AMRITAPURI, BENGALURU, COIMBATORE, CHENNAI

DEPARTMENT OF CHEMICAL ENGINEERING AND MATERIALS SCIENCE

B.Tech. in CHEMICAL ENGINEERING (BTC-CHE)

CURRICULUM AND SYLLABI
(2019)

GENERAL INFORMATION

ABBREVIATIONS USED IN THE CURRICULUM

Cat	-	Category
L	-	Lecture
T	-	Tutorial
P	-	Practical
Cr	-	Credits
ENGG	-	Engineering Sciences (including General, Core and Electives)
HUM	-	Humanities (including Languages and others)
SCI	-	Basic Sciences (including Mathematics)
PRJ	-	Project Work (including Seminars)

AES	-	Aerospace Engineering
AIE	-	Computer Science and Engineering - Artificial Intelligence
BIO	-	Biology
CCE	-	Computer and Communication Engineering
CHE	-	Chemical Engineering
CHY	-	Chemistry
CSE	-	Computer Science and Engineering
CVL	-	Civil Engineering
CUL	-	Cultural Education
EAC	-	Electronics and Computer Engineering
ECE	-	Electronics and Communication Engineering
EEE	-	Electrical and Electronics Engineering
ELC	-	Electrical and Computer Engineering
HUM	-	Humanities
MAT	-	Mathematics
MEE	-	Mechanical Engineering
PHY	-	Physics

Course Outcome (CO) – Statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. NBA has defined the Program Outcomes for each discipline.

PROGRAM OUTCOMES FOR ENGINEERING

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs)

To produce graduates in chemical engineering, who, immediately after graduation or within five years of it:

- can apply the knowledge for engineering practice, research, and management in the chemical and allied industries such as bulk chemicals, specialty chemicals, petroleum & petrochemicals, energy, advanced materials, microelectronics, healthcare, biotechnology, consumer products, and other industries, while adhering to values in the context of ethical, health, environmental, social, safety and economic issues,
- can make worthy progress towards the acquisition of advanced degrees, are motivated to pursue additional training and certifications, and use their knowledge and skills to participate in the activities of local/national/international professional societies,
- have good written and oral communication skills, and communicate their ideas and knowledge via scholarly articles, patents, delivery of effective presentations, and/or training of co-workers and associates,
- strive for continuous self-development and life-long learning and engage in their daily work with awareness of the global or social implications.

Program Specific Outcomes (PSOs)

The undergraduate chemical engineering graduates will be able to:

- obtain, apply, and demonstrate knowledge of core concepts and principles associated with chemical engineering unit operations and unit processes, along with the associated ethics, economics, safety, and sustainability aspects required to work in manufacturing, service, and R&D sectors,
- formulate chemical engineering problems, and then apply computational and simulation tools to solve them for effective, efficient, and sustainable design, operation, and optimization of chemical processes, while being socially and environmentally responsible, and
- plan, design and conduct scientific experiments, analyse the data, apply critical thinking to make valid inferences, and prepare technical and scholarly reports that include management and economics.

SEMESTER I

Cat.	Code	Title	Credit
HUM	19ENG111	Technical Communication	3
SCI	19MAT103	Linear Algebra for Chemical Engineers	4
ENGG	19CSE100	Problem Solving and Algorithmic Thinking	4
SCI	19PHY102/ 19CHY101	Engineering Physics - B /Engineering Chemistry - A	3
SCI	19PHY182/ 19CHY181	Engineering Physics Lab - B / Engineering Chemistry Lab - A	1
ENGG	19MEE100	Engineering Graphics - CAD	3
ENGG	19EEE100	Basic Electrical and Electronics Engineering	3
ENGG	19MEE181	Manufacturing Practice	1
HUM	19CUL101	Cultural Education - I	2
		TOTAL	**24**

SEMESTER II

Cat.	Code	Title	Credit
SCI	19MAT113	Differential and Integral Calculus	4
SCI	19PHY102/ 19CHY101	Engineering Physics - B /Engineering Chemistry - A	3
SCI	19PHY182/ 19CHY181	Engineering Physics Lab - B / Engineering Chemistry Lab - A	1
ENGG	19CSE102	Computer Programming	4
ENGG	19CHE101	Material Balances	4
ENGG	19CHE111	Introduction to Chemical Engineering	3
ENGG	19CHE102	Statics	2
ENGG	19EEE181	Basic Electrical and Electronics Engineering Lab	1
HUM	19CUL111	Cultural Education - II	2
		TOTAL	**24**

SEMESTER III

Cat.	Code	Title	Credit
ENGG	19CHE201	Energy Balance and Thermodynamics	3
ENGG	19CHE202	Fluid Mechanics	3
ENGG	19CHE203	Mechanical Operations	3
ENGG	19CHE204	Principles of Heat Transfer	3
ENGG	19CHE205	Materials Technology	3
SCI	19MAT207	Ordinary & Partial Differential Equations	3
HUM		Free Elective I**	2
ENGG	19CHE281	Chemical Engineering Lab 1	1
HUM	19AVP201	Amrita Values Program I	1
		Total	**22**

SEMESTER IV

Cat.	Code	Title	Credit
ENGG	19CHE211	Chemical Engineering Thermodynamics	3
SCI	19CHE212	Industrial Chemistry	3
ENGG		Professional Elective I*	3
ENGG	19CHE213	Design of Heat Transfer Equipment	2
ENGG	19CHE214	Strength of Materials	3
SCI	19CHE215	Statistical Analysis of Process Data	3
ENGG	19CHE282	Chemical Engineering Lab 2	1
HUM	19SSK211	Soft Skills I	2
HUM	19AVP211	Amrita Values Program II	1
HUM	19LAW300	Indian Constitution	P/F
		Total	**21**

SEMESTER V

Cat.	Code	Title	Credit
ENGG	19CHE301	Chemical Reaction Engineering I	3
ENGG	19CHE302	Chemical Technology	1
ENGG	19CHE303	Principles of Mass Transfer	3
HUM	19ENV300	Environmental Science	P/F
SCI	19MAT302	Numerical Methods	3
ENGG	19CHE381	Chemical Engineering Lab 3	1
HUM	19SSK301	Soft Skills II	2
SCI	19CHE304	Instrumental Methods of Analysis	3
ENGG		Professional Elective II*/ [Live-in –Labs] ***	3
		Total	**19**

SEMESTER VI

Cat.	Code	Title	Credit
ENGG	19CHE311	Chemical Reaction Engineering II	3
ENGG	19CHE312	Design of Mass Transfer Equipment	3
ENGG	19CHE313	Transforms & Control Systems Theory	4
ENGG		Professional Elective III *	3
ENGG	19CHE314	Pumps, Fittings and Valves	1
ENGG	19CHE382	Chemical Engineering Lab 4	1
PRJ	19CHE383	Project Based Learning	2
HUM	19SSK311	Soft Skills III	2
ENGG		Professional Elective IV */ [Live-in –Labs] ***	3
		Total	**22**

SEMESTER VII

Cat.	Code	Title	Credit
ENGG	19CHE401	Process Design and Integration	3
ENGG	19CHE402	Process Equipment Design	3
ENGG	19CHE403	Transport Phenomena	3
HUM		Free Elective **	2
ENGG	19CHE404	Chemical Engineering Software Development	1
HUM	19CHE405	Process Economics	1
ENGG	19CHE481	Chemical Engineering Lab 5	1
ENGG	19CHE482	Process Simulation Lab	3
PRJ	19CHE495	Project Phase- I	2
		Total	**19**

SEMESTER VIII

Cat.	Code	Title	Credit
PRJ	19CHE499	Project Phase - II	10
HUM	19MNG300	Disaster Management	P/F
ENGG	19CHE411	Chemical Engineering Process Safety	1
		Total	**11**

TOTAL CREDITS	**162**

***Professional Elective -** Electives categorised under Engineering, Science ,Mathematics, Live-in-Labs, and NPTEL Courses . Student can opt for such electives across departments/campuses. Students with CGPA of 7.0 and above can opt for a maximum of 2 NPTEL courses with the credits not exceeding 8.

**** Free Electives -** This will include courses offered by Faculty of Humanities and Social Sciences/ Faculty Arts, Commerce and Media / Faculty of Management/Amrita Darshanam -(International Centre for Spiritual Studies).

***** Live-in-Labs -** Students undertaking and registering for a Live-in-Labs project, can be exempted from registering for an Elective course in the higher semester.

PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVES			
Cat.	**Code**	**Title**	**Credit**
ENGG	19CHY231	Biomaterials Science	3
ENGG	19CHY232	Green Chemistry and Technology	3
ENGG	19CHE431	Environmental Engineering for Process Industries	3
ENGG	19CHE432	Chemical Process Modelling and Simulation	3
ENGG	19CHE433	Nanoscience and Nanotechnology	3
ENGG	19CHE434	Material Characterization and Spectroscopic Methods	3
ENGG	19CHE435	Solar Energy	3
ENGG	19CHE436	Process Intensification	3
ENGG	19CHE437	Interfacial Science and Engineering	3

Cat.	Code	Title	Credit
ENGG	19CHE438	Polymer Composites	3
ENGG	19CHE439	Polymer Processing	3
ENGG	19CHE440	Modern Separation Methods	3
ENGG	19CHE441	Biochemical Engineering	3
ENGG	19CHE442	Petroleum Refining and Petrochemical Technology	3
ENGG	19CHE443	Process Instrumentation	3
ENGG	19CHE444	Polymer Materials – Structure Property Relations	3
ENGG	19CHE445	Safety and Hazard Management in Chemical Industries	3

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

Cat.	Code	Title	Credit
CHEMISTRY			
SCI	19CHY243	Computational Chemistry and Molecular Modelling	3
SCI	19CHY236	Electrochemical Energy Systems and Processes	3
SCI	19CHY240	Fuels and Combustion	3
SCI	19CHY232	Green Chemistry and Technology	3
SCI	19CHY239	Instrumental Methods of Analysis	3
SCI	19CHY241	Batteries and Fuel Cells	3
SCI	19CHY242	Corrosion Science	3
PHYSICS			
SCI	19PHY340	Advanced Classical Dynamics	3
SCI	19PHY342	Electrical Engineering Materials	3
SCI	19PHY331	Physics of Lasers and Applications	3
SCI	19PHY341	Concepts of Nanophysics and Nanotechnology	3
SCI	19PHY343	Physics of Semiconductor Devices	3
SCI	19PHY339	Astrophysics	3
Mathematics			
SCI	19MAT341	Statistical Inference	3
SCI	19MAT342	Introduction to Game Theory	3
SCI	19MAT343	Numerical Methods and Optimization	3

FREE ELECTIVES

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM			
Cat.	**Code**	**Title**	**Credit**
HUM	19MNG331	Financial Management	3
HUM	19MNG332	Supply Chain Management	3
HUM	19MNG333	Marketing Management	3
HUM	19MNG334	Project Management	3
HUM	19MNG335	Enterprise Management	3
HUM	19MNG338	Operations Research	3
HUM	19MEE401	Industrial Engineering	3
HUM	19MEE346	Managerial Statistics	3
HUM	19MEE347	Total Quality Management	3
HUM	19MEE342	Lean Manufacturing	3
HUM	19CSE358	Software Project Management	3
HUM	19CSE359	Financial Engineering	3
HUM	19CSE360	Engineering Economic Analysis	3
HUM	19MNG331	Financial Management	3
HUM	19CSE362	Information Systems	3

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS			
Cat.	**Code**	**Title**	**Credit**
HUM	**19CUL230**	**Achieving Excellence in Life - An Indian Perspective**	**2**
HUM	**19CUL231**	**Excellence in Daily Life**	**2**
HUM	**19CUL232**	**Exploring Science and Technology in Ancient India**	**2**
HUM	**19CUL233**	**Yoga Psychology**	**2**
HUM	**19ENG230**	**Business Communication**	**2**
HUM	**19ENG231**	**Indian Thought through English**	**2**
HUM	**19ENG232**	**Insights into Life through English Literature**	**2**
HUM	**19ENG233**	**Technical Communication**	**2**
HUM	**19ENG234**	**Indian Short Stories in English**	**2**
HUM	**19FRE230**	**Proficiency in French Language (Lower)**	**2**
HUM	**19FRE231**	**Proficiency in French Language (Higher)**	**2**
HUM	**19GER230**	**German for Beginners I**	**2**
HUM	**19GER231**	**German for Beginners II**	**2**
HUM	**19GER232**	**Proficiency in German Language (Lower)**	**2**
HUM	**19GER233**	**Proficiency in German Language (Higher)**	**2**
HUM	**19HIN101**	**Hindi I**	**2**
HUM	**19HIN111**	**Hindi II**	**2**
HUM	**19HUM230**	**Emotional Intelligence**	**2**
HUM	**19HUM231**	**Glimpses into the Indian Mind - the Growth of Modern India**	**2**
HUM	**19HUM232**	**Glimpses of Eternal India**	**2**
HUM	**19HUM233**	**Glimpses of Indian Economy and Polity**	**2**
HUM	**19HUM234**	**Health and Lifestyle**	**2**
HUM	**19HUM235**	**Indian Classics for the Twenty-first Century**	**2**

HUM	**19HUM236**	**Introduction to India Studies**	**2**
HUM	**19HUM237**	**Introduction to Sanskrit Language and Literature**	**2**
HUM	**19HUM238**	**National Service Scheme**	**2**
HUM	**19HUM239**	**Psychology for Effective Living**	**2**
HUM	**19HUM240**	**Psychology for Engineers**	**2**
HUM	**19HUM241**	**Science and Society - An Indian Perspective**	**2**
HUM	**19HUM242**	**The Message of Bhagwad Gita**	**2**
HUM	**19HUM243**	**The Message of the Upanishads**	**2**
HUM	**19HUM244**	**Understanding Science of Food and Nutrition**	**2**
HUM	**19JAP230**	**Proficiency in Japanese Language (Lower)**	**2**
HUM	**19JAP2313**	**Proficiency in Japanese Language (Higher)**	**2**
HUM	**19KAN101**	**Kannada I**	**2**
HUM	**19KAN111**	**Kannada II**	**2**
HUM	**19MAL101**	**Malayalam I**	**2**
HUM	**19MAL111**	**Malayalam II**	**2**
HUM	**19SAN101**	**Sanskrit I**	**2**
HUM	**19SAN111**	**Sanskrit II**	**2**
HUM	**19SWK230**	**Corporate Social Responsibility**	**2**
HUM	**19SWK231**	**Workplace Mental Health**	**2**
HUM	**19TAM101**	**Tamil I**	**2**
HUM	**19TAM111**	**Tamil II**	**2**

SYLLABUS

SEMESTER I

19ENG111	TECHNICAL COMMUNICATION	L-T-P-C: 2-0-3-3

Course Objectives

To introduce the students to the fundamentals of mechanics of writing
To facilitate them with the style of documentation and specific formal written communication
To initiate in them the art of critical thinking and analysis
To help them develop techniques of scanning for specific information, comprehension and organization of ideas
To enhance their technical presentation skills

Course Outcome

CO1: To gain knowledge about the mechanics of writing and the elements of formal correspondence.
CO2: To understand and summarise technical documents.
CO3: To apply the basic elements of language in formal correspondence.
CO4: To interpret and analyze information and to organize ideas in a logical and coherent manner.
CO5: To compose project reports/ documents, revise them for language accuracy and make technical presentations.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1										3				
CO2				1						2				
CO3										3				
CO4				1						2				
CO5									2	1				

Syllabus

Unit 1
Mechanics of Writing: Grammar rules -articles, tenses, auxiliary verbs (primary & modal) prepositions, subject-verb agreement, pronoun-antecedent agreement, discourse markers and sentence linkers
General Reading and Listening comprehension - rearrangement & organization of sentences

Unit 2
Different kinds of written documents: Definitions- descriptions- instructions-recommendations- user manuals - reports – proposals
Formal Correspondence: Writing formal Letters
Mechanics of Writing: impersonal passive & punctuation
Scientific Reading & Listening Comprehension

Unit 3
Technical paper writing: documentation style - document editing – proof reading - Organising and formatting
Mechanics of Writing: Modifiers, phrasal verbs, tone and style, graphical representation
Reading and listening comprehension of technical documents
Mini Technical project (10 -12 pages)

Technical presentations

Reference(s)

Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals". II Edition. New York: IEEE press, 2002

Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003

Strunk, William Jr. and White. EB. "The Elements of Style" New York. Alliyan& Bacon, 1999.

Riordan, G. Daniel and Pauley E. Steven. "Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.

Michael Swan. '' Practical English Usage'', Oxford University Press, 2000

Evaluation Pattern

Assessment	Internal	External
Periodical 1	20	
Periodical 2	20	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		20

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19MAT103	LINEAR ALGEBRA FOR CHEMICAL ENGINEERS	L-T-P-C: 3-1-0-4

Course objectives:

The primary objective of the course is to introduce linear algebraic systems in chemical engineering, their vector, matrix and function representations, properties. Specifically, the students will learn eigen representations and their use in principal component analysis. The course will teach the students analytical and numerical techniques to solve systems of linear algebraic equations. Finally, extending these understandings, the course will also introduce nonlinear algebraic equations encountered commonly in chemical engineering. Students will learn numerical techniques to solve single and a pair of nonlinear algebraic equations.

Course Outcomes

CO1: Using the basic concepts of vector and matrix algebra, such as linear dependence / independence, basis and dimension of a subspace, rank and nullity, vector and inner product spaces, analyze matrices and systems of linear algebraic equations.
CO2: Using appropriate numerical techniques, solve systems of linear algebraic equations and determine inverses of invertible matrices, and apply these solutions to engineering problems.
CO3: Use the characteristic polynomial to compute the eigenvalues and eigenvectors of a square matrix, diagonalize matrices, identify linear transformations of finite dimensional vector spaces and compose their matrices. Apply the eigensystem analysis to solve engineering problems.
CO4: Develop numerical techniques to solve single and systems of nonlinear algebraic equations and apply them to solve engineering problems.
CO5: Define correlation between variables, use it to develop linear regression models and apply them to engineering problems.
CO6: Use software for scientific computation (e.g., MATLAB), to enhance and facilitate mathematical understanding, as well as an aid in solving engineering problems and presenting solutions.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3					3	2		2		2	2
CO2	2	3	3	3					3	2		2		2	2
CO3	2	3	3	3					3	2		2		2	2
CO4	2	3	3	3					3	2		2		2	2
CO5	2	3	3	3					3	2		2		2	2
CO6	2	3	3	3	3				3	3		2		2	2

Syllabus

Unit -1
Vectors and Vector Spaces: Inner Products, Linear Dependence, Dimension, Basis, Gram-Schmidt Orthonormalization; Matrix Representation of Vectors: Matrix Algebra and Vector Algebra, Introduction to MATLAB®.

Systems of Linear Algebraic Equations: Cramer's Rule, Gauss Elimination, Gauss-Seidel Iteration, Diagonal Dominance, Tridiagonal Matrix Algorithm (TDMA); Applications: Mass Balance in Flow Sheets, Flow networks, solving electrical circuit problems, stoichiometric equations, Linear ODEs and Linear PDEs

Unit -2

Eigenvalues and Eigenvectors: Definitions and Properties, Positive definite, Negative Definite and Indefinite Matrices, Diagonalization and Orthogonal Diagonalization, Quadratic form, Transformation of Quadratic Form to Principal axes, Symmetric and Skew Symmetric Matrices, Hermitian and Skew Hermitian Matrices and Orthogonal Matrices; Power Method for Eigenvalues and Eigenvectors, Applications to Principal Component Analysis; MATLAB® Exercises

Unit -3

Solution of nonlinear Algebraic Equations: nonlinear algebraic equations; analytical techniques and Numerical techniques for solving single nonlinear equations; Numerical techniques for solving systems of nonlinear equations – Bisection method and Newton-Raphson method. Systems of nonlinear Algebraic Equations: Multivariable Newton-Raphson Method; Applications: Fluid Mechanics, Thermodynamics (Engines), Equation of State, Vapor-Liquid Equilibrium, Conversion in Reversible Reactions; MATLAB® Exercises

Linear Regression: Least Squares, Interpolation and Curve Fitting, Applications: Correlations for Thermodynamic and Transport Properties; MATLAB® Exercises

Textbook(s)

Gilbert Strang, Linear Algebra and Its Applications, 4th Edition, Cengage Learning, 2006
Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley-India Pvt. Ltd., 2011
Bruce A. Finlayson, Introduction to Chemical Engineering Computing, John Wiley & Sons, 2006

Reference(s)

Michael Greenberg, Advanced Engineering Mathematics, 2nd Edition, Pearson, 2011
Kenneth J. Beers, Numerical Methods for Chemical Engineering: Applications in MATLAB, Cambridge University Press, 2006
Alkis Constantinides, Navid Mostoufi, Numerical Methods for Chemical Engineers with MATLAB Applications, Prentice Hall International Series, 1999.
Pradeep Ahuja, Introduction to Numerical Methods in Chemical Engineering, PHI Learning Pvt Ltd, 2010

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CSE100	PROBLEM SOLVING AND ALGORITHMIC THINKING	L-T-P-C: 2-1-3-4

Course Objectives

- This course provides the foundations of computational problem solving.
- The course focuses on principles and methods thereby providing transferable skills to any other domain.
- The course also provides foundation for developing computational perspectives of one's own discipline.

Course Outcomes

CO 1: Apply algorithmic thinking to understand, define and solve problems
CO 2: Design and implement algorithm(s) for a given problem
CO 3: Apply the basic programming constructs for problem solving
CO 4: Understand an algorithm by tracing its computational states, identifying bugs and correcting them

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1												
CO2	3	2	3		3			3	3	3				
CO3	2	1												
CO4	1	1	2		2									

Syllabus

Unit 1
Problem Solving and Algorithmic Thinking Overview – problem definition, logical reasoning; Algorithm – definition, practical examples, properties, representation, algorithms vs programs.

Unit 2
Algorithmic thinking – Constituents of algorithms – Sequence, Selection and Repetition, input-output; Computation – expressions, logic; algorithms vs programs, Problem Understanding and Analysis – problem definition, input-output, variables, name binding, data organization: lists, arrays etc. algorithms to programs.

Unit 3
Problem solving with algorithms – Searching and Sorting, Evaluating algorithms, modularization, recursion. C for problem solving – Introduction, structure of C programs, data types, data input, output statements, control structures.

Text Book(s)
Riley DD, Hunt KA. Computational Thinking for the Modern Problem Solver. CRC press; 2014 Mar 27.

Reference(s)
Ferragina P, Luccio F. Computational Thinking: First Algorithms, Then Code. Springer; 2018.
Beecher K. Computational Thinking: A beginner's guide to Problem-solving and Programming. BCS Learning & Development Limited; 2017.
Curzon P, McOwan PW. The Power of Computational Thinking: Games, Magic and Puzzles to help you become a computational thinker. World Scientific Publishing Company; 2017.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHY101	ENGINEERING CHEMISTRY - A	L-T-P-C: 2-1-0-3

Course Objectives

- The main objective of the course is to impart knowledge on the fundamentals concepts of chemistry involved in application of several important engineering materials that are used in the industry/day-to day life

Course Outcomes

CO1: Understand the basic principles behind the properties of engineering materials through sound knowledge in Chemical bonding, photochemistry and electrochemistry**.**
CO2: Apply the chemistry concepts to assess and justify the choice of materials for industrial applications.
CO3: Evaluate the physical and chemical parameters for the selection of suitable materials for industrial processes and Applications.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-									
CO2	3	3	2									
CO3	2	3	2									

Syllabus

Unit 1

Atomic Structure and Chemical Bonding
Fundamental particles of atom – their mass, charge and location – atomic number and mass number – Schrondinger equation. Significance of ψ and ψ^2 – orbital concept – quantum numbers - electronic configuration. Periodic properties. Formation of cation and anion by electronic concept of oxidation and reduction – theories on bonding- octet, Sidgwick and Powell, VSEPR and VBT-MOT. Formation of electrovalent, covalent and coordination compounds. Chemistry of weak interactions – van der Waals force and hydrogen bonding.

