject: Introduction to Chemical Engineering (CET-201)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To acquaint the students with the fundamentals of Chemical Engineering principles, their application and to build their broader perspective in a wholesome manner.

Course outcomes (COs): Upon successful completion of the course, student should be able to:

CO1. Introduction to Chemical Engineering: Origin, Growth, and Relation to other sciences

CO2. Knowledge of Unit Operations and Unit Processes and its application to Chemical Process Industries

CO3. Gain an insight into involvement of Chemical Engineering in areas of Energy, Environment, materials, health, bioengineering and safetyetc,

CO4. Implementation of Chemical Engineering Basics to simple systems

CO5. Role of computer softwares, modeling, simulation etc. in chemical engineering education.

Details of the Syllabus:

Unit I	Chemical Engineering and Chemical technology. Chemical engineering: origin, growth and role. Chemical Process Industry: Definition, origin, growth and the present scenario. Overview of chemical engineering through discussion and engineering analysis of physical and chemical processes. Concepts of unit processes and unit operations.
Unit II	Process flow sheeting and symbols. Process calculations. Basic concepts of material and energy balances, energy and mass transport, and kinetics of chemical reactions.
Unit III	Introduction of following fields and Role of Chemical Engineers in these (*case studies if any*); Biochemical engineering and Biotechnology, Catalysis, Computational fluid dynamics, Energy and Environment , Petroleum engineering, Electrochemistry, Pharmaceutical engineering, Safety engineering, Membrane processes, Textile engineering, Ceramics , Chemical weapons , Cost estimation , Fischer Tropsch synthesis, Food engineering, Fuel cell, Microfluidics, Nanotechnology, Nuclear processing, Pharmaceutical engineering, Polymers, Paper engineering, Safety engineering.
Unit IV	Dimensional analysis.Different system of units. Basic and derived units, dimensional and empirical equation. Buckingham Pi Theorem. Different ways of expressing units of quantities and physical constants. Concepts of scale-up, modelling and simulation.
Unit V	Computers in chemical engineering. Introduction, use and utility of various Chemical Engineering Software’s.

Books Recommended:

Text Books	1. Anderson, L.B., Wenzel, L.A., “*Introduction to Chemical Engineering*", McGraw-Hill Book Company, Inc., New York (1961). 2. Ghosal, S.K., Sanyal, S.K., Datta, S., “*Introduction to Chemical Engineering*”, Tata McGraw-Hill Publishing Company Ltd., New Delhi (1997). 3. Pushpavanam, S., "*Introduction to Chemical Engineering*", PHI Learning Pvt. Ltd. (2012).
Reference Books	1. Rao, M.G., Sittig, M., “*Dryden’s Outlines of Chemical Technology*”, East-West Press (1997). 2. Perry, R.H., Green, D.W., “*Perry's Chemical Engineers' Handbook*”, McGraw-Hill Book Company (2008). 3. Pushpavanam, S., "*Introduction to Chemical Engineering*", PHI Learning Pvt. Ltd. (2012).

Material and Energy Balance (CET-202)

<table>
<tr><td rowspan="3">Subject: Material and Energy Balance (CET-202)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To formulate and solve Material and Energy balances for Chemical process systems.

Course outcomes (COs): At the end of the course, student will be able to:

CO1. Understand the basic concepts involved in material and energy balances of chemical processes.
CO2. Understand the ideal and real behavior of gases, vapors and liquids.
CO3. Perform material balances on chemical processes and non conventional separation processes without and with reactions.
CO4. Perform energy balances on chemical processes and non conventional separation processes without and with reactions.

Details of the Syllabus:

Unit-I	Mole concept and mole fraction, weight fraction and volume fraction, concentration of liquid solutions, molarity, molality, normality, ppm, density and specific gravity, composition relationships, stoichiometric principles.Ideal and real gas laws, critical properties, properties of mixtures and solutions, and phase equilibria.
Unit-II	**Mass Balance:** Concepts of limiting and excess reactants, tie element, recycle, purging, bypass etc., in batch, stage-wise and continuous operations in systems with and without chemical reactions, and in unit operations
Unit-III	**Mass balance of some prominent Unit Operations;** Mass balance calculations of *single and multistage* unit operations like; Evaporation, Distillation ,Crystallization etc.
Unit-IV	**Energy Balance:** Concepts, calculation of enthalpy changes for systems with and without reactions. Energy balance, heat capacity, estimation of heat capacities, calculation of enthalpy changes (without phase change), enthalpy change for phase transitions, general energy balance, thermochemistry, Hess's law of Summation- heat of formation, reaction, combustion, solution and mixing, theoretical flame temperature and effects of pressure and temperature on them.
Unit-V	Material and energy balance for nuclear, electrochemical, photochemical, biochemical and non-conventional separation processes.

Books Recommended

Text Books	1. Himmelblau, D.M., "*Basic Principles and Calculations in Chemical Engineering*", 8thEdn.,Prentice-Hall of India Ltd. (2012). 2. Felder, R.M., Rousseau, R.W., "*Elementary Principles of Chemical Processes*" Wiley, 3rdEdn., 2000. 3. Hougen, D.A., Watson, K.M., Ragatz, R.A., "*Chemical Process Principles, Part-I* ", 2ndEdn., John Wiley & Sons (1995). 4. Bhatt, B.I., Vora, S.M., "*Stoichiometry*", 5thEdn., Tata McGraw-Hill (2010).
Reference Books	1. Narayanan, K. V., Lakshmikutty, B., "*Stoichiometry and Process Calculations*", Prentice Hall of India (2006). 2. Venkataramani, V., Anantharaman, N., Begum, K.M.M.S., "*Process Calculations*", PHI Learning Pvt. Ltd. 2nd Edition. 3. Gavhane,K. A.,"*Introduction to Process Calculations Stoichiometry*", NiraliPrakashan, 2012. 4. Williams, E.T., Johnson, R.C., "*Stoichiometry for Chemical Engineers*", McGraw-Hill Book Company Ltd. (1958).

Process Fluid Mechanics (CET-203)

<table>
<tr><td rowspan="3">Subject: Process Fluid Mechanics (CET-203)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term (30 Marks)</td><td>Class Assessment (10 Marks)</td><td colspan="3">Final-Term (60 Marks)</td></tr>
</table>

Course Objective: To understand the fundamental aspects & basic principles of fluid mechanics and its application to chemical process industries.

Course outcomes (COs):

CO1. Understand the fundamentals & basics concepts of fluid mechanics & able to describe fluid pressure and its measurement.

CO2. Analyze fluid flow problems with the application of conservation laws & ability to evaluate energy losses and pressure drop in fluid flow system.

CO3. Able to describe function of flow measuring devices and apply Bernoulli equation to determine the performance of flow measuring devices.

CO4. Determine and analyze the performance aspects &characteristics of fluid machinery.

Details of the Syllabus:

Unit-I	Introduction: Introduction to fluids and the concept of viscosity, Newtonian and non-Newtonian fluids. Fluid Statistics: Fluid forces and pressure measurement. Kinematics: Eulerian and Lagrangian description of fluid motion, concept of local and convective accelerations, steady and unsteady flows.
Unit-II	Integral analysis: Control volume analysis for mass, momentum and energy. Differential analysis: Differential equations of mass and momentum for incompressible flows: inviscid - Euler equation and viscous flows - Navier-Stokes equations, concept of fluid rotation, vorticity, stream function, Exact solutions of Navier-Stokes equation for Couette flow and Poiseuille flow.
Unit-III	Invicid flows: Bernoulli's equation - assumptions and applications, potential function. Dimensional analysis and similitude. Internal flows: Fully developed pipe flow, empirical relations for laminar and turbulent flows: friction factor and Darcy-Weisbach relation.
Unit-IV	Boundary layer theory: Concept and assumptions, qualitative idea of boundary layer and separation, boundary layer equations, Blasius solution for laminar boundary layer, momentum-integral equation of boundary layer.
Unit-V	Flow measurements: Basic ideas of flow measurement using venturimeter, pitot-static tube and orifice plate. Pumps, blowers and compressors. Characteristics and applications of pumps, blowers and compressors.

Books Recommended

Text & Reference Books	1. Shames, J.H., "*Mechanics of Fluid*", McGraw-Hill (1992). 2. Darby, R., "*Chemical Engineering Fluid Mechanics*", Marcel Dekker (1996). 3. Wilkes, J.O., "*Fluid Mechanics for Chemical Engineers*", Prentice-Hall International Series (1998). 4. Streeter, V.L., Wylie E.B., Bedford, K.W. "*Fluid Mechanics*" McGraw-Hill Book Company, New York (1998). 5. Mc Cabe, W.L., Smith, J.C., Harriott, P., "*Unit Operation of Chemical Engineering*", McGraw-Hill (2004).

Thermodynamics & Chemical Kinetics (CET-204)

<table>
<tr><td rowspan="3">Subject: Thermodynamics & Chemical Kinetics (CET-204)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term (30 Marks)</td><td>Class Assessment (10 Marks)</td><td colspan="3">Final-Term (60 Marks)</td></tr>
</table>

Course Objective: To understand basic concepts of thermodynamics and chemical kinetics and their applications in solving engineering problems.

Course outcomes (COs):

CO1. Understanding and application of laws of thermodynamics.
CO2. Ability of application of thermodynamics to phase equilibrium and reaction equilibrium.
CO3. Basic Idea of Reactors.
CO4. ;Basic insight into the interpretation of kinetic data and reactor design.

Details of the Syllabus:

Unit I	**Introduction:(8 Hours)** Thermodynamic system, surroundings, state, process, properties, equilibrium, heat and work. Properties of Pure Simple Compressible Substance: P-V-T surface, P-V, T-V and T-P diagrams. Equations of state for ideal and real gases. Virial equation of state, van der Waals and Redlich-Kwong equations of state; Use of Thermodynamic tables.
Unit II	**First Law of Thermodynamics:(8 Hours)** Energy balance for closed systems. Various forms of energy balance. Specific heat, internal energy, enthalpy, and specific heat of ideal gases. Application of first law to non-flow isochoric, isobaric, isothermal, and adiabatic and polytropic processes. Conservation of mass for a control volume, mass and volume flow rates, mass balance for steady flow processes, flow work, steady flow energy equation. Application to various practical systems viz. nozzles, diffusers, etc. Transient Analysis.
Unit III	**Second Law of Thermodynamics:(8 Hours)** Second law, reversible and irreversible processes, Clausius and Kelvin Planck statements. Carnot cycle, Clausius inequality, entropy as a property, principle of increase of entropy. Calculation of entropy change.Thermodynamic Cycles: Otto, Diesel, Rankine cycles and their applications.
Unit IV	**Rate Expression and Reaction Mechanism:(12 Hours)** Use of pseudo steady state approximation to get rate expression from mechanism, temperature-dependence of reaction rate-collision theory, transition state theory, thermodynamics and Arrhenius law. Interpretation of Kinetic Data of Batch Reactors: Constant volume and variable volume batch reactions, Integral and differential methods of analysis of data of uni, bi and tri-

	molecular irreversible reactions. Reversible reactions, homogeneously catalysed, auto-catalysed, series and parallel reactions. Estimation of rate constants and its temperature-dependence.
Unit V	**Solid-Catalysed Fluid Reactions:(8 Hours)** Characterization of catalyst, Physical and chemical adsorption, various reaction steps, Langmuir-Hinshelwood kinetics.Kinetics of Biochemical Reactions: Microbial and enzymatic reactions. Substrate and product inhibition.

Books Recommended

Text Books	1. Narayanan, K.V., "*Chemical Engineering Thermodynamics*", Prentice Hall (2007). 2. Smith, J.M., Van Ness, H.C., Abbott, M.M., "*Introduction to Chemical Engineering Thermodynamics*", 7th Edn. McGraw-Hill (2005). 3. Fogler, H.S., "*Elements of Chemical Reaction Eng*.", Prentice Hall of India (2005). 4. Levenspiel, O., "*Chemical Reaction Engineering*", John Wiley & Sons (1998).
Reference Books	1. Koretsky, M.D., "*Engineering and Chemical Thermodynamics*", John Wiley (2004). 2. Kyle, B.G., "*Chemical and Process Thermodynamics*", 3rdEdn, Prentice Hall (1999). 3. Sandler, S.I., "*Chemical, Biochemical and Engineering Thermodynamics*", 4th Edn, John Wiley (2006). 4. Borgnakke, C., Sonntag R.E., "*Fundamentals of Thermodynamics*", John Wiley & Sons (2009). 5. Çengel, Y.A., Boles, M.A., "*Thermodynamics: An Engineering Approach*", 6thEdn., McGraw-Hill (2008).

Basic Electronics Engineering (ECT-205)

Subject: Basic Electronics Engineering (ECT-205)	Year & Semester: B. Tech Chemical Engineering 2nd Year & 3rd Semester		Total Course Credit: 3		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objectives: Familiarize with the basic semiconductor devices and to know about the working and performance of semiconductor devices like diodes, BJTs and FETs. To understand different applications of Electronic circuits and instrumentation.

Course outcomes (COs):

CO1. Familiarization with basic semiconductors

CO2. Understanding the behavior of different types of diodes, transistors at circuit level and behavior of operational amplifiers, & its applications

CO3. Analyze and study the measurement and Instrumentation techniques and devices

CO4. Understanding and applications of Digital Logic gates and blocks

Details of the Syllabus: (Total Contact Hours: 45)

Unit I	**IntroductiontoSemiconductors:**Intrinsicandextrinsicsemiconductorstransportmechanismofcharge carriers, electric properties, Temperaturedependence
Unit II	**P-N junction diode: Current components in p-n junction,** Characteristics-piece wise linear approximation,and diodecircuit'shalf wave,fullwaverectifiers,Photodiodes.
Unit III	**BJT:Operationandcharacteristics:** CE,CBandCCconfigurationinput, outputcharacteristicsBiasingandBiasstability,Low frequency,h-parametermodel,AnalysisandDesignoftransistoramplifiercircuitsusingh-parameters. Multistage amplifiers,Transistor as a switch. Introduction to Feedback and Sinusoidal Oscillators
Unit IV	**Operational Amplifier:**Operational amplifiers stages, Differential amplifier, CMRR, Cascade amplifier, Ideal and practical operational amplifier characteristics and properties OP amp applications, inverting and non inverting amplifiers, Difference amplifier, summer differentiator and integrator, rectifiers etc. Instrumentation Amplifier
Unit V	**Measurement and Instrumentation**: Sensors and Actuators; Measurement of physical parameters like displacement, pressure, force, velocity, humidity, and temperature. LVDT, Strain Gauge, Pyrometer, Thermistor, etc. Digital Multimeter. Data acquisition system and processing.
Unit VI	**Digital Logic:** Introduction to Boolean theorems and codes, code conversion; Logic gates, Combinatorial and Sequential blocks

Books Recommended

1.	Fundamentals of Microelectronics	BehzadRazavi
2.	Analysis and Design of Analog Integrated Circuits	Gray, Hurst, Lewis, Meyar
3.	Electronic Devices and Circuits	Millman, Halkias, and SatyabrataJit
4.	ElectronicDevices&Circuits	Allan Mottershed
5.	Digital System Design An Integrated Approach	Uyemura
6.	Digital Logic &ComputerDesign	M Morris Mano
7.	Measurement and Instrumentation	Cooper

Ethics and Self-Awareness (HST-201)

<table>
<tr><td rowspan="3">Subject: Ethics and Self-Awareness (HST-201)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 2</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term (30 Marks)</td><td>Class Assessment (10 Marks)</td><td colspan="3">Final-Term (60 Marks)</td></tr>
</table>

Course Objective: To explain human behavior in situational, social and cultural context**.**Define culture, ethics, morality and values along withtraining the students tothink critically and evaluate theories, concepts and perspectives related to psychology and human behavior as well as current societal advances related to career.