Unit 2

Electrochemical energy system
Faradays laws, origin of potential, electrochemical series, reference electrodes, Nernst equation, introduction to batteries – classification – primary, secondary and reserve (thermal) batteries. Characteristics – cell potential, current, capacity and storage density, energy efficiency. Construction, working and application of Leclanche cell-Duracell, Li-MnO_2 cell, lead acid batteries. Ni-Cd battery, Lithium ion batteries. Fuel cell - construction and working of PEMFC.

Unit 3

Photochemistry and solar energy
Electromagnetic radiation. Photochemical and thermal reactions. Laws of photochemistry, quantum yield, high and low quantum yield reactions. Jablonski diagram - photophysical and photochemical processes, photosensitization, photo-polymerization and commercial application of photochemistry.
Solar energy - introduction, utilization and conversion, photovoltaic cells – design, construction and working, panels and arrays. Advantages and disadvantages of PV cells. DSSC (elementary treatment).

Unit 4

Corrosion control and metal finishing
Introduction, causes and different types of corrosion and effects of corrosion, theories of corrosion – chemical corrosion, Pilling Bed-worth ratio, electrochemical corrosion and its mechanism, factors affecting corrosion – galvanic series. Corrosion control methods – cathodic protection, sacrificial anode, impressed current cathode. Surface coatings - galvanizing, tinning, electroplating of Ni and Cr, organic surface coatings – paints, constituents and functions. Anodising and electroplating of aluminium.

Unit 5

Water Technology
Hardness of water – types – expression of hardness – units – estimation of hardness of water by EDTA. Numerical problems – boiler troubles (scale and sludge). Treatment of boiler feed water – Internal treatment (phosphate, colloidal, sodium aluminate and calgon conditioning). External treatment – Reverse Osmosis, ion exchange process.

Text Book(s):
Vairam and Ramesh "Engineering Chemistry", Wiley, 2012Amrita Vishwa Vidyapeetham, Department of sciences, "Chemistry Fundamentals for Engineers", McGraw Hill Education, 2015.

Reference Book(s):
Jain and Jain, "Engineering Chemistry", DhanpatRai Publishing company, 2015
Puri, Sharma and Patania, " Principles of Physical chemistry", Vishal Publishing Co., 2017.
Atkins, "Physical Chemistry", OUP, Oxford, 2009

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHY181	ENGINEERING CHEMISTRY LAB - A	L-T-P-C: 0-0-3-1

Course Objective

- The objective of the laboratory sessions is to enable the learners to get hands-on experience on the principles discussed in theory sessions and to understand the applications of these concepts in engineering.

Course Outcomes

CO1: Estimate the quantity of chemical substance in the given sample by electrochemical methods
CO2: Determine the water quality parameters using titrimetric analysis for domestic and industrial applications.
CO3: Examine the physical and chemical parameters of materials for engineering applications.
CO4: Examine the separation of components and analyze the sample by spectrophotometry.

CO-PO Mapping

PO/PSO CO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	2	1									
CO 3	3	2										
CO4	3	2										

Lab

1. Estimation of alkalinity in given water samples
2. Adsorption of acetic acid by charcoal
3. Potentiometric titration – acid-base/redox
4. Conductometric titration
5. Estimation of hardness by ion-exchange method
6. Determination of kinematic viscosity by Redwood Viscometer
7. Anodisation of Aluminium – Relation between current and thickness
8. Determination of acid value of an oil
9. Separation techniques – TLC, Column chromatography
10. Verification of B-L law by UV-spectrophotometer

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

* CA – Principles of experiment, skill, result analysis and report

19MEE100	ENGINEERING GRAPHICS - CAD	L-T-P-C: 2-0-3-3

Course Objectives

- Familiarize with Bureau of Indian Standards (BIS) for creating engineering drawings
- Train the students on proper dimensioning and construction of simple geometries
- Inculcate with the concept of developing orthographic projections and isometric views using CAD drafting package

Note:

1. Drawing practice to be carried out using drafting package (Auto-CAD)
2. First angle projection to be followed

Course Outcomes

CO1: Understand the engineering drawing standards and their usage
CO2: Interpret engineering drawings
CO3: Construct and dimension 2-D geometries using CAD software
CO4: Improve coherent visualization skills
CO5: Inculcate with the concept of developing orthographic projections and isometric views

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2	3	1	2	3		3	2	2	2
CO2	3	3	3	3		2	3	1	2	3		3	2	2	2
CO3	3	3	3	3	3	2	3	1	2	3		3	2	2	2
CO4	3	3	3	3		2	3	1	2	3		3	2	2	2
CO5	3	3	3	3	3	2	3	1	2	3		3	2	2	2

Syllabus

Unit 1
Basic principles of engineering drawing, Standards and conventions, lettering and types of lines, Introduction to drafting software, standard tool bar/menus, navigational tools. Co-ordinate system and reference planes. Creation of 2 dimensional drawing environment. Selection of drawing size and scale. Sketching of 2D simple geomentries, editing and dimensioning of 2D geomentries.

Unit 2
Orthographic Projections: Introduction, planes of projection, projection of points in all the four quadrants. Projection of straight lines, Projection of Plane Surfaces, Projection of regular solids, Sectioning of solids

Unit 3
Plan and elevation of simple buildings with dimensions

Text Book
BasantAgarwal and C M Agarwal., "Engineering Drawing", 2e, McGraw Hill Education, 2015

Reference Book(s)
Bhat N.D. and Panchal V.M. , " Engineering Drawing Plane and Solid Geometry , 42e, Charoatar Publishing House , 2010James D. Bethune, "Engineering Graphics with AutoCAD", Pearson Education, 2014
K.R. Gopalakrishna, "Engineering Drawing", 2014, Subhas Publications

Narayan K.L. and Kannaiah P, Engineering Drawing, SciTech Publications, 2003
John K.C., "Engineering Graphics for Degree", 1e, Prentice Hall India, 2009

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19EEE100	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

- To impart basic knowledge of electrical quantities and provide working knowledge for the analysis of DC and AC circuits.
- To understand the construction and working principle of DC and AC machines.
- To facilitate understanding of basic electronics and operational amplifier circuits.

Course Outcomes

CO 1: Understand the basic electric and magnetic circuits
CO 2: Analyse DC and AC circuits
CO 3: Interpret the construction and working of different types of electrical machines
CO 4: Analyse basic electronic components and circuits.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	1		-	-	-	-	-	-	-	-	-
CO3	3	3	-	-		-	-	-	-	-	-	-	-	-
CO4	3	3	3	2	-	1	-	-	-	-	-	-	-	-

Syllabus

Unit 1
Introduction to Electrical Engineering, Current and Voltage sources, Resistance, Inductance and Capacitance; Ohm’s law, Kirchhoff’s law, Energy and Power – Series parallel combination of R, L, C components, Voltage Divider and Current Divider Rules – Super position Theorem, Network Analysis – Mesh and Node methods- Faraday’s Laws of Electro-magnetic Induction, Magnetic Circuits, Self and Mutual Inductance, Generation of sinusoidal voltage, Instantaneous, Average and effective values of periodic functions, Phasor representation. Introduction to 3-phase systems, Introduction to electric grids.

Unit 2
Electrical Machines: DC Motor: Construction, principle of operation, Different types of DC motors, Voltage equation of a motor, significance of back emf, Speed, Torque, Torque-Speed characteristics, Output Power, Efficiency and applications. Single Phase Transformer: Construction, principle of operation, EMF Equation. Regulation and Efficiency of a Transformer. Induction Machine: Three Phase Induction Motor: Construction and Principle of Operation, Slip and Torque, Speed Characteristics. Stepper motor: Construction, principle and mode of operation.

Unit 3
PN Junction diodes, VI Characteristics, Rectifiers: Half wave, Full wave, Bridge. Zener Diode- characteristics, Optoelectronic devices. BJT – characteristics and configurations, Transistor as a Switch. Junction Field Effect Transistors - operation and characteristics, Thyristor – Operation and characteristics. Fundamentals of DIAC and TRIAC. 555 Timer, Integrated circuits. Operational Amplifiers – Inverting and Non-inverting amplifier – Instrumentation amplifiers.

Text Book(s)
Edward Hughes. “Electrical and Electronic Technology”, 10th Edition, Pearson Education Asia, 2019.
D. P. Kothari, I J Nagrath, “Electric Machines”, 5th Edition, Tata McGraw Hill, 2017.

A. P. Malvino, "Electronic Principles", 7th Edition, Tata McGraw Hill, 2007.

Reference(s)

S. K. Bhattcharya, "Basic Electrical and Electronics Engineering", Pearson, 2012.
Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall of India Private Limited, 2nd Edition, 2003.
David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.
Michael Tooley B. A., "Electronic circuits: Fundamentals and Applications", 3rd Edition, Elsevier Limited, 2006.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19MEE181	MANUFACTURING PRACTICE	L-T-P-C: 0-0-3-1

Course Objectives

- Introduce basic concepts pertaining to product dismantling and assembly.
- Familiarize with basic pneumatic components and design & validate simple pneumatic circuits.
- Familiarize with sheet metal tools and operations.
- Provide hands-on training on welding and soldering.
- Familiarize with plumbing tools and processes.
- Inculcate and apply the principles of 3D printing to build simple geometries.

Course Outcomes

CO1: Interpret the functionality of various components in a product through dismantling and assembly
CO2: Identify various pneumatic and electro-pneumatic components
CO3: Fabricate simple sheet metal objects using concepts of surface development
CO4: Perform metal joining operations using soldering and arc welding
CO5: Make simple plumbing joints for domestic applications
CO6: Build simple geometries using 3D printing tools

CO-PO MAPPING

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1							2	1		1	1		
CO2	2	2	1		1				2	1		1	1	1	
CO3	2	2							2	1		1	1		
CO4	2	1							2	1		1	1		
CO5	2		2		2							1	1	1	
CO6	2	2	1		1				2	1		1	1	1	

Syllabus

Product Workshop
Disassemble the product of sub assembly-Measure various dimensions using measuring instruments-Free hand rough sketch of the assembly and components-Name of the components and indicate the various materials used-Study the functioning of the assembly and parts-Study the assembly and components design for compactness, processing, ease of assembly and disassembly-Assemble the product or subassembly.

Pneumatic and PLC Workshop
Study of pneumatic elements-Study of PLC and programming. Design and simulation of simple circuits using basic pneumatic elements-Design and simulation of simple circuits using electro-pneumatics.

Sheet Metal Workshop
Study of tools and equipment - Draw development drawing of simple objects on sheet metal (cone, cylinder, pyramid, prism, tray etc.)-Fabrication of components using small shearing and bending machines-Riveting practice.

Welding, Soldering and Plumbing Workshops
Study of tools and equipment - Study of various welding & soldering methods
Arc welding practice - fitting, square butt joint and lap joint - Soldering practice. Plumbing tools – Make a piping joint to a simple piping layout (should include cutting, threading and pipe fixing)

3D-Printing Workshop

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CUL101	CULTURAL EDUCATION I	L-T-P-C: 2-0-0-2

Course Objective

- The course is designed as an introductory guide to the variegated dimensions of Indian cultural and intellectual heritage, to enable students to obtain a synoptic view of the grandiose achievements of India in diverse fields.
- It will equip students with concrete knowledge of their country and the mind of its people and instil in them some of the great values of Indian culture.

Course Outcomes

CO1: Be introduced to the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education**.**
CO2: Understand the foundational concepts of Indian civilization like *puruśārtha*-s, law of karma and *varṇāśrama*.
CO3: Gain a positive appreciation of Indian culture, traditions, customs and practices**.**
CO4: Imbibe spirit of living in harmony with nature, and principles and practices of Yoga.
CO5: Get guidelines for healthy and happy living from the great spiritual masters

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						3	2	3				2		
CO2						3	1	3				2		
CO3						3	1	3				2		
CO4						3	3	3				2		
CO5						3	1	3				2		

Syllabus

Unit 1
Introduction to Indian culture; Understanding the cultural ethos of Amrita Vishwa Vidyapeetham; Amma's life and vision of holistic education.

Unit 2
Goals of Life – Purusharthas; Introduction to Varnasrama Dharma; Law of Karma; Practices for Happiness.

Unit 3
Symbols of Indian Culture; Festivals of India; Living in Harmony with Nature; Relevance of Epics in Modern Era; Lessons from Ramayana; Life and Work of Great Seers of India.

Text Book
Cultural Education Resource Material Semester-1

Reference Book(s)
The Eternal Truth (A compilation of Amma's teachings on Indian Culture)
Eternal Values for a Changing Society. Swami Ranganathananda. BharatiyaVidyaBhavan.
Awaken Children (Dialogues with Mata Amritanandamayi) Volumes 1 to 9
My India, India Eternal. Swami Vivekananda. Ramakrishna Mission.

Evaluation Pattern:

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

SEMESTER II

19MAT113	DIFFERENTIAL AND INTEGRAL CALCULUS	L-T-P-C: 3-1-0-4

Course Objectives

This course introduces the concepts of shifting and scaling of functions, their continuity, one- and two-sided limits, differentiability. It introduces tangents, normals, binormals, curvatures, minima and maxima of functions of single variables, and their applications. It then introduces derivatives of functions of multiple variables and concepts of partial differentiation. It also provides a basic understanding of the finite difference approximations of derivatives. The course then introduces integral as anti-derivative, area under a curve, limit of Riemann. It provides a strong foundation on the techniques of integration, evaluation of definite integrals and their engineering applications. It then introduces the student to numerical integration algorithms. Finally, the course provides an introduction to multiple integrals involving functions of more than one variables and their engineering applications.

Course Outcomes

CO1: Select suitable parameterization of curves and to find their arc lengths
CO2: Find partial derivatives of multivariable functions and to use the Jacobian in practical problems.
CO3: Understand the finite differences and apply to numerical differentiations.
CO4: Understand the concept of integration and numerical integration.
CO5: Apply Fundamental Theorem of Line Integrals and multiple integrals to solve problems in fluid mechanics, thermodynamics and other problems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3											2
CO2	2	3	3	3											2
CO3	2	3	3	3											2
CO4	2	3	3	3											2
CO5	2	3	3	3											2

Unit 1
Functions – Functions and their graphs, Shifting and scaling of graphs; Limits and Continuity of a function- one-sided and two-sided limit; Differentiation – Tangents and derivative, derivative as function, differentiability, continuity of a function; vertical tangent; horizontal and vertical asymptotes, Slope, Tangent, Normal, Curvature, Binormal, Minima and Maxima of a function; Application of derivatives – Concavity and Curve Sketching; Filling and draining of tanks; Derivative of a function - Chain Rule, Implicit Differentiation, Mean Value Theorem, Partial and Total Derivative

Unit 2
Finite differences - Difference Approximations – Forward, Backward and Central Differences; Numerical Differentiation.
Integral as Anti-derivative, Area under Curve, Limit of Sums: Riemann Integral; Integration Formulae - Techniques of Integration; Definite Integrals - Lengths, Areas, Volume, Work, Pressures, Forces; Numerical Integration: Trapezoidal and Simpson's Rules.

Unit 3
Double and Triple Integrals: An Introduction; Application Problems: Thermodynamics (Heat, Work), Fluid Mechanics (without introducing vector calculus), Mass Transfer (NTU in packed beds), Chemical Reaction Engineering (RTD)

Text Books
James Stewart, Calculus: Early Transcendentals, 7^{th} Edition, Cengage Learning, 2012
Maurice D. Weir and Joel Hass, Thomas' Calculus, 12^{th} Edition, Pearson Education India Pvt. Ltd., 2016

References Books
Bruce A. Finlayson, Introduction to Chemical Engineering Computing, John Wiley & Sons, 2006

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19PHY102	ENGINEERING PHYSICS - B	L-T-P-C: 2- 1- 0- 3

Course Objectives

- To enable the student to apply fundamental principles of mechanics, optics, modern physics including elements of quantum mechanics and its role in materials with specific focus on engineering problems.

Course outcomes

CO1: Apply Newton's formulation to dynamical system including central force problem and conservation laws.
CO2: Understand the elements of optics including phenomena of interference, diffraction and polarization.
CO3: Be exposed to the Einstein's theory of matter radiation interaction and different types of lasers.
CO4: Be familiar with basic idea of quantum mechanics and its application to particle in a box and tunnelling.
CO5: Be introduced to crystal physics – free electron theory and the concept of energy band and fermi energy.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										
CO2	3	2										
CO3	3	2	1									
CO4	3	2										
CO5	3	2	1									

Syllabus

Unit 1
Mechanics
Newton's laws of motion – forces, frictional forces, dynamics of uniform circular motion, work, kinetic energy, work-energy theorem, potential energy, conservation of energy, Newton's law of gravitation, motion in uniform gravitational field, centre of mass, conservation of linear and angular momentum.

Unit 2
Waves and Optics
Huygens' Principle, superposition of waves and interference of light by wave front splitting and amplitude splitting, Young's double slit experiment, Newton's Rings, Michelson interferometer.
Fraunhofer diffraction from single slit and circular aperture, Rayleigh criterion for limit of resolution and its application to vision, diffraction gratings and their resolving power.
Polarization: Unpolarized, polarized and partially polarized lights, polarization by reflection, double refraction by uniaxial crystals, Polaroid, half wave and quarter wave plates.

Unit 3
Lasers
Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO_2), solid-state lasers (Ruby, Neodymium), dye lasers.

Unit 4
Quantum Mechanics

De Broglie waves, wave functions, wave equation, Schrodinger wave equation: time dependent and time independent form, operators – Eigen functions and Eigen values, uncertainty principle, particle in a finite potential one -dimensional box, tunnelling effect (Qualitative).

Unit 5
Introduction to Solids
Crystal systems – Miller indices, crystal planes and directions, packing fraction, Classification of solids: Metals, semiconductors and insulators (qualitative), free electron theory of metals, Fermi level, Density of states, Kronig-Penney model and origin of energy bands.

Text Books
Halliday, Resnick, Jearl Walker, "Principles of Physics", 10th Edition, Wiley,2015.
Ajay Ghatak, "Optics", 6th Edition, McGraw Hill Education India Private Limited, 2017.
Eugene Hecht, A R Ganesan, "Optics", 4th Edition, Pearson Education, 2008.
Arthur Beiser, ShobhitMahajan, S RaiChoudhury"Concepts of Modern Physics" McGraw Hill Education India Private Limited, 2017.
Charles Kittel, "Introduction to Solid State Physics" 8th Edition, Wiley, 2012.

Reference Books
David Kleppner, Robert Kolenkow, "An Introduction to Mechanics", 1st Edition, McGraw Hill Education, 2017.
F A Jenkins, H E White, "Fundamental of Optics", 4thEdition,McGraw Hill Education India Private Limited, 2017.
David J Griffiths, "Introduction to Quantum Mechanics",2nd Edition, Pearson Education,2015
M A Wahab, "Solid State Physics", 3rd Edition, Narosa Publishing House Pvt. Ltd., 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19PHY182	ENGINEERING PHYSICS LAB - B	L-T-P-C: 0- 0-3- 1

Course Objective

- To introduce experiments for testing the understanding of physics concepts in the areas of mechanics, optics, solid state and quantum mechanics and electricity and magnetism.
- To make the student to acquire practical skills in finding properties of mater, optical properties, electrical characteristics of semiconductor materials and quantum behavior of materials

.

Course Outcomes

CO1: Be able to perform experiment to study elastic properties of materials.
CO2: Be able to design, perform experiments on dispersion, interference and diffraction.
CO3: Be able to design; perform experiments to measure semiconducting properties.
CO4: Perform experiment to study atomic spectrum of H_2 atom and quantum nature of light.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1									
CO2	3	1	1									
CO3	3	1	1									
CO4	3	1	1									

List of Experiments:

1. Young's modulus - non-uniform bending. [CO 1]
2. Rigidity modulus – moment of inertia of the disc and rigidity modulus of the wire using torsional oscillation. [CO 1]
3. Spectrometer- dispersive power of the material of prism. [CO 2]
4. Radius of curvature of given convex lens- Newton's rings method. [CO 2]
5. Laser- wavelength of diode laser and mean size of Lycopodium particles. [CO 2]
6. Band gap of a semiconductor. [CO 3].
7. Solar cell - determining efficiency and fill factor. [CO 3].
8. Photoelectric effect - Planck's constant and work function of the given metal. [CO 4]
9. Experiment to verify the quantum nature of hydrogen atom by measuring the wavelengths of spectral lines in Balmer series. [CO 4].

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA-Basic principles of experiment, skill, result analysis and viva

19CSE102	COMPUTER PROGRAMMING	L-T-P-C: 3- 0-3- 4

Pre-Requisite(s): 19CSE100 Problem Solving and Algorithmic Thinking

Course Objectives

- This course provides the foundations of programming.
- Apart from the usual mechanics of a typical programming language, the principles and methods will form the main focus of this course.
- Shift from learn to program to programming to learn forms the core of this course.

Course Outcomes

CO 1: Understand the typical programming constructs: data (primitive and compound), control, modularity, recursion etc. thereby to understand a given program
CO 2: Understand and analyze a given program by tracing, identify coding errors and debug them
CO 3: Make use of the programming constructs appropriately and effectively while developing computer programs
CO 4: Develop computer programs that implement suitable algorithms for problem scenarios and applications

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1							1						
CO2	1	1	1					1						
CO3	1	2	2					2						
CO4	2	3	2					3						

Syllabus

Unit 1
Introduction and Review of C language constructs. Functions – inter function communication, standard functions, scope. Recursion – recursive definition, recurivse solution, designing recursive functions, limitations of recursion. Arrays – 1D numeric, searching and sorting, 2D numeric arrays.

Unit 2
Pointers: introduction, compatibility, arrays and pointers, Dynamic memory allocation, arrays of pointers, pointer arithmetic. Strings: fixed length and variable length strings, strings and characters, string input, output, array of strings, string manipulation functions, sorting of strings.

Unit 3
Structures: structure vs array comparison, complex structures, structures and functions, Union. Files and streams, file input output, command line arguments.

Text Book(s)
Forouzan BA, Gilberg RF. Computer Science: A structured programming approach using C. Third Edition, Cengage Learning; 2006.

Reference(s)
Byron Gottfried. Programming With C. Fourth Edition, McGrawHill,; 2018.
Brian W. Kernighan and Dennis M. Ritchie. The C Programming Language. Second Edition, Prentice Hall, 1988.
Eric S. Roberts. Art and Science of C. Addison Wesley; 1995.

Jeri Hanly and Elliot Koffman. Problem Solving and Program Design in C. Fifth Edition, Addison Wesley (Pearson); 2007.

Evaluation Pattern:

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE101	MATERIAL BALANCES	L-T-P-C: 3-1-0-4

Pre-Requisite(s): None

Course Objectives

The objective of the course is to introduce unit operations, unit processes, fundamental concepts of Stoichiometry, express the composition of solids, liquids and gases, discuss ideal gas laws and P-V-T calculations, identify excess and limiting reactants, estimate yield and conversion, humidity, calculations involving humidity charts, steady and unsteady material balance in unit operations, understand and use concepts of recycle, bypass and purge, single-pass and overall conversions, perform Orsat, proximate and ultimate analyses of coal, sulphur, nitrogen, phosphorous and chlorine compounds, and develop steady flow material balance equations in multiple unit operations.