Course outcomes (COs): Upon successful completion of the course, student should be able to:

CO1. Study human experience and behavior situation in social and cultural context
CO2. Promote the appreciation of students' own culture, ethics and values as well as the culture, ethics and values of others
CO3. Empower students to think critically and evaluate theories, concepts and perspectives related to psychology , human mind and human behavioras well as current societal advances related to career
CO4. Develop an understanding of the importance of self-awareness, self-reflection and self-regulation as well as gain practical knowledge and experience

Details of the Syllabus:

Unit I	**Introduction to Ethics;** Definition of ethics, approaches to ethics: psychological, philosophical, social; view of Kohelberg: Morality and Ideology, culture and morality, morality in everyday context. Ethical concerns: work ethics and work values, Business ethics, human values in organizations
Unit II	**Self-Awareness** Self-concept: Johari window; self: Character strengths and virtues, emotional intelligence, social intelligence, positive cognitive states and process: self efficacy; transactional analysis

Books Recommended:

Text Books	1. Hall, Calvin S., Lindzey, Dardner.,&Cambell, John B. "*Theories of Personality"*. USA: Hamilton Printing Company. 2. Manuel E.G. Velasquez, " *Business Ethics – Concepts & Cases*" , 6th Edn., Prentice Hall of India. 3. David. J.Fritzche, "*Business Ethics*".McGraw-Hill/Irwin 4. William H. Shaw, "*Business Ethics*", Thompson,
Reference Books	1. Carr, Alan. "*Positive Psychology: The Science of happiness and human strengths"*. NewYork, Brunner-Routledge 2. Leary, Mark R. "*The curse of self-awareness, egotism and the quality of human life"*. NewYork, Oxford University Press. 3. Louis P. Pojman. "*The moral life: An introductory reader in ethics and literature"*. NewYork, Oxford University Press. 4. Corey, G. Schneider Corey, M&Callan, P. "*Issues and ethics in the helping professions"*. CA: Brooks/Col 5. Snyder, C.R. Lopez, Shane, J., &Pedrotti, J.T. "*Positive Psychology* (2nd Edn). New Delhi: Sage

Chemical Engineering Mathematics-I (MAT-201)

<table>
<tr><td rowspan="3">Subject: Chemical Engineering Mathematics-I (MAT-201)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2^{nd} Year & 3^{rd} Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course outcomes (COs): At the end of the course, a student should be able to:

CO1. Solve problems related to Differentiation of complex functions, Analytic functions, harmonic functions and conformal mapping.
CO2. Solve problems related to Integration of complex functions.
CO3. Expand Complex functions in terms of Taylor series, Laurant series and classify singularities of a complex function and calculation of residues.
CO4. Apply the concepts of Complex Analysis in Boundary value problems and potential theory.
CO5. Solve problems related to Legendre and Bessel functions.

Details of the Syllabus:

Unit-I	**Analytic Functions (10 hours)** Function of a Complex variable, Limit, Continuity and Differentiablity of complex function. Cauchy-Riemann Equations, Polar Coordinates, Analytic function, Harmonic functions and Properties of Analytic functions, Construction of Analytic function whose real or imaginary part is given, Elementary function, Reflection Principle,Conformal Mapping, Angle of Rotation, Mapping by Elementary functions. Bilinear Transformation.
Unit-II	**Complex Integration (10 Hours)** Derivatives of functions w(t), Definite Integrals of functions w(t), Contours and Contour Integrals, ML Theorem, Cauchy Integral Theorem, Antiderivatives and Definite Integrals, Cauchy Integral Formula, Cauchy Integral formula for Derivatives, Evaluation of Improper Definite Integrals by Contour Integration, Liouville's Theorem and its consequences.
Unit-III	**Taylor and Laurant Series- Residue Theorem and Applications (7 Hours)** Taylor Series, Laurant Series, Classification of Singularities, Residues, Cauchy's Residue Theorem and its Applications, Zeros of Analytic functions, Rouche's Theorem and its consequences, Gauss Lucas Theorem.
Unit-IV	**Boundary Value Problems and Potential Theory (6 Hours)** Laplace's Equation and Conformal Mappings, Standard Solution of Laplace equation, Steady –State Temperature Distribution, Steady Two Dimensional Fluid Flow.
Unit-V	**Special Functions (10 Hours)** Legendre's functions, Rodrigue's formula, generating functions for Legendre's Polynomials and recurrence formulae. Bessel's functions, Recurrence formulae and Bessel's functions of integral order.

Books Recommended

Text Books	1. Brown,J. W., Churchill, R. V.,*Complex Variables and Applications*, 8thEdn., 2009, Mc-Graw- Hill International Edition. 2. Jain, R.K.,Iyengar, S.R.K., *Advanced Engineering Mathematics*, 3rdEdn., Narosa Pub. House, 2008
Reference Books	1. Alan J., *Complex Analysis and Applications*, 2nd Edn.,2005, CRC Press. 2. Needham, T.,*Visual Complex Analysis*, Oxford University Press.

4^{th} Semester

Chemical Engineering Thermodynamics (CET-250)

<table>
<tr><td rowspan="3">Subject: Chemical Engineering Thermodynamics (CET-250)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
2^{nd} Year & 4^{th} Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To understand the theory and applications of thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

Course outcomes (COs):

CO1. Basic understanding of the thermodynamic properties of fluid, mixture and solutions.
CO2. Apply thermodynamic principles to understand fugacity, partial molar properties, chemical potential, and activity coefficients for non-ideal fluid systems.
CO3. Investigate binary phase equilibria; perform vapour-liquid equilibrium (VLE) calculations.
CO4. Apply thermodynamic principles to reaction equilibrium between phases and reactions.

Details of the Syllabus:

Unit I	**Thermodynamic Properties of Homogeneous Fluids: (10 Hours)** Fundamental property relations, Maxwell's relations, Residual properties and their estimation, two phase systems, thermodynamic diagrams and tables, generalized property correlation for gases.
Unit II	**Thermodynamic Properties of Mixtures or Solutions: (8 Hours)** Property relationships for systems of variable composition; chemical potential, partial molar properties, fugacity and fugacity coefficients – pure species and species in a mixture, fugacity in ideal solutions, activity coefficients, excess properties.
Unit III	**Applications of Solution Thermodynamics: (8 Hours)** VLE-qualitative behavior, Duhem's theorem, simple models for VLE (Raoult's law, modified Raoult's law, etc.). Liquid properties from VLE. Activity coefficients from experimental data – Margules, Van-Laar, and Wilson equations. Property changes of mixing, heat effects in mixing processes.
Unit IV	**Phase Equilibria: (8 Hours)** Importance of phase equilibria in process industries, equilibrium and stability, vapour-liquid equilibria (VLE) for miscible, partially miscible and immiscible systems, their phase diagrams, azeotropes. VLE calculations at low and high pressures, analysis of multi- component systems.

Unit V	**Chemical Reaction Equilibria:** **(10 Hours)** Reaction coordinate, application of equilibrium criteria to chemical reactions, standard Gibbs energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of equilibrium constant and composition. Calculation of equilibrium compositions for single reactions; Phase rule and Duhem‟s theorem for reacting systems. Thermodynamic Analysis of Processes: Work and free energy, availability, analysis of mixing, separation processes, heat exchange, lost work calculations.

Books Recommended:

Text Books	1. Narayanan, K.V., "*Chemical Engineering Thermodynamics*", Prentice Hall (2007). 2. Smith, J.M., Van Ness, H.C., Abbott, M.M., "*Introduction to Chemical Engineering Thermodynamics*", 7th Edn. McGraw-Hill (2005).
Reference Books	1. Koretsky, M.D., "Engineering and Chemical Thermodynamics", John Wiley (2004). 2. Kyle, B.G., "*Chemical and Process Thermodynamics*", 3rd Edn, Prentice Hall (1999). 3. Sandler, S.I., "*Chemical, Biochemical and Engineering Thermodynamics*", 4th Edn, John Wiley (2006).

Heat Transfer (CET-251)

<table>
<tr><td rowspan="3">Subject: Heat Transfer (CET-251)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To understand the fundamentals & basic principles of heat transfer mechanisms in solids and fluids and their applications in various heat transfer equipment in process industries.

Course outcomes (COs): At the end of the course, student will be able to:

CO1. Identify, formulate, analyze & solve problems involving steady state heat conduction in simple geometries..
CO2. Understand the fundamentals and basic principles of convection heat transfer and evaluate heat transfer coefficients for natural and forced convection.
CO3. Calculate radiation heat transfer between black body surfaces & grey body surfaces.
CO4. Able to perform the thermal analysis and sizing of heat exchangers & evaporators.

Details of the Syllabus:

Unit-I	Introduction: Modes of heat transfer. Thermal conductivity of material. Effect of temperature on thermal conductivity of different solids, liquids and gases. Derivation of generalized heat conduction equation in Cartesian, cylindrical and spherical coordinates and its reduction to specific cases, general laws of heat transfer.
Unit-II	Conduction: Fourier's law, steady state conduction through flat wall, multi-layer wall, cylinders and hollow spheres. Lagging of pipes and optimum lagging thickness. Heat transfer from extended surface: Types of fin, heat flow through rectangular fin, infinitely long fin, fin insulated at the tip and fin losing heat at the tip, efficiency and effectiveness of fin.
Unit-III	Convection: Natural and forced convection, Newton's law of cooling, dimensional analysis applied to forced and free convection, dimensionless numbers and their physical significance, empirical correlations for free and forced convection, continuity, momentum and energy equations, thermal and hydrodynamic boundary layer.
Unit-IV	Heat transfer with phase change: Boiling of liquids, Pool boiling curve, different types of pool boiling, condensation of vapor. Film wise & drop wise condensation. Radiation: Emissivity, absorptivity, black body and grey body radiation, view factors, radiation between various types of surfaces.
Unit-V	Heat exchanger: Classification, heat exchanger analysis, LMTD for parallel and counter flow exchanger, condenser and evaporator, overall heat transfer coefficient, fouling factor, correction factors for multi pass arrangement, effectiveness and number of transfer unit for parallel and counter flow heat exchanger, introduction of heat pipe and compact heat exchanger.

Books Recommended

Text Books & Reference Books	1. McCabe, W.L., Smith, J.C., "*Unit Operation of Chemical Engineering*", 7th Edn., 2. Holman, J.P., " *Heat Transfer*", 10th Edn., McGraw-Hill (2009) 3. Bergman, T.L., Lavine, A.S., Incropera, F.P., DeWitt, D.P., "*Introduction to Heat Transfer*", 6th Edn., Wiley (2011). 4. Kreith, F., Manglik, R.M., Bohn, M., "*Principles of Heat Transfer*", 7th Edn., Cengage Learning (2010). 5. Hewitt, G.F., Shires, G.L., Bott, T.R., "*Process Heat Transfer*", Begell House (1995). 6. Kern, D.Q., "*Process Heat Transfer*", McGraw- Hill (2001).

Mechanical Operations (CET-252)

<table>
<tr><td rowspan="3">Subject: Mechanical Operations (CET-252)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2^{nd} Year & 4^{th} Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course description:

Understand properties and characterization of particulate solids and mechanical solids separation methods such as screening, filtration, sedimentation, transportation of solids, agitation etc and associated equipments used for achieving these methods.

Course Objectives:

1. To impart the basic concepts of mechanical operations
2. To develop an understanding of size analysis, size reduction, and solid handling
3. To understand mechanical separation methods such as filtration, sedimentation, transportation of solids etc and associated equipment used for achieving these methods

Course outcomes (COs): Upon successful completion of the course, students will be able to:

CO1. Understand the characterization, classification, conveying and storage of solids

CO2. Calculate the power requirements and crushing efficiencies of size reduction equipment using laws of communition and understand the working of different size reduction equipment

CO3. Analyze the screening results to estimate the screen effectiveness and acquire knowledge of screening mechanism and separation of solids from solids and gases

CO4. Apply the knowledge of filtration theory to estimate the filtration time, specific cake and medium resistance of filtration processes and understand the settling characteristics

CO5. Acquire the knowledge of agitation and different types of agitated vessels

Details of the Syllabus:

Unit-I	**Introduction:** Properties of particulate solids, characterization of solid particles and mixed particle size.Storage and transportation of bulk solids (types of conveyers, their selection), Pneumatic and hydraulic conveying of solids, general characteristics and flow relations, mechanical conveyers.
Unit-II	**Crushing and Grinding**: Theory of Crushing. Laws of crushing-Rittingers‟ law, Kick‟s law, Classification of crushing and grinding machinery, Coarse Crushers (jaw crusher, gyratory crusher), intermediate crushers (roll, disc or cone crusher, edge runners, squired cage disintegrator, hammer mill), fine grinders-burhstones, roller mills, ball and tube mills.
Unit-III	**Solid-Solid and Gas-Solid Separation:** Principle of screening, screen analysis, types

	of screening equipment (grizzlies, trommels, shaking and vibrating screens), effectiveness of a screen, air separating method (cyclone separator, bag filters, electrostatic precipitator, scrubbers).
Unit-IV	**Solid-Liquid Separation: Settling:** Free and hindered settling, classification of classifiers (simple and mechanical), introduction to the design of continuous thickeners. **Filtration:** Classification of filters, effect of pressure on filtration, filter aids, constant pressure and constant rate filtration theory, membrane filtration.
Unit-V	**Agitation and Mixing:** Theory of mixing, power consumption of mixer impellers, mixing liquids with liquids, mixing gas with liquid, mixing of viscous masses, mixing of solids with solids mixing of solid with liquid.

Books Recommended

Text Books	1. McCabe, W.I., Smith, J.C., "*Unit Operations in Chemical Engineering",* 7th Edn.,McGraw-Hill (2011). 2. Swain,A.K., Patra,H., Roy,G.K., " *Mechanical Operations*" 1st Edn.,McGraw-Hill (2010).
Reference Books	1. Badger, L.W., Banchero, T.J., "*Introduction to Chemical Engineering",* 3rd Edn., McGraw-Hill (1997). 2. Coulson, J.M., Richardson, J.F., "*Chem. Engineering, 2nd Vol.*", Butterworth-Heinemann. 3. Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., "*Principles of Unit Operations*", 2nd Ed., Wiley-India (2008). 4. Perry, R.H., Green, D.W., "*Perry's Chemical Engineers' Handbook",* 7th Edn.", McGraw-Hill Book Company (2008).

Material Science and Technology (CET-253)

<table>
<tr><td rowspan="3">Subject: Material Science and Technology (CET-253)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering 2^{nd} Year & 4^{th} Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term (30 Marks)</td><td>Class Assessment (10 Marks)</td><td colspan="3">Final-Term (60 Marks)</td></tr>
</table>

Course Objective: This course is aimed at providing students the information regarding availability of various types and classes of materials involved in engineering practices. This course will help the students in selection of suitable materials in construction of process equipment in particular.

Course outcomes (COs): Upon successful completion of the course, student should be able to:

CO1. Analyze the micro structure of crystalline materials like lattice systems, unit cells and theoretical density
CO2. Clear the concept of mechanical behavior of materials through calculations and appropriate equations along with their failure mechanics including corrosion.
CO3. Understand the concept of phase diagrams and their construction, usage and applications.
CO4. Understand and analyze the heat treatment processes and their types involving solid state diffusion processes

Details of the Syllabus:

Unit-I	**Introduction :** Properties of materials of importance to chemical equipment. Materials of construction for chemical industries (metallic and non-metallic). Principles of usage of materials. FCC, BCC, HCP crystal planes. Microscopic and macroscopic structure of metallic crystals. **Imperfection in crystals:** Point imperfection, line imperfection and surface imperfection. Single phase metals, properties of single phase metals. Plastic deformation, re-crystallization. Plastic deformation of metal crystals, properties of plastically deformed metals, mechanism of slip.
Unit-II	**Failure of Metals:** Creep, mechanized creep, ductile fracture, cleavage fracture, fracture in glass and theory of fracture, fatigue and mechanism of fatigue.
Unit-III	**Iron-Carbon Alloys:** Definition of alloys, Substitution and interstitial solid solutions, eutectic and eutectoid reactions, peritectic transformation, peritectic and pertectoid reaction, constituent diagram for iron-carbon system, time-temperature-transformation curves.
Unit-IV	**Inorganic Materials:** Ceramic, example of ceramic phases. Structure of silicates. Dielectric ceramic semiconductors. Mechanical behavior of ceramic materials. Introduction to

	Composite Materials **Corrosion:** Corrosion by solution, electrochemical oxidation. Electrode potential, galvanic couples. Types of galvanic cells. Corrosion prevention. Protective surfaces, avoidance of galvanic couples, use of galvanic protection. Use of organic, inorganic and metallic linings.
Unit-V	**Polymers:** Structure, deformation, plastic deformation. **Electrical conductivity:** Definition, insulators and semi-conductors, intrinsic and extrinsic semiconductors. Magnetic behavior of metals. Introduction to ferromagnetism.