Course Outcomes

CO 1: Understand the fundamental concepts of stoichiometry and identifying process variables, estimation of composition of mixtures and solutions, conversion and yield.
CO 2: Ability to make and solve material balance equations on unit operations and processes
CO 3: Ability to perform material balances with chemical reactions
CO 4: Ability to perform material balances involving multiple unit operations

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	-	-	-	-	-	-	-	2	2	-
CO2	3	3	3	3	2	-	-	-	-	-	-	-	3	2	-
CO3	3	3	3	3	2	-	-	-	-	-	-	-	3	2	-
CO4	3	3	3	3	2	-	-	-	-	-	-	-	2	3	-

Syllabus

Unit 1
Chemical Engineering approach-Streams, Units and Processes; Unit operations and processes: Fluid and solid operations, Heat transfer operations, Mass transfer and separation operations, Chemical reactors, Control of processes, Costing and Economics, Representing streams: Dimensions and unit conversions, Conversion factors, Dimensional consistency, Dimensionless numbers in chemical engineering, Representing compositions of mixtures and solutions: Binary and ternary mixtures, Compound stoichiometry, Representing gas phases: Ideal gas law, P-V-T calculations, Partial pressures and pure component volumes in mixtures. Representing reactions: Reaction stoichiometry, Conversion, Yield, Selectivity, Limiting and excess reactants,Dissociating gases. Representing moist gases: Humidity, Wet and dry bulb temperatures, Humidity chart

Unit 2
Material balance-Control volume, Conservation of mass and species in a unit; Steady and unsteady state processes, Batch and Continuous processes; Basis for calculation; Degrees of freedom; Steady and unsteady material balance in unit operations: Evaporation; Crystallization; Leaching; Adsorption; Dying; Liquid-Liquid Extraction; Absorption; Distillation; Recycle, Bypass and Purge

Unit 3
Combustion: Orsat analysis, Proximate and ultimate analysis of coal; Single-pass and overall conversions; Oxidation of sulphur compounds; Reactions involving phosphorous; Reactions involving nitrogen; Reactions involving chlorine; Extraction of metals from ores; Hydrogenation, hydration and oxidation; Electrochemical reactions; Recycle bypass and purge involving reactions

Text Book(s)

Bhatt, B.L, and Vora, S.M, Stoichiometry, 3rd Edition, Tata McGraw Hill, New Delhi,1996.
K.V. Narayanan & B. Lakshmikutty, Stoichiometry and Process Calculations, Prentice Hall of India, New Delhi, 2009.
Murphy, R.M., Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw Hill International Edition, NewYork,2007.

Reference(s)

David M Himmelblau, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall Inc., New York,2003.
Richard M Felder & Ronald W. Rousseau Elementary Principles of Chemical Processes, 3rd Edition, John Wiley and Sons, New York,2003.
Hougen, O.A, Watson K.M., and Ragatz, R.A, Chemical Process Principles Part I, CBS Publishers,1973.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE111	INTRODUCTION TO CHEMICAL ENGINEERING	L-T-P-C: 3-0-0-3

Pre-Requisite(s): None

Course Objectives

The students will learn different areas where Chemical Engineers have significantly contributed. After this, they will learn the fundamentals of important courses in Chemical Engineering and different physical quantities and dimensionless numbers. Further, they will develop mathematical equations for simple equipment and processes.

Course Outcomes

CO 1: Understand various fields to which chemical engineers have contributed and identify the roles of a modern Chemical Engineer.
CO 2: Convert the batch process of a chemical production into a continuous process
CO 3: Convert units of physical quantities from one system to another and converting them into suitable dimensionless form
CO 4: Understand the skeleton of Chemical Engineering curriculum and ethics to be followed in Chemical Engineering profession
CO 5: Develop simple mathematical equations of a process using conservation principles and solve them using suitable mathematical techniques
CO 6: Develop a process flow diagram and equipment required for a given process based on a problem statement and perform preliminary profitability analysis.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				2								3		
CO2		2											1		
CO3	3												3		
CO4	2												2		
CO5	3	3												3	
CO6				2										3	

Syllabus

Unit 1
Historical evolution of chemical engineering; what is chemical Engineering; the impact & role of chemical engineering; representing chemical processes using process diagrams and flow sheets (introduction to unit operations and unit processes; batch vs. continuous operation); understanding prevalent symbols; chemical process industries: evolution, broad classification, characteristics, origin, growth, present scenario, & projections; opportunities and challenges; roles of the modern chemical engineer.

Physical quantities: units & dimensions, conversion & conversion factors; important process variables, making the connection between the variables and their measurements; conventions in methods of analysis and measurement, basis, chemical equations and stoichiometry, conversion, and yield; industrially important physical and chemical properties.

Unit 2
Introduction to fluid flow (pressure-flow interaction, non-flowing fluids, pumps & turbines), heat transfer (applications of heat exchange in the industry), mass transfer (molecular vs. bulk transport), reaction engineering

(important of describing reaction rate and design of reaction vessel), materials (important properties and their influence on selection of materials), and control (need for control and strategies); mathematical representation of process. Dimensional consistency and Dimensional analysis related to Chemical Engineering

Unit 3
Computer aided calculations & spreadsheets; graphing (basic plots, interpreting trends, curve fitting, log-log & semi-log representation); Relation between chemical engineering and physico–chemical sciences and other engineering disciplines; modern view of chemical engineering; economics (costs in industry, profitability considerations, analytical view of process and reporting of performance); safety-health-environment; ethics; case studies.
Representing Processes: Creating Flow sheets; Degrees of freedom Analysis of flow sheets; Material Balance Involving unit operations; Modular and Overall equation-solving approaches; Case studies involving flow sheets.

Text Book(s)
K.A. Solen and J.N. Harb, Introduction to Chemical Engineering – Tools for Today and Tomorrow, 5th Edition, Wiley, 2011.
Morton M. Denn, Chemical Engineering – An Introduction, Cambridge University Press, 2012

Reference(s)
Walter L. Badger and Julius T. Banchero, Introduction to Chemical Engineering, Tata McGraw-Hill, 1955
S. Pushpavanam, Introduction to Chemical Engineering, Prentice Hall India, 2012.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

* CA – Open book Quizzes and Course Project

19CHE102	STATICS	L-T-P-C: 1-1-0-2

Course Objectives

The overall objective of this course is to introduce the concept of rigid body mechanics called Statics. The understanding of rigid body mechanics is essential in engineering applications as it is used to evaluate the equilibrium of bodies subjected to forces and moments..

Course Outcomes

CO1: To understand the vector and scalar representation of forces and moments and to develop simple mathematical models for engineering problems and carry out static analysis.
CO2: To analyze and solve rigid body equilibrium problems using free-body diagrams and accurate equilibrium equation
CO3: To determine centroid and second moment of area of selected sections

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	3	1										1	2
CO2	3	3	1	1									2	2	2
CO3	3	3	1	1									2	2	

Syllabus

Unit 1
System of Forces: Coplanar and Concurrent Forces -Resultant – Resolution of Forces-Equilibrium of system of Forces: Free body diagrams-Equations of Equilibrium of Coplanar Systems and Spatial Systems

Unit 2
Moment of Forces and its Application, Centroids of lines, areas, volumes and composite bodies, Second moment of area- moment of inertia.

Text Books:
R.C. Hibbeler, Statics and Mechanics of Materials, Prentice Hall, 2013.
F.P. Beer, E.R. Johnston & D.Mazurek, Vector Mechanics for Engineers: Statics, McGraw-Hill Higher Education, 2012.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19EEE181 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB L-T-P-C: 0-0-3-1

(Aerospace, Civil, Mechanical, ECE, CCE and Chemical)

Course Objective

- To understand the basics of electrical connections and analyse the performance of electrical machines and electronic circuits.

Course Outcome

CO1: To create basic electrical connections for domestic applications
CO2: To measure the various electrical parameters in the circuit
CO3: To Analyse the performance of electrical machines.
CO4: To Analyse basic electronic circuits.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3		2			2			3			1		
CO2	3				2				3			1		
CO3	3	1	2	2					3			1		
CO4	3	1	2						3					

LIST OF EXPERIMENTS:

Electrical

1. a) Wiring practices
   b) Study of Electrical protection systems.
2. Verification of circuit theorem
3. Experiment on DC machine
4. Experiment on single phase Transformer
5. Experiment on induction motor
6. VI characteristics of PN junction and Zener diode
7. Implementation of Half wave and Full wave rectifier using PN junction diode
8. Transistor as a switch
9. Experiment on Thyristor
10. Implementation of inverting and non-inverting amplifier using Op-amp

REFERENCES / MANUALS / SOFTWARE:

Lab Manuals

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CUL111	CULTURAL EDUCATION II	L-T-P-C: 2-0-0-2

Course Objective

- To deepen students' understanding and further their knowledge about the different aspects of Indian culture and heritage.
- To in still into students a dynamic awareness and understanding of their country's achievements and civilizing influences in various fields and at various epochs.

Course Outcome

CO1: Get an overview of Indian contribution to the world in the field of science and literature.
CO2: Understand the foundational concepts of ancient Indian education system.
CO3: Learn the important concepts of Vedas and *Yogasutra*-s and their relevance to daily life.
CO4: Familiarize themselves with the inspirational characters and anecdotes from the *Mahābhārata* and *Bhagavad-Gītā* and Indian history.
CO5: Gain an understanding of Amma's role in the empowerment of women

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						3	3					2		
CO2						1		3				2		
CO3						3	3	3				2		
CO4						3	3	3				2		
CO5						1		1						

Syllabus

Unit 1
To the World from India; Education System in India; Insights from Mahabharata; Human Personality. India's Scientific System for Personality Refinement.

Unit 2
The Vedas: An Overview; One God, Many Forms; Bhagavad Gita – The Handbook for Human Life; Examples of Karma Yoga in Modern India.

Unit 3
Chanakya's Guidelines for Successful Life; Role of Women; Conservations with Amma.

Text Book
Cultural Education Resource Material Semester-2

Reference Book(s)
Cultural Heritage of India. R.C.Majumdar. Ramakrishna Mission Institute of Culture.
The Vedas. Swami ChandrashekharaBharati. BharatiyaVidyaBhavan.
Indian Culture and India's Future. Michel Danino. DK Publications.
The Beautiful Tree. Dharmapal. DK Publications.
India's Rebirth. Sri Aurobindo. Auroville Publications.

Evaluation Pattern:

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

SEMESTER III

19CHE201	ENERGY BALANCE AND THERMODYNAMICS	L-T-P-C: 2-0-3-3

Pre-Requisite(s): Material Balances, Linear and Matrix Algebra

Course Objectives

The objective of the course is to introduce the fundamental concepts of system, state, equilibrium, process, laws of thermodynamics, property diagrams for phase change processes, equations of state, energy analysis of closed systems and control volumes, unit operations and to understand the concepts of heat engines, refrigerators, heat pumps, principles of Carnot cycle, entropy, estimate thermodynamic efficiencies and energy analysis of gas cycles.

Course Outcome

CO 1: Understand the basic thermodynamic concepts, laws, P-v-T behavior of fluids and estimate the property change during a process.
CO 2: Apply fundamental laws of thermodynamics to engineering applications and analyze using property tables
CO 3: Develop energy balance equations for mechanical devices and unit operations
CO 4: Estimate thermodynamic efficiencies of gas cycles based on entropy and carnot cycle

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	3	3	-
CO2	2	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO3	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO4	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-

Syllabus

Unit 1
Systems, Properties, Processes, Cycles; State of a system and state postulate; State and path functions; Temperature and zeroth law of thermodynamics; Pressure and pressure measurement; Energy and its forms: Potential and Kinetic energy, Internal energy; Energy sources; Energy transfer – Heat, Work, Electricity; Mechanisms of heat transfer; Work: Moving boundary work, Flow work, Shaft, spring, elasticity, surface tension, and electrical work; Energy balance – First law for open and closed systems, steady and unsteady state processes.

Phases and phase diagrams of a pure substance, Saturation, Superheating, T-*v*, P-*v*, P-T diagrams and the P-*v*-T surface; Enthalpy; Property tables; Ideal and non-ideal gases: van der Waals, Soave-Redlich-Kwong, Peng-Robinson equations of state; Virial equation and its physical meaning; Compressibility factor.

Unit 2
Estimation of heat capacities: Solids, Liquids, Gases, Mixtures, Temperature dependence; Enthalpy changes: Mixing, Fusion, Vaporization – Clapeyron equation, Clausius-Clapeyron equation, Watson equation, Trouton's rule, Kistiakowsky equation; Energy analysis of gas cycles; Energy analysis using property tables.

Mechanical energy balance – Bernoulli equation; Energy transfer by mechanical work: Nozzles and diffusers, Turbines, compressors and pumps, Throttling valves, Pipe and duct flow; Energy transfer by heat: Heat exchangers, Boilers and Furnaces; Energy balance in unit operations: Mixers and splitters; Drying; Evaporation; Crystallization; Leaching; Adsorption; Liquid-Liquid Extraction; Absorption; Distillation; Recycle, Bypass, Purge.

Unit 3
Standard heat of reactions – Combustion and Formation; Hess's law; Effect of temperature and pressure; Adiabatic reaction temperature; Recycle in reactors; Combined material and energy balance in flow sheets – Degree of freedom analysis; Modular and overall equation -solving approaches.

Entropy and thermodynamic temperature; Combined first and second law for closed systems and cycles: Carnot cycle; Refrigerators, Heat pumps; Thermodynamic efficiency and coefficient of performance; Second law for open systems – Entropy balance; Statistical meaning of entropy.

Text Book(s)
Cengel Y. A., and Boles, M. A., Thermodynamics: An Engineering Approach, 7th Special Indian Edition, McGraw-Hill India, New Delhi, 2011
Rao, Y. V. C., Chemical Engineering Thermodynamics, Universities Press, 1997
J.M Smith, H C Van Ness, M M Abbott, Introduction to Chemical Engineering Thermodynamics, 2010.

Reference(s)
Narayanan, K. V., and Lakshmikutty B., Stoichiometry and Process Calculations, Prentice Hall India, New Delhi, 2009
Murphy, R. M., Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw Hill International Edition, New York, 2007
O'Connell, J. P., and Haile, J. M., Thermodynamics: Fundamentals for Applications, Cambridge University Press, Cambridge, 2005

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE202	FLUID MECHANICS	L-T-P-C: 3-0-0-3

Pre-Requisite(s): None

Course Objectives

The objective of the course is to introduce fundamental aspects of fluid properties and flow behavior, to develop steady state mechanical energy balance equation for fluid flow systems, estimate pressure drop in fluid flow systems and apply fluid mechanics concepts to chemical process industries including pipe flow, packed bed and fluidized bed.

Course Outcome

CO 1: Understanding of basic properties of fluids, stress-strain relationship in fluids, classify their behavior and establish force balance in static systems

CO 2: Understanding of mechanism of momentum transport processes, develop shell balances for steady flow and ability to analyze fluid flow problems in different configurations with the application of the momentum and energy equations.

CO 3: Develop understanding of principles and functioning of flow metering devices and apply Bernoulli equation to determine the performance of flow-metering devices. Develop dimensionless groups that help in scale-up and scale-down of fluid flow systems

CO 4: Ability to analyze fluid behaviour in fixed bed systems , computer power requirement in fixed bed system and determine minimum fluidization velocity in fluidized bed

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	-	-	-	-	-	-	-	3	3	1
CO2	3	3	2	-	-	-	-	-	-	-	-	-	3	3	1
CO3	3	3	3	-	-	-	-	-	-	-	-	-	3	3	1
CO4	3	3	3	-	-	-	-	-	-	-	-	-	3	3	1

Syllabus

Unit 1

Nature of fluids- Physical properties of fluids - incompressible and compressible fluids, Newtonian and non-Newtonian fluids.Fluid statics - Pressure, hydrostatic equilibrium, Pressure Measurement using manometers of different types.Hydrostatic force on plane and curved surfaces, Buoyancy and floatation. Kinematics of fluid flow- Flow types- Ideal flow – Stream function, potential function – Velocity vectors; Path line, streak line and stream line. Application of one-dimensional steady flow; circulation and vorticity. Reynolds number – laminar and turbulent flow, transition from laminar to turbulent flow, Eddy viscosity, flow in boundary layers, boundary layer formation, laminar and turbulent flow in boundary layers. Mechanisms of momentum transport.

Unit 2

Shell momentum balance, boundary conditions; equation of continuity, momentum and mechanical energy. Bernoulli's equation, correction for fluid friction, correction for pump work. Applications of Bernoulli equation to flow meters – Pitot tube, Nozzle, Venturi meter and Orifice meter.

Flow of incompressible fluids in conduits and thin layers: Hagen- Poiseuille equation, derivation of velocity profile using shell balance method, velocity distributions in falling film and circular tube; friction factor, relationships between skin-friction parameters, average velocity for laminar flow of Newtonian fluids, Darcy-Weisbach relation, hydraulically smooth pipe, von Karman equation, roughness parameter, friction-factor chart, equivalent diameter. Velocity profile in turbulent flows; Power required to overcome pressure drop; Moody chart; Minor losses – Pipe fittings and pipe networks, equivalent length for pipe in pipe fittings.

Unit 3

Laminar flow between parallel plates – Taylor-Coutte flow and Poiseulle flow; Two dimensional flows - Boundary layer; Boundary layer equation; Blasisus solution for boundary layer flow; boundary layer separation and its control. Application of dimensionless analysis in fluid flow.

Flow past immersed objects - Flow of fluids through solids - Form drag - Skin drag - Drag coefficient - Flow around solids and packed beds, Friction factor for packed beds, Ergun's Equation - Motion of particles through fluids - Motion under gravitational and centrifugal fields - Terminal settling velocity Stokes' law, Newton's law, criterion for settling regime - Fluidization , mechanism, types, general properties and applications.

Text Book(s)

Noel de Nevers, Fluid Mechanics for Chemical Engineers, McGraw Hill Inc., International Edition, 2004
Cengel Y.A., and Cimbala J.H, Fluid Mechanics: Fundamentals and Applications, McGraw Hill Publishers, 3rd Edition,, 2013

Reference(s)

Holland F.A., and Bragg R., Fluid Flow for Chemical Engineers, Butterworth Heinmann, 2nd Edition,, 2002
Ron Darby, Chemical Engineering Fluid Mechanics, Marcel Dekker Inc., 2nd Edition,, 2001
Frank M. White, Fluid Mechanics, McGraw Hill Inc., 4th Edition, 2011
R.B. Bird, W.E. Stewart and E.W. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley, 2002

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE203	MECHANICAL OPERATIONS	L-T-P-C: 3-0-0-3

Pre-Requisite(s) : None

Course Objectives

This course introduces students to the concepts of solids handling, mechanical size reduction, mechanical separation, mixing and agitation of liquids, and filtration of solids.

Course Outcomes

CO1: To develop basic knowledge on particle technology and analyze particle size and shape with deeper understanding on different particle diameters
CO2: To develop understanding on various size reduction operations and mechanical separations with basic understanding on size reduction laws and principles
CO3: To understand various ways of storing, handling solids and agitation of solids in chemical industries
CO4: To apply and analyze appropriate unit operations for separation of solids from solids and separation of solids from liquids

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	1									1	1	2
CO2	3	3	2	2									3	3	3
CO3	2	2	2	3									2	2	2
CO4	3	3	3	3									3	3	3

Syllabus

Unit 1
Properties and handling of particulate solids- characteristics of solid particles, standard screen series, mixed particle size and screen analysis, effectiveness and capacity of screens, Transportation and storage of solids: bins, hoppers and silos, flow out of bins; conveyor selection, different types of conveyers and their performance characteristics. Comminution of solids (Size Reduction): comminution laws: Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption, size reduction equipment, closed circuit and open circuit operation.

Unit 2
Separation of solids: gravity settling, sedimentation, thickening, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation - continuous centrifuges, bowl classifier, super centrifuges, design of basket centrifuges; Industrial dust removing equipment - cyclones and hydro cyclones, with special reference to electrostatic and magnetic separators; Heavy media separations, floatation. Mixing and Agitation: Mixing of liquids (with or without solids), mixing of liquids (with solids), mixing of liquids (with solids), mixing of powders, selection of suitable mixers, power requirement for mixing

Unit 3
Filtration: Principle of Cake filtration, Pressure drop through filter media, compressible and incompressible filter cakes, Constant pressure and rate filtration, Continuous filtration, washing of filter cakes; Filtration – Theory, Filtration considerations, Batch and continuous filtration equipment (Pressure and Vacuum) – selection, operation and design of filters and optimum cycle of operation.

Text Book(s)
W.L. McCabe, J.C. Smith, and P. Harriot, "Unit Operations in Chemical Engineering, 6th Edition, McGraw-Hill, 2001.
W.L. Badger and J.T. Banchero, "Introduction to Chemical Engineering", Tata McGraw Hill, 1997.
A.S. Foust, L.A. Wenzel, C.W. Clump, L. Naus, and L.B. Anderson, "Principles of Unit Operations", 2nd Edition, John Wiley & Sons, 1994.

Reference(s)
J.M. Coulson and J.F. Richardson, "Chemical Engineering Vol. I", 4th Edition, Asian Books Pvt Ltd., India, 1998.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments

19CHE204	PRINCILES OF HEAT TRANSFER	L-T-P-C:2-1-0-3

Pre-requisites: None

Course Objective

The main objective of the course is to impart knowledge on the fundamental concepts of heat transfer which is important for engineering applications.

Course Outcomes

CO1: Ability to define, describe, and apply terminology for conductive, convective, and radiative modes of heat transfer

CO2: Ability to apply problem solving fundamentals for heat transfer operations (units, dimensional analysis, law of conservation of mass & energy, graphing, and empirical equations)

CO3: Ability to analyze thermal systems (rectangular, cylindrical, spherical; boundary and initial conditions; steady state, transient; with and without heat generation; apply energy balance and/or heat equation)

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										3	2	1
CO2	3	2	1										3	2	1
CO3	3	2	1										3	2	1

Syllabus

Unit 1
Modes of heat transfer: Conduction, convection, and radiation; material properties of importance for heat transfer; conduction in regular bodies: slab, cylinder, sphere, and variable area; Convective heat transfer: heat transfer in fluid, heat transfer coefficient (individual and overall), extended surface, critical insulation for cylinder and sphere; Heat transfer in forced laminar flow: Laminar flow over horizontal flat plate, flow through pipe, flow over cylinders and spheres

Unit 2
Heat transfer in forced turbulent flow: Analogies for heat transfer coefficient, Reynold's analogy, Chilton-Colburn analogy, Prandtl analogy, Von Karman analogy. Heat transfer with phase change: Stages in boiling, boiling curve, heat transfer during condensation, dropwise – film-wise condensation on vertical surface and horizontal tube banks, heat exchangers

Unit 3
Heat transfer by radiation and governing laws, Shell Balance: Steady state and unsteady state equation for heat transfer in Cartesian coordinate system, cylindrical coordinate system, and spherical coordinate system with convective heat transfer, Introduction to Fourier series, Solution to heat equation.

Text Books:
McCabe, Simth, and Harriott, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hill, International Edition, 2001.
J. M Coulson and J. F. Richardson, Chemical Engineering Vol. I, 4th Edition, Asian Books Pvt Ltd,India, 1998.

Reference Books:
J. R. Welty et al., Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2000.
Binay K Datta, Heat Transfer – Principles and Applications, PHI Learning Pvt Ltd, 2001.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE205	MATERIALS TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives

This course provides students an understanding of basic structure and crystal arrangement of materials, mechanical behaviour of materials, the phase diagrams, alloying elements used in steel, the effect of heat treatment on the properties of metals, the need and application of nanomaterials

Course Outcomes

CO1: To understand the structure, directions, planes and directions in polycrystalline materials
CO2: To understand the different types of deformation and mechanical behavior of materials
CO3: To create awareness on the various test methods for the selection of materials for specific applications
CO4: To gain fundamental knowledge on the construction of phase diagrams for alloy systems and heat treatment methods
CO5: To obtain an overview on the methods employed for nanomaterials synthesis

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2											2		
CO2	2	2	3										2		
CO3	3	3	3	3									3	3	
CO4	2	3	3	2									3	2	2
CO5	2	2	2	2										3	3

Syllabus

Unit 1
Basics of Materials Structure: crystal systems – space lattice – miller indices of atomic planes and directions – small problems in crystallography – crystal defects point, line and surface defects. Mechanical Behaviour of Materials: stress- strain curve – elastic deformation- characteristics of elastic deformation-atomic mechanism of elastic deformation-inelastic deformation- strain time curves – viscous deformation-plastic deformation- -slip and Twinning-Schmidt's law- critical resolved shear stress – Strengthening mechanisms; work hardening-grain boundary hardening, dispersion hardening.