Books Recommended:

Text Books	1. William D. Callister, Jr. *" Material Science and Engineering, An introduction"* 8th Edn., (2010), John Wiley and Sons Inc. 2. Raghavan, V., *" Materials Science and Engineering- A First Course",* 5th Edn., Prentice-Hall India (2009).
Reference Books	1. Van Vlack, L.H., "*Elements of Material Science and Engineering*", 6th Edn., Pearson Education (1989). 2. Fisher, T.,*" Material Science for Engineering students",* Academic Press, Elsevier-Edition (2009). 3. D. R. Askaland, P.P Fulay, "*Essentials of Material Science & Engineering*" 2nd Edn., Cengage Learning (2009).

Process Instrumentation (CET-254)

Subject: Process Instrumentation (CET-254)	Year & Semester: B. Tech Chemical Engineering 2nd Year & 4th Semester		Total Course Credit: 3		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective: This course enables the students to know about the process principles and make the students knowledgeable in various types of measuring instruments used in chemical process industries.

Course outcomes (COs): At the end of the course, student will be able to:

CO1.	Understand basic concept of instrumentation, principles and applications
CO2.	Understand the measurement techniques for Temperature
CO3.	Understand the measurement techniques for Pressure
CO4.	Understand the measurement techniques for Flow and Level

Details of the Syllabus:

Unit-I	**Introduction**: Measuring instruments and their function, elements of measurement, important characteristics of industrial measurement. Classification of Instruments: Recording and measuring types.
Unit-II	**Temperature measurement**: Classification of thermometers, and pyrometers, response of thermometers, protecting wells. Fluid filled expansion thermometers. Thermocouples: Resistance thermometers. Radiation and optical pyrometers.
Unit-III	**Pressure and vacuum measurement**: Classification. Manometers- Inverted well pressure gauges. Bourdon tube pressure gauges, diagram of pressure gauges. Special measuring devices: Pressure and vacuum, McLeod gauge. Thermal conductivity and ionization gauges.
Unit-IV	**Flow and Liquid Level Measurement:** Head and area flow meters-flow measuring devices, Visual indicators float motivation, liquid level instruments. Pressure differential type level gauge, Electrical contact type liquid level indicators.

Books Recommended

Text Books	1.	Dunn, W.C., "Fundamentals of Industrial Instrumentation and Process Control", Tata McGraw-Hill (2009).
	2.	Nakra B. C., Chaudhry K. K., "Instrumentation, Measurement and Analysis" Tata McGraw-Hill (2004).
	3.	Andrew, W. G., "Applied Instrumentation in the Process Industries, Vol. I.", Gulf Publishing Company (1993).
Reference Books	4.	Liptek, B.G., "Instrument Engineers' Handbook: Process Control and Optimization, Volume II", Taylor and Francis, CRC press (2006).
	5.	Johnson, C., "Process Control Instrumentation Technology", Prentice Hall (2005).

Chemical Engineering Mathematics-II (MAT-250)

<table>
<tr><td rowspan="3">Subject: Chemical Engineering Mathematics-II (MAT-250)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course outcomes (COs): At the end of the course, a student should be able to:

CO1. Evaluate Laplace and Inverse Laplace transforms of various functions and related problems.

CO2. Evaluate Fourier and Inverse Fourier transforms of various functions and related problems.

CO3. Apply the methods of Laplace and Fourier transforms in solving ODE, PDE and Integral equations.

CO4. Solve the problems related to random variables, Probability density function, Mathematical expectation, Moments, Moment generating function, Inequalities of Markov and Chebyshev and their applications.

CO5. Solve the problems related to Binomial, Poisson and normal Distributions, Beta and gamma Distribution, t-distribution, F-Distribution, Chi-square Distribution and their applications.

Details of the Syllabus:

Unit-I	**Laplace Transforms:** **(15 Hours)** Laplace transform, Condition for the existence of Laplace transform, Laplace transform of some elementary functions, Properties of Laplace transform, Differentiation and Integration of Laplace transform. Laplace transforms of periodic functions and other special functions, Unit Impulse function, Dirac-delta function and its Laplace transform, Heaviside's expansion theorem, Inverse Laplace transform, Initial and Final value theorems, Convolution theorem and properties of Convolution, Evaluation of definite integrals by Laplace transforms, Use of Laplace transforms in the solution of linear differential equation.
Unit-II	**Fourier Transforms:** **(12 Hours)** Definition of Fourier transform, Fourier Integral Theorem, Properties of Fourier transform, Fourier sine and cosine, Convolution Theorem, Parseval's Identity for Fourier transform, Solution of Integral equations, Evaluation of definite integrals using Fourier transform, Applications of Fourier transforms to Ordinary and Partial differential equations.
Unit-III	**Probability:** **(15 Hours)** Point function and Set function, Probability Set function, Random variable, Probability density function, Mode and median of distribution of a random variable, Probability distribution function and its properties, Mathematical expectation, Laws of expectation, Mean, Variance, Moments, Moment generating function, Inequalities of Markov and Chebyshev and their applications. Binomial, Poisson and normal Distributions, Beta and gamma Distribution, t-distribution, F-Distribution, Chi-square Distribution and their applications.

Books Recommended

Text Books	1. Debnath, L., Bhatta, D., *Integral Transforms and their Applications*, 2^{nd} Edn., CRC press, 2007. 2. Murray, R. S., *Schaum's Outlines Laplace Transforms*, Tata Mc-Graw Hill Edition, 2005. 3. Robert V. H., Joseph W. M., Allen T. C., *Introduction to Mathematical Statistics*, 2^{nd} Edn., LPE Pearson Prentice hall, 2007.
Reference Books	1. Jain, R. K., Iyengar, S. R. K., *Advanced Engineering Mathematics*, 3^{rd} Edn., Narosa Pub. House, 2008. 2. Rohatgi, V.K. Ehsanes Saleh, A. K. Md., *An Introduction to Probability and Mathematical Statistics,* 2^{nd} Edn., John Wiley and sons, 2008.

Fluid Mechanics & Mechanical Operations Lab. (CEL-255)

<table>
<tr><td rowspan="3">Subject: Fluid Mechanics & Mechanical Operations Lab. (CEL-255)</td><td rowspan="3">Year & Semester: B.Tech Chemical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 2</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term/Class Assessment (40 Marks)</td><td colspan="3">Final-Term (60 Marks)</td></tr>
</table>

Course Objective: To understand basic concepts of thermodynamics and chemical kinetics and their applications in solving engineering problems.

Course outcomes (COs):

CO1. Make velocity measurements using flow meters and viscosity measurements by Stokes Apparatus

CO2. Understand the laminar and turbulent flow behaviour, verify Bernoulli's principle and pipe fittings

CO3. Understand the classification, conveying and communition of solids

CO4. Understand the theories of sedimentation and to study the settling characteristics of batch settling

List of Experiments and Equipments

S.No.	Name of the Experiment	Name of the Equipment
1	Measurement of liquid viscosity by Stokes Method	Stokes Apparatus
2	Reynolds Experiment to demonstrate laminar and turbulent flow	Reynolds Apparatus
3	Verification of Bernoulli's Principle	Bernoulli's Apparatus
4	Flow through Orificemeter	Orifice meter
5	Flow through Venturimeter	Venturi meter
6	Flow through Rotameter	Rotameter
7	Determine the Efficiency of a Ball Mill	Ball Mill
8	Determine the Efficiency of a Vibrating Screen	Vibrating Screen
9	Find out the discharge at different angles of elevation of Screw conveyor	Screw Conveyor
10	Study the settling Characteristics of Slurry	Sedimentation Apparatus
11	Demonstration of Trommel	Trommel Apparatus
12	Determine the Capacity of Belt Conveyor	Belt Conveyor
13	Pipe Fittings	---

Books Recommended

1.	McCabe W. L., Jullian Smith C. and Peter Harriott - *Unit operations of Chemical Engineering*, 7th Edn., McGraw-Hill international edition, 2005.
2.	Coulson J.M and Richardson. J.F, *Chemical Engineering Volume I and II*, 5th Edn., Elsevier India, 2006.

Basic Electronics Engineering Laboratory (ECL-256)

<table>
<tr><td rowspan="3">Subject: Basic Electronics Engineering Laboratory (ECL-256)</td><td rowspan="3">Year & Semester: B. Tech Chemical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term/Class Assessment</td><td colspan="3">Final-Term</td></tr>
</table>

Course Objectives: To acquire knowledge and become familiar with the different characterization techniques to analyze diode circuits, BJT circuits, operational amplifiers, Digital Logic Gates, and Instrumentation systems.

Details of the Syllabus: (Total Contact Hours: 12X2)

S. No.	Particulars
1	Study of CRO - Measurement of Voltage frequency and Phase of a given waveform
2	To obtain diode characteristics. Half wave and a full wave rectifier and to study their performance. Clipping and Clamping circuits
3	To obtain transistor characteristics in the following configurations. a. Common base b. Common emitter
4	To assemble a CE amplifier and observe its performance
5	To assemble a differential amplifier and obtain its CMRR.
6	To study different applications of OP AMPS. a. OP-AMP as an inverting amplifier. b. OP AMP as a non inverting amplifier c. OP AMP as an integrator d. OP AMP as a differentiator
7	To measure the following parameters of a typical OP-AMP. a. I/P Impedance b. O/P Impedance c. Slew rate d. CMRR
8	To verify the truth table of following logic gates: a. AND OR and NOT b. NAND, NOR, XOR and XNOR c. To realize any one of above gate using discrete active and passive components.
9	To implement XOR and XNOR using universal logic gates.
10	To study a Linear Variable Differential Transformer (LVDT) and use it in a simple experimental set up to measure a small displacement.
11	To study measurement of displacement using strain gauge.

5^{th} Semester

Process Equipment Design-I (CET-305)

Course Objective:

Subject: Process Equipment Design-I (CET-305)	Year & Semester: B.Tech. Chemical Engineering 3^{rd} year & 5^{th} Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

The objective of the course is to provide basic knowledge of design parameters and their applications in the design of the equipments such as pressure vessels, storage tanks and tall towers used in the process industries along with the flanges and supports.

Course Outcomes (COs)

CO1.	Getting basic idea about the mechanics of materials.
CO2.	Understanding of mechanical design of storage tank, pressure vessel and tall tower.
CO3.	Acquiring knowledge of flanges and supports with respect to design and applications.

Details of the Syllabus

Unit-I	Mechanics of Materials: Stress, strain, biaxial stress, stress-strain relationship for elastic bodies, theories of failure, thermal stresses, membrane stresses in shells of revolution, thin and thick cylinder.
Unit-II	Pressure Vessel: Selection of type of vessels, material of construction selection and design considerations. Introduction of codes for pressure vessel design, classification of pressure vessels as per codes. Design of cylindrical and spherical shells under internal and external pressure; Pipe thickness calculation under internal and external pressure; Selection and design of closures and heads, design of jacketed portion of vessels. Compensation of openings. Design of high pressure monoblock and multilayer vessels. Inspection and testing of pressure vessels
Unit-III	Flanges: Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges.
Unit-IV	Tall Tower Design: Design of shell, skirt, bearing-plate and anchor bolts for tall tower used at high wind and seismic conditions.
Unit-V	Supports: Design of lug and leg supports. Design of saddle supports including bearing plates and anchor bolts.
Unit-VI	Storage Tanks: Introduction to Indian standards codes, filling and breathing losses; classification of storage tanks; optimum length to diameter ratio, design of liquid and gas storage tanks with and without floating roof

Books Recommended

Text Books	1.	Brownell, L. E., Young, H. E., “Process Equipment Design”, John Wiley (2004). 4. 6.
	2.	Bhattacharya, B. C., “Introduction of Chemical Equipment Design”, CBS Publisher (2003).
	3.	I.S.:2825-1969, “Code for Unfired Pressure Vessels”, (1969).
	4.	I.S.:803-1974, “Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks”, (1984).
Reference Books	1.	Moss, D. R., "Pressure Vessel Design Manual”, 3rd Edn., Gulf (2004).
	2.	Megyesy, E. F., "Pressure Vessel Handbook", 12th Edn., Pressure Vessel Publishing (2001

Chemical Reaction Engineering (CET-306)

<table>
<tr><td rowspan="3">Subject: Chemical Reaction Engineering (CET-306)</td><td colspan="2" rowspan="3">Year & Semester: B.Tech Chemical Engineering
3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 5</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>2</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Continuous Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objectives

The aim of the course is to impart basic knowledge of ideal reactor design for single and multiple reactions, the non-ideal flow, non-isothermal operations and stability of reactors, and understanding about the solid catalyzed and non-catalytic systems.

Course outcomes (COs): Upon successful completion of the course, students will be able to:

CO1	Explain the different types of reactors, their behaviour and performance for single reaction.
CO2	Design of batch, plug-flow and mixed flow reactors for multiple reactions
CO3	Analyze and size the reactors while accounting the non-isothermal conditions and non-ideal flow patterns.
CO4	Design reactors for the homogenous and heterogeneous catalyzed reactions, and understand their effect on performance equations of catalytic reactors.

Details of the Syllabus

Unit-I	**Introduction to Reactor Design:** Classification of rector types, material and energy balance for an element of volume of the reactor, basic performance equation, symbols and relationship between concentration and conversion. **Ideal Reactors:** Design equations for ideal reactors-batch, CSTR and plug Flow
Unit-II	**Design for Single Reaction**: Design equation for single reaction systems – batch reactor, CSTR, PFR and recycle reactor, auto catalytic reactions, reactor choice for single reaction - size comparison of single reactors and multiple-reactor systems.
Unit-III	**Design for Multiple Reactions:** Parallel and series reactions, quantitative treatment of product distribution and of reactor size for different types of ideal reactors, selectivity and yield factors, potpourri of multiple reactions, reactor choice for multiple reactions, Denbigh reactions.
Unit-IV	**Non-isothermal Operation and Stability of Reactors:** Non-isothermal design of ideal reactors, hot spot in tubular reactor, auto-thermal process, steady state multiplicity optimal temperature progression for first order reversible reaction.
Unit-V	**Non-ideal Flow:** Residence time distribution (RTD) theory, role of RTD in determining reactor behavior, age distribution (E) of fluid, experimental methods for finding E, relationship between E and F curve, models for non-ideal flow – single parameter and multi parameter models (axial dispersion, tanks in series), performance estimation of reactor using reactor models.
Unit-VI	**Solid-Catalyzed and Non-catalytic Reactions:**Catalytic reactions - homogeneous and heterogeneous,steps in solid catalyzed reaction, rate limiting steps, effect of external resistance and diffusion on reaction, Thiele modulus and effectiveness factor, performance equations for catalytic reactors (packed bed, fluidized bed), basic equations for trickle bed and moving bed reactors, fluid-particle reactions-shrinking core model.

Books Recommended

Text Books	1.	Levenspiel, O., "Chemical Reaction Engineering", 3rd Edn., John Wiley & Sons, New York (1998).
	2.	Fogler, H.S., "Elements of Chemical Reaction Engineering", 4th Edn., Prentice-Hall of India Pvt. Ltd. (1995).
Reference Books	1.	Smith, J.M., "Chemical Engineering Kinetics", 2nd Edn., McGraw-Hill Book Company, New York (1981).
	2.	Doraiswamy, L.K., Uner, D., "Chemical Reaction Engineering: Beyond the Fundamentals", CRC Press (2013)
	3.	Froment, G.F., Bischoff, K.B., De Wilde, J.D., " Chemical Reactor Analysis and Design", 3rd Edn., John Wiley & Sons, Inc. (2011).

Mass Transfer-I(CET-307)

Subject: Mass Transfer-I (CET-307)	B. Tech Chemical Engineering 5th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective:

The main purpose of the course is to provide fundamental understanding of basic principles of mass transfer in gases and in liquids and their applications in various mass transfer systems used in process and allied industries.