Unit 2
Mechanical Testing and Fracture of Materials : Tensile test- stress – strain curves for ductile and brittle materials – proof stress – Compression test – Hardness test – Impact test – Fatigue test –S-N curve – Creep; primary, secondary and tertiary creep- Fracture: Ideal fracture stress – brittle fracture – Griffith's theory cup and cone type fracture Phase Diagrams: solid solution – intermetallic compound, cooling, curves, non-equilibrium cooling-phase rule-Equilibrium diagrams- isomorphous- eutectic, peritectic and eutectoid reactions with examples-Iron-Iron carbide phase diagram.

Unit 3
Engineering materials: steels and cast irons- properties and applications- Heat treatment of steels: Annealing – Normalizing- Hardening-Tempering- Hardenability and its testing – TTT diagram Nanomaterials - Synthesis - Chemical routes methods -Thin films methods- chemical vapor deposition- physical vapor deposition -ball milling- mechanical attrition. Special nanomaterials: carbon nanotubes, fullerenes, nanowires, porous silicon.

Text Book(s)
R. Balasubramaniam, Callister's Materials Science and Engineering, Wiley, 2013.
W F Smith, J Hashemi, R Prakash, Materials Science and Engineering, McGraw Hill 2008.

ReferenceBook(s)

L H Van Vlack, Elements of Materials Science and Engineering , Pearson India 2008
D.R .Askeland, P. P Fulay, W. J .Wright,The Science and Engineering of Materials, CL Engineering 2012.
F. J. Owens and C.P. Poole Jr, The Physics and Chemistry of Nanosolids, Wiley-Interscience, 2008

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19MAT207	ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS	L-T-P-C : 2-0-3-3

Prerequisite: Linear Algebra for Chemical Engineers, Differential and Integral Calculus

Course objective

- To model chemical engineering process using differential equations.
- To analyse and solve ordinary differential equations.
- To understand numerical techniques for solving ordinary differential equations.
- To model physical problems using PDEs and to solve them using numerical techniques.

Course Outcomes

CO1: State the existence theorem for first-order ordinary differential equations and use them to define a solution interval. Recognize variable separable, homogeneous, exact, Bernoulli and Euler-Cauchy first-order ordinary differential equations, determine relevant integrating factors and obtain general and particular solutions for them, and apply them to solve chemical engineering problems.

CO2: Develop numerical (Euler and Runge-Kutta) techniques for solving first-order ordinary differential equations, analyze error propagation and convergence in these techniques, and apply them to solve chemical engineering problems.

CO3: Reduce higher-order ordinary differential equations to a system of first-order differential equations, solve them using the method of eigenvector expansions and apply the solutions to chemical engineering problems

CO4: Using existence theorem for boundary value problems, determine the uniqueness of solutions, use Wronskian to determine a set of linearly independent functions, use their linear combinations to construct general and particular solutions for homogeneous and non-homogeneous second-order ordinary differential equations using the methods of undetermined coefficients and variation of parameters.

CO5: Develop finite difference approximations of second-order ordinary differential equations, reduce to systems of linear/non-linear algebraic equations, and solve chemical engineering problems. Analyze error propagation and convergence of the solutions.

CO6: Understand the types of partial differential equations arising from two-dimensional modeling. Use separation of variables to solve linear partial differential equations. Develop finite-difference approximations for linear partial differential equations and solve chemical engineering problems. Analyze error propagation and convergence of the solutions.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2		2	3									
CO3	1	2	2	3								
CO4	2	1	1	3								
CO5	1	1	2	2								
CO6	1		2	2								

Syllabus

Unit 1
Origin of Ordinary Differential Equations (1st and 2nd Order) - One-Dimensional Modeling; First Order ODE: Direct Integration, Integrating Factor – Linear and Nonlinear Equations; Numerical Integration: Euler, Improved Euler and 4th Order Runge-Kutta; Applications: Mixer, Isothermal CSTR, Isothermal PFR (steady state), Heat Exchanger

Systems of First Order ODEs: Solution using Eigenvectors; Applications: Series-Parallel Reactions;

Unit 2
Second Order ODE: Homogeneous and Non-homogeneous – Linear equations with constant coefficients; Numerical Integration: Finite Difference Approach, Convective-Diffusion Equations, Flow and Level Control problems.

Unit 3
Partial Differential Equations - Two-Dimensional Modeling, Separation of Variables, Numerical Solution of PDEs: Heat Equation, Shock Wave Propagation in Compressible Fluid Flow;

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE281	CHEMICAL ENGINEERING LAB-1	L-T-P-C: 0-0-3-1

Pre-Requisite(s): None

Course Objectives

Students will learn how to perform accurate analytical/quantitative measurements by using equipment / instruments. Students will also learn how to estimate the error in measurement using measurement systems analysis.

Course Outcomes

CO1: Understand and apply the principles behind the process instrumentation for measuring process and quality parameters
CO2: Perform calorimetry experiments and estimate the specific heat of a given material
CO3: Perform Gauge R&R Analysis and test the suitability of an instrument for a given process.
CO4: Develop a working model of an instrument for measuring any one of the process parameters based on the principles and sensing mechanism.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				3								3	3	2
CO2	3	2		2	3				3	3			3	2	3
CO3	3	3			3				3	2	1		3	2	2
CO4	3	3			3				3	2	1		3	2	2

Syllabus

List of Experiments

<u>Chemical Technology:</u> Acid value, Iodine value, & Saponification value of oils; Preparation and analysis of soap;Preparation and analysis of Anacin; Calorimetry;Available chlorine in bleaching powder and hypochlorite

<u>Chemical Engineering Instrumentation:</u> Helicopter Gage R&R, temperature measurement; pressure measurement; Flow measurement; Concentration measurement

Text Book(s)
Griffin, Technical Methods of Analysis, McGraw Hill,
G.S. Patience, Experimental Methods and Instrumentation for Chemical Engineers, Elsevier, 2013

Reference Book(s)
A.Dieffenbacher and W.D. Poclington, Standard Methods for the Analysis of Oils, Fats and Derivatives 6th Edition, Blackwell Scientific Publications, London.
V.R. Radhakrishnan, Instrumentation and Control for the Chemical, Mineral and Metallurgical Processes, Allied Publishers Pvt. Ltd., 1997
Alok Barua, Fundamentals of Industrial Instrumentation, Wiley India, 2011
Estimation of Acid Value, Iodine Value and Saponification Value of Oils, Virtual Amrita Laboratories.
https://www.classle.net/book/estimation-total-alkali-content-soap
https://www.classle.net/book/estimation-total-fatty-matter-contentsoaps

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Experiment evaluations, viva-voce exams, on-line exams, model development.

19AVP201	AMRITA VALUES PROGRAM I	1 0 0 1
19AVP211	AMRITA VALUES PROGRAM II	1 0 0 1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcome

CO1: Understanding the impact of *itihasas* on Indian civilization with a special reference to the *Adiparva* of Mahabharata
CO2: Enabling students to importance offighting*adharma* for the welfare of the society through Sabha and Vanaparva.
CO3: Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishma parvas.
CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna,Shalya, Sauptika Parvas.
CO5: Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and Swargarohana Parvas.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	2	2	3	3	3	-	3	-	-
CO2	-	-	-	-	-	3	3	3	3	2	-	3	-	-
CO3	-	-	-	-	-	3	2	3	3	3	-	3	-	-
CO4	-	-	-	-	-	3	-	3	3	3	-	3	-	-
CO5	-	-	-	-	-	3	-	3	3	2	-	3	-	-

Courses offered under the framework of Amrita Values Programmes I and II

Message from Amma's Life for the Modern World
Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Lessons from the Ramayana
Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads
Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, Satyakama Jabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita
Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda
Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India
Sri Rama, Sri Krishna, Sri Buddha, Adi Shankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri Ramana Maharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature
The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation
The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting
Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability
Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma's words "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems
Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India
India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This

course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

TEXT BOOKS/REFERENCES:

Rajagopalachari. C, *The Ramayana*

Valmiki, *The Ramayana*, Gita Press

SEMESTER IV

19CHE211 CHEMICAL ENGINEERING THERMODYNAMICS L-T-P-C : 2-1-0-3

Prerequisites:

Energy balance and Thermodynamics, Ordinary and Partial Differential equations, Linear and Matrix Algebra

Course Objectives

The objective of the course is to understand the significance of thermodynamic potentials (U, H, A,G),derive the Maxwell relations, thermodynamic property relations using partial derivatives, the evaluation of departure functions from equations of state, estimation of partial molar properties, concept of chemical potential, fugacity and activity coefficient, mixture rule, to discuss properties of solutions, and excess properties, VLE calculations, concepts of azeotropes, liquid-liquid equilibrium and to understand chemical reaction equilibria and estimation of equilibrium conversion.

Course Outcomes

CO1: Evaluate the thermodynamic properties of pure fluids from measurable quantities like P-V-T and analyze the deviation from ideal behavior
CO2: Estimate the phase of a given substance (pure/mixture) at a given P-T values based on equation of state and excess properties
CO3: Estimate vapor and liquid compositions using VLE for ideal and non-ideal solutions and analyze the effect of P and T during flash separation.
CO4: Understand the criterion of chemical reaction equilibrium, and calculate the conversion at equilibrium and to predict the effect of controllable variables like temperature and pressure on the conversion.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	-	-	-	-	-	-	3	2	-
CO2	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO3	3	3	2	3	-	-	-	-	-	-	-	-	3	2	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-	3	2	-

Syllabus

Unit 1
Pure gaseous substances-P-v-T behavior of pure substances, Calculation of work done, heat transferred, change in enthalpy in different processes-Ideal and non ideal gases, Equation of state, Compressibility factor
Gas mixtures-P-v-T behavior of gas mixtures, Ideal and non ideal mixtures, Mixture rules, Compressibility factor for mixtures.
Excess properties of mixtures-Temperature and Pressure dependence, Gibbs- Duhem equation

Unit 2
Ideal and non ideal solutions; vapor pressure of solutions; fugacity and activity coefficients and their estimation; Criterion for vapor liquid equilibrium (VLE); Binary VLE-Bubble and dew point calculations. Equation of state and Activity coefficient models; Multi component VLE-K factor approach; Thermodynamic consistency of VLE data.

Criterion for liquid- liquid equilibrium; Estimation of distribution coefficient from activity models. Composition estimation in problems related to extraction

Unit 3
Criterion for chemical reaction equilibrium-feasibility of chemical processes, Equilibrium constant.
Conversion calculations in a reaction-Homogeneous gas phase reactions, Gas liquid reactions, effect of temperature and pressure on conversion

Text book(s)
Y.V.C Rao , Chemical Engineering Thermodynamics,1st Edition,2001
J P O'Connell and J M Haile, Thermodynamics:Fundamentals for Applications, Cambridge University Press,2005.
Yunus A Cengel, Thermodynamics:An Engineering Approach,7th Edition,2010.

Reference book(s)
K.A Gavhane, Chemical Engineering Thermodynamics,4th edition,2015
KV Narayanan,Chemical Engineering Thermodynamics,2nd edition,2013.
J.M Smith, H C Van Ness, M M Abbott, Introduction to Chemical Engineering Thermodynamics, 2010.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE212	INDUSTRIAL CHEMISTRY	L-T-P-C: 3-0-0-3

Prerequisites: Nil

Course Objectives

The objective of the course is to gain knowledge of the chemistry and technology of industrial chemical manufacturing, following the sequence of phases from laboratory synthesis to large scale manufacture, with due considerations given to thermodynamic, kinetic, environmental, economic, and safety considerations.

Course Outcomes

CO1: Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries
CO2: To understand and evaluate theoretical and practical aspects relating to the transfer of the production of chemical products from laboratories to the industrial scale, in accordance with environmental considerations
CO3: Industrial chemical processes are described and analyzed in terms of thermodynamic and kinetic aspects and are also highlighted the most important technology.
CO4: Problems associated with the cost, sustainability and safety of an industrial process are discussed.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1		2	2	2					2	2	1	1
CO2	2	1	2				2					1	1		2
CO3	3	2	3	2			3					2	2	1	
CO4	2	3	2				2					2	1		2

Syllabus

Unit 1
Carbohydrate – Introduction. Monosaccharides - glucose & fructose. Disaccharides - maltose, cellulose, lactose & sucrose. Polysaccharides - amylose, amylopectin & cellulose. sugar and paper – manufacturing.Pharmaceutical: Classification, alkylation, condensation and cyclization, dehydration, halogenations, oxidation, sulfonation, amination. Fermentation process; Manufacture of antibiotic - Penicillin, Streptomycin and Erythromycin.

Unit 2
Ceramics/ refractory: Materials used as ceramics, Requirement of good refractories, manufacture of refractories. Classification properties of refractories and selection of refractories.Composition of glass and cement, setting of cement.Polymers: Polymers, reaction and mechanism of polymerization. Preparation of some commercially important polymers (Fibers, elastomers, adhesives and plastics).Engineering uses of polymeric materials.

Unit 3
Explosive and propellants: Explosive, classification of explosives, oxygen balance, preparation and application explosive, precautions using storage of explosives. Blasting fuses, Rocket propellants, properties and classification of propellants.Dye & Pigments: Colour and constitution, Classification of Dyes, Nitro Dyes, Nitroso Dyes, Azo Dyes, Acridine dyes, Quinoline Dyes, Vat dyes, Fluorescent brightening agent. Paints.

Text Book(s)

B. K. Sharma, Industrial Chemistry (Including Chemical Engineering), Krishna Prakashan Media, Meerut, 2016.
A. Arora, Industrial Chemistry, Sonali Publication, 2009.

Reference Book(s)
C. E. Dryden, "Outlines of Chemicals Technology" , 2nd Edition, Edited and Revised by M. Gopala Rao and M. Sitting, Affiliated East–West Press, 1993.
G. I. Austin, "Shreve's Chemical Process Industries", 5th Edition, Tata McGraw Hill, Singapore, 1990.
Speight G. James, "Handbook of Industrial Chemistry", McGraw-Hill, New York, 2005.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE213	DESIGN OF HEAT TRANSFER EQUIPMENT	L-T-P-C:2-0-0-2

Course Objective

The main objective of the course is to impart knowledge on the design concepts of heat transfer equipment used in chemical industries.

Course Outcomes

CO1: Ability to understand and describe the working principles and operation of heat transfer equipment in a chemical engineering process
CO2: Ability to evaluate the performance of heat transfer equipment (heat transfer coefficient, surface-to-volume ratio, effectiveness, NTU)
CO3: Ability to understand the thermal and mechanical aspects of design of heat transfer equipment (including ASPEN)

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2										3	2	
CO2	2	3	3										2	3	2
CO3		2	3		3									2	3

Syllabus

Unit 1

Heat Exchangers: Double pipe shell and tube, flow pattern, specialized heat exchangers, effectiveness, NTU method, construction and operational features, selection criterion for heat exchanger.
Computer Lab: ASPEN based design of double pipe heat exchanger, shell and tube heat exchanger.

Unit 2

Evaporators: Theory of evaporation, types: single and multiple effect evaporator, design consideration, economy, design of evaporators.

Condensers: Theory of condensation, types of condenser, heat rejection ratio, design considerations.
Computer Lab: ASPEN based Design of evaporators and condensers

Text Book(s)
McCabe, Simth, and Harriott, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hill, International Edition, 2001.
Binay K Datta, Heat Transfer – Principles and Applications, PHI Learning Pvt Ltd, 2001.

Reference Book(s)
J. R. Welty et al., Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2000.
J. M Coulson and J. F. Richardson, Chemical Engineering Vol. I, 4th Edition, Asian Books Pvt. Ltd., India, 1998.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE214	STRENGTH OF MATERIALS	L-T-P-C : 3-0-0-3

Pre-Requisite: Statics

Course Objectives

The objective of the course is to impart the concept of stresses and strains on elastically deformable members subjected to axial, bending, and torsional loads. The course discusses in detail, the shear force bending moments on beams, bending stresses, and stresses developed in pressure vessels.

Course Outcomes

CO1: To gain a fundamental understanding on types of stresses, strain and moduli in solids subjected to elastic deformation.
CO2: To draw shear force, bending moment diagrams and estimate deflection and bending stresses developed in beams.
CO3: To understand the behavior of structural members in torsion, compression and stresses developed in pressure vessels**.**

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1									2	1	
CO2	3	3	3	2									1	3	1
CO3	3	3	3	2									2	2	3

Syllabus

Unit 1
Simple Stresses and Strains: Hooke's law-Elastic limit , tension, compression and shear stresses- Stiffness - Poisson's ratio - Analysis of varying sections -bars of composite sections – Thermal stresses, Complex stress; principal stresses and principal planes- principal strains – graphical method.

Unit 2
Shear force and bending moment: Different types of support conditions and loads-Cantilever – simply supported – Overhanging beams, point loads, uniformly distributed loads-Theory of Simple bending; flexural formula analysis of stresses in beams – load carrying capacity of beams , Deflection of beams- computation of slopes and deflections in beams.

Unit 3
Torsion of circular sections ; Derivation of torsional formula –Power transmitted – Solid and hollow shafts. Thin Shells; Thin cylindrical shells subjected to internal pressure – Circumferential stress – Longitudinal stress – change in diameter – length-volume – Thin spherical shells. Columns; Axially loaded Columns – Different end conditions – Euler's formula for long columns.

Text Book(s)
R.C. Hibbeler, Statics and Mechanics of Materials, Prentice Hall, 2013.
F. W. Cheng, Statics and Strength of Materials, McGraw-Hill India, 2013.

Reference Book(s)
F.P. Beer, E.R. Johnston & D. Mazurek, Vector Mechanics for Engineers: Statics, McGraw-Hill Higher Education, 2012.
J.M. Gere and B.J. Goodno, Mechanics of Materials, CL Engineering, 2012.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE215	STATISTICAL ANALYSIS OF PROCESS DATA	L-T-P-C: 2-0-3-3

Pre-Requisite(s): Introduction to Chemical Engineering, Differential and Integral Calculus

Course Objectives

This course is aimed at providing the skills to support chemical engineering positions with respect to statistical data analysis relative to process operations, business analytics, R&D, planning, inventory control, production, quality, safety, process control, troubleshooting and design. Learning outcomes are to be achieved through a combination of conceptual understanding, hands-on training, and case studies.

Course Outcomes

CO1: To have an understanding of the effect of uncertainty in process data and plant management, and to quantify it, via application of probability models

CO2: To be able to apply probability distribution models for decision making in manufacturing processes, and characterize process variation for troubleshooting and process capability estimation

CO3: To be able to design experiments for product and process development, as well as process optimization, and subsequently monitor the process for stability sections

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	3	1										1	2
CO2	3	3	1	1									2	2	2
CO3	3	3	1	1									2	2	

Syllabus

Unit 1

Nature of process data and its collection; Objectives of process data analysis; Probability and its applications to plant troubleshooting (including introduction to acceptance sampling); Random variables and their probability distributions – with emphasis on special distributions and their probability determinations;

Unit 2

Descriptive statistics – numerical versus graphical methods of analysis; Normal distribution, Importance of Central Limit Theorem and its applications in measurement of process parameters; Hypothesis testing and its applications for plant operations and R&D - tests for single mean and variance, tests for equality of two means and two variances, ANOVA; Case studies

Unit 3

Statistical design of experiments – understanding the importance of exploratory and confirmatory analyses in R&D – and process optimization - factorial designs (creating factorial and fractional factorial designs, design structure, main effects, interactions, resolution & confounding, analysis), central composite and Box-Behnken designs and analysis; A very basic introduction to control charts; Case studies

Textbook(s)

K.M. Ramachandran and Chris P. Tsokos, "Mathematical Statistics with Applications", 1st Edition, Academic Press, 2009.

Douglas C. Montgomery and George C.Runger, "Applied Statistics and Probability for Engineers", 3rd Edition, John Wiley, 2008.

Douglas C. Montgomery, "Design and Analysis of Experiments", 5th Edition, Wiley, 2000.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	10	
Periodical 2 (P2)	10	
*Continuous Assessment (CA)	45	
End Semester		35

CA – Can be Quizzes and Assignments.

19CHE282	CHEMICAL ENGINEERING LAB 2	L-T-P-C : 0-0-3-1

Course Objectives

To develop ability to do chemical engineering experiments related to fluid dynamics and particle mechanics.

Course Outcomes

CO1: To develop ability to do experiments in fluid flow meters such as venturi, orifice and to do performance test on pumps
CO2: To develop ability to conduct experiments in packed column, helical coil and drag studies
CO3: To learn particle analysis of heterogeneous mixtures using sieve analysis to calculate particle diameter, specific surface area and screen effectiveness
CO4: To develop ability to do experiments on size reduction, sedimentation and filtration

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				2	3	2			3	3	3
CO2	3	3	3	3				2	3	2			3	3	3
CO3	3	3	3	3				2	3	2			3	3	3
CO4	3	3	3	3				2	3	2			3	3	3

Syllabus

Fluid Mechanics Laboratory

- Flow through Venturi meter/ orifice meter
- Performance test on centrifugal pump
- Flow through helical coil pipe
- Drag reduction studies
- Flow through packed bed

Mechanical Operations Laboratory

- Sieve analysis and screen effectiveness
- Jaw crusher and Ball mill
- Sedimentation and cyclone separator
- Plate and frame filter
- Vacuum filter

Evaluation Pattern

Assessment	Internal	End Semester
*CA_Continuous Assessment	80	
End Semester		20

*CA – Can be Quizzes and Assignments.

19SSK211	SOFT SKILLS I	L-T-P-C: 1-0-3-2

Course Outcomes

CO1: **Soft Skills:** At the end of the course, the students would have developed self-confidence and positive attitude necessary to compete and challenge themselves. They would also be able to analyse and manage their emotions to face real life situations.
CO2: **Soft Skills:** At the end of the course, the students would hone their presentation skills by understanding the nuances of content creation, effective delivery, use of appropriate body language and the art of overcoming nervousness to create an impact in the minds of a target audience.
CO3: **Aptitude:** At the end of the course, the student will have acquired the ability to analyze, understand and classify questions under arithmetic, algebra and logical reasoning and solve them employing the most suitable methods. They will be able to analyze, compare and arrive at conclusions for data analysis questions.
CO4: **Verbal:** At the end of the course, the students will have the ability to dissect polysyllabic words, infer the meaning, inspect, classify, contextualise and use them effectively.
CO5: **Verbal:** At the end of the course, the students will have the ability to understand the nuances of English grammar and apply them effectively.
CO6: **Verbal:** At the end of the course, the students will have the ability to identify, analyse and interpret relationship between words and use the process of elimination to arrive at the answer. They will also have the ability to judge, evaluate, summarise, criticise, present and defend their perceptions convincingly.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	3	3		3
CO2									2	3		3
CO3		3		2								
CO4										3		3
CO5										3		3
CO6									3	3		3

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work -environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, Self motivation and continuous knowledge upgradation.

Self-confidence: Characteristics of the person perceived, characteristics of the situation, characteristics of the perceiver. Attitude, values, motivation, emotion management, steps to like yourself, positive mental attitude, assertiveness.