Course Outcomes (COs):

CO1	Fundamental understanding of mass transfer operations.
CO2	Acquiring knowledge of inter phase mass transfer, and their coefficients.
CO3	Exhibiting basic understanding and analysis of gas absorption, humidification, drying and crystallization.
CO4	Understanding and analysis of the equipments used for the mass transfer operations.

Details of the Syllabus

Unit-I	**Principles of Mass Transfer, Steady and Unsteady States** Molecular diffusion in fluids, diffusivities of fluids, applications of moleculardiffusion-analogies and mass transfer coefficients in laminar flow, concepts of effective diffusivity.Eddy diffusion, mass transfer in turbulent flow, models of mass transfer operations.
Unit-II	**Interphase Mass Transfer** Interphase mass transfer-diffusion between phases, two phases mass transfer coefficients, individual and overall coefficients, stage wise process. Concurrent and counter current processes.
Unit-III	**Gas Absorption** Equilibrium relationships. Material balances for co-current and counter current multistage equipment. Dilute system. HETP, HTU and NTU individual and overallcoefficients. Equipment: General characteristics of tray towers, efficiencies, wetted wall towers, packedtowers, characteristics of packed towers, mass transfer coefficients in packed towers.
Unit-IV	**Humidification** General theory, psychometric chart, fundamental concepts in humidification and dehumidification. Cooling towers and related equipment. **Crystallization** Principles, yield calculation, heat effects and equipment.
Unit-V	**Drying** Equilibria, drying rate curve definitions. Batch and continues drying. Mechanism of drying. Calculation of batch and continuous drying.

Books Recommended

Text Books & Reference Books	**1.**	McCabe, W.L., Smith, J.C., "*Unit Operation of Chemical Engineering*",7th Edn.,**McGraw-Hill (2011).**
	2.	Treybal, R.E., "Mass Transfer Operations" 3rd Edn., McGraw-Hill Book Company (1980).
	3.	Basmadjian, D., "Mass Transfer and Separation Processes: Principles and Applications", CRC Press (2007).
	4.	Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., "Principles of Unit Operations", 2 nd Ed., Wiley-India (2008).
	5.	Seader J DErnest J. Henley, D. Keith Roper, Separation Process Principles , with application using process simulators. 4rth edition John Wiley.

Chemical Technology-I(CET-308)

Subject:Chemical Technology-I (CET-308)	Year & Semester: B.Tech. Chemical Engineering 3rd year &5th Semester		Total Course Credit: 3	
			L / T / P	3 / 0 / 0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)	

Course Objective

To study process technology, availability of raw materials, production trends, preparation of flow sheets, engineering and environmental problems of various chemical industries and manufacturing technologies.

Course Outcomes (COs)

CO1	Understanding of processes used by chemical process industries for production of various chemical products.
CO2	Application of process flow diagram for the chemical process industries.
CO3	Ability to deal with apparatus, unit operations, and chemical economics.
CO4	To enable chemical Engineering solutions to meet the needs of process industry while conserving environment.

Details of the Syllabus

Unit-I	Technology of Water: Classification of water, industrial and municipal purposes, methods for obtaining fresh water from sea water.
Unit-II	Basic Chemical Industries: Common salt, its uses, economics and manufacture. Soda ash, its uses, raw materials, manufacture by Solvay process and its modification. Caustic soda-chlorine types of cells, raw materials, reactions, uses and manufacture.
Unit-III	Bleaching Powder and Hypochlorites: The methods of production. Sulphuric acid: Raw materials, method of manufacture by contact process. Synthetic ammonia: Uses, reactions, manufacturing process, concentration of nitric acid.
Unit-IV	Nitrogenous Fertilizers: Ammonium sulphate, ammonium nitrate and urea, their methods of production. Phosphate Industries: Phosphorous, uses and manufacture; phosphoric acid, uses and types of manufacturing procedures; phosphate fertilizers, raw materials and uses. Manufacture of super-phosphates, granular super phosphate and triple super-phosphate
Unit-V	Cement: History, various types of cements, raw materials, manufacture of Portland cement. Glass: history, uses and composition of glass; different types of glasses, unit operation and processes in the glass manufacture. Ceramics: Uses, basic raw materials, unit processes in ceramic industry. Porcelain: Manufacturing procedure. Enamels: Raw metals, preparation of metal paint, application of enamel and firing.

Books Recommended

Text Books	1.	Rao, M.G., Sittig, M., "Dryden's Outlines of Chemical Technology for the 21st Century", East-West Press, New Delhi (2002).
	2.	Austin, G.T., "Shreve's Chemical Process Industries", 5thEdn., McGraw Hill Book Company (1984).
	3.	Kent, J.A., *"Riegel's Handbook of Industrial Chemistry*," *CBS* Publishers (1997).
Reference Books	1.	Mall I. D., "Petrochemical Process Technology", Macmillan India Ltd., New Delhi (2007).
	2.	Moulijn, J. K., Makkee, M., Van Diepen, A., "Chemical Process Technology", Wiley (2001).

Basic Management Principles (HST-309)

Subject: Basic Management Principles (HST-309)	Year & Semester: B.Tech Chemical Engineering 3rd Year & 5th Semester		Total Course Credit: 3		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

The main objective of the course is to make the students aware of the fundamental understanding of the management principles which could be useful for them in the process, bioprocess industries or in any organization with respect to management.

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

CO1	Acquiring basic knowledge of management and function of the managers.
CO2	Exhibiting understanding about planning, organizing, decision making and objectives.
CO3	Fundamental knowledge with respect to delegation and decentralization of authority.
CO4	Enabling with the importance of human resource development, motivation, communication skill and management information systems.

Details of the Syllabus

Unit-I	Management: It's nature, purpose and definition, management as a pre-requisite for any organization, aims of management, management-art of science. Functions of Managers: Planning, organizing, actuating and controlling.
Unit-II	Planning: Nature and purpose of planning, types of plans, steps in planning/planning process. Objectives: The nature and importance of objectives, types of objectives, primary, secondary, individual and personal objectives. Guidelines for setting objectives.
Unit-III	Decision Making: Importance and limitations of rational decision making, types of decisions, programmed and non-programmed decisions, process of decision making under certainty. Organizing: Nature and process of organizing, steps in organizing/process of organizing, formal and informal organization, span of control, and factors determining effective span.
Unit-IV	Decentralization of Authority: The nature of decentralization, degrees of decentralization, decentralization, philosophy and policy. Delegation of Authority: Meaning of authority/delegation, steps in the process of delegation, factors determining the degree of delegation, art of delegation.
Unit-V	Line/Staff Organization: Line organization, staff organization, line and staff organization, functional and committee organization, the nature of line and staff relationship. Actuating: Nature and purpose of actuating, steps in actuating/actuating process.
Unit-VI	Human Resource Management: Importance of human resource planning, recruitment, selection, training and development, performance appraisal, compensation, packages, promotions, transfers, demotion and separation etc. Leadership: Meaning and importance leadership qualities, effective and ineffective leaders, leadership styles.
Unit-VII	Motivation: Need, want and satisfaction chain. Need hierarchy. Improving employee motivation.

	Communication: Meaning and importance of effective communication, communication process, formal and informal communication. Controlling: Nature and purpose of controlling, steps in controlling/process of controlling, types of controls, requirement of effective controls.
Unit-VIII	Management Information System (MIS): Definition, elements and importance of MIS, manager, management and information, changing MIS environment, managing and controlling the MIS function. New Trends in Management.

Books Recommended

Text Books& Reference Books	1.	George, R., Terry, Irwin, "Principles of Management", (1974).
	2.	Tara Chand, "Industrial Organization and Management", Nem Chand & Brothers, (1973).
	3.	Shukla , M.C., "Business Organization Management 3rd Edition", S. Chand(1967).
	4.	Dean, J. "Management Economics" Prentice-Hall of India Pvt. Ltd., New Delhi (1976).
	5.	"Principles of Management (Ascent Series)" Tata McGraw-Hill (2004).

Numerical Methods (MAT-310)

Subject: Numerical Methods (MAT-310)	Year & Semester: B.Tech Chemical Engineering 3rd Year & 5th Semester		**Total Course Credit: 4**		
			L	T	P
			4	0	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective: The objective is to make the students aware of the numerical methods for the solution of scienceand engineering related problems which cannot be solved analytically.

Course outcomes (COs)

CO1	Acquire fundamental understanding with respect to error estimation and solving algebraic and transcendental equations, and ordinary differential equations with the help of numerical techniques.
CO2	Exhibiting knowledge for solution of simultaneous linear algebraic equations.
CO3	Fundamental knowledge for construction of interpolating polynomial and finding intermediate values.
CO4	Applying the knowledge of numerical methods for solution of chemical engineering based problems

Details of the Syllabus

Unit-I	**Errors in Numerical Calculations** Floating- point form of numbers, Round-off, Algorithm, Stability, Programming errors, Errors of Numerical Results, Error propagation, Basic error principle, Loss of significant digits.
Unit-II	**Numerical Solution of Algebraic and Transcendental Equations** Bolzano's bisection method, iteration method, Regula-Falsi method, Newton-Raphson method, Numerical Solution for system of equations.
Unit-III	**Solution of Simultaneous Linear Algebraic Equations** Gauss elimination method, Gauss-Jordan method, Computation of Inverse by Gauss's Method, LU decomposition, Gauss-Siedel iteration method, Jacobi method, The Eigen value problem.
Unit-IV	**Finite Differences and Interpolation** interpolation Forward, Backward and Shift operators, Central differences, their relations . Existence, Uniqueness of interpolating polynomial, error of interpolation - unequally spaced data; Lagrange's formula, Newton's divided difference formula. Equally spaced data : finite difference operators and their properties, , Newton's forward and backward interpolation formulae, Gauss's forward and backward.
Unit-V	**Numerical Differentiation and Integration** Numerical differentiation using difference techniques, Trapezoidal, Simpson's 1/3 and Simpson's 3/8 rule, Truncation error, Romberg's method.
Unit-VI	**Numerical Solution of Ordinary Differential Equations** Picard's method, Taylor series method, Euler and modified Euler method, Runge-Kutta

	method of 4th order, Predictor-Corrector methods (Adam's-Moulton method & Milne's method.
Unit-VII	**Application of Numerical Methods in Chemical Engineering** Numerical treatment of chemical reaction kinetics, Transport processes, Numerical methods for solving problems arising in heat and mass transfer.

Books Recommended

Text Books	1.	Numerical Methods for Scientists and Engineering M.K. Jain, S. R. Iyengar& R.K. Jain, Wiley Eastern Ltd New age international publishers, 7th Edition, 2019, ISBN: 9789387477254, 9387477258..
	2.	Introductory methods in Numerical Analysis, S.S. Sastry, 5th Edition, Prentice Hall India learning Pvt Ltd, ISBN: 9788120345928, 9788120345928.
	3.	Elementary Numerical Analysis, Kendall E. Atkinson, Han , 3rd Edition, 2006, Wiley India Pvt Ltd, ISBN-13: 978-9754142747
Reference Books	1. 2.	S. D. Conte and C. de Boor, Elementary Numerical Analysis An algorithmic approach, McGraw-Hill, 1980, **ISBN-13:** 978-0070124479. Mathematical Numerical Analysis J.B. Scarborough, Oxford and IBH Publishers, 6th Edition, 2020, ISBN: 9788120417595, 9788120417595
	3.	Numerical Methods for Mathematics, Sciences and Engg. J. H. Mathews, Publishers: Prentice hall college division, 2nd Edition, 1992, ISBN: 9789387477254, 9387477258.

Heat Transfer Lab (CEL-311)

Subject: Heat Transfer Lab. (CEL-311)	**Year & Semester: B.Tech Chemical Engineering 3rd Year & 5th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy*	Total Marks (100)			

**Based on written examination and viva-voce. External examiner from the department to be nominated by H.O.D.*

Course Objective: Purpose of the course is to provide basic understanding of various modes of heat transfer operations, the equipments used for, and their applications.

Course outcomes (COs)

CO1	Acquiring knowledge about estimation and measurement of physical parameters, such as thermal conductivity, heat transfer coefficients and emissivity in various heat transfer systems.
CO2	Generation and analysis of the data with respect to the physical parameters and their applications in design.

List of Experiments

S.No	Experiment
1.	Study of heat transfer by natural convection.
2.	Study of heat transfer by forced convection.
3.	Study of heat transfer in filmwise and dropwise condensation.
4.	Study of heat transfer through a multiple composite wall.
5.	Emissivity measurement of a gray body.
6.	Study of finned tube heat exchanger.
7.	Study of shell and tube heat exchanger.

Books Recommended

1.	McCabe, W.L., Smith, J.C., "Unit Operation of Chemical Engineering", 7th Edn., McGraw-Hill (2011).
2.	Holman, J.P., " Heat Transfer", 10th Edn., McGraw-Hill (2009)
3.	Bergman, T.L., Lavine, A.S., Incropera, F.P., DeWitt, D.P., "Introduction to Heat Transfer", 6th Edn., Wiley (2011).
4.	Kreith, F., Manglik, R.M., Bohn, M., "Principles of Heat Transfer", 7th Edn., Cengage Learning (2010).
5.	Hewitt, G.F., Shires, G.L., Bott, T.R., "Process Heat Transfer", Begell House (1995).

Computer Simulation Lab (CEL-312)

<table>
<tr><td rowspan="3">Subject: Computer Simulation Lab
(Code: CEL312)</td><td rowspan="3">Year & Semester: B.Tech Chemical Engineering 3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td>Evaluation Policy*</td><td colspan="4">Total
(100 Marks)</td></tr>
</table>

**Based on written examination and viva-voce. External examiner from the department to be nominated by H.O.D.*

Course Objective: The objective of the laboratory is to encourage the students to use **Software's pertaining to Chemical Engineering stream.**

Course outcomes (COs): At the end of the course, student will be able to:

CO1.	Understand the basics of some software/s.
CO2.	Model development of the chemical engineering process systems.
CO3.	Perform the simulation of individual equipments.
CO4.	Simulation of Flow Sheets

Details of the Syllabus

A basic background in Numerical Methods and Chemical Engineering is expected, though all the key concepts required for the lab will be reviewed during the course of the semester. Basics of software, key computational techniques relevant to software and use them for simulation and analysis, Simulation of individual equipments and Simulation of flow sheets, Simulation of case studies related to chemical engineering applications.

Books Recommended

1.	Nayef Ghasem, "Modeling and Simulation of Chemical Process Systems", CRC Press, Taylor & Francis Group (2019).
2.	Amiya K Jana, "Chemical Process Modelling and Computer Simulation", 2nd Edition, PHI Learning Private Limited, (2011).
3.	http://courses.washington.edu/overney/ChemE435.html.

6^{th} Semester

Process Equipment Design-II (CET-355)

Subject: Process Equipment Design-II (CET-355)	Year & Semester: B.Tech. Chemical Engineering 3rd year &6^{th} Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

The main purpose of the course is to enable the students to acquire fundamental knowledge with respect to the design and selection of process equipments.

Course Outcomes (COs)

CO1	Acquire basic understanding about the process equipments based on heat and mass transfer operations.
CO2	Exhibit knowledge with respect to design of Process equipments.
CO3	Selection of equipments for various applications.

Details of the Syllabus

Unit-I	Shell-Tube Heat Exchangers: Basic design procedure of heat transfer equipment, overall heat transfer coefficient and fouling factors, shell & tube heat exchangers – construction details, selection algorithm, design codes, mean temperature difference, general design considerations, tube-side heat transfer coefficient and pressure drop, shell-side heat transfer coefficient and pressure drop, various design methods, CAD of shell & tube heat exchangers, mechanical and fabricational aspects. Drawing of heat exchangers.
Unit-II	Condensers: Design of condensers for single vapors, heat transfer coefficient correlations for condensation inside and outside of tubes of the vertical and horizontal condensers, design of desuperheater-cum-condenser and condenser-cum-sub-cooler, condensation of mixtures, pressure drop in condensers.
Unit-III	Reboilers, Vaporizers and Evaporators: Pool boiling, convective boiling, selection of reboilers, & vaporizers, design of reboilers, vaporizers and evaporators, drawing of evaporators
Unit-IV	Distillation Column: Basic design consideration of distillation column, degree of freedom analysis, various design methods of distillation column, general design consideration of multicomponent distillation, plate efficiency, tray hydraulics of sieve and valve – trays. Drawing of distillation column
Unit-V	Packed Columns: Type of packing, packed bed height, column diameter, column internals, design methods, Design of liquid-liquid extraction equipment.
Unit-VI	Miscellaneous Equipment: Design of Crystalizers, Agitated vessels and selection of agitators, design of gas-liquid separators and mixing equipment.

Books Recommended

Text Books	1.	Brownell, L. E., Young, H. E., “Process Equipment Design”, John Wiley (2004). 4. 6.
	2.	Bhattacharya, B. C., “Introduction of Chemical Equipment Design”, CBS Publisher (2003).
	3.	I.S.:2825-1969, “Code for Unfired Pressure Vessels”, (1969).
	4.	I.S.:803-1974, “Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks”, (1984).
Reference Books	1.	Moss, D. R., "Pressure Vessel Design Manual”, 3rd Edn., Gulf (2004).
	2.	Megyesy, E. F., "Pressure Vessel Handbook", 12th Edn., Pressure Vessel Publishing (2001

Mass Transfer-II (CET-356)

Subject: Mass Transfer-II (CET-356)	Year & Semester: B.Tech Chemical Engineering 3rd Year & 6thSemester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

The aim of the course is toenable the students to understand the fundamentals of mass transfer operations, such as distillation, extraction, adsorption and leaching along with their commercial significance and applications.

Course Outcomes (COs)

CO1	Exhibit knowledge about various types and aspects of distillation operations which are commercially important.
CO2	Acquiring basic understanding with respect to extraction, adsorption and leaching operations and their applications.

Details of the Syllabus

Unit-I	**Distillation: V**apour-liquid equilibria for ideal and non-ideal systems. Relative volatility. Azeotropes, enthalpy-concentration diagrams. Single stage flash vaporisation. Partial condensation. Differential distillation for binary systems. Fractionation, McCabe-Thiele and Ponchen-Savarit methods for multistage operations. Reflux, reflux ratio and optimum reflux ratio. Reboilers. Total and partial condensers. Tray efficiencies. Azeotropic, extractive and steam distillations.
Unit-II	**Extraction:** Ternary liquid equilibria, calculation of single stage, multistage cocurrent and multistage counter current operations.
Unit-III	**Adsorption:** Adsorption equilibria, calculations for vapour, gas and liquid adsorptions. Adsorption operations such as single stage, multi stage, cocurrent and multistage counter current operations. Equipments.
Unit-IV	**Leaching:** Principles. Equilibria, Calculations of single stage and multistage leaching processes equipment.

Books Recommended

Text Books & Reference Books	1.	Treybal, R.E., “Mass Transfer Operations” 3rd Edn., McGraw-Hill Book Company (1980).
	2.	McCabe, W.L., Smith, J.C., Harriott, P., “Unit Operations of Chemical Engineering”, 7thEdn., McGraw-Hill Book Company (2011).
	3.	Basmadjian, D., “Mass Transfer and Separation Processes: Principles and Applications”, CRC Press (2007).
	4.	Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., “Principles of Unit Operations”, 2nd Edn., Wiley-India (2008).

Chemical Technology-II (CET-357)

Chemical Technology-II (CET-357)	Year & Semester: B.Tech. Chemical Engineering 3rd year & 6th Semester		Total Course Credit: 3		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

To study process technology, availability of raw materials, production trends, preparation of flow sheets, engineering and environmental problems of various chemical industries.

Course Outcomes (COs)

CO1	Understanding of processes used by chemical process industries for production of various products.
CO2	Application of process flow diagram by the chemical process industries.
CO3	Ability to deal with apparatus, unit operations, and chemical economics.
CO4	To enable chemical Engineering solutions to meet the needs of process industry while conserving environment.

Details of the Syllabus

Unit-I	Coal and Coal Tars: Cola chemicals, law temperature and high temperature carbonization, chemicals from coal tar.
Unit-II	Sugar and Starch: Manufacture of raw sugar crystals from sugar cane, refining operations, manufacture of starch from various materials, starch derivatives, manufacture of glucose. Leather and Gelatin: Preparation of hides, vegetable and chrome tanning, finishing operations, manufacture of gelatin from its raw materials, uses. Glues and adhesives-types and their manufacture.
Unit-III	Pulp & Paper: Sulphite and Kraft processes for manufacture of paper.
Unit-IV	Oils, fats, soaps and detergents: Classification of vegetable oils and fats, production of edible oil and fats, purification, hydrogenation of oils, classification of cleaning compounds and their uses, methods for the production of soaps and detergents.
Unit-V	Man Made Fibres: Classification, cellulosic products. Viscose Rayons, their uses and manufacture. Polyamides-66-nylon, chemical process and method of production. Polyester (Dacron miller), its manufacturing process. Synthetic Plastics: Methods of polymerization, phenol formaldehyde, urea formaldehyde, polyethylene and polyvinylchloride their uses and methods of production. Natural and Synthetic Rubbers: Natural rubber and its processing. Butadiene-styrene polymer, its methods of production. Polychloroprene and its manufacture.
Unit-VI	Dyestuffs: A general study of dye stuffs with reference to their classification based on chemical structure & on its application, azo and vat dyes.
Unit-VII	Petroleum and Petrochemicals: Occurrence, refinery, practice, chemical refining, ethylene, acetylene, synthesis gas, butadiene, their uses and methods of production.

Books Recommended

Text Books	1.	Rao, M.G., Sittig, M., “Dryden’s Outlines of Chemical Technology- for the 21stCentury.East-West Press (1997).
	2.	Austin, G.T., “Shreve’s Chemical Process Industries”, McGraw-Hill Book Company (1984).
	3.	Kent, J.A., "Riegel's Handbook of Industrial Chemistry,” CBS Publishers (1997).

Reference Books	1.	Pandey, A., "Concise Encyclopaedia of Bioresource Technology", CRC Press (2004).
	2.	Mall I. D., "Petrochemical Process Technology", Macmillan India Ltd., New Delhi (2007).
	3.	Moulijn, J. K., Makkee, M., Van Diepen, A., “Chemical Process Technology”, Wiley (2001).

Energy Technology (CET-358)

Subject: Energy Technology (CET-358)	Year & Semester: B.Tech. Chemical Engineering 3rd year &6th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective:

The aim of this course is to provide the fundamental knowledge regarding the utilization and characteristics of various energy resources available (natural or transformed) which usually pertain to Chemical Engineering field.

Course Outcomes (COs):

CO1	Exposure todifferent types of energy resources available.
CO2	Acquire knowledge of different types of nonconventional sources of energy.
CO3	Learn the fuel and flue gas calculations.
CO4	Exposure to design of combustion equipment and energy audit.

Details of the Syllabus:

Unit-I	Survey of different sources of energy and their utilization. Natural fuels-coal, petroleum, processed fuels, coke, water gas, producer gas, refinery gas-LPG,
Unit-II	Non-conventional sources of energy: Introduction to geothermal energy, wind energy, solar energy,nuclear energy, Biogas/Gobar Gas. Harnessing of energy from biomass and its transformed forms.
Unit-III	Combustion calculation of coal and petroleum fractions.
Unit-IV	Design of burner, stackers and furnaces. Recovery of waste heat from chemical and metallurgical processes, selection of suitable energy sources.
Unit-V	Energy audit and management- Role of Energy Managers in Industries – Energy monitoring, auditing &targeting – Economics of various Energy Conservation schemes.

Books Recommended

Text Books	1.	Sarkar, S. "*Fuel and Combustion*" (2000).
	2.	Griswold, J. , "Fuels, Combustion and Furnaces"
	3.	Larry C Whitetal, "*Industrial Energy Management & Utilization".*
	4.	Himus, G.W., "*The Elements of Fuel Technology*"
Reference Books	1.	Duffia , Beckman "*Solar Energy-Thermal Processes*" .
	2.	Beredict, M., Pigford, T.M., "*Nuclear Chemical Engineering*".
	3.	KhadiGrammodyog Commission Report on "*Gobar Gas Plant*".
	4.	S. Van Loo, "*Handbook of Biomass Combustion and Co-Firing*" ,Twente University Press, 2002.

Chemical Process Safety (CET-359)

<table>
<tr><td rowspan="3">Subject: Chemical Process Safety (CET-359)</td><td colspan="2" rowspan="3">Year & Semester: B.Tech Chemical Engineering
3nd Year &6thSemester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Continuous Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objectives

The objective is to impart knowledge about the importance of safety and evaluate suitable strategies for risk mitigation with the help of basic understanding of physical, chemical and physico-chemical transformations of the materials in process industries with respect to safety.

Course Outcomes (COs): Upon successful completion of the course, students must be able to:

CO1	Exhibit understanding about anticipation, recognition, investigation and evaluation of thehazardous conditions and practices which affect the masses, their properties and the environment.
CO2	Develop and evaluate appropriate strategies designed to mitigate risk by understanding the importance of plant safety and safety regulations, different types of plant hazards and their measurement, control, principles and procedures of safety audit.
CO3	Appreciate the importance of physical, chemical and physico-chemical transformations of the material in process industries with respect to safety.
CO4	Analyze the hazards and assess therisk and undertake appropriate preventive steps to address the need of safety.

Details of the Syllabus

Unit-I	**Introduction:**Introduction, safety program, engineering ethics, concept of loss prevention, acceptable risks, accident and loss statistics, nature of accident process, inherent safety, accident investigations-case histories.
Unit-II	**Toxicology:**UN and other classification of chemicals, toxicants entry route, acute and chronic exposure effects, Dose versus response, models for dose and response curves, TLV and PEL. **Industrial Hygiene:** Identification, Material safety data sheets, Industrial hygiene evaluation and control
Unit-III	**Basics of Fires and Explosion:** Fire triangle, definitions, flammability characteristics of liquid and vapours, LOC and inerting, types of explosions, Designs for fire prevention.
Unit-IV	**Hazard Identification:**Work permit systems, color coding of chemical pipe lines, HAZCHEM Code, Hazard survey, checklist, HAZOP, safety reviews, what if analysis
Unit-V	**Risk Assessment:** Probability theory, event tree, fault tree, QRA and LOPA, Dow's fire and explosion index, Mond's index, Dow's Chemical release model.

Books Recommended

Text Book	1.	Crowl, D.A., Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall (2011).
Reference Books	1.	Coulson, Richardson &Sinnott R.K., " Chemical Engineering Volume-6, An Introduction to Chemical Engineering Design", Elsevier Butterworth Heinemann (2005).
	2.	Dow Chemical Company, Dow's Chemical Exposure Index Guide (1993).
	3.	Lees, F. P., "Loss Prevention in Process Industries", Butterworth, London (1996).
	4.	Wells, G. L., "Safety in Process Plant Design", George Godwin Ltd., New York (1980).

Transport Phenomena (CET-360)

Subject: Transport Phenomena (CET-360)	Year & Semester: B. Tech Chemical Engineering 3rd Year & 6th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective:

The aim of this course is to provide the basic understanding of various Transport Processes, Momentum, Mass and Heat.

Course Outcomes (COs):

CO1	To understand Newton's Law of Viscosity (Molecular Momentum) and use vectors /tensors for analysis of same.
CO2	To study the Momentum Transport.
CO3	To study the Energy Transport.
CO4	To study the Mass Transport.

Details of the Syllabus:

Unit-I	Introduction of Transport phenomena. Newton's Law of Viscosity (Molecular Momentum) Transport) Momentum Flux. Generalization of Newton's Law of Viscosity. Vector and Tensor calculations.
Unit-II	Shell Momentum Balances and Velocity Distributions in Laminar Flow The Equations of Change for Isothermal Systems The Equation of Continuity Normal Stresses at Solid Surfaces for Incompressible Newtonian Fluids The Equation of Motion The Bernoulli Equation for the Steady sate case Use of the Equations of Change to Solve Flow of Various typical cases.
Unit-III	Shell Energy Balances and Temperature Distributions. Heat Conduction in various typical cases like a Nuclear Heat Source , Viscous Heat Source , Chemical Heat source and through Composite Walls etc.
Unit-IV	Mass Transport Diffusivity and the Mechanisms of Mass Transport Molecular Mass Transport Temperature and Pressure Dependence of Diffusivities Mass and Molar Transport by Convection Mass and Molar Fluxes Concentration Distributions in Solids and Laminar Flow Shell Mass Balances of some selected cases.

Books Recommended

Text Books	1.	Bi Bird, R.B., Stewart, W.D., Lightfoot, E.W., "*Transport Phenomena*", 2nd Edn., JohnWiley & Sons (2002).
Reference Books	1.	Deen, W. M., "*Analysis of Transport Phenomena*", Oxford University Press (1998).
	2.	Brodkey R. S. and Hershey H. C., "*Basic Concepts of Transport Phenomena*", Vol. 1 and 2, Brodkey Publishing (2001).

Energy Technology Lab. (CEL-361)

Subject: Energy TechnologyLab. (CEL-361)	Year & Semester: B.Tech. Chemical Engineering 3rd year &6th Semester	Total Course Credit: 1		
		L	T	P
		0	0	2
Evaluation Policy*	Total Marks (100)			

**Based on written examination and viva-voce. External examiner from the department to be nominated by H.O.D.*

Objective:

The aim of this laboratory is to perform various experiments pertaining to solid andliquid fuels and their characteristics.

Outcomes (COs):

CO1	Exposure to different types of energy resources.
CO2	Analyze the Proximate analyses parameters of fuels.
CO3	Characterize the various liquid and solid fuels.

Details of the Experiments:

Experiments	1: To determine the Proximate analysis Parameters of coal and other solid fuels. 2. Determination of calorific value of solid fuels. 3. Test for cloud and pour point of petroleum products. 4. Determination of flash point, fire point and specific gravity of petroleum products. 5. To find the Smoke point of a liquid fuel. 6. To study the briquetting/pelletization of biomass.

Books Recommended

Text Books	1.	Sarkar, S. "*Fuel and Combustion*" (2000).
	2.	Griswold, J. , "Fuels, Combustion and Furnaces"
	3.	S. Van Loo, "*Handbook of Biomass Combustion and Co-Firing*" ,Twente University Press, 2002.

Thermodynamics and Reaction Engineering Lab (CEL-362)

<table>
<tr><td rowspan="3">Subject: Thermodynamics and Reaction Eng. Lab. (CEL-362)</td><td rowspan="3">Year & Semester: B.Tech Chemical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td>Evaluation Policy*</td><td colspan="4">Total Marks
(100)</td></tr>
</table>

**Based on written examination and viva-voce. External examiner from the department to be nominated by H.O.D.*

Course Objective

To provide experience on analysis of reaction engineering

Course Outcomes (COs): At the end of the laboratory course, student will be able to:

CO1	The students could independently calculate the reaction kinetics of various reactors used for manufacturing of chemicals in industries.
CO2	Characterize laboratory reactors through residence time distributions.

List of Experiments

Experiment No. 1: Standardization of the given solution of NaOH.
Aim: To determine the normality of NaOH solution

Experiment No. 2: Plug flow reactor
Aim: To determine the second order reaction rate constant for saponification reaction between NaOH and ethyl acetate in a plug flow reactor

Experiment No. 3: RTD study in CSTR
Aim: (a) To plot the RTD curve for a CSTR using a pulse input as a tracer
(b) To determine the dispersion number

Experiment No. 4: Isothermal batch reactor
Aim: To determine the pseudo first order reaction rate constant for the saponification reaction between NaOH and $CH_3COOC_2H_5$ in a constant volume adiabatic batch reactor

Experiment No. 5: Adiabatic batch reactor
Aim: To determine the pseudo first order reaction rate constant for the saponification reaction between NaOH and $CH_3COOC_2H_5$ in a constant volume adiabatic batch reactor

Experiment No. 6: Continuous Stirred Tank Reactor (CSTR)
Aim: To study of a non-catalytic homogeneous second order liquid phase reaction in a CSTR under ambient conditions.