Presentations: Preparations, outlining, hints for efficient practice, last minute tasks, means of effective presentation, language, gestures, posture, facial expressions, professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy, etc. Faulty comparison, wrong form of words and confused words like understanding the nuances of spelling changes and wrong use of words. Listening skills: The importance of listening in communication and how to listen actively.

Prepositions, articles and punctuation: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving level I: Number system; LCM &HCF; Divisibility test; Surds and indices; Logarithms; Ratio, proportions and variations; Partnership;

Problem solving level II: Time speed and distance; work time problems;

Data interpretation: Numerical data tables; Line graphs; Bar charts and Pie charts; Caselet forms; Mix diagrams; Geometrical diagrams and other forms of data representation.

Logical reasoning: Family tree; Deductions; Logical connectives; Binary logic; Linear arrangements; Circular and complex arrangement; Conditionalities and grouping; Sequencing and scheduling; Selections; Networks; Codes; Cubes; Venn diagram in logical reasoning; Quant based reasoning; Flaw detection; Puzzles; Cryptogrithms.

Textbook(s)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quantitative Aptitude by R. S. Aggarwal,S. Chand
Quantitative Aptitude – Abijith Guha, TMH.
Quantitative Aptitude for Cat - Arun Sharma. TMH.

Reference(s)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

SEMESTER V

19CHE301 CHEMICAL REACTION ENGINEERING - I L-T-P-C : 3-0-0-3

Pre-Requisite(s):

1. Chemical Process Calculations or Material Balances
2. Energy Balance and Thermodynamics
3. Chemical Engineering Thermodynamics
4. Principles of Heat Transfer
5. Linear and Matrix Algebra
6. Ordinary and partial differential equations

Course Objectives

The students attending the course will design reactors for homogeneous reactions, obtain kinetic rate parameters based on the experimental data from homogeneous reactions. Further, students will also learn how to optimize recycle ratio for autocatalytic reactions and minimize total reactor volume in a multiple reactor system.

Course Outcome

CO 1: Estimate rate parameters rate constant, order, pre-exponential factor and activation energy from experimental data obtained from batch, mixed flow and plug flow reactors.
CO 2: Analyze the effect of parameters such as temperature, pressure etc.on reaction and reactor performance.
CO 3: Develop reaction mechanisms for non-elementary reactions based on experimentally determined rate
CO 4: Design and optimize reactors for single and multiple homogeneous reactions for required conversion, productivity and selectivity.
CO 5: Optimize recycle ratio for autocatalytic reactions
CO 6: Develop the relation between temperature and conversion for adiabatic reactions to operate them near isothermal

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3								3	2	
CO2	3	3	3	3	3								3	3	3
CO3	3			3									3	3	3
CO4	3	3	3										3	3	3
CO5	3	3	3		3								3	3	3
CO6	3	3	3		3								3	3	3

Syllabus

Unit 1
Chemical Kinetics: Rate of reaction – Homogeneous and Heterogeneous, rate expression, elementary and non-elementary reactions, rate constant – Effect of temperature and pressure on rate constant – Activation energy; rate mechanism for elementary reactions – analysis of rate mechanism from the order of reaction for a particular species; Analysis of batch reactor data: Evaluation of reaction rate parameters – Integral and differential analysis – their limitations – use Microsoft EXCEL for analysis of batch reactor data;

Unit 2
Design of Ideal reactors for isothermal homogeneous reactions : Derivation of performance equations for Batch, tubular plug flow and stirred tank reactors – space time and space velocities, size comparison of reactors; Reactors choice for single reactions – Reactors in series and in parallel, Effect of recycle on reactor performance; Reactor design for multiple reactions – Series and parallel reactions, selectivity, fractional and overall conversion, choice of contacting pattern for parallel and series reactions, reactor size determination for series and parallel reactions;

Unit 3
Effect of pressure drop on reactor performance – Gas and liquid phase reactions; standard heat of reaction – effect of temperature on heat of reaction, Design of non-isothermal reactions – non-isothermal PFR and CSTR, adiabatic reactors, effect of spatial variations of temperature on non-isothermal PFR, optimization of reactor temperature – gas and liquid phase reactions

Text Book(s)
Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley Publishers, 1999
Rutherford Aris, Elements of Chemical Reaction Engineering,

Reference(s)
H.S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, 2000
G.F. Froment and K.B. Bischoff, Chemical Reactor Analysis and Design, 2nd Edition, John-Wiley Publishers, 1990

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Open book Quizzes and Course Project

19CHE302	CHEMICAL TECHNOLOGY	L-T-P-C : 1-0-0-1

Pre-Requisite(s): Introduction to Chemical Engineering

Course Objective

The main objective of the course is to understand the manufacturing techniques involved in the making of chemical and allied products including the process safety and economic aspects

Course Outcomes

CO1: To strengthen the understanding of modern green chemistry principles and stoichiometry of chemical synthesis
CO2: To develop the global perspective on selected chemical process industries and provide an overview of top chemical companies
CO3: To strengthen the knowledge of process safety, economic considerations and setting up of industries in a broader perspective
CO4: To develop expertise in formulating and proposing the flowsheets for the manufacture of selected chemical products

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3					2	2	2					2	2	1
CO2	1					2	2	2					2	2	1
CO3	2	1	1			2	2	2					2	2	1
CO4	3	1				2	2	2					2	2	1

Syllabus

Worldwide and India chemical industry scenario; Economic aspects of chemical industry; Process safety; Green chemistry and green manufacturing; Manufacturing processes - Understanding the chemical formula, product applications, chemistry and stoichiometry of synthesis, flowsheet depicting process operations, equipment used, processing conditions, and economic considerations for: Industrial catalysis, Petroleum and Petrochemicals, Plastics, Synthetic fibers, Rubber, Paper, Chlor-alkali, Sulfur and sulfuric acid, Industrial gases, Sugar, Soap, Surface coatings, Agrochemicals, Biomass conversion

Textbook(s)
C.E. Dryden, Outlines of Chemicals Technology, 2nd Edition, Edited and Revised by M.G. Rao and M. Sitting, Affiliated East–West Press, 1993.
G.I. Austin, Shreve's Chemical Process Industries, 5th Edition, Tata McGraw Hill, Singapore, 1990
James A. Kent, Kent &Riegel's Handbook of Industrial Chemistry & Biotechnology, 11th Edition, Springer, 2007.

Reference Book(s)
Karl Heinz Buchel, Hans-Heinrich Moretto, and Peter Woditsch, Industrial Inorganic Chemistry, Wiley-VCH, 2000
Harold A. Witcoff, Bryan G. Reuben, and Jeffrey S. Plotkin, Industrial Organic Chemicals, Wiley-Interscience, 2004

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	-	
Periodical 2 (P2)	-	
*Continuous Assessment (CA)	50	
End Semester**		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE303	PRINCIPLES OF MASS TRANSFER	L-T-P-C:2-1-0-3

Pre-Requisite(s): Material Balance, Energy Balance & Thermodynamics, Principles of Heat Transfer, Fluid Mechanics

Course Objective

The main objective of the course is to impart knowledge on the fundamental concepts of mass transfer which is important for engineering applications.

Course Outcomes

CO1: Ability to define, describe, and apply terminology for diffusive and convective modes of mass transfer
CO2: Ability to apply fundamental concepts to solve problems involved in mass transfer operations **(**mass transfer coefficient, design of absorbers)
CO3: Understanding the concept of shell balance and its applications for systems involving mass transfer

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		1									3		
CO2	3	3	3	2									3	3	
CO3	3	3		3									3		

Syllabus

Unit 1
Modes of mass transfer, Fick's law of diffusion, Diffusivity measurement and correlations, molecular diffusion in gases, liquids, and solids; Multi-component diffusion, Knudsen diffusion, eddy diffusion, Mass transfer across the interface and concept of mass transfer coefficient.

Unit 2
Mass transfer under forced convection, flux equation, falling film, flat horizontal plate, dimensionless numbers in mass transfer, correlations for mass transfer coefficient in laminar flow; theories and analogies for mass transfer in turbulent flow, film theory, penetration theory, surface renewal theory, two film theory, individual and overall mass transfer coefficient, number of theoretical plates, NTU & HTU concept for absorber.

Unit 3
Shell balance: Steady state and unsteady state equation for mass transfer with homogeneous/heterogeneous chemical reaction in Cartesian coordinate system, cylindrical coordinate system, and spherical coordinate system.

Text Book(s)
R. E. Treybal, Mass transfer operations, 3rd Edition, McGraw Hill, 1981.
J. R. Welty et al., Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2000.

Reference Book(s)
J. M Coulson and J. F. Richardson, Chemical Engineering Vol. II, 4th Edition, Asian Books Pvt Ltd, India, 1998.
McCabe, Simth, and Harriot, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hill, International Edition, 2001.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19MAT302	NUMERICAL METHODS	L-T-P-C: 2-0-3-3

Pre-Requisite(s):

Linear Algebra for Chemical Engineers, Differential and Integral Calculus, Ordinary and Partial Differential Equations

Course Objective

The main objective of the course is to impart knowledge on the solution of mathematical equations using different numerical/computational methods and their implementation in MATLAB

Course Outcomes

CO1: Understanding basic concepts of Numerical Mathematics
CO2: Learn to analyze and apply basic schemes in Numerical Analysis of Linear and Nonlinear systems in chemical engineering field.
CO3: Understanding and applying numerical methods for solving ordinary differential equations in chemical engineering problems
CO4: Understanding and applying numerical methods for solving partial differential equations in chemical engineering problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1		2	3									1	2
CO2	2			1	3								2	2	
CO3	3	2			3								3	3	1
CO4	3	2		3	3								3	3	2

Syllabus

Unit 1
Review of Errors: Accuracy and precision, round off error and truncation error Roots of transcendental and polynomial equations: bisection method, Iteration methods based on first degree equation, rate of convergence, system of non-linear equation. Review of Matrix Algebra: systems of equations, eigenvalues and eigenvectors Solution of system of linear algebraic equations: Gauss elimination and Gauss Jordan method, Iteration methods, Jacobi method for symmetric matrices, and power method for arbitrary matrices

Unit 2
Interpolation and Approximation: Lagrange and Newton Interpolation for unequal intervals, finite difference operators, interpolating polynomials using finite differences

Unit 3
Review of Ordinary Differential equations (ODEs):
Solution of ODEs: Initial value problem, single step method, Taylor series method, second , third and fourth order RungeKutta method.

Lab implementation of these methods: MATLAB or EXCEL or free and open source software.

Text Book(s)
Steven Chapra and Raymond Canale, Numerical Methods for Engineers, McGraw Hill, 2007

Reference Book(s)
M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International publishers, Fifth Edition, 2007.

C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, 7th Edition, Addison Wesley, 2009
Ritzwan Butt, Introduction to numerical analysis using MATLAB, Jones and Bartlett Publishers,2010

Evaluation Pattern

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE381	CHEMICAL ENGINEERING LAB - 3	L-T-P-C: 0-0-3-1

Course Objective

The main objective of the course is to impart practical knowledge on determination of fundamental quantities involved in heat transfer and strength of materials.

Course Outcomes

CO1: Ability to determine conductivity and heat transfer coefficient for different systems
CO2: Ability to study heat transfer equipment like heat exchangers and determine their performance indices
CO3: To gain fundamental knowledge on the mechanical behaviour of materials when subjected to tensile, impact and bending loads.
CO4: Ability determine the mechanical properties like strength, modulus, hardness, toughness and stiffness of materials

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2				2						3
CO2	3	3	3	2	2				2						3
CO3	3	3	2	2	2				2						2
CO4	3	2	2	2	1				1						2

Syllabus

Heat Transfer:

Thermal conductivity of solid materials, Heat transfer in pool boiling and through submerged coils in agitated vessels, Heat exchanger and efficiency of heat transfer equipment, Natural convection, Forced convection

Strength of Materials:

Tensile test on Metals, Impact test - Charpy and Izod, Static Bending Test, Double shear test & Compression test, Hardness test- Rockwell and Brinell

Evaluation Pattern

Assessment	Internal	External
*Continuous Assessment (CA)	80	
End Semester		20

* Lab Sessions

19SSK301	SOFT SKILLS II	L-T-P-C: 1-0-3-2

Course Outcomes

CO1: **Soft Skills:** At the end of the course, the students will have the ability to communicate convincingly and negotiate diplomatically while working in a team to arrive at a win-win situation. They would further develop their inter-personal and leadership skills.

CO 2: **Soft Skills:** At the end of the course, the students shall learn to examine the context of a Group Discussion topic and develop new perspectives and ideas through brainstorming and arrive at a consensus.

CO3: **Aptitude:** At the end of the course, students will be able to identify, recall and arrive at appropriate strategies to solve questions on geometry. They will be able to investigate, interpret and select suitable methods to solve questions on arithmetic, probability and combinatorics.

CO4: **Verbal:** At the end of the course, the students will have the ability to relate, choose, conclude and determine the usage of right vocabulary.

CO5: **Verbal:** At the end of the course, the students will have the ability to utilise prior knowledge of grammar to recognise structural instabilities and modify them.

CO6: **Verbal:** At the end of the course, the students will have the ability to comprehend, interpret, deduce and logically categorise words, phrases and sentences. They will also have the ability to theorise, discuss, elaborate, criticise and defend their ideas.

Syllabus

Professional grooming and practices: Basics of corporate culture, key pillars of business etiquette. Basics of etiquette: Etiquette – socially acceptable ways of behaviour, personal hygiene, professional attire, cultural adaptability. Introductions and greetings: Rules of the handshake, earning respect, business manners. Telephone etiquette: activities during the conversation, conclude the call, to take a message. Body Language: Components, undesirable body language, desirable body language. Adapting to corporate life: Dealing with people.
Group discussions: Advantages of group discussions, structured GD – roles, negative roles to be avoided, personality traits to do well in a GD, initiation techniques, how to perform in a group discussion, summarization techniques.

Listening comprehension advanced: Exercise on improving listening skills, grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading comprehension advanced: A course on how to approach middle level reading comprehension passages.
Problem solving level III: Money related problems; Mixtures; Symbol based problems; Clocks and calendars; Simple, linear, quadratic and polynomial equations; special equations; Inequalities; Functions and graphs; Sequence and series; Set theory; Permutations and combinations; Probability; Statistics.
Data sufficiency: Concepts and problem solving.

Non-verbal reasoning and simple engineering aptitude: Mirror image; Water image; Paper folding; Paper cutting; Grouping of figures; Figure formation and analysis; Completion of incomplete pattern; Figure matrix; Miscellaneous.
Spacial aptitude: Cloth, leather, 2D and 3D objects, coin, match sticks, stubs, chalk, chess board, land and geodesic problems etc., related problems.

Textbook(s)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quick Maths – Tyra.
Quicker Arithmetic – Ashish Aggarwal
Test of reasoning for competitive examinations by Thorpe.E. TMH
Non-verbal reasoning by R. S. Aggarwal, S. Chand

Reference(s)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

15CHE304	INSTRUMENTAL METHODS OF ANALYSIS	L-T-P-C: 3-0-0-3

Pre-Requisite(s): General chemistry/Engineering chemistry knowledge is a prerequisite for learning this course

Course Objectives

To learn the principles, operation methods and basic components of instruments used for various qualitative and quantitative analyses of chemicals and raw materials>

Course Outcomes

CO1: Understand the theory, instrumentation and methods of analytical equipment used in laboratories and in industries.
CO2: Apply the methods used for testing the quality of raw materials, intermediates and products.
CO3: Evaluate the importance of analytical instrumentation/methods during the purification, compounding and formulating the finished product.
CO4: Design the cell/equipment to carry out different analyses.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1		3								2	1	
CO2	1	2	1		2								2	2	
CO3	2	2	2		3									2	1
CO4	2	1	3		3									2	2

Syllabus

Unit 1
Error analysis and sampling: Accuracy –precision-classification of errors –standard deviation-coefficient of variance- F test, T test, ANOVA –significant figures. Sampling and physical state- safety measures of sampling. Good laboratory practices (GLP), laboratory maintenance standard operating procedures (SOPs), and methods of validation.

Unit 2
Separation techniques: Brief outline of column, paper and thin layer chromatography- ion exchange methods-principle and application –HPLC, HPTLC, GPC. Supercritical chromatography - Gas chromatography – principle and applications - GC and LC detectors.Electrophoresis.

Unit 3
Electroanalytical techniques- potentiometry - titration-determination of equivalence point, acid, base, complexometric, redox and precipitation titrations- merits and demerits; voltametry-cyclic voltametry - basic principle and application; polarography- introduction-theoretical principles-migration current-residual current-half wave potential-instrumentation-analytical applications.

Text Book(s)
Willard H W, Merritt J R, 'Instrumental methods of analysis ', Prentice Hall, 1989.
Skoog, Douglas A, West Donald, 'Fundamental of analytical chemistry'- New York, Addision – Wesley, 2001

Reference(s)
Vogels, Textbook of Quantitative Chemical Analysis, 6th Edition, ELBS, 2000
Kaur. H, Instrumental Methods of Chemical Analysis, 2009, 5th Edition, Goel Publisher

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

***CA** – Can be Quizzes, Assignment, Projects, and Reports

19LIV390	**LIVE-IN-LAB I**	**L-T-P-C: 3-0-0-3**

Course Objectives

- Identify and analyse the various challenge indicators present in the village by applying concepts of Human Centered Design and Participatory Rural Appraisal.
- User Need Assessment through Quantitative and Qualitative Measurements
- Designing a solution by integrating Human Centered Design concepts
- Devising proposed intervention strategies for Sustainable Social Change Management

Course Outcome

CO1: Learn ethnographic research and utilise the methodologies to enhance participatory engagement.
CO2: Prioritize challenges and derive constraints using Participatory Rural Appraisal.
CO3: Identify and formulate the research challenges in rural communities.
CO4: Design solutions using human centered approach.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3		3		1	1		3	3		3
CO2		3						3	3	3		
CO3		3					1		3	3		3
CO4	3		3				3	3	3	3		3

Syllabus

This initiative is to provide opportunities for students to get involved in coming up with technology solutions for societal problems. The students shall visit villages or rural sites during the vacations (after 4th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

The objectives and the projected outcome of the project will be reviewed and approved by the department chairperson and a faculty assigned as the project guide.

Evaluation Pattern

Assessment	Marks
Internal (Continuous Evaluation) [75 marks]	
Workshop (Group Participation)	15
Village Visit Assignments & Reports	15
Problem Identification and Assessment	15
Ideation: Defining the Needs, Proposed Designs & Review	20
Poster Presentation	10
External [25 marks]	
Research Paper Submission	25
Total	**100**
Attendance (To be added separately)	5
Grand Total	**105**

SEMESTER VI

19CHE311	CHEMICAL REACTION ENGINEERING – II	L-T-P-C: 3-0-0-3

Pre-Requisite(s):

1. Principles of Mass Transfer
2. Chemical Reaction Engineering - I

Course Objectives

Students will learn about the important steps in heterogeneous reactions, obtain final rate expression based on rate determining step and examine the suitability of rate expression for an experimental data. These rate expressions along with heat and mass transfer will be used to design a heterogeneous reactor. Additionally, the students will analyse the effect of catalyst deactivation on reactor performance.

Course Outcomes

CO1: Develop rate expressions for different steps in heterogeneous catalytic and non-catalytic reactions
CO2: Identify the rate limiting step in heterogeneous reactions
CO3: Design catalysts for pore diffusion control /elimination
CO4: Analyze the effect of parameters on heat and mass transfer, and catalyst deactivation in heterogeneous systems on reactor performance
CO5: Design reactors for Gas-Solid & Liquid-Solid catalytic and non-catalytic reactions
CO6: Analyze the effect of non-ideal mixing in reactors on mean residence time and reactor performance

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3											3		2
CO2		3		3									3		
CO3				3									3		3
CO4				3									2	3	3
CO5			3		3										3
CO6				3									3		

Syllabus

Unit 1
Review of homogenous chemical reactor design
Non-ideal mixing: Factors affecting the ideal mixing, residence time distribution (RTD), measurement of RTD – tracer injection analysis, Models for non-ideal flow – Dispersion model and tanks-in-series model; Heterogeneous reactions – reaction rate definition; concentration profiles in heterogeneous reactions; effects of diffusion;

Unit 2
Solid catalyzed reactions – nature of catalysts, various resistances – adsorption and desorption, pore diffusion, surface reaction, rate-limiting step; surface area and pore volume distribution – methods of solid catalyst preparation; Gas-Solid catalytic reactions- Diffusion within the catalyst pellet, effective diffusivity and thermal conductivity, heat and mass transfer within the catalyst pellet, effectiveness factor and Thiele modulus; Extension Gas-Liquid-Solid reaction - Application and performance estimation of packed bed, fluidized bed and trickle bed

reactors – Steam-methane reformation and Fischer-Tropsch Synthesis; Optimal Reactor configuration and Scaleup;

Unit 3
Fluid-Solid non-catalytic reactions – kinetic models, volume and surface reactions, rate-limiting steps, time for complete conversion – Application to fuel oxidation and catalyst regeneration, Chemical vapor deposition and Microelectronics – Packed bed and Fluidized bed reactors; Dimensional Analysis and Reactor Scaleup; Biochemical Reactions and Reactor Design;

Text Book(s)
Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley Publishers, 1999
G.F. Froment and K.B. Bischoff, Chemical Reactor Analysis and Design, 2nd Edition, John-Wiley Publishers, 1990

Reference(s)
H.S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, 2000
E. Bruce Nauman, Chemical Reactor design, Optimization and Scaleup, McGraw Hill Inc., 2002

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	35	
End Semester		35

*CA – Open book Quizzes and Course Project

19CHE312	DESIGN OF MASS TRANSFER EQUIPMENT	L-T-P-C: 3-0-0-3

Pre-Requisite(s):

Material Balance, Energy Balance & Thermodynamics, Fluid Mechanics, Principles of Heat Transfer, Principles of Mass Transfer

Course Objectives

To obtain strong understanding of design and operations of various mass transfer processes.

Course Outcomes

CO1: Develop a strong conceptual understanding of various mass transfer processes
CO2: Understand general design and operations of mass transfer equipment
CO3: Analyze chemical engineering operations involving mass transfer equipment
CO4: Ability to solve problems involving staged mass transfer processes such as distillation, extraction, absorption and drying.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2						2				3		
CO2	3	2	2						2				3	2	
CO3	3	3	2						2				3	2	
CO4	3	3	3	2					2				3	2	

Syllabus

Unit 1
Design of mass transfer equipment based on the concept of equilibrium stage;
Distillation: vapor-liquid equilibria, Raoult's law and deviations from ideality, methods of distillation; Equilibrium and operating line concepts; Design calculations by McCabe-Thiele and Ponchon-Savarit methods; Continuous contact distillation (packed tower) design; Extractive and azeotropic distillation, low pressure distillation; Steam distillation; Tray tower equipment.

Unit 2
Absorption: Design of tray tower absorbers; Operating characteristics of stagewise and differential contactors; Design calculations for single stage, multistage concurrent and countercurrent absorbers.

Unit 3
Theory and mechanism of drying, drying curves, classification of dryers, design of batch and continuous dryers.
Liquid-liquid extraction: Equilibrium in ternary systems; Design calculations for batch and continuous extractors, equipment – spray, packed and mechanically agitated contactors; Pulsed extractors, centrifugal extractors.

Texbook(s)
R.E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
J.D. Seader and E. J. Henley, Separation Process Principles, 2nd Edition, Wiley, 2005.

Reference(s)
J.M.Coulson and J.F. Richardson, "Chemical Engineering Vol. II", 4th Edition, Asian Books Pvt Ltd, India, 1998.
W.L.McCabe, J.C.Smith and P. Harriot, "Unit operations of Chemical Engineering", 6th Edition, McGraw Hill, International Edition, 2001.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes and Assignments.