Experiment No. 7: RTD study in Packed Bed Reactor (PBR)
Aim: (a) To plot the RTD curve for a PBR, using a pulse input as a tracer
(b) To determine the dispersion number

Books Recommended

<table>
<tr><td rowspan="3">Text Books</td><td>1.</td><td>Levenspiel, O., “Chemical Reaction Engineering”, 3 rdEdn., John Wiley & Amp;Sons, New York (1998).</td></tr>
<tr><td>2.</td><td>Fogler, H.S., “Elements of Chemical Reaction Engineering”, 4 thEdn. Prentice-Hall of India Pvt. Ltd. (1995).</td></tr>
<tr><td>3.</td><td>Smith, J.M., “Chemical Engineering Kinetics”, 2 ndEdn., McGraw-HillBook Company, New York (1981).</td></tr>
</table>

Industrial Training & Presentation (Code: CEI-363)

<table>
<tr><td rowspan="3">Subject: Industrial Training & Presentation (Code: CEI-363)</td><td rowspan="3">Year & Semester: B.Tech Chemical Engineering 3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 2</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Evaluation Policy*</td><td colspan="4">Total Marks
(100 Marks)</td></tr>
</table>

**Based on presentations by each of the student before a panel of examiners nominated by H.O.D with due weightage to report submitted.*

Course Objective:
To gain practical experience in Industry or research organization.

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

CO1	Correlate class room learning to real industrial applications.
CO2	Development of written and oral communication skills.
CO3	Ability to be a multi-skilled engineer with good practical knowledge.
CO4	Development of management, leadership and entrepreneurship skill.

7^{th} Semester

Pre-Project work (CEP-413)

Subject: Pre-Project work (CEP-413)	Year & Semester: B.Tech. Chemical Engineering 4^{th} Year &7^{th}Semester	Total Course Credit: 2		
		L	T	P
		0	0	4
Evaluation Policy*	Total Marks (100)			

**Based on presentations by each of the student before a panel of examiners nominated by H.O.D with due weightage to Supervisor evaluation and final report submitted.*

Course Objective

This course enables the students to get first-hand experience acquainting with principles and applications of chemical engineering by analysing as well as solving problems concerning industries, research etc.

Course outcomes (COs):

CO1	Acquaint students with research methodology.
CO2	Enable students to correlate class mode learning to real industrial as well as research applications
CO3	Understand the literature and previous studies concerning the problem
CO4	Learn technical report writing and enhance the communications skills.

Note: This is prerequisite for completion of the seventh semester along with other subjects. There is no course content fixed. Collection of information, survey of literature and procurement of materials including chemicals are in scope. Objective of the pre-project work is decided, how the project work would be carried out in the eighth semester, same is finalized at this stage. The same project may be continued for the eighth semester. This includes report writing for pre-project work, presentation of the work done followed by viva-voce examination by the examiner (preferably external).

Seminar (CES-414)

Subject: Seminar (CES-414)	Year & Semester: B. Tech. Chemical Engineering 4th year & 7th Semester	Total Course Credit: 1		
		L	T	P
		0	0	2
Evaluation Policy*	Total Marks (100)			

**Based on presentations by each of the student before a panel of examiners nominated by H.O.D with due weightage to report submitted.*

Course Objective

To nurture skills in writing and communication of technical papers amongst the students so as to become effective engineering professionals.

Course Outcomes (COs)

CO1	Carry out up to date and effective literature study upon a selected topic.
CO2	Report writing and submission under the guidance of a faculty member of the Department.
CO3	Enhancement in communication skills through seminar presentation.

Details of the Syllabus

Each student in batch will be assigned a topic pertaining to Chemical Engineering field. He /she will carry out up-to-date literature survey regarding the topic under guidance of a faculty member. Evaluation will be carried out towards end of semester by a committee of faculty members nominated by the HOD. The evaluation will be based on i) Report writing (format and originality) ii) Presentation skill iii) Understanding and solution of problem/topic assigned.

Process Dynamics &Control (CET-415)

<table>
<tr><td rowspan="3">Subject: Process Dynamics & Control
(CET-415)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
4th Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective:
The aim of this course is to provide the basic understanding of process control;its elements, various order processes and their behaviour towards different inputs/disturbances.

Course Outcomes (COs):

CO1	To understand and introduce the control problem.
CO2	To study the dynamics of a First order system.
CO3	To study the dynamics of a Second order system.
CO4	To study the dynamics of various controllers.

Details of the Syllabus:

Unit-I	Introductory concepts of process control. The chemical process industrial perspective of a typical process control problem, variables of a process. Use of Laplace transformation in control systems.
Unit-II	Feed forward, feedback systems, block diagrams. Linear open loop system transfer function. Derivation of Transfer function and study of transient response of a *First Order* system towards different inputs.
Unit-III	Study of 1st order systems in series. Transfer function and Study of transient response and of *2nd order*system. Study of parameters of *2nd order* under damped response.
Unit-IV	Components of control system. Negative versus positive feedback. Study and behavior of different controllers like Proportional controller, PD Controller, PID Controller.
Unit-V	Derivation of Closed loop transfer functions for physical systems. Transient response of simple control systems for Servo and Regulatory case. Stability criterion, Routh test.

Books Recommended

Text Books	1.	Coughanowr, D.R., LeBlanc, S., “Process System Analysis and Control”, 3rd Edn., McGraw-Hill (2017).
	2.	Stephanopoulos G. “Chemical Process Control – An Introduction to Theory and Practice”, Prentice-Hall of India (2015)
Reference Books	1.	Carlos A. Smith, Armando B. Corripio “Principles and Practices of Automatic Process Control (latest edition).

Process Economics & Plant Design (CET-416)

Subject: Process Economics & Plant Design (CET-416)	Year & Semester: B. Tech Chemical Engineering 4th Year & 7th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

The objective of the course is to provide basic concepts in engineering economics, plant design, safety features and its importance for chemical engineering.

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

CO1	Understand the role of economics in process plant design.
CO2	Exhibit knowledge in design optimization, depreciation and cost estimation.
CO3	Understand the application of various project management techniques.
CO4	Know about the replacement and maintenance analysis.

Details of the Syllabus:

Unit-I	**Time Value of Money**: Interest; Compounding and Discounting Factors; Loan Payments; Cash Flow Pattern: Discrete Cash Flow, Continuous Cash Flow. **Methods for Calculating Profitability**: Methods that do not consider the time value of money; Methods that consider the time value of money; Alternative Investments by Different Profitability Methods; Effect of Inflation on Profitability Analysis; Methods of Profitability Evaluation for Replacements.
Unit-II	**Depreciation**: Straight Line, Declining Balance, Double Declining Balance, sum-of-the years-digit, Sinking Fund. **Analysis of Cost Estimates:** Factors Affecting Investment and Production Costs; Capital Investment; Types of Capital Cost Estimates; Methods for Estimating Capital Investment; Estimation of Revenue; Estimation of Total Product Cost; Gross Profit; Net Profit and Cash Flow; Contingencies.
Unit-III	**Optimum Design and Design Strategy:** Procedure with one, two and more variables; Optimum Production Rates in Plant Operation; Case Studies; Linear Programming: Simplex Algorithm, Dynamic Programming for Optimization; Application of Lagrange Multipliers; Method of Steepest Ascent or Descent.
Unit-IV	**Plant Location and Layout**: Factors for Selection of Plant Location; Site Selection and Preparation; Plant Layout and Installation. **Scale-Up:** Pilot Plants and Models; Principle of Similarity; Dimensional Analysis; Empirical and Semi-empirical Model Building; Regime Concept: Static Regime, Dynamic Regime; Similarity Criteria and Scale Equations for Important Equipments.

Books Recommended

1.	Peters, M. S., Timmerhaus, K. D. and West, R. E., "Plant Design and Economics for Chemical Engineers", McGraw Hill, (2002).
2.	Towler, G., Sinnott, R. K., "Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design", Butterworth-Heinemann, (2012).
3.	Couper, J. R., "Process Engineering Economics (Chemical Industries)", CRC Press, (2003).
4.	Zlokarnik, M., "Scale-up in Chemical Engineering", Wiley-VCH, (2006).
5.	Silla H., "Chemical Process Engineering: Design and Economics”, Marcel Dekker (2003).

Biochemical Engineering (CET-417)

Subject: Biochemical Engineering (CET-417)	Year & Semester: B. Tech. Chemical Engineering 4th year & 7th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective: The objective of the course is to provide basic understanding of biochemistry and microbiology, and their applications to analysis and design of the biological systems with the help of chemical engineering principles.

Course Outcomes (COs)

CO1.	Fundamental understanding of the subject based on various conversion routes.
CO2.	Acquire basic knowledge of microbiology and biochemistry.
CO3.	Exhibit knowledge for analysis of the bioprocess and the unit operations used.
CO4.	Able to analyze the data and their application for bioprocess development.

Details of the Syllabus

Unit-I	Evolution of modern biochemical processes. Role of biochemical engineer in the development of modern fermentation processes. Status of biochem. eng. in the fermentation industry.
Unit-II	Types of Microorganism: Bacteria, fungi, viruses, algae, protozoa. Cell types and structure (Eucaryotic and Procaryotic).
Unit-III	Chemicals of Life: Carbohydrates, fats, proteins, RNA and DNA (structure, uses and functions). Understanding Enzymes: Naming and classification, specificity of enzyme action, active cites, factors affecting enzyme-catalyzed reactions. Kinetics of enzyme-catalysed reactions (Michaelis-Menten equation and Lineweaver Burk Plot).
Unit-IV	Sterilization. Aerobic and anaerobic fermentation. Requirement for growth and media formation. Growth cycle phases for batch cultivation. Parameters of growth and analysis of growth data. Growth kinetics. Aeration and agitation. Scale-up. Bio-reactors. Bio-separation processes.

Books Recommended

Text Books	**1.**	Shijie, L., "Bioprocess Engineering-Kinetics, Sustainability and Reactor Design", 2nd Edn., Elsevier (2017).
	2.	Shuler, M., Kargi, F., “Bioprocess Engineering, Basic Concept”, 2nd Edn., Prentice Hall of India Pvt. Ltd. (2004).
	3.	Bailey, J. E., Ollis, D. F., “Biochemical Engg. Fundamentals”, 2nd Edn., McGraw-Hill Book Company, New York (1985).
	4.	Paul A. Belter, E.L. Cussler, Wei-Shou Hu, "Bio separations, Downstream Processing for Biotechnology", 2nd Edn., Wiley-India (1988).
Reference Books	1.	Pelczar, M.J., Chan, E.C.S., Krieg, N.R., “Microbiology”, 5th Edn. McGraw-Hill Book Company (1986).
	2.	Fairley, J .L.,Kilgour, G. L., “Essentials of Biological Chemistry”, 2nd Edn., Van Nestrond Reinhold Publishing Corporation (1966).
	3.	Palmer, T., “Understanding Enzymes”. Ellis Horwood Limited, Halsted Press, a division of John Wiley & Sons (1985).
	4.	Pirt, S.J., "Principles of Microbe and Cell Cultivation", 1stEdn., Blackwell Scientific Publications, 1975
	5.	McCabe, W., Smith, J. and Harriott, P., "Unit Operations of Chemical Engineering", 7thEdn.McGraw-Hill (2017).

Process Dynamics &Control Lab (CEL-418)

Subject: Process Dynamics & Control Laboratory (CEL-418)	Year & Semester: B. Tech Chemical Engineering 4th Year & 7th Semester	Total Course Credit: 1		
		L	T	P
		0	0	2
Evaluation Policy*	Total Marks (100)			

**Based on written examination and viva-voce. External examiner from the department to be nominated by H.O.D.*

Objective

The purpose of the course is to impart practical understanding about the dynamic behaviour of the control systems and evaluate the responses with respect to the first and higher order systems.

Outcomes (COs): At the end of the laboratory course, student will be able to:

CO1	Estimate the dynamic behavior of the control systems
CO2	Understand the controllability, speed of response of the control systems.
CO3	Tuning of a PID control via manual and automatic tuning.
CO4	Choose PID modes that effect controllability, speed of response the control systems.

List of Experiments:

1. **Temperature Measurement**
   a) Study the different types of temperature sensor for characteristics and time constants.
   b) Study the Seebeck effect
2. **Temperature control Trainer**
   a) Study of on-off controller
   b) Study of open loop response
   c) Study of proportional controller
   d) Study of proportional integral controller
3. **Level control Trainer**
   a) Study of on-off controller
   b) Study of open loop response
   c) Study of proportional controller
   d) Study of proportional integral controller
4. **Multi process Control Trainer**
   a) To study the multi process control trainer for various control experiments simultaneous on a single setup.
5. **Pressure control Trainer**
   a) Study of on-off controller
   b) Study of open loop response
   c) Study of proportional integral controller
   d) Study of proportional integral controller
6. **Two tank interacting liquid level system**
   e) To study the operation of the interacting system and find its Transfer Function
7. **Two tank non interacting liquid level system**
   a) To study the operation of the non-interacting system and find its Transfer Function
8. **First order and second order system**
   a) Study of step response of thermometer
   b) Study of step response of mercury manometer

Mass Transfer Lab (CEL-419)

<table>
<tr><td rowspan="3">Subject: Mass Transfer Lab (CEL-419)</td><td rowspan="3">Year & Semester: B. Tech Chemical Engineering
4th year 7th Semester</td><td colspan="3">Total Course Credit: 2</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Evaluation Policy*</td><td colspan="4">Total Marks
(100)</td></tr>
</table>

**Based on written examination and viva-voce. External examiner from the department to be nominated by H.O.D.*

Course Objective

The purpose of the course is to impart fundamental understanding with respect to the experimental determination of physical parameters, such as diffusivity, heat and mass transfer coefficients, and their significance in mass transfer operations, and in chemical reactions.

Course outcomes (COs): At the end of the course, student will be able to:

CO1	Acquire knowledge of basic techniques for determining gas and liquid diffusivities.
CO2	Exhibit fundamental understanding with respect to the experimental determination of heat and mass transfer coefficients using wetted wall column and cooling tower, respectively.
CO3.	Plot drying rate cure using wet solid.
CO4.	Determine gas absorption characteristics using packed tower.

Details of the Experiments:

Expt-I	To determine the mass transfer coefficient in wetted wall column
Expt-II	To determine effectiveness/efficiency and heat and mass transfer coefficient of cooling tower
Expt-III	To determine the diffusion coefficient of organic vapor in air
Expt-IV	To produce drying rate curve for wet solid being dried with air of fixed temperature and humidity
Expt-V	To determine diffusivity of ionic salt in water at different temperature
Expt-VI	To study absorption with chemical reaction in packed bed

Books Recommended

1.	Treybal, R.E., “Mass Transfer Operations” 3rd Edn., McGraw-Hill Book Company (1980).
2.	McCabe, W.L., Smith, J.C., Harriott, P., “Unit Operations of Chemical Engineering”, 7 thEdn., McGraw-Hill Book Company (2011).
3.	Basmadjian, D., “Mass Transfer and Separation Processes: Principles and Applications”, CRC Press (2007).
4.	Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., “Principles of Unit Operations”, 2nd Edn., Wiley-India (2008).

Elective-I: Polymer Science and Engineering (CET-020)

Subject: Polymer Science and Engineering (CET-020)	Year & Semester: B. Tech. Chemical Engineering 4thYear &7th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

To impart knowledge about polymers, polymerization reactions and their kinetics, polymerization processes, and the mathematical understanding with respect to the rheological behavior of polymers.

Course outcomes (COs): At the end of the course, student will be able to:

CO1	Acquire knowledge about polymerization reaction and its kinetics.
CO2	Exhibit understanding with respect to estimation of molecular weight.
CO3	Get knowledge of processes about polymerization.
CO4	Conceive understanding of mathematical expressions reflecting rheological behavior of polymers.

Details of the Syllabus

Unit-I	**Chemistry of Polymerisation Reaction:** Functionality, polymerization reactions, polycondensation, addition free radical and chain polymerization, copolymerization, block and graft polymerizations, stereo specific polymerization
Unit-II	**Polymerisation Kinetics:** Kinetics of radial, chain and ionic polymerization and co-polymerisation systems.
Unit-III	**Molecular Weight Estimation:** Average molecular weight, number average and weight average, theoretical distributions, methods for the estimation of molecular weight.
Unit-IV	**Polymerisation Processes:** Bulk, solution, emulsion and suspension polymerization. Thermoplastic composites, fibre reinforcement fillers, surface treatment, reinforced thermoset composites-resins, fibers additives, fabrication methods.
Unit-V	**Rheology:** Simple rheological equations, simple linear viscoelastic models-Maxwell, Voigt, materials response time, temperature dependence of viscosity.

Books Recommended

1.	Kumar, A., Gupta, R., “Fundamentals of Polymer Engineering”, CRC (2003).
2.	Fried, J., “Fundamentals of Polymer Science”, Prentice Hall (2004).
3.	Williams, D.J., “Polymer Science &Engg.” Prentice Hall (1971).
4.	Billmayer, Jr., W., “Textbook of Polymer Science” Wiley Tappers (1984).
5.	Rodriguez, F., “Principles of Polymer Systems”, 5thEdn., CRC Press (2003).

Elective-I: Computational Fluid Dynamics (CET-021)

<table>
<tr><td rowspan="3">Subject: Computational Fluid Dynamics
(CET-021)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
4th Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To learn the fundamental concepts of computational fluid dynamics along with basic numerical techniques and discretization techniques using Finite difference method.

Course outcomes (COs):

CO1.	Fundamental understanding and interpretation of governing equations involved in heat and fluid flow problems
CO2.	Understanding of basic numerical technique's involved
CO3.	Understanding of Grid formation
CO4.	Understanding discretization technique's using FDM

Details of the Syllabus

Unit-I	**Basic Concepts of Fluid Flow**: Philosophy of computational fluid dynamics (CFD), review of equations governing fluid flow and heat transfer, simplified flow models such as incompressible, inviscid, potential and creeping flow.
Unit-II	**Overview of numerical methods:** understanding of numerical methods involved like Gauss-Seidel, Rungekutta and Crank Nicolson method**.**
Unit-III	**Grid Generation**: Structured and unstructured grids, choice of suitable grid, grid transformation of equations, Grid Independence test.
Unit-IV	**Finite Difference Method (FDM):** Discretization of ODE and PDE, approximation for first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.

List of Books:

Text and Reference Books	1. Ghosh, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill (1998). 2. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Taylor and Francis (2004). 3. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques", Springer-Verlag (1998). 4. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics, Vol. 2: Specific Techniques for Different Flow Categories", Springer-Verlag (1998). 5. Anderson, J.D., "Computational Fluid Dynamics", McGraw Hill (1995).

Elective-I: Advanced Separation Processes (CET-022)

Subject: Advanced Separation Processes (CET-022)	Year & Semester: B. Tech Chemical Engineering 4^{th} Year & 7^{th} Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective:

The aim of this course is to study the basic concepts of some separation processes usually not covered in other core subjects.

Course Outcomes (COs):

CO1	Introduce various traditional separation processes emphasizing the drying and crystallization processes.
CO2	To study the adsorption separation process.
CO3	To study the membrane separation processes.
CO4	To study the Ionic separations and some novel separation processes.

Details of the Syllabus:

Unit-I	Introduction: Review of conventional separation processes based on size and surface properties. (Theory and equipment used). Classification of Dryers, Dryer Selection and Design. Crystallization: Solid-Liquid Phase Equilibrium, Nucleation and Crystal Growth.
Unit-II	Separations by adsorption techniques Separation by adsorbents and foam separation.Hydro-cyclones, platecolumns, electro static precipitators.
Unit-III	Membrane separations: Types of membranes. Fundamentals of Dialysis, microfiltration, ultrafiltration, nanofiltration& reverse osmosis.
Unit-IV	Ionic separations: Electrophoresis, Dielectrophoresis, Electrodialysis .
Unit-V	Introduction to other novel techniques: Pervaporation , crystallization ,Supercritical extraction,Flash Vaporization etc.

Books Recommended

Text Books	1.	R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill, 1983
	2.	Ernest J. Henley, J. D. Seader Separation Process Principles, 2^{nd} Edition” (2010)
	3	Baker, R.W., *Membrane technology and applications*, 2nd ed., John Wiley 2004

Elective-I: Operations Research (MAT-023)

<table>
<tr><td rowspan="3">Subject: Operations Research (MAT-023)</td><td rowspan="3" colspan="2">Year & Semester: B. Tech. Chemical Engineering
4th year 7th Sem.</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective

This course enables the students to understand mathematical models used in Operations Research and to apply these techniques constructively to make effective business decisions.

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

CO1	Identify, formulate, and solve the practical Engineering design problems by applying the optimization techniques.
CO2	Determine the schedule for transporting goods from source to destination in a way that minimizes the shipping cost.
CO3	Figure out the optimal value of the objective function besides presenting an organized strategy for evaluating a feasible region's vertices.
CO4	Determine performance of queuing situation for deciding an appropriate level of service for the facility. Utilize concepts of game theory to tackle safety management in multi-plant Chemical Industrial settings.

Details of the Syllabus:

Unit-I	**<u>Introduction to Operations Research</u>** Concepts and utility of OR in Chemical Engineering, Formulation of Linear Programming Problems, General Statement of LPP, Assumptions Underlying LP, Solution of Linear Programming Problems: Graphic Method. Some Special Cases of Graphic Method, Convex Set: Extreme points of Convex Set, Convex hull.
Unit-II	**<u>Transportation Problem- Models & Solutions</u>** Mathematical Model of Transportation Problem, Methods of finding Initial basic feasible solution by NWC Rule, LCM, VAM, Test for optimality by Stepping Stone and MODI method, Balanced and Unbalanced Transportation Problems, Degeneracy. Assignment Model: Mathematical Model of Assignment Problem, The Hungarian Method, Simplex Explanation of the Hungarian Method.
Unit-III	**<u>Simplex Techniques</u>**: LP Model in Equation Form, Transition From Graphical To Algebraic Solution, Simplex Algorithm, Artificial starting solution: Big M-Method, Two-phase Method, Special cases in Simplex Method: Degeneracy, Alternative Optima, Unbounded solution, infeasible solution.
Unit-IV	**<u>Engineering Applications</u>:** <u>Queuing Theory</u>: General Structure of Queuing System, Operating Characteristics of Queuing System, Queuing Models, Role of Poisson and Exponential Distributions, Pure Birth and Death Models, Generalized Poisson Queuing Model, Specialized Poisson Queues: Single, Multiple and Machine Serving Models. Game Theory: Introduction to Game theory, Two-person, zero-sum games.Dominance.

List of Books:

Recommended	1. Linear Programming by G. Hadlay, Addison Wasley. 2. Operations Research – An Introductory by Hamidi A. Taha, Macmillan.

Books:	3. Operations Research – Methods and problems by M. Sasieni, A. Yaspam and L. Friedman, John Wily and Sons Inc. London.
References:	1.Linear Programming by S.I. Gass, Mc-Graw Hill. 2. Introduction to Operations Research. John Wiley and Sons, New York. 3. Operations Research: An Introduction. Prentice Hall of India Private Limited, New Delhi Wagner.

Elective-I: Process Heat Integration (CET-024)

Subject: Process Heat Integration (CET-024)	Year & Semester: B. Tech Chemical Engineering 4th Year & 7th Semester		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective: Optimizing industrial processes by identifying the heat recovery potential and the optimal integration of energy conversion systems.

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

CO1.	Ability to understand the fundamentals of process integration
CO2.	Ability to determine the minimum heating and cooling requirements
CO3.	Ability to design minimum energy heat exchanger networks
CO4.	Ability to understand the composite and grand composite curves

Details of the Syllabus:

Unit-I	**Process Integration and its Building Blocks:** Definition of Process Integration (PI), School of thoughts, Areas of application and Techniques available for PI, Onion diagram.
Unit-II	**Pinch Technology – An Overview:** Introduction, Basic concept, How it is different than energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology.
Unit-III	**Pinch Technology:** Data extraction, Targeting, Designing, Optimization-Supertargteing. Grid diagram, Composite curve, Problem table algorithm, Grand composite curve. **Targeting of Heat Exchanger Network (HEN):** Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting.
Unit-IV	**Designing of HEN:** Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.
Unit-V	**Heat Integration of Equipments:** Heat engine, Heat pump, Distillation column, Reactor, Evaporator, Drier, Refrigeration systems. **Heat and Power Integration:** Co-generation, Steam turbine, Gas turbine.

Books Recommended

Text and Reference Books	**1.**	Kemp I. C., "Pinch Analysis and Process Integration: A user Guide on Process Integration for the Efficient Use of Energy", Butterworth-Heinemann. (2007)
	2.	Smith R.., "Chemical Process Design and Integration", 2nd Ed., Wiley. (2005)
	3.	Shenoy U. V., "Heat Exchanger Network Synthesis", Gulf Publishing Company. (1995)
	4.	Halwagi, M. M., "Process Integration", 7th Ed., Academic Press. (2006)

Elective-II: Cement Technology(CET-025)

<table>
<tr><td rowspan="3">Subject: Cement Technology (CET-025)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech. Chemical Engineering
4th Year & 7th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To learn the fundamental concepts of the behavioral aspects of various materials in cement making and special concretes.

Course Outcomes (COs):

CO1	Describe the materials used to make cement and technology involved in manufacturing the cement
CO2	Identify, describe and carry out tests relevant to the use of cement and concrete on site
CO3	Explain how good cement is produced

Details of the Syllabus:

Unit-I	Introduction to Cement and cement manufacturing process: Cement and its importance in construction, History of cement and Cement manufacturing process, flow sheet & material composition of cement, various unit operation of cement manufacture, the present status and future of cement industry in India.
Unit-II	Types of Cement and their brief description and application. Calcareous Raw Materials: Source of Lime, Limestone, Chalk, Marl, Industrial waste, geological distribution of limestone deposits in India, Argillaceous Raw Materials: Source of Silica, Alumina, Iron Oxide, Shale and effect of coal ash and additives use as corrective materials, Fly ash , Slag, lime sludge as cement raw materials. Reactivity of Raw materials, Proportioning of Raw materials and preparation of kiln feed.
Unit-III	Pyroprocessing and clinker formation. Characterization of Portland Cement Clinker., Mineralizer, Role of additive in clinker formation, various mineralizer and fluxes, their role in manufacture of clinker. Properties of Cement Paste.
Unit-IV	Cement milling, Finess of cement, Setting times, workability, Compressive strength, Heat of hydration.
Unit-V	Environmental impact of Cement manufacture. Air and Water emissions,

Books Recommended

Text Books	**1.**	Properties of concrete / A.M.Neville / Pearson 5th edition.
	2.	Concrete Technology,(4th edition) by Gambhir, M.L., Tata McGraw-Hill, New Delhi, 2009.
	3.	Rao, M.G., Sittig, M., "*Dryden's Outlines of Chemical Technology- for the 21st Century*.East-West Press (1997).

Elective-II: Managerial Economics for Engineers (HST-026)

Subject: Managerial Economics for Engineers (HST-026)	Year & Semester: B. Tech Chemical Engineering 4th Year & 7th Semester		Total Course Credit: 3		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Course Objective

The objective is to familiarize the students with the basic understanding of managerial economics essential for engineers.

Course Outcomes (COs): At the end of the course, students will be able to:

CO1	Exhibit fundamental understanding about business economics.
CO2	Acquire knowledge of demand and supply.
CO3	Get basic concept with respect to production and cost.
CO4	Understand the market structure and monopoly.

Details of the Syllabus

Unit-I	Introduction to economics & business economics, definition of economics, branches of economics , meaning of business economics, nature, scope &objective of business economics
Unit-II	Theory of demand & supply, meaning of demand & supply, the demand & supply schedule, demand function & supply function, law of demand & supply, individual and market demand & supply, determinants of demand & supply, semand& supply curve, equilibrium with supply & demand curve, types of elasticity of demand & supply, calculating elasticity, measurement of elasticity, degree of elasticity, Consumer Equilibrium – utility analysis, consumer equilibrium – Indifference curve analysis
Unit-III	Theory of production and cost, basic concept of production, the production function, factors of production, total average & marginal product, short & long run production function, law of variable proportion, law of return to scale, law of diminishing marginal product, expansion path, concept of cost and total, marginal & average cost, short run &long run cost, relationship between marginal & average cost
Unit-IV	Market Structure: Meaning & characteristics of perfect competition, price & output determination under perfect competitive market, short run & long run equilibrium, monopoly, definition of imperfect competition , basic concept of monopoly, features of monopoly equilibrium under monopoly short & long run, concept of monopolistic competition, features of monopolistic competition

Books Recommended

Text Books	Paul, Koushil:"Managerial Economics", Cengage Learning, New Delhi,
	Vanita Agarwal: "Managerial Economics", Pearson, New Delhi, 2013.
	Dominick Salvatore: "Managerial Economics", Oxford University Press, New Delhi,2010.
	H.L. Ahuja: "Managerial Economics", S. Chand & Company Ltd, New Delhi-55.
Reference Books	1. Managerial Economics, Geetika, Piyali Ghosh, Purba Roy Choudhury
	2. Principle of Microeconomics, Gregory Mankiw, Cenagage Learning Publications
	Economics, Samuleson and Nordhaus, TMH Publishers Ltd. New Delhi

Elective-II: Multi-component Distillation (CET-027)

<table>
<tr><td rowspan="3">Subject: Multi-component Distillation (CET-027)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
4th Year & 7th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: The objective of the course is to understand the principles and operation of various distillation processes for Multi-component distillation systems.

Course outcomes (COs): At the end of the course, student will be able to:

CO1: VLE calculations like determination bubble point and dew point for multi-component systems using K-values and relative volatility.
CO2: They learn about various types of MCD column.
CO3: Students able to design multi-component distillation unit.

Details of the Syllabus:

Unit-I	Basic concepts of phase equilibria. Distribution co-efficient. Ideal and non-ideal systems. Design variables.
Unit-II	Equilibrium flash separation. Binary distillation, x-y diagrams. Enthalpy concentration diagrams. Design calculations.
Unit-III	Multi-component distillation. Design calculations. Theoretical analysis. Azeotropic and extractive distillation. Distillation equipment. Plate and packed towers. Design procedures.

List of Books:

Recommended Books:	1. Holland, C. D., "Fundamentals of Multi-component Distillation", McGraw-Hill (1981). 2. S*herwood, T.K., Pigford, R.L.,Wilkes, C.R.,"MassTransfer", McGraw-Hill* (1975). 3. Buford D. Smith, B.D., Brinkley, W. K., " General Short- cut Equation for Equilibrium stage Processes", AIChE Journal: 6 (3),446–450 (1960).
References:	1. Sawistowski, H., Smith, W. "Mass Transfer Process calculations", Eng. News: 41, 68 (1963). 2. Treybal, R. E., " Mass-Transfer Operations", 3rd Edn., McGraw-Hill (1981).

Elective-II: Optimization Techniques in Chemical Engineering (CET-028)

<table>
<tr><td rowspan="3">Subject: Optimization Techniques in Chemical Engineering(CET-028)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
4th Year & 7th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: The objective of the course is to understand the detailed theory and application of optimization in chemical engineering and related fields.

Course outcomes (COs): At the end of the course, student will be able to:

CO1	understand the objective functions and conditions for optimization
CO2	Application of optimization to different chemical engineering problems, problem formulation procedures for optimization
CO3	Use of various methods for both constrained and unconstrained optimization problems.

Details of the Syllabus:

Unit-I	Basic concepts of systems analysis and optimization, classical optimization techniques, linear programming, two phase simple method and duality in linear programming,
Unit-II	Transportation models, assignment models, non-linear programming, method of Lagrange multipliers, Wolf's method for solving N.L.P.P,
Unit-III	Formulation of optimization problems in Chemical and allied Engineering. Introduction to dynamic programming, application to chemical engineering.

List of Books:

Recommended Books:	1. Rangaiah, G.P., "*Multi-Objective Optimization: Techniques and Applications in Chemical*", World Scientific Publishing Company Pvt. Ltd. (2009). 2. Deb, K., "*Optimization for Engineering Design: Algorithms and Examples*", 2nd Edn.,PHI (2012). 3. Rao., S.S., " *Engineering Optimization: Theory and Practice*", John Wiley & Sons Inc. (2009).
References:	1. Vlide, I., "*Optimum Seeking Methods"*, Prentice-Hall Inc. (1964). 2. Gass, S.I., "*Linear Programming: Methods and Applications*", McGraw-Hill (2003). 3. Bazaraa, M. S., ,Sherali, H. D., Shetty, C.M., "*Non-Linear Programming: Theory and Algorithms*", John Wiley & Sons (2013).