19CHE313	TRANSFORMS AND CONTROL SYSTEMS THEORY	L-T-P-C: 3-1-0-4

Pre Requisite(s):

Differential and Integral Calculus, Material Balance, Energy Balance & Thermodynamics, Principles of Heat Transfer, Principles of Mass Transfer, Chemical Reaction Engineering I

Course Objectives

The objective of the course is to introduce the concept of Laplace transforms for solving differential equations, understand dynamic modeling of a physical process using first principles, develop transfer functions, understand the principle of various control configuration, analyze control system stability and apply the control system in various processes.

Course Outcome

CO1: Understanding of the concepts of Laplace transform and its properties, ability to obtain Laplace transform of standard functions and apply the concepts to solve the initial value problems and ODEs.
CO2: Ability to apply basic principles to dynamic modelling, developing transfer functions and system behaviour study to various input functions.
CO3: Ability to develop block diagram and utilize control algorithms to design and analyze transient response of control schemes for various configurations.
CO4: Ability to analyze stability of control systems and perform tuning of process controllers.
CO5: Understanding of advanced control systems and application of control systems in chemical processes.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	-	3	3	3
CO5	3	3	3	2	-	-	-	-	-	-	-	-	3	3	1

Syllabus

Unit 1
Laplace transformation: Time-Frequency Mapping, transform of standard functions, derivatives and integrals, inversion, theorems, application to solve ODEs. Open – Loop systems, Transfer functions and input output models, Dynamic behavior of first order systems, pure capacitive process, first order systems in series, second order systems and systems with dead time. linearization and its application in process control. State space and transfer function matrix models.

Unit 2
Closed loop control systems: concept of feedback control, development of block diagram for feedback control systems, closed loop transfer functions, servo and regulatory problems, transfer function for controllers and final control element, transient response of closed – loop control systems – effect of proportional, integral, derivative and composite control action.Stability Analysis of Feedback systems: Characteristic equation, Routh – Hurwitz stability criterion, root locus analysis.

Unit 3
Frequency response of open and closed – loop systems, Bode plots, stability criterion, controller tuning. Introduction to advanced control systems - cascade control, Feed-forward control, ratio; Control of chemical processes.

Text Book(s)

Donald R. Coughanowr, Steven E. LeBlanc, “Process Systems Analysis and Control – 3rdEdn., Tata Mcgraw Hill Education, 2011.
G. Stephanopoulos, “Chemical Process Control”, 8thEdn, Prentice Hall of India. 2015.

Reference(s)

Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley India Pvt. Ltd., New Delhi, 2013
Peter Harriott,Process Control, Tata McGraw Hill, New Delhi, 2009

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE314	PUMPS, FITTINGS AND VALVES	L-T-P-C: 1-0-0-1

Pre-Requisite(s): Fluid Mechanics

Course Objectives

The objective of the course is to introduce different types of pumps, evaluate their performance characteristics, to identify pumps for specific applications, do sizing for fittings, analyse pressure drop in fittings.

Course Outcome

CO1: Understanding of types and working of hydraulic pumps,analyse performance curves and choose suitable pump for a given process

CO2: Understanding of types of valves and fittings, analyze the effect of pressure drop in pipe line fittings.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	3	2	-	-	-	-	-	-	-	3	2	2
CO2	3	3	-	3	2	-	-	-	-	-	-	-	3	2	2

Syllabus

Unit 1

The Source of Hydraulic Power: Pumps, Pumping Theory, Pump Classification – reciprocating, centrifugal, diaphragm; Pump Performance, Pump Selection
Hydraulic Valves - Directional Control Valves, Pressure Control Valves, Flow Control Valves, Servo Valves, Proportional Control Valves, Cartridge Valves
Hydraulic Conductors and Fittings - Conductor Sizing for Flow-Rate Requirements, Pressure Rating of Conductors, Pipes, Tubing, Hoses, Quick Disconnect Couplings.

Text Book(s)

Warren McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering, 7thedn, McGraw-Hill, 2014
W.L. Badger and J.T. Banchero, "Introduction to Chemical Engineering", Tata McGraw Hill, 1997.
G. Stephanopoulos, "Chemical Process Control", 8thEdn, Prentice Hall of India. 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	-	
Periodical 2 (P2)	-	
*Continuous Assessment (CA)	50	
End Semester		50

*CA – Can be Quizzes, Model development, Assignment, Projects, and Reports

19CHE382	CHEMICAL ENGINEERING LAB - 4	L-T-P-C: 0-0-3-1

Course Objectives

This course provides hands-on practical training on understanding, operating, measuring, analysing and characterizing chemical engineering units and phenomena, with specific focus on thermodynamics and chemical reaction engineering. Thermodynamics lab aims to introduce students to thermodynamic analysis of machines (e.g., turbine, refrigerator) and on analysis of equilibria of mixtures (e.g., VLE, LLE, reaction). Chemical Reaction Engineering Lab introduces obtaining data from different reactors and use the experimental data to estimate the rate parameters of a reaction.

Course Outcomes

CO1: Understand the working principles of operation of machines such as turbines and refrigerators. Operate the machines under different standard conditions and carry out a thermodynamic analysis of their performance.
CO2: Understand how phase and reaction equilibria may be analysed using thermodynamic principles. Perform experiments on vapor-liquid equilibria of binary mixtures, liquid-liquid equilibria of ternary mixtures and reaction equilibria in liquid phases. Analyse the obtained data to characterize these equilibria.
CO3: Estimate rate parameters rate constant, order, pre-exponential factor and activation energy from experimental data obtained from batch, mixed flow and plug flow reactors.
CO4: Determine the mixing conditions in a given reactor vessel using either tanks-in-series model or dispersion model from tracer experimental data

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2				3	2		1	2	1	3
CO2	3	3	3	3	2				3	2		1	2	1	3
CO3	3	2	3	2	3								3	2	
CO4	3	2	3	2	3	2							3	2	

Syllabus

Unit 1

Thermodynamics Lab

1. Performance of a Turbine and Thermodynamic Analysis of a Power Cycle
2. Thermodynamic Analysis of a Refrigerator
3. Vapor-Liquid Equilibrium of a Binary Mixture
4. Liquid-Liquid Equilibrium of a Ternary Mixture (Liquid-Liquid Extraction)
5. Reaction Equilibrium in Liquid Phase

Unit 2

Chemical Reaction Engineering Lab

1. Batch reactor
2. Semi-batch reactor
3. Plug flow reactor (PFR)
4. Continuous stirred tank reactor (CSTR)
5. Reactor combinations – PFR+CSTR or CSTRs
6. RTD studies to find the mixing phenomena in the reactors

Text Book(s)
Y. V. C. Rao, Chemical Engineering Thermodynamics, University Press, 2001
Y. Cengel, M. A. Boles, Thermodynamics: An Engineering Approach, McGraw Hill Education, 8th Edition, 2017
Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley Publishers, 1999

Reference(s)
H.S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, 2000

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Evaluation of weekly experiments, reports, viva voce

19CHE383	PROJECT BASED LEARNING	L-T-P-C: 0-0-3-2

Pre-Requisites: Material and Energy Balances, Chemical Technology, Chemical Reaction Engineering - I

Course Objectives

The projects are to be based on gaining a hands-on understanding of the gamut of activities and operations in a chemical engineering manufacturing facility, through selection of an industrial chemical, stoichiometry, literature review,flow sheeting, mass and energy balances, work flow, process & equipment design, plant layout, safety, sustainability, and process economics.

Course Outcomes

CO1: Ability to construct detailed process flow chart, and develop the associated mass and energy balances
CO2: Understand aspects of equipment, process, and plant design & economics
CO3: Ability to prepare a detailed project report for set up of a chemical plant

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			2				3				3	1	
CO2	3	3	3	3	2	2	3	1			2	2		3	
CO3										3	3				3

Evaluation Pattern

Assessment	Internal	End Semester
Internal Review	40	
Guide Evaluation	20	
Final Review		40

19SSK311	SOFT SKILLS III	L-T-P-C: 1-0-3-2

Course Outcomes:

CO1: **Soft Skills:** At the end of the course, the students will have the ability to prepare a suitable resume (including video resume). They would also have acquired the necessary skills, abilities and knowledge to present themselves confidently. They would be sure-footed in introducing themselves and facing interviews.

CO2: **Soft Skills:** At the end of the course, the students will have the ability to analyse every question asked by the interviewer, compose correct responses and respond in the right manner to justify and convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.

CO3: **Aptitude:** At the end of the course, students will be able to interpret, critically analyze and solve logical reasoning questions. They will have acquired the skills to manage time while applying methods to solve questions on arithmetic, algebra, logical reasoning, and statistics and data analysis and arrive at appropriate conclusions.

CO4: **Verbal:** At the end of the course, the students will have the ability to understand and use words, idioms and phrases, interpret the meaning of standard expressions and compose sentences using the same.

CO5: **Verbal:** At the end of the course, the students will have the ability to decide, conclude, identify and choose the right grammatical construction.

CO6: **Verbal:** At the end of the course, the students will have the ability to examine, interpret and investigate arguments, use inductive and deductive reasoning to support, defend, prove or disprove them. They will also have the ability to create, generate and relate facts / ideas / opinions and share / express the same convincingly to the audience / recipient using their communication skills in English.

Syllabus

Team work: Value of team work in organisations, definition of a team, why team, elements of leadership, disadvantages of a team, stages of team formation. Group development activities: Orientation, internal problem solving, growth and productivity, evaluation and control. Effective team building: Basics of team building, teamwork parameters, roles, empowerment, communication, effective team working, team effectiveness criteria, common characteristics of effective teams, factors affecting team effectiveness, personal characteristics of members, team structure, team process, team outcomes.

Facing an interview: Foundation in core subject, industry orientation / knowledge about the company, professional personality, communication skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.

Syllogisms, critical reasoning: A course on verbal reasoning. Listening comprehension advanced: An exercise on improving listening skills.

Reading comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Problem solving level IV: Geometry; Trigonometry; Heights and distances; Co-ordinate geometry; Mensuration.

Specific training: Solving campus recruitment papers, national level and state level competitive examination papers; Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In mathematics). Lateral thinking problems. Quick checking of answers techniques; Techniques on elimination of options, estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

Textbook(s)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
The Hard Truth about Soft Skills, by Amazone Publication.

Data Interpretation by R. S. Aggarwal, S. Chand
Logical Reasoning and Data Interpretation – Niskit K Sinkha
Puzzles – Shakuntala Devi
Puzzles – George J. Summers.

Reference(s)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources

www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

19LIV490	LIVE-IN-LAB II	L-T-P-C: 3-0-0-3

Course Objectives

- Proposal writing in order to bring in a detailed project planning, enlist the materials required and propose budget requirement.
- Use the concept of CoDesign to ensure User Participation in the Design Process in order to rightly capture user needs/requirements.
- Building and testing a prototype to ensure that the final design implementation is satisfies the user needs, feasible, affordable, sustainable and efficient.
- Real time project implementation in the village followed by awareness generation and skill training of the users (villagers)

Course Outcome

CO1: Learn co-design methodologies and engage participatorily to finalise a solution
CO2: Understand sustainable social change models and identify change agents in a community.
CO3: Learn Project Management to effectively manage the resources
CO4: Lab scale implementation and validation
CO5. Prototype implementation of the solution

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	3			1	3	3	3		3
CO2									3	3		
CO3									3	3	3	
CO4	3		3			3	1	3	3	3		3
CO5			1						3	3		

Syllabus

The students shall visit villages or rural sites during the vacations (after 6th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

Evaluation Pattern

Assessment	Marks
Internal (Continuous Evaluation) [63 marks]	
1. Proposed Implementation	**2**
Presentation Round 1	
2. Proposal Submission + Review	**6**
3. Co-design	**6**
i. Village Visit I (Co-Design Field Work Assignments)	4
ii. Presentation of Co-design Assessment	2
4. Prototype Design	**14**
i. Prototype Design	4
ii. Prototype Submission	8
iii. Sustenance Plan	2
5. Implementation	**35**
i. Implementation Plan Review	3
ii. Implementation	24
iii. Testing & Evaluation	4
iv. Sustenance Model Implementation	4
External [37 marks]	
6. Research Paper	**18**
7. Final Report	**15**
8. Poster Presentation	**4**
Total	**100**
Attendance	5
Grand Total	**10**

SEMESTER VII

19CHE401	PROCESS DESIGN AND INTEGRATION	L-T-P-C: 3-0-0-3

Pre-Requisite(s):

1. Principles of Heat Transfer
2. Design of Heat transfer equipment
3. Principles of mass transfer
4. Mass transfer equipment
5. Chemical reaction Engineering I
6. Chemical reaction Engineering II

Course Objectives

The objective of the course is to enable the students to understand general design considerations involving process development, to carry out process optimization based on economic profitability by connecting economics with design principles for real chemical engineering processes and to learn process integration with regard to energy efficiency, waste minimization and an efficient use of raw materials.

Course Outcome

CO1: Understand the concepts and hierarchy of chemical of process design. Apply heuristics to process design. Synthesize flow sheets.

CO2: Use knowledge of reaction type and kinetics to identify performance criterion, optimum reactor configurations, conditions and reactor networks.

CO3: Apply heuristics and thermodynamic principles to separation system synthesis- distillation columns sequencing for ideal and non-ideal mixtures

CO4: Appreciate the pinch concept and able to identify minimum energy targets, identification of different choices and constraint during heat exchange networking, heat integration of process equipment.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	1	-	-	-	-	-	3	3	3
CO2	3	3	3	3	1	-	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	1	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	3	1	-	1	-	-	-	-	-	3	3	3

Syllabus

Unit 1

Nature of Chemical process design and integrations, Hierarchy of chemical process design, Batch versus Continuous process, New design vs. retrofit, Heuristics for process design. Conceptual Process Synthesis – Diagrams for understanding chemical processes, Structure and hierarchical synthesis of flow sheets.Reactor Network Synthesis - Reactor type, conditions and configuration for reaction systems, geometric techniques for synthesis of reactor networks.

Unit 2

Separation system Synthesis – Distillation column sequencing for ideal liquid mixtures, Separation system structure for non-ideal mixtures using distillation / residue curves.Reaction, Separation and recycle systems for batch and continuous processes.

Unit 3

Heat Exchanger Network: Synthesis using Pinch Technology – Targets for minimum utilities, area, total cost. Pinch design method for heat exchange network design, Evolutionary synthesis for minimum number of exchanges design. Heat integration of process equipment.

Text Book(s)

Robin Smith, Chemical Process Design and Integration, John Wiley & Sons Ltd., New Delhi, 2014.

Reference(s)

Warren D. Seider, J. D. Seader, Daniel R. Lewin, SoemantriWidagdo, Product and Process Design Principles: Synthesis, Analysis and Design, 3rdEdn, Wiley, 2010
Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, 3rdEdn, Pearson Education, 2008
Biegler, L.T., Grossmann, I.E., and Westerberg, A.W. "Systematic Methods for Chemical Process Design", Prentice-Hall, 1997.
Douglas, J.M. "Conceptual Design of Chemical Processes", McGraw-Hill, 1988.
Harry Silla, Chemical Process Engineering Design and Economics, Marcel Dekker, Inc., New York, 2003

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE402	PROCESS EQUIPMENT DESIGN	L-T-P-C: 2-0-3-3

Pre-Requisite(s):

1. Mechanical operations
2. Principles of Heat transfer
3. Design of Heat transfer equipment
4. Principles of mass transfer
5. Mass transfer equipment

Course Objective

The main objective of the course is to impart knowledge on the design concepts of various equipment used in chemical industries.

Course Outcomes

CO1: Understand general design considerations involving process design development.
CO2: Able to design the components of pressure vessel and heat exchanger
CO3: Demonstrate procedures in designing the evaporators and mass transfer column such as distillation and absorption
CO4: Able to design the agitation system components and drier

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1						1				3	3	1
CO2	2	2	3			1			2				3	3	1
CO3	2	2	3			1			2				3	3	1
CO4	2	2	3			1			2				3	3	1

Syllabus

Unit 1
Design of process equipment: Pressure vessels, Pressure vessel codes, Design of shell and its components, vessel closure, Supports; Storage vessels: nozzles and mountings. Design of heat exchanger: Mechanical design of shell & tube heat exchanger.

Unit 2
Design of evaporators. Design of mass transfer column:Column sizing, design and construction features of Plate contactors, column internals, plate hydraulic design, packed column design

Unit 3
Mixing and agitation: Power requirement for agitation, design of agitation system components. Design of driers: Introduction, types driers, design consideration of driers

Text Book(s)
M.V Joshi and V VMahajan, "Process Equipment Design"3rd Edition, McMillian India Ltd.,1996 0
S B Thakore and B I Bhatt, "Introduction to Process Engineering and Design" 1st Edition, Mc-Graw Hill Publications,2008

Reference Book(s)
Sinnott R. K.; "Coulson and Richardson's Chemical Engineering Series", Vol. VI, 4th Edition,, Asian Books PvtLtd,India
I.S.:2825-1969, "Code for Unfired Pressure Vessels"
Kern, D.Q., Process Heat Transfer, International Student Edition, McGraw Hill (2002).

Bhattacharyya, B.C., Introduction to Chemical Equipment Design, Mechanical Aspects, CBS Publishers and Distributors (2009).
Brownell, L.E. and Young, E.H., Process Equipment Design, Wiley India (P.) Limited (2004).
Perry, R.H. and Green, D, Chemical Engineer's Handbook, 8th Edition, McGraw Hill, New York. (2008)

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE403	TRANSPORT PHENOMENA	L-T-P-C: 3-0-0-3

Pre-Requisite:

Introduction to Chemical Engineering, Material Balances, Fluid Mechanics, Principles of Heat Transfer, Principles of Mass Transfer

Course Objectives

To utilize Navier Stokes equation for rectangular, cylindrical and spherical coordinates to solve chemical engineering industrial problems.

Course Outcomes

CO1: Understanding of mechanism of various transport processes like momentum, heat and mass transport
CO2: Develop shell balances for steady flow through various geometries in momentum, heat and mass transport problems
CO3: Analyze chemical engineering industrial problems along with their appropriate boundary conditions for momentum, heat and mass transport problems
CO4: Ability to develop steady and time dependent solutions with their limitations for momentum, heat and mass transport problems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2					2				3	2	
CO2	3	2	2	2					2				3	3	
CO3	3	3	2	2					2				3	3	
CO4	3	3	3	3					2				3	3	

Syllabus

Unit 1
Review of basic vector algebra and introduction to tensors, Macroscopic – Microscopic-Molecular views of phenomena; Momentum Transport: viscosity, pressure and temperature effect on viscosity of gases and liquids, Newton’s law of viscosity, mechanisms of momentum transport, non-Newtonian fluids & power-law models, derivation of velocity profile using shell balance method, velocity distributions in falling film and circular tube; equations of continuity, motion, and mechanical energy; use of equations of change to solve flow problems; unsteady viscous flow.

Unit 2
Energy Transport: Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier’s law, mechanisms of energy transport, derivation of temperature profile using shell energy balance (with electrical, nuclear, viscous and chemical heat source); temperature distribution in solids and laminar flow, heat conduction through composite walls, and cylinders; Combined energy flux vector; equation of energy (alternate forms) - applications to specific systems (forced convection laminar flow in tube, tangential flow in annulus, transpiration cooling); unsteady heat conduction in solids.

Unit 3
Mass Transport: Diffusivity, mechanisms of mass transport, concentration distribution in solids and in laminar flow, Fick’s law, temperature and pressure effect, theory of diffusion in gases and liquids, types of diffusion (ordinary, thermal, pressure, and forced), mass and moles transport, mass & molar average velocities; shell mass balances; concentration distribution through stagnant gas, diffusion in heterogeneous and homogeneous chemical

reaction, falling film; Equations of change for multicomponent systems and concentration distribution in turbulent flows: derivation of equation of continuity for binary mixture.

Textbook(s)
R.B. Bird, W.E. Stewart and E.W. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley, 2002.

Reference(s)
R.S. Brodkey and H. C. Hershey, Transport Phenomena, McGraw Hill, 1988.
J.R. Welty, R.W. Wilson and C.W. Wicks, Fundamentals of Momentum, Heat, and Mass Transfer, 3rd Edition, John Wiley, 1984.
J.S. Slattery, Advanced Transport Phenomena, Cambridge University Press, 1992.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes and Assignments.

19CHE404	CHEMICAL ENGINEERING SOFTWARE DEVELOPMENT	L-T-P-C: 1-0-0-1

Pre-Requisite(s):

1. Computational Thinking and Problem Solving
2. Computer programming or Python programming
3. Material Balances Chemical Engineering Thermodynamics
4. Chemical Reaction Engineering - I
5. Chemical Reaction Engineering - II

Course Objectives

Students will learn about basics of different components of an end-end-to simulation of a process equipment starting from how the properties are calculated based on process variation, parameters required for property calculations, duty calculations, equipment size etc.,

Course Outcomes

CO1: Develop Algorithms for the equations encountered in Chemical Engineering
CO2: Understand different methods of data transfer between the user and the software
CO3: Develop a simulator any one of the process equipment, including parameters for property calculations

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3							3	3	3	
CO2		2			3				2					3	
CO3					3				2			3	3	3	

Syllabus

Unit 1

Properties of the data entry choices; data transfer between main program and its subroutines; Definition of Global variables, Algorithms for equations encountered in Chemical Engineering, Subroutines relevant to Chemical Engineering, Dynamic stream creation, data transfer and retrieval; Introduction to database development for thermodynamic property calculations;

Applications – Software development for flash drum, pumps and compressors,and distillation column design.

Text Book(s)
Scott T. Smith, MATLAB Advanced GUI Development, Dog Ear Publishing, 2006

Reference(s)
Burkhard A. Meier, Python GUI Programming Cookbook, PACKT Publishing Limited, 2015.
Patrick Marchand, Graphics and GUIs with MATLAB, Taylor & Francis, 1999

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	-	
Periodical 2 (P2)	-	
*Continuous Assessment (CA)	50	
End Semester**		50

*CA – Model development – 20%; Quizzes – 10%; Course Project on Pump selection for a process – 20%
** Not a written exam. This will be a software-based project

19CHE405	PROCESS ECONOMICS	L-T-P-C: 1-0-0-1

Pre-Requisite(s): None

Course Objectives
The objective of the course is to prepare students to analyze cost / revenue data, carry out economic analysis in decision making to justify project alternatives on economic basis.

Course Outcome

CO1: Ability to evaluate present worth, future worth and annual worth of alternatives, knowledge of cost estimation techniques.
CO2: Ability to perform profitability analysis and compare investment alternatives
CO3: Ability to apply economic principles for decision making in chemical plants

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	3	2	-	-	-	-	-	-	-	3	2	2
CO2	3	3	-	3	2	-	-	-	-	-	-	-	3	2	2

Syllabus

Unit 1

Cash flows – Time value of money, Capital costs, Depreciation. Break even analysis, Estimation of capital costs, manufacturing costs and working capital, Economic feasibility of project
Profitability Analysis – Rate of return, Payback period, Discounted rate of return, Net present worth, Internal rate of return, Comparing investment alternatives.
Economic decisions in Chemical Plant – Economics of size – Essentials of economic balance –economic balance for insulation, evaporation, heat transfer

Text Book(s)
Peters, M.S. and Timmerhaus, K.D., "Plant Design and Economics for Chemical Engineers", McGraw-Hill, 1980.