Elective-II: Heterogeneous Catalysis and Catalytic Processes (CET-029)

<table>
<tr><td rowspan="3">Subject: Heterogeneous Catalysis and Catalytic Processes (CET-029)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech. Chemical Engineering
4th Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective

To gain the knowledge of catalyst characteristics, mechanism of catalytic reactions, and design of catalytic reactors.

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Course outcomes (COs): At the end of the course, student will be able to:

CO1	Develop various catalytic reaction mechanisms.
CO2	Characterize a catalyst.
CO3	Assess the effects of external heat and mass transfer effects in heterogeneous catalysis.
CO4	Calculate the effectiveness of a porous catalyst.
CO5	Design different types of reactors for catalytic reactions.

Details of the Syllabus

UNIT-01	**Catalysis:** Homogeneous and heterogeneous catalysts, classification of catalytic reactions and catalysts, commercial chemical catalysts, steps in catalytic reactions.
UNIT-02	**Preparation and Properties of Catalysts:** Methods of catalyst preparation, physical properties of catalyst – surface area, pore volume, pore size distribution, solid density, particle density, bulk density, void volume, catalyst promoters and inhibitors, catalyst accelerators and poisons.
UNIT-03	**Adsorption and Catalytic Reactions:** Adsorption isotherms, surface reaction, single site and dual site mechanism, desorption, catalyst deactivation, pore structure and surface area estimation and their significance.
UNIT-04	**External Transport Processes:** Fluid particle mass and heat transfer, Mass transfer-limited reactions in packed beds, Non-isothermal behavior of packed-bed reactors, Staged packed bed reactors for approaching optimum temperature progression, Stable operating conditions in reactors and hot spot formation, Effect of external transport processes on selectivity under non-isothermal conditions.
UNIT-05	**Diffusion and Reaction in Porous Catalysts:** Intra-pellet mass transfer and diffusion in cylindrical and spherical porous catalyst particles, Thiele modulus, Diffusion controlled and surface reaction controlled kinetics, Effectiveness factor for catalysts, Effects of heat transfer – temperature gradients across fluid-solid film and across catalyst pellet, Fluidized bed reactors, Three phase reactors – slurry and trickle bed reactors.
UNIT-06	**Generalized Design:** Design of catalytic reactors under adiabatic and non-adiabatic conditions, Design of industrial fixed-bed, fluidized-bed and slurry reactors.

Books Recommended

1.	Smith, J.M., "Chemical Engineering Kinetics", McGraw-Hill (1981).
2.	Fogler, H.S., "Elements of Chemical Reaction Engineering", Prentice-Hall India (2009).
3.	Denbigh, K.G., and Turner, J.C.R., "Chemical Reactor Theory: An Introduction", Cambridge University Press (1984).
4.	Carberry, J.J., "Chemical and Catalytic Reaction Engineering", McGraw-Hill, (2001).
5.	Levenspiel, O., "Chemical Reaction Engineering", John Wiley (2006).

8^{th} Semester

Project Work (CEP-464)

Subject: Project (CEP-464)	Year & Semester: B. Tech Chemical Engineering 4^{th} Year & 8^{th}Semester	Total Course Credit: 8		
		L	T	P
		0	0	16
Evaluation Policy*	Total Marks (100)			

**Based on presentations by each of the student before a panel of examiners nominated by H.O.D with due weightage to Supervisor evaluation and final report submitted.*

Course Objective

This course enables the students to get first-hand experience acquainting with principles and applications of chemical engineering by analyzing as well as solving problems concerning industries, research etc.

Course outcomes (COs): At the end of the course, student will be able to:

CO1	Acquaint students with research methodology.
CO2	Enable students to correlate class mode learning to real industrial as well as research applications
CO3	Understand the literature and previous studies concerning the problem
CO4	Facilitate the learning of proper report writing and comprehensive communications skills.

Note: There is no course content fixed. Based on collection of information, survey of literature and procurement of materials including chemicals during the pre-project work, the final semester project work is carried out in the eighth semester and is finalized by the end of the semester. The final evaluation is based on quality of report, presentation and viva voice examination by the examiner (preferably external).

Bioresource Technology (CET-465)

Subject: Bioresource Technology (CET-465)	Year & Semester: B. Tech. Chemical Engineering 4th year &8th Semester		Total Course Credit: 4 L: 3, T: 1, P: 0	
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)	

Course Objective:

The aim of this course is to provide fundamental knowledge for bioenergy generation and product formation with the help of various conversion processes adequate to diverse bioresource characteristics.

Course Outcomes (COs):

CO1	Fundamental understanding of the bioresources and its applications for attainment of social objectives (energy, environment, product, sustainability).
CO2	Acquire knowledge with respect to the properties of the bioresources and the conversion technologies.
CO3	Exhibiting knowledge of the systems used for bioresource technology.
CO4	Understanding about analysis of data and their applications in design of the systems and development of the bioprocess.

Details of the Syllabus:

Unit-I	Bioresources- natural and anthropogenic; importance of bio-resources and their utilization. Natural bio-resources: agricultural, forestry and aquatic biomass. Biomass availability, production and food security, non- edible biomass characteristics. Anthropogenic bio-resources: Organic wastes-domestic and industrial; characteristics of municipal sewage / sludge and industrial sludges.
Unit-II	Conversion processes : biochemical, thermo-chemical and physico-chemical conversion processes. Biochemical processes : Microbial anaerobic and aerobic processes, enzymatic processes ; fermentation for alcohols and acids ; penicillin and other therapeutic products. Production of single cell protein (SCP) ; bio-pulping, biogasification. Thermo-chemical processes: pyrolysis (coke and pyro-oils), oxidation-combustion, gasification (downdraft, updraft and fixed bed gasification, fluidized bed and entrained bed gasification). Various methods of manufacture of activated carbons
Unit-III	Physico-chemical processes: Pretreatment, steam/acid/alkali hydrolysis, effect of temperature onhydrolysis.
Unit-IV	Special topics: biofuels , biomaterials, specialty chemicals (gylcol, acetic acid and down stream chemicals), anhydrous alcohols-ethanol and butanol; biodiesel, bio-aviation turbine fuel (BATF).

Books Recommended

Text Books	1.	Shuler, M., Kargi, F., "*Bioprocess Engineering, Basic Concep*", 2nd Edn.,Prentice Hall of India Pvt. Ltd. (2004).
	2.	Chakraverty, A., "*Biotechnology and other Alternative Technologies*", Oxford and IBH Publishing Co. Pvt. Ltd. (1995).
	3.	Rao, M.G., Sittig, M., "*Dryden's Outlines of Chemical Technology- for the 21stCentury*.East-West Press (1997).
	4.	Austin, G.T., "*Shreve's Chemical Process Industries*", McGraw-Hill Book Company (1984).
Reference Books	1.	Pandey, A., "*Concise Encyclopaedia of Bioresource Technology*", CRC Press (2004).
	2.	Glaucia, M.S. et al. (eds), "Bioenergy &Sustainability: Bridging the Gaps", SCOPE 72, Universidade de São Paulo, Brazil (2015).
	3.	Eckert &Trihn (eds), "Biotechnology for Biofuel Production and Optimization",

		Elsevier (2016).
	4.	Cock, "Encyclopedia of Life Support Systems (EOLSS)", UNESCO, (2011)
	5.	S. Van Loo, "Handbook of Biomass Combustionand Co-Firing" ,Twente University Press, 2002.
	6.	Wang, W.C. et al., " Review of Biojet FuelConversion Technologies", National Renewable Energy Laboratory (USDE), Technical Report, 2016.

Biochemical Engineering Lab (CEL-466)

<table>
<tr><td rowspan="3">Subject: Biochemical Engineering Lab. (CEL-466)</td><td rowspan="3">Year & Semester: B. Tech. Chemical Engineering
4th year &8th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td>Evaluation Policy*</td><td colspan="4">Total Marks
(100)</td></tr>
</table>

Course Objective:

The purpose is to impart fundamental knowledge with respect to the equipments and techniques essential for carrying out fermentation for generation and analysis of the data and finally development of the bioprocess.

Course Outcomes (COs):

CO1	Acquire basic knowledge of various equipments used in biochemical engineering lab.
CO2	Fundamental understanding of techniques with respect to sterilization, preparation of solid and liquid media, culture growth and preservation.
CO3	Basic understanding of estimation techniques for biomass, substrate and product.
CO4	Generation and analysis of data for design and development of bioprocess.

Details of the Syllabus:

Unit-I	Study of various equipments used in biochemical engineering lab.
Unit-II	Study of sterilization. Preparation of culture media, agar slants and agar plates, growth and preservation of microbial cultures.
Unit-III	Study of aeration and agitation, determination of volumetric mass transfer coefficient ($k_l a$) of oxygen. Methods for estimation of biomass, substrate and product concentrations.
Unit-IV	Kinetic study of fermentation. Study of bioseparation.

List of Experiments

S.No.	Experiments
1.	Study the fundamentals of bioreactor, shaking incubator, spectrophotometer, HPLC, laminar flow chamber, autoclave, centrifuge. w.r.t. its construction, function (application) and principle of operation.
2.	To prepare basic solid media as agar slants and agar plates.
3.	Study of sterilization by application of a steam autoclave.
4.	Quantitative estimation of glucose concentration by DNS colorimetric method or by phenol-sulfuric acid method.
5.	Estimation of cell concentration.
6.	Determination of volumetric mass-transfer co-efficient of O_2 by static method.
7.	Determination of volumetric mass-transfer co-efficient of O_2 by dynamicmethod.
8.	To study the kinetics of alcohol (ethyl alcohol) fermentation by using baker's yeast (*Saccharomyces cerevisae*) in a batch bioreactor.

References

1.	Shuler, M., Kargi, F., "*Bioprocess Engineering, Basic Concep*", 2ndEdn.,Prentice Hall of India Pvt. Ltd. (2004).
2.	Bhattacharya, R.N., "Experiments with Microorganisms", Emkay Publications, Delhi (1986).
3.	Aneja, K.R., "Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation", VishwaPrakashan (New Age International (P) Limited), New Delhi (1996).
4.	Experiments Handouts (Departmental)

Modelling & Simulation of Chemical Process Systems (Code: CET-467)

<table>
<tr><td rowspan="3">Subject: Modelling& Simulation of Chemical Process Systems (Code: CET-467)</td><td rowspan="3" colspan="2">Year & Semester: B.Tech Chemical Engineering
4th Year & 8th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Class Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objective: To provide adequate information to the modelling of chemical engineering process systems and also familiarize the numerical simulation of model equations.

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

CO1.	Identify the terms involved in inventory rate equation of mass, energy and momentum
CO2.	Recall the basic concepts involved in modeling and simulation
CO3.	Apply conservation of mass, momentum and energy equations to engineering problems
CO4.	Develop model equations for chemical engineering systems
CO5	Solve the model equations and chemical engineering problems using numerical techniques

Details of the Syllabus:

Unit-I	**Introduction**: Introduction to process modeling and simulation, terminology of Process modeling and simulation, Steps for building a mathematical model, Inventory rate equation of the conserved quantities, Mathematical formulation of the conserved quantities (Mass, Momentum and Energy equations), Molecular and Convective Transport.
Unit-II	**Rate of generation term and steady state macroscopic balance:** Rate of Generation in Momentum, Energy and Mass Transfer, Steady-State Macroscopic Balances, comparison of microscopic and macroscopic balances, steady state macroscopic balance problem solving using least square method.
Unit-III	**Unsteady state macroscopic balance:** Building blocks of unsteady state macroscopic balance, Pseudo-Steady-State-Approximation, Conservation of Chemical Species, Momentum, Energy and total Mass, Unsteady state Energy balance around a Continuous Stirred Tank, unsteady state macroscopic balance problem solving using Euler’s method.
Unit-IV	**Modeling of chemical process systems:** Models, need of models and their classification, models based on transport phenomena principles, alternate classification of models, Continuous Stirred Tank Reactor (CSTR) with constant holdup, Continuous Stirred Tank Reactor (CSTR) with Variable holdup, Two Heated Tank, Gas phase Pressurized CSTR, Multi-Component Flash Drum, Gravity Flow Tank, Non-isothermal CSTR, Ideal Binary Distillation Column, Batch reactor.
Unit-V	**Process simulation:** Simulation of chemical process equipment, program development and numerical solution, Case Studies.

Books Recommended

Text Books	1.	Luyben, W. L., "Process Modeling, Simulation and Control for Chemical Engineers". McGraw Hill (1990).
	2.	NayefGhasem**, "**Modeling and Simulation of Chemical Process Systems", CRC Press, Taylor & Francis Group (2019).
	3.	Ismail Tosun, Modeling in Transport Phenomena – A Conceptual Approach, 2nd Edn, Elsevier Publications 2007.
Reference Books	1.	Davis M.E., Numerical Methods and Modeling for Chemical Engineers, Wiley, New York, 1984
	2.	Ashok Kumar Verma, Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Press, Taylor & Francis Group (2015).
	3.	Amiya K Jana, "Chemical Process Modelling and Computer Simulation", 2nd Edition, PHI Learning Private Limited, (2011).

Industrial Pollution Abatement (CET-468)

<table>
<tr><td rowspan="3">Subject: Industrial Pollution Abatement (CET-468)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Chemical Engineering
4th Year & 8th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>Evaluation Policy</td><td>Mid-Term
(30 Marks)</td><td>Continuous Assessment
(10 Marks)</td><td colspan="3">Final-Term
(60 Marks)</td></tr>
</table>

Course Objectives:

1. To understand the significance of industrial pollution abatement
2. To understand the sources, effects and prevention of pollution and recycling of water and waste
3. To design and understand the working of pollution control equipment

Course outcomes (COs): Upon successful completion of the course, students will be able to:

CO1.	Understand the sources, effects and prevention of pollution and recycling of water and waste
CO2.	Illustrate the methods to measure the industrial pollution
CO3.	Understand the principles of industrial pollution control and design air pollution control systems
CO4.	Apply the basic chemical engineering concepts in design of industrial wastewater treatment systems

Details of the Syllabus:

Unit-I	**Introduction:** Environment and environmental pollution from chemical process industries, characterization of emission and effluents, environmental Laws and rules, standards for ambient air, noise emission and effluents
Unit-II	**Pollution Prevention**: Process modification, alternative raw material, recovery of by/co products from industrial emissions/effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission/effluents and leakages and their control-housekeeping and maintenance
Unit-III	**Air Pollution Control:** Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption; Design of cyclones, ESP, fabric filters and absorbers.
Unit-IV	**Water Pollution Control:** Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation. *Biological Treatment:* Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying
Unit-V	**Solids Disposal:** Solids waste disposal – composting, landfill, briquetting / gasification and incineration

Books Recommended

<table>
<tr><td rowspan="3">Text Books</td><td>1.</td><td>Tchobanoglous , G., Burton, F. L., Stensel, H.D., “Waste Water Engineering: Treatment and Reuse”, Tata McGraw Hill, (2003)</td></tr>
<tr><td>2.</td><td>Vallero, D., “Fundamentals of Air Pollution”, Academic Press, (2007)</td></tr>
<tr><td>3.</td><td>Eckenfelder W. W., “Industrial Water Pollution Control”, McGraw Hill, (1999)</td></tr>
<tr><td rowspan="2">Reference Books</td><td>1.</td><td>Kreith F. and Tchobanoglous G., “Handbook of Solid Waste Management”, Mc Graw Hill, (2002)</td></tr>
<tr><td>2.</td><td>Pichtel, J., “Waste Management Practices: Municipal, Hazardous and Industrial”, CRC (2005)</td></tr>
</table>

Elective –III (CET-069-072)
Elective- IV (CET-073--076)

The two of the electives will be online courses, each having 03 no. of credits (Total 06 credits). Courses will be managed by the faculty mentor from the Department (to be nominated).The courses will be floated at the time of beginning of semester preferably from SWAYAM etc..The student will have to opt for any two of such courses of his/her choice.
The Department will be floating the following subjects as an option for online courses:
1. CET-069 Petroleum Refining
2. CET-070 Clean Technology in Process Industries
3. CET-073 Food Technology
4. CET-074 Instrumental Methods of Analysis
5. CET-075 Nanoscience and Technology

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