Reference Book(s)
Mahajani, V.V., Mokashi S.M., Chemical Project Economics, Macmillan Indian Ltd., New Delhi, India (2005)
D.E. Garrett, Chemical Engineering Economics, Springer Science & Business Media, 2012
Perry, R. H. and Green, D., "Chemical Engineer's Handbook ", 8th Edition, McGraw Hill, 2007

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	-	
Periodical 2 (P2)	-	
*Continuous Assessment (CA)	50	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE481	CHEMICAL ENGINEERING LAB 5	L-T-P-C: 0-0-3-1

Pre Requisite(s): Principles of mass transfer, Transforms and Control Theory

Course Objectives

The objective of the course is to reinforce the students' understanding of the analysis of applications pertaining to Mass Transfer and Process Control through suitably designed experiments.

Course Outcome

CO1: To understand the molecular diffusion in fluids and to determine the diffusion coefficient for given organic fluid into air and mass transfer coefficient for the evaporation of liquid into air under natural and forced convection conditions
CO2: Understand the basic principles of distillation and conduct simple and steam distillation. Understand the working and principles of continuous and staged mass transfer equipment.
CO3: Understand the principles of adsorption and interpret through adsorption isotherms
CO4: Understand the dynamic response of first and second order systems, first order systems in series in interacting and non-interacting manner and evaluate system parameters, types of control valves and their characteristics.
CO5: Analyse the response of control systems (level, flow, pressure etc) in feedback and advanced control configurations for various control parameter settings, perform tuning of control configurations

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2											3	2	
CO2	3	2											3	2	
CO3	3	2											3	2	
CO4	3	3		3	3				3	3			3	3	3
CO5	3	3		3	3				3	3			3	3	3

Syllabus

Unit 1
Adsorption isotherm, Diffusivity and mass transfer coefficient measurement, Simple distillation, Steam distillation, Continuous and staged equipment for mass transfer.

Unit 2
Dynamic response of first order, second order, interacting and non-Interacting systems, Transient response of feedback control characteristics (different control configurations) for level, pressure, flow control etc., Controller tuning, Advanced Control Strategies (cascade, ratio, feed forward), Control valve characteristics

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be evaluation of experiments, reports, viva voce

19CHE482	PROCESS SIMULATION LAB	L-T-P-C: 2-0-3-3

Pre-Requisite(s):

1. Material Balances
2. Chemical Engineering Thermodynamics
3. Principles of Mass Transfer
4. Chemical Reaction Engineering - I
5. Chemical Reaction Engineering - II

Course Objectives

Students will learn the fundamentals of a process simulation software along with the equations and solution strategies required for solving different types of problems in Chemical processes. In all these simulations, Chemical Engineering Thermodynamics will be used to estimate the properties. After learning simulation of individual equipment, students will simulate full flow sheet of a process given to them.

Course Outcome

CO1: Understand the basic structure of a process simulation software
CO2: Formulate governing equations for a process based on conservation principles and analyze degrees of freedom for a stream, equipment and process
CO3: Develop and simulate a process flow sheet based on given problem statement
CO4: Perform case studies for a chemical process

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3				3				3	3	2
CO2	3	3			3				3				3	3	2
CO3	3	3			3								3		
CO4	3	3			3		3						3	2	

Syllabus

Introduction to Aspen Plus / HYSYS; Thermodynamics Property methods; Solution strategies; Simulation of Pressure Changing devices (Pumps, Compressors and Turbine); Simulation of Two-phase and Three phase Separation units; Simulation of heat exchangers; simulation of reactors (Plug flow, mixed-flow, conversion, Gibbs and Equilibrium reactors and their combinations); Simulation of distillation, absorption and extraction columns; Dynamics of process equipment; Flow sheet simulations with recycle; Case study and sensitivity analysis;

Additionally, the process chosen in Project Based Learning will be simulated in this course.

Text Book(s)
Gil Chaves, I.D., López, J.R.G., García Zapata, J.L., LeguizamónRobayo, A., Rodríguez Niño, G, Process Analysis and Simulation in Chemical Engineering, Springer, 2016

Reference Book(s)
Ralph Schefflan, Teach Yourself the Basics of Aspen, 2015
Aspen Hysys Manual, Free Source from Aspen One

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80%	
End Semester		20%

*CA –Weekly Exercises – 50%; Course Project of process selected in Project based Learning – 30%

19CHE495	PROJECT PHASE I	L-T-P-C: 0-0-6-2

Course Objectives

To execute a chemical engineering project to understand and to apply various concepts studied throughout the course.

Course Outcomes

CO1: Create a set up through proper design and investigate the system using the engineering knowledge acquired
CO2: Estimate and manage the cost and time of the project
CO3: Present the project with clarity and ethics in both oral and written mode
CO4: Develop a team and effectively participate in the team to execute the project
CO5: Support the environmental, social and engineering discipline through the project

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3								3	3	3
CO2											3		3	3	
CO3								3	3	3			3		3
CO4									3				3		3
CO5						3	3					3	3		3

Syllabus

Identification of the problem based on the current need gaps of the industry/knowledge/other academic/theoretical aspects; literature survey, identification of the project deliverables, identification of materials/equipment requirements, preparation of the methodology for the experimentation and procurement of the materials. Presentation of project progress report to the department for evaluation at the end of the semester.

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment	60	
End Semester		40

SEMESTER VIII

19CHE499	PROJECT PHASE II	L-T-P-C: 0-0-30-10

Course Objectives

To execute a chemical engineering project by applying the various concepts studied throughout the course.

Course Outcomes

CO1: Create a set up through proper design and investigate the system using the engineering knowledge acquired
CO2: Estimate and manage the cost and time of the project
CO3: Present the project with clarity and ethics in both oral and written mode
CO4: Develop a team and effectively participate in the team to execute the project
CO5: Support the environmental, social and engineering discipline through the project

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3								3	3	3
CO2											3		3	3	
CO3								3	3	3			3		3
CO4									3				3		3
CO5						3	3					3	3		3

Syllabus

Identification of the problem based on the current need gaps of the industry/knowledge/other academic/theoretical aspects; literature survey, identification of the project deliverables, identification of materials/equipment requirements, preparation of the methodology for the experimentation and procurement of the materials. Presentation of project progress report to the department for evaluation at the end of the semester.

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment	60	
End Semester		40

19CHE411	CHEMICAL ENGINEERING PROCESS SAFETY	L-T-P-C: 1-0-0-1

Pre-Requisites: None

Course Objectives

The objective of the course is to sensitize students to be mindful of risks and hazards in chemical industries, understand formal methods of assessment, and the associating safety control designs.

Course Outcomes

CO1: Identify the typical sources of risks in a process plants by hazard identification and examination of case studies.
CO2: Evaluate the workplace to determine occupational safety and health hazards.
CO3: Select appropriate control methodologies to prevent hazards in industries.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2			2						3	2	2
CO2	3	3	3	2			2						3	2	2
CO3	3	3	3	3			2						3	2	2

Syllabus

Hazard identification: General hazards of plant operation toxic hazards, fire and explosions – hazards. Storage and transport of chemicals, emergency management, planning for safety, preventive and protective measures.
Hazards of plant operation: Toxic hazards, fire and explosion hazards, reaction hazards, literature calculations & explosions screening, normal reaction, gas evolution, characterizing runaway, control and mitigation of gas emanations, absorption with chemical reaction, health and environmental effects.
Risk analysis, evaluation, mitigation, Hazop, Hazan, definition, probability quantification – risk, engineering, clean technology, initiatives, standards, emergency handling, accident investigation, legislation, nil-risk quantification methods.
Case histories of accidents, examples of hazards assessment, examples of use of Hazan, explosion hazards in batch units, technical process, documentation for hazardous chemicals, format and methods.

Text Book(s)
A.K. Rohatgi, "Safety handling of Hazardous Chemicals", J.K. Enterprises, Mumbai, 1986.
S.K. Shukla, "Enviro Hazards and Techno Legal Aspects", Shashi Publications, Jaipur, 1993.
G.L. Wells and R.M.C. Seagrave, "Flow sheeting for safety", Institution of Chemical Engineering, London, 1977.

Reference Book(s)
T. Kletz, "Learning from Accidents", 3rd Edition, Gulf Professional Publishing, London, 1988.
J. Barton and R. Rogers, "Chemical Reaction Hazards – A Guide to Safety", Institution of Chemical Engineering, Gulf Professional Publishing, London, 1997.

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment	65	
End Semester		35

*CA – Can be Quizzes, Assignment, Projects, and Reports

PROFESSIONAL ELECTIVES

19CHY231 BIOMATERIALS SCIENCE L-T-P-C : 3-0-0-3

Pre-requisite: None

Objectives:

- Introduce basic structure and properties of different classes of materials.
- Introduce the basics of molecular and cellular host responses and biocompatibility testing.
- Apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications.

Course Outcomes:

Upon successfully completing this course, students will be able to:

CO1: Apply the understanding of materials and biocompatibility in designing materials and devices for some biomedical applications
CO2: Design materials for biomedical applications including cardiovascular, ophthalmologic, orthopedic, dental and other applications
CO3: Interpret the results from common materials characterization instruments.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2		1	3				1					
CO2	2	1	2		1	3				1					
CO3	2	1	1		1					1					

CO1 is related to basic concepts in materials science and physiology and hence is moderately aligned with PO1. It has a minimum amount of problem analysis and hence is weakly aligned with PO2. These concepts are essential in designing biomedical materials and devices and hence it is moderately aligned with PO3. The content related to CO1 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10. Since the main objective of this course is enhancing human health, it is strongly aligned with PO6.

CO2 is related to the applications of biomaterials in various areas of health science. Since it draws upon basic concepts in science and mathematics, it is moderately aligned with PO1. It has a limited amount of problem analysis and hence is weakly aligned with PO2. These concepts are essential in designing devices and materials and hence it is moderately aligned with PO3. The content related to CO2 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10. Since the main objective of this course is enhancing human health, it is strongly aligned with PO6.

CO3 is related to the characterization of biomaterials. Since it draws upon basic concepts in science and mathematics, it is moderately aligned with PO1. It has a minimum amount of problem analysis and hence is weakly aligned with PO2. CO3 has only a weak bearing on the design of materials and devices and hence it is weakly aligned with PO3. The content related to CO3 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10.

Syllabus

Unit 1
Introduction to Biomaterials –Overview of the Biomedical Product Development Process and Regulation.Basics of Material Structure, Overviews of Metals, Polymers, Ceramics and Natural Materials used in Biomedical Engineering.Surface Modification Methods.Properties and Characterization of Materials.

Unit 2
Structure, Function and Adhesion of Proteins, Cell-Surface Interactions, Blood-Materials Interactions, Molecular and Cellular Host Responses, Biocompatibility, Degradation of Biomaterials, Testing of Biomaterials.

Unit 3
Biomedical Applications of Materials in the Areas - Cardiovascular, Orthopedic, Ophthalmologic, Dental Implants, Sutures, Burn Dressings, Adhesives & Sealants, Bioelectrodes, Biomedical Sensors & Biosensors, Tissue Engineering and Scaffolds.

Text Books / References:
Ratner B D, Hoffman A S, Schoen F J and Lemons J E, *Biomaterials Science: An Introduction to Materials in Medicine*, Third Edition, Academic Press, 2012.
Hill D, *Design Engineering of Biomaterials for Medical Devices*, John Wiley, 1998.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHY232	GREEN CHEMISTRY AND TECHNOLOGY	L-T-P-C: 3-0-0-3

Pre Requisite(s): Engineering Chemistry - I

Course Objectives

Understanding basic chemical properties of materials and for producing new materials/products for suitable application with manufacturing methods, cost, non toxic and environmental related issues.

Course Outcome

CO1: Able to understand and apply 12 principles of green chemistry
CO2: Set-up green engineering problems for solution
CO3: Application of appropriate technology to match a green engineering problem
CO4: Understanding the issues like environmental law, toxic and safety/ safe design.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
CO1	3	2	2	-	2	-	-	2	-	-	-	-	2	2	-
CO2	3	2	3	-	2	-	-	-	-	-	-	-	2	-	2
CO3	3	2	2	-	3	-	-	-	-	-	-	-	2	2	-
CO4	3	3	2	-	2	-	-	2	-	-	-	-	2	3	2

Syllabus

Unit 1

Green chemistry fundamentals : Green Chemistry, tools, principles, and practice: Principles of Green Chemistry, Principles of Green Chemistry, Nature of chemicals and world chemical scenario, prevention, atom economy, less hazardous chemical synthesis, Methods to Design Safer Chemicals, and Future Trends, Measuring & Controlling Environmental Performance, Catalysis & Green Chemistry, Sustainable Industrial Chemistry: Catalysis, Organic Solvents.

Unit 2

Green technologies & processes: Green product design definition, product strategy, Life cycle of product, ISO 14000, Environmental load of product, material selection, resource use, production requirements and planning for the final disposition (recycling, reuse or disposal) of a product. Integration with existing product design approaches such as quality, functionality and upgradability.

Unit 3

Legal aspects & Case Studies International laws on take – back laws, extended responsibility, Eco-labeling, Examples from pharmaceuticals, foods, cosmetics, packaging, computers, polymers.automobiles and electronics industry Designing Greener Processes, Industrial Case Studies, Cases study in Green Chemistry application

Text Book(s)
"Green Chemistry-An introductory text", by Mike Lancaster, Royal Society of Chemistry, Cambridge,200,2 ISBN 0-85404-620-8.
"Green Chemistry: Theory and Practice" , by Paul T. Anastas and John C. Warne,Oxford University Press,2000.

Reference(s)

Martin Charter and Ursula Tischner,“ Sustainable Solutions: Developing Products and Services for the Future” , A Greenleaf Publishing book,2000.
Jay Warmke, Annie Warmke, “Green Technology” ,Educational Technologies Group, 2009.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE431 ENVIRONMENTAL ENGINEERING FOR PROCESS INDUSTRIES L-T-P-C: 3-0-0-3

Prerequisite: None

Course Objective

The main objective of the course is to develop understanding on water and air pollutants and suggest suitable technologies for water and air pollution control .

Course Outcomes

CO1: To develop basic knowledge on water pollutants and wastewater characteristics and build expertise in analysis and testing of water samples
CO2: To understand the significance of various unit operations and unit processes involved in wastewater treatment
CO3: To design and apply specific treatment methods for effluents of various chemical process industries
CO4: To acquire knowledge on industrial air pollutants of various chemical process industries and suitable treatment techniques

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					1								1	2
CO2	2	1				2	2	2					2	1	1
CO3	2	1				2	2	2					2	1	1
CO4	2	1				2	2	2					2	1	1

Syllabus

Unit 1
Water Pollution Control: wastewater characteristics: physical, chemical and bacteriological, Types of pollutants in waste water of chemical industries, Methods of sampling, preservation of samples and analysis. Methods for the treatment of liquid wastes: Physical, chemical and biological methods, Selection and design of equipment. Physical treatment: pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation. Chemical Treatment: Anaerobic with special reference to UASB and aerobic treatment biochemical kinetics, trickling filter, activated sludge process, lagoons, aeration systems, fluidized bed bioreactors; Disinfection, Ion exchange, Electro-dialysis, Reverse Osmosis. Pollution control in selected process industries– fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Tanning industries, Sugar industries, Dairy, Alcohol industries, Electroplating and metal finishing industries, Radioactive wastes, ranking of wastewater treatment alternatives, Case Studies

Unit 2
Solid Wastes Management: Characterization of wastes-hazardous and non-hazardous wastes. Waste disposal and management laws and guidelines; Problems of collection and handling; various processing techniques used in solid waste management - treatment, disposal, utilization and management; value extraction from the wastes; Industrial waste management and Pollution Prevention: Process modification, alternative raw material, recovery of by co-product, recycle and reuse of waste, energy recovery and waste utilization

Unit 3
Air Pollution Control: Sources and effects of air pollutants on physical environment and living systems, Methods of measuring and sampling of gaseous and particulate pollutants, meteorological aspects of air pollution ,effects,

Selection and Design of particulate and gaseous pollution control equipment; mechanical separation, Bag filter, cyclone separator, electrostatic precipitation, wet gas scrubbing, adsorption and absorption

Text Book(s)

C*.S. Rao, "Environmental Pollution Control Engineering," 2nd Edition, New Age International Publishers, 2006.*
G. Kiely, "Environmental Engineering", Special Indian Edition, Tata McGraw-Hill, 2009.
G. Tchobanoglous, F.L. Burton, and H.D. Stensel, "Wastewater Engineering: Treatment and Reuse", 4th Edition, McGraw Hill Science, 2002.
S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, 2001.
A.P. Sincero and G.A. Sincero, "Environmental Engineering: A Design Approach", Prentice Hall, 1995.

Reference Book(s)

H.S. Peavy, D.R. Rowe, and G. Tchobanoglous, "Environmental Engineering", 7th Edition, McGraw Hill, 1987.
M.N. Rao and H.V.N. Rao, "Air Pollution", Tata McGraw Hill, 2001.
8. F. Kreith and G. Tchobanoglous, "Handbook of Solid Waste Management", 2nd Edition, McGraw Hill, 2002.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE432 CHEMICAL PROCESS MODELLING AND SIMULATION L- T- P-C : 3-0-0-3

Pre-Requisite(s):

1. Material Balances
2. Energy Balance and Thermodynamics
3. Chemical Engineering Thermodynamics
4. Fluid Mechanics
5. Principles of Heat Transfer
6. Principles of Mass Transfer
7. Chemical Reaction Engineering I

Course Objectives

This course will lay the foundations of chemical process modeling and simulation based on a systems approach, summarizing the core concepts learned in the various chemical engineering courses and using them to build predictive and control models of chemical processes that reveal interesting underlying physics of the processes. A systematic approach will be developed for modeling and simulation, involving the following aspects:

- Recognizing and rigorously formulating the physics/chemistry of a process as a mathematical model,
- Making judicious assumptions that do not compromise but instead highlight the essential physics, and,
- Developing simple mathematical models of chemical systems and analyzing them, gradually leading to more complex models.

In applying the principles of chemical systems modeling to practical problems, there are at least two other aspects that are critical:

- Choosing model parameters that best capture the physics of the process, and estimating their sensitivity on the model behavior, and,
- Developing methods of validating the model against appropriately designed experiments.

These will not be a focus of this introductory course. However, together, the five aspects listed above constitute a reasonable systematic approach to modeling chemical engineering problems. Once this approach has been developed, starting from the simplest linear problem of filling and draining a cylindrical tank, the course will introduce modeling in single dimension followed by modeling of multiscale and nonlinear processes such as chemical vapor deposition and packed bed reactors.

Course Outcomes

CO1: For a given chemical system, recognize the various processes taking place whose relative rates will influence system performance. Identify the characteristic scales appropriate to the system and processes and derive dimensionless groups.

CO2: For a given chemical system, write the appropriate conservation and constitutive equations that determine the rates of the processes or specify the equilibrium conditions for reversible processes taking place.

CO3: Determine appropriate specifications of model parameters for a chemical system - lumped, distributed or staged system, to solve simple design and rating problems involving the system.

CO4: Derive mathematical models for basic chemical engineering unit - lumped, distributed, and staged - operations and processes. Perform a dimensional analysis to understand interactions between competing phenomena, identify controlling physics, and reduce the model to simpler cases.

CO5: Understand sequential modular and equation oriented approaches to flowsheet simulations. Determine tear streams and partition flowsheets. Apply thermodynamic principles to calculate state variables of streams in flowsheets. Apply the mathematical models developed to simulate various operations and processes in a flowsheet.

CO-PO-PSO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3		1	2		3			3	3	3	3
CO2	3	3	3	3		1	1					3	3	3	3
CO3	3	3	3	3		1	1					3	3	3	3
CO4	3	3	3	3	3	1	1					3	3	3	3
CO5	3	3	3	3	3	1	2					3	3	3	3

Syllabus

Chemical engineering problems; Modeling – Steps involved; Variables – Stream, Unit, and Process variables; Constraints – Conservation relations, Sources and sinks, Material, Energy, Momentum balances; Equilibrium relations, Constitutive models; Common assumptions in modeling; Types of models – Lumped, Distributed, and Staged parameter models; Design variables – Characteristic length, time, velocity, temperature, mass, force; Change of variables; Dimensionless groups in modeling

Lumped Parameter Systems – Selected models from: Filling and draining tanks: Steady and unsteady states, Varying inlets and outlets, Level and flow control; Mixing tanks: Two and multiple streams, Composition control; Heated tank: Jacketed kettle with steam condensation, Electrical heating, Phase change; Isothermal CSTR: 1st and 2nd order reactions, Enzyme kinetics; Non-isothermal CSTR; Centrifugal separation
Distributed Parameter Systems – Selected models from: Shell balances: Flow through a pipe, Continuity equation; Compressible fluid flow, Shock waves; Double-pipe heat exchanger: Steam condensing in shell/tube, Parallel vs. counter flow; Pipeline flashing; Isothermal PFR: Component continuity equation, 1st and 2nd order reactions; Non-isothermal PFR: 1st and 2nd order reaction

Staged Parameter Systems – Selected models from: Triple effect evaporator; Binary distillation: continuous and batch columns; Multicomponent distillation: Underwood-Gilliland model; Gas absorption into a laminar liquid jet; Tray tower absorption: Rigorous models; Reactive absorption in a wetted wall column; Multistage countercurrent liquid-liquid extraction
Flowsheet simulation: Sequential modular approach – determination of tear streams and partitioning of flowsheets; Equation oriented approach; Thermodynamic options for simulations: Multicomponent phase equilibrium; Liquid-phase activity coefficient models; Equation of state models; Density and enthalpy calculations; Multicomponent flash simulation – TP, PQ and Inside-out calculations; Rigorous simulation of multicomponent distillation; Simulation of mixers, splitters, pumps, compressors, turbines, heat transfer equipment, stoichiometric reactors, equilibrium reactors and kinetics-based reactors.

Textbook(s)
W. L. Luyben, *Process Modeling, Simulation and Control for Chemical Engineers*, 2nd Edition, McGraw Hill, 1996.
C. L. Smith, R. W. Pike and P. W. Murrill, *Formulation and Optimization of Mathematical Models*, International Textbook Company, USA, 1970.
L. T. Biegler, E. I. Grossman and A. W. Westerberg, *Systematic Methods of Chemical Process Design*, Prentice Hall, 1997.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA includes assignments, quizzes – 10%; Course project – 10%

19CHE433	NANOSCIENCE AND NANOTECHNOLOGY	L-T-P-C: 3-0-0-3

Prerequisite(s): None

Course Objectives:

To learn fundamentals dealing with the processing, characterization of nanomaterials and nanoensembles for the fabrication of various electronic devices and for the biological applications in nano scale levels

Course Outcomes:

Knowledges on the processing, characterization of nanomaterials and nanoensembles for the fabrication of various electronic devices and systems will be imparted

CO1: Understanding of length scale concepts, top-down and bottom-up preparation methods of nanomaterials and nanostructures.
CO2: Demonstrate the principles of processing and characterization methods of nanomaterials and nanoensembles.
CO3: Apply the electron and scanning probe microscopes to characterize and to manipulate different nanostructures and nanodevices.
CO4: Evaluate and analyze the electrical, mechanical and thermal properties of nanostructured metals, semiconductors, quantum dots and carbon nanotubes.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2		2										
CO2	1	1	2	1	2								1	1	
CO3	2	2	2	2	3								2	2	1
CO4	3	2	2	2	2								3	2	

Syllabus

Unit 1
Nanotechnology Fundamentals- Atomic structure, molecules and phases, surfaces, biosystems, metals, and other materials - Molecular recognition, nanostructure preparation techniques, top-down and bottom up approach, self-assembly, nano manipulations - overview
Familiar Nanostructures – SAMs, monolayer protected nanoparticles, quantum dots and core-shell nanoparticles, preparations, characterizations and applications

Unit 2
Nano fabrication methods: Top-down approach – nanolithography techniques – dip pen, projection optical, e-beam, Extreme UV, proximity x-ray and MBE -Bottom-up approach: self-assemblies – hydrogen bonded, biomimetic and dimensional nanoparticle arrays.
Carbon nanomaterials - Quantum dots –Nanocomposites- Synthesis, characterizations and their applications in electronics and energy storage applications

Unit 3
Molecular switches –monomolecular in solutions, on surfaces (electron, pH and light driven switches)
Micro/ Nanoelectronics (Nanowires: transistors, LEDs, Lasers, photodetectors).
Nano-Bio Technology (Lipid and lipid templates, self assembled monolayers, biological computing, Protein Engineering, biosensors, drug delivery, PDT) - Social implications of nanotechnology

Text Book(s)
Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr, "Introduction to Nanoscale Science and Technology" Kluwer Academic Publishers, 2004
T. Pradeep, Nano: The Essentials/ Understanding Nanoscience and Nanotechnology, Tata Mcgraw-Hill Publishing Company Limited, 2007

Reference(s)
Cristian Contescu, Karol Putyera, Dekker Encyclopaedia of Nanoscience and Nanotechnology, 2nd Edition, CRC Press Publications, 2009, ISBN 978-0-8493-9639-7 (six volume set)

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE434	MATERIAL CHARACTERISATION AND SPECTROSCOPIC METHODS	L-T-P-C: 3-0-0-3

Pre Requisite(s): Engineering Chemistry - I

Course Objectives

To make students aware of various characterization techniques and to evaluate the material with suitable characterization techniques.

Course Outcome

CO1: Understand the fundamental principles behind the individual characterization methods which are included in the curriculum.
CO2: Analyze, interpret and present observations from the different characterization methods.
CO3: Assess which methods of characterization are appropriate for different material / requirement/ condition/ problems.
CO4: Able to evaluate the uncertainty of observations and results from the different characterization methods.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2					2					2	2	1	2
CO2	3	2					2					2	1	2	2
CO3	3	2					2					2	2	2	2
CO4	2	2	3		2							2	2	2	1

Syllabus

Unit 1
Imaging microscopies and Image analysis: Optical Microscopy, Scanning electron microscopy, Scanning probe microscopy, X-ray microscopy and Transmission electron microscopy, Image analysis.

Unit 2
X-ray -diffraction, properties of x-rays, review of crystal systems and miller indices, stereographic projections, Laue conditions, braggs conditions, diffraction methods, phase identifications, electron diffraction methods.

Unit 3
EDAX, XPS, scattering methods, Thermal and Thermomechanical analysis: differential scanning calorimetry and Differential thermal analysis. Thermogravimetric analysis, Dynamic mechanical analysis and TMA.

Text Book(s)
Yang Leng, "Materials Characterization: Introduction to Microscopic and Spectroscopic Methods", 2013, Wiley VCH; ***ISBN-10:*** *3527334637,* ***ISBN-13:*** *978-3527334636.*
KP. Menard, "Dynamic mechanical analysis: A practical introduction", CRC press, 1999

Reference(s)
BD Cullity and SR Stock, "Elements of X-ray diffraction", 3rd Edition,, Prentice Hall 2001

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Report

19CHE435	SOLAR ENERGY	L-T-P-C : 3-0-0-3

Pre-requisite: None

Course Objectives:

- To determine the position of the sun based on its daily and yearly movement in the sky for photovoltaic and thermal applications.
- To understand the working principle of a photovoltaic cell and factors affecting its efficiency.
- To introduce students to the solar cell fabrication process.
- To design a simple solar photovoltaic system.

Course Outcomes:

Upon successfully completing this course, students will be able to:

CO1: Determine the placement of solar panels based on the daily and yearly movement of the sun in the sky.
CO2: Explain the basic functioning of photovoltaic cell along with its efficiency, figures of merit and main sources of losses.
CO3: Describe the main solar cell fabrication methods.
CO4: Design a simple solar photovoltaic system.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2		1		3			1					
CO2	2	1	2		1		3			1					
CO3	2	1	1		1		3			1					
CO4	1	1	3		1		3			1					

CO1 is related to the daily movement of the sun in the sky along with the seasonal changes and its implications on the solar photvoltaic and thermal applications. This has bearing on the amount of solar energy that a system can ultimately harvest. Since it draws upon basic concepts in science and mathematics, it is moderately aligned with PO1. It has a limited amount of problem analysis and hence is weakly aligned with PO2. These concepts are essential in designing solar energy systems and hence it is moderately aligned with PO3. The content related to CO1 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10. Since CO1 deals with the applications of solar energy to replace environmentally harmful energy forms, it contributes strongly towards environment and sustainability (PO7).
CO2 is related to the functioning of a solar cell. Since it draws upon basic concepts in science and mathematics, it is moderately aligned with PO1. It has a limited amount of problem analysis and hence is weakly aligned with PO2. These concepts are essential in designing solar energy systems and hence it is moderately aligned with PO3. The content related to CO2 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10. Since CO2 deals with the working of solar cells which are meant to replace environmentally harmful energy forms, it contributes strongly towards environment and sustainability (PO7).

CO3 is related to the fabrication of solar cells. Since it draws upon basic concepts in science and mathematics, it is moderately aligned with PO1. It has a limited amount of problem analysis and hence is weakly aligned with PO2. CO3 has only a weak bearing on the design solar energy systems and hence it is weakly aligned with PO3. The content related to CO3 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10. Since CO3 deals with the working of solar cells which are meant to replace environmentally harmful energy forms, it contributes strongly towards environment and sustainability (PO7).

CO4 is related to the design of solar energy systems. Since it draws upon a few basic concepts in science and mathematics, it is weakly aligned with PO1. It has a limited amount of problem analysis and hence is weakly aligned with PO2. CO4 mainly deals with the design solar energy systems and hence it is strongly aligned with PO3. The content related to CO4 requires students to use modern tools and communicate with peers and the instructor and hence it weakly maps with PO5 and PO10. Since CO4 deals with the working of solar cells which are meant to replace environmentally harmful energy forms, it contributes strongly towards PO7 (environment and sustainability).

Syllabus

Unit 1
Solar radiation, its measurements and analysis.Solar angles, day length, angle of incidence on tilted surface, Sunpath diagrams, Shadow determination. Extraterrestrial characteristics, Effect of earth atmosphere, measurement & estimation on horizontal and tilted surfaces.
Solar thermal collectors, flat plate collectors, concentrating collectors. Basic theory of flat plate collectors, solar heating of buildings, solar still, solar water heaters, solar driers; conversion of heat energy into mechanical energy, solar thermal power generation systems.

Unit 2
p-n junction, homo and hetro junctions, Metal-semiconductor interface, Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, efficiency measurements, high efficiency cells, Tandem structure.
Preparation of metallurgical, Electronic and Solar grade Silicon, Production of Single Crystal 'Si', Chocharlski (CZ) and Float Zone (FZ) method for preparation of silicon, procedure of masking, photolithography and etching, Design of a complete silicon, GaAs, InP solar cell. High efficiency III-V, II-VI multijunction solar cell, a-Si-H based solar cells, Quantum well solar cell, Thermophotovoltaics.Nanosolar cells.

Unit 3
Solar cell arrays, system analysis and performance prediction, shadow analysis, reliability, solar cell array design concepts, PV system design, Design process and optimization, Detailed array design, storage autonomy, Voltage regulation, maximum tracking, Power electronic converters for interfacing with load and grid, use of computers in array design, Quick sizing method, Array protection and trouble shooting
Centralized and decentralized SPV systems, stand alone, hybrid and grid connected systems, system installation, operation and maintenances, case studies and field experience, PV market analysis and Economics of SPV systems.

Textbook(s)/ Reference Book(s)

John W Twidell and A D Weir, *Renewable Energy Resources*, ELBS
Garg H P., Prakash J., *Solar Energy: Fundamentals & Applications*, Tata McGraw Hill, New Delhi, 1997
S P Sukhatme, *Solar Energy*, Tata McGraw Hill
J F Kreider and Frank Kreith, *Solar Energy Handbook*, McGraw Hill
D Y Goswami, Frank Kreith and J F Kreider, *Principles of Solar Engineering*, Taylor & Francis.

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE436	PROCESS INTENSIFICATION	L-T-P-C : 3-0-0-3

Pre-Requisite(s):

1. Principles of Mass Transfer
2. Chemical Reaction Engineering – I
3. Chemical Reaction Engineering – II

Course Objectives

The students will understand basics of process intensification and its application to chemical engineering, to reduce the cost of operation by improving the rates of heat transfer, mass transfer, reactions and separations and how to overcome equilibrium limitations.

Course Outcomes

CO 1: Identify inefficiencies, and economic pressures and environmental impacts of a process or operation
CO 2: Understand the principles of process intensification
CO 3: Assess the developmental stage or a process of an intensification technology based on evaluation of scientific and engineering literature (e.g. journals and patents), and industrial benchmarking.
CO 4: Choose a variety of process technologies that can be used to intensify reaction kinetics, separations and/or transport phenomena, or that reduce processing cost.
CO 5: Evaluate different process options based on qualitative and quantitative measures to arrive at an optimal process design choice

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2				2						2	3		3
CO2	3												3		3
CO3	3	3	3	3	3							2	3	3	3
CO4	3	2	3	3		2							3	3	3
CO5	3	3	3	3	3	3	2				2		3	3	3

Syllabus

Unit 1
Electrically Enhanced Processes; Microfluidics: Electrokinetics, Magnetohydrodynamics, Opto-microfluidics; Pressure-based Enhancement;
Compact Heat Exchangers: Plate Heat Exchanger, Printed-Circuit Heat Exchanger, Spiral Heat Exchanger, Chart-Flow Heat Exchanger, Polymer-Film Heat Exchanger, Foam Heat Exchanger, Mesh Heat Exchanger; Micro-heat exchangers: Small Channels and Designs; Significance of dimensionless numbers

Unit 2
Intensified Reactors: Spinning Disk Reactors; Oscillatory Baffled Reactors; Taylor-Couette Flow Reactor Microreactors: Basics & Applications; HEX Reactors; Induction Heating, Sonochemistry, Microwave Enhancement, Plasma Enhancement, Laser-Induced Reactions; Choice of reactors based on reaction type; Operating regimes of reactors - Dimensionless Analysis

Supercritical Operation; Intensified Separation: Distillation Columns – Divided Wall Columns, Compact Heat Exchangers; HiGee; Centrifuges; Membrane-based intensified separation; Intensified Mixing: In-line Mixers: Static Mixer, Mixing on a Spinning Disk, Induction-Heated Mixer;

Unit 3
Reactive Separations: Reactive Distillation and Reactive Extraction; Membrane Reactors - Applications to dehydrogenation; Steam-methane reformation;
Case studies: Reaction separation of Plastic/Biomass pyrolysis; Petrochemicals and Fine Chemicals, Refineries, Bulk Chemicals, & Nuclear Industry

Text Book(s)
David Reay, Colin Ramshaw, and Adam Harvey, "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility" Butterworth-Heinemann, 2008

Reference(s)
Frerich J. Keil, "Modeling of Process Intensification", Wiley-VCH, 2007
Relevant journal publications

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Quizzes – 10%; Assignments – 10%

19CHE437	INTERFACIAL SCIENCE AND ENGINEERING	L-T-P-C: 3-0-0-3

Prerequisite(s): Introduction to Chemical Engineering, Fluid Mechanics

Course Objectives:

To learn the surface and interfacial phenomena relevant to the thin film coatings, solid surfaces and colloids for better processing of different industrial products, intermediates and raw materials

Course Outcome:

Knowledge on the surface and interface properties of Colloids, Thin films and Coatings will be disseminated for the formulation of new products and product quality improvements.

CO 1: Understand the fundamental theories associated with the surface and interface properties.
CO 2: Identify the surface and interfacial phenomena of thin film coatings and colloids.
CO 3: Analyze the role of surface and interface properties in the processing methods of different industrial products, intermediates and raw materials.
CO 4: Design of new product formulations with superior surface and interface properties.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	2		2						2	1	
CO2	3	2	1	1	2		2						2	1	
CO3	3	3	1	1	1		1						3	2	
CO4	3	2	3	2	1		1						1	3	

Syllabus

Unit 1
Introduction to Colloids, Surfaces and Interfaces, Surface and Interface – Molecular Origin, the work of cohesion and adhesion, Interaction forces and potential, chemical and physical interaction, classification of physical forces. Van der Waals force, interaction between surface and particles
Electrostatic forces and electric double layer, DLVO theory, Hamaker constant, Boltzmann distribution, Debye length, specific ion adsorption, ion adsorption, Stern layer, Electrostatic, steric and electrosteric stabilization, Zeta potential

Unit 2
Theory of capillarity –Young Laplace equation, capillary flow and spreading process, wetting and spreading, contact angle and its measurement technique-Thermodynamics of wetting, Young's equation, spreading co-efficient equilibrium dynamics and stability of free liquid surfaces -Chemical equilibrium across a curved interface, generalized Kelvin equation, Oswald ripening, capillary condensation, theory of heterogeneous nucleation.

Unit 3
Effects of solutes on surface tension, Adsorption, Gibbs surface excess, Gibbs adsorption equation, Adsorption isotherms, surfactant adsorption. Surfactants, self assembly thermodynamics, bilayers, vesicles, Thin films, Surfactant assisted nanoparticle synthesis.

Stability of colloids – emulsions, microemulsions, foams, aerosols, polymers at interface Clusters, Nanomaterials, Light scattering by small particles, Self-organization. Application involving various colloidal systems

Text Book(s)

Drew Myers, Surfaces, Interfaces, and Colloids: Principles and Applications. 2nd Edition,, Wiley-VCH, 1999
A.W. Adamson and A.P. Gast, Physical Chemistry of Surfaces, 6th Edition,, Wiley-Interscience, 1997

Reference(s)

P.C. Hiemenz and R. Rajagopalan (Editors), Principles of Colloid and Surface Chemistry, 3rd Edition,, Academic Press, New York, 1997.
J.N. Israelachvili, Intermolecular and Surface Forces, 2nd Edition,, Academic Press, New York, 1992.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE438	POLYMER COMPOSITES	L-T-P-C: 3-0-0-3

Prerequisite: None

Course Objectives

The objective of this course is to impart an understanding, of the constituents used for polymer composites preparation, different manufacturing methods available for composites processing, and test methods employed.

Course Outcomes

CO1: To identify different matrices and reinforcements used in polymer composites
CO2: To understand the various approaches for strengthening the interface and test methods for interface characterization
CO3: To study the various processing techniques for polymer composites manufacture for specific applications
CO4: To understand and apply the different testing and characterization methods for the evaluation of properties of the polymer composite products

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		3			1	3						3		
CO2	2	3	3										1		
CO3	3	1	3				1						3		2
CO4	2	1	3			1	1						3		2

Syllabus

Unit 1
General introduction to composite materials: Concept and definition, classification of composites (CMC, MMC, PMC).Functional roles of reinforcement and matrix and importance of interface. Polymer matrix composites (PMCs): Fiber reinforced and particulate filled polymer composites. Reinforcements (glass, carbon/graphite, Kevlar), Matrices - Thermoset matrices -polyesters, epoxides, phenolics, vinyl esters, cyanate esters- Thermoplastic matrices.Choice of reinforcements and matrices for different application needs.

Unit 2
Fiber reinforced polymer composites (FRPs): Basic rule of mixtures, stress-strain relationships. Tailoring of structural properties through laminar-sequencing and choice of fiber fractions/fiber orientations, to meet design requirements.Effect of environmental conditions on properties. Mechanical behavior of FRP composites: Fiber controlled and matrix dependent properties (tensile , compressive, shear).Experimental determination of composite properties by standard test methods. Composite constructions: Monolithic composite laminates: unidirectional and bidirectional,multi-axial,3D,filament wound and braided types.

Unit 3
Composite precursors: SMCs, DMCs, BMCs prepreg materials and their choice in specific applications.Fabrication processes for FRP Composites: hand lay-up, spray up, vacuum bag moulding , compression moulding, filament winding, braiding, pultrusion, RTM,RIM, RRIM, RFI, autoclave moulding, injection moulding etc. Room temperature and hot curing of composites, Joining composite elements and repairs, Recycling of polymer composites.

Text book(s)
B. Astrom, "Manufacturing of Polymer Composites", CRC Press,1997.
P K Mallick, "Fiber-Reinforced Composites: Materials, Manufacturing, and Design", CRC Press, 2007.

Reference Book(s)
F.C.Campbell (Ed), Manufacturing processes for advanced composites, Elsevier, 2004.
S T Peters (Edition,), "Handbook of Composites", Springer, 1998.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE439	POLYMER PROCESSING	L-T-P-C: 3-0-0-3

Prerequisite: None

Course Objectives

To objective of this course is to develop fundamental knowledge in the area of polymer processing emphasizing the basic principles of all shaping operations used in the polymer industry

Course Outcomes

CO1: Understand the fundamental background to the processing of polymeric materials like flow behaviour and mixing of additives
CO2: Comprehend the practical and theoretical basis of injection moulding and extrusion and their offshoot processes.
CO3: Familiarize a wide range of polymer processing operations like compression and transfer moulding, rotational moulding, blow moulding, thermoforming and assembling techniques.
CO4: Develop capability for selecting an appropriate processing method for the conversion of polymer feed to products.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			1								2		1
CO2	2	3			2							3	3		3
CO3	2	3			2							3	3		3
CO4	1	3			3							3	3		3

Syllabus

Unit 1
Physical Basis of Polymer Processing-Mixing-distributive and dispersive mixing equipment. Extrusion-Features of a Single Screw Extruder, Analysis of Flow, Aspects of Screw Design, Operating Point. Twin Screw Extrusion-Processes – Pipe, Profile, Blown Film, Wire and Cable coating, Fibre, Film and sheet extrusion, Co extrusion-Melt Fracture-Sharkskin-Die swell.

Unit 2
Injection Moulding-Principles- Moulding Cycle- ReciprocatingScrew injection Moulding Machine-Types of Clamping Units-PVT diagram-Aspects of Product Quality-Hot Runner Moulding-Gas Assisted Injection Moulding.Blow Moulding-Principles- Injection Blow Moulding – Extrusion Blow Moulding – Stretch Blow Moulding - Troubleshooting – Thermoforming-Vacuum Forming-Pressure Forming-Material Stress and Orientation-Applications in Packaging.

Unit 3
Compression and Transfer Moulding - Types of Moulding Machines-Transfer Moulding-Trouble shooting – Comparison. Polymers in Rubbery State- Calendering process-Types of Calendars, Roll Deflection and Cambering-Rotational Moulding-Types of machines, Moulds, Materials. Fibre Reinforced Plastics-Materials-Lay up processes-SMC, DMC-Resin Transfer Moulding-Pultrusion, Bag Moulding Processes-Filament Winding. Joining and machining of Plastics-Welding of Plastics-Ultrasonic, Induction, Hotplate, High Frequency. Solvent Cementing-Adhesive Bonding.

Text Book(s)
B. Strong, "Plastics: Materials and Processing", Prentice Hall ,2012.
D.H. Morton-Jones," Polymer Processing", Chapman & Hall, 1989.

Reference Book(s)

C.A. Harper (Ed), "Handbook of Plastic Processes", John and Wiley 2006.
M.L.Berins (ed.), "Plastics Engineering Handbook Of The Society Of The Plastics Industry", Springer, 2012.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE440	MODERN SEPARATION METHODS	L-T-P-C: 3-0-0-3

Pre-requisite: 1. Fluid Mechanics 2. Chemical Engineering Thermodynamics 3. Principles of Mass Transfer

Course objectives

To be able to design distillation columns having multiple feed streams. To be able to understand the operating principles behind the various types of modern separation methods and to be able to select appropriate method for a particular application.

Course Outcomes

CO1: Ability to design multi component distillation columns with multiple feed streams.
CO2: Describe the structure, characteristics and operational features of different types of synthetic membranes and membrane modules
CO3: Explain the characteristic features, applications, limitations and advantages of separation operations like filtration, reverse osmosis, electrodialysis, pervaporation, gas separation and chromatographic separations
CO4: Describe the governing principles and characteristic features of combined reaction and separation techniques, ionic separations, supercritical fluid extractions, industrial effluent treatment, reactive extraction and reactive distillation

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2		2								2	2	
CO2	3		2										3		
CO3	3	2	2		2		1						3	2	
CO4	3		2				1						3		

Syllabus

Unit 1
Introduction to binary distillation – The concept of K-factor; Multi-component distillation –Design, Models for multi-component design; Design of distillation columns for more than one feed stream; Pressure drop and tray-efficiency calculations

Unit 2
Nature of Synthetic Membranes, General membrane Equation, Cross-Flow Microfiltration, Ultrafiltration, Reverse Osmosis, Membrane Modules and Plant Configuration, Membrane Fouling, Electrodialysis, Reverse Osmosis Water Treatment Plant, Pervaporation, Liquid Membranes. Gas Separations - Chromatographic Separations: Elution Chromatography, Band Broadening and Separation Efficiency, Types of Chromatography, Large Scale Elution Chromatography, Selective Adsorption of Proteins, Simulated Countercurrent Techniques, Pressure Swing Adsorption.

Unit 3
Combined Reaction and Separation, Comparison with Other Separation Techniques - Ionic Separations: Ion Exchange Resins, Resin Capacity, Equilibrium, Exchange Kinetics; Ion Exchange Equipment - Other Techniques: Supercritical Fluid Extraction, Oil Spill Management; Industrial Effluent Treatment by Modern Techniques. Reactive Extraction, Reactive Distillation.

Text Book(s)
J.M. Coulson and J.F. Richardson, "Chemical Engineering - Volume 2", 5th Edition, Butterworth-Heinemann, 2002.

Reference(s)
J.D. Seader and E.J. Henley, "Separation Process Principles ", 2nd Edition, Wiley, 2005.
R.W. Baker, "Membrane Technology and Applications ", John Wiley & Sons Ltd, UK, 2004.
P.C. Wankat, "Separation Process Engineering", 2nd Edition, Prentice Hall, 2006.
R.W. Rousseau, "Handbook of Separation Process Technology", Wiley-Interscience, 1987.
Y. Osada and T. Nakagawa, "Membrane Science and Technology", Marcel Dekker, 1992.
Relevant journal publications.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE441	BIOCHEMICAL ENGINEERING	L-T-P-C: 3-0-0-3

Prerequisite:

Introduction to Chemical Engineering, Material Balance, Fluid Mechanics, Principles of Heat Transfer, Chemical Reaction Engineering I, Chemical reaction Engineering II

Course Objectives:

To apply the chemical engineering principles in biological systems and to study the role of enzymes and microbes in biotechnology sectors.

Course Outcomes

CO1: Understand the basics of biomolecules and microbes to study different biochemical reactions.
CO2: Study the basic concepts and kinetics of enzyme and immobilized enzyme
CO3: Design and analyze the bioreactors
CO4: Understand the downstream processing and industrial bioreactors

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1					1						1	1	
CO2	3	3					1						3	3	
CO3	3	3	2				1						3	3	
CO4	3	3	2				1						3	3	

Syllabus

Unit 1
Introduction: History and need for biochemical Engineering; Essential life sciences: Biomolecules; Microbial world; Metabolism and Bioenergitics; Cell and their function;Enzymes and enzyme kinetics : Enzymes fundamental concepts, Classification of enzymes; Industrial application of enzymes; Industrially important enzymes; Mechanism of enzymatic reactions; Kinetics: Michaelis-Menten and Briggs Haldane equation; Evaluation of kinetic parameters; Enzymes inhibition; Factors affecting the reaction rates;

Unit 2
Immobilized enzyme: Medical and analytical application of immobilized enzyme; Techniques; Immobilized Enzyme kinetics: Effect of mass transfer resistance.Microbial kinetics : Typical growth characteristics of microbial cells, factors affecting growth; Monod's equation; Transport in microbial system : Newtonian and Non-Newtonian behaviour of broths; Agitation and Mixing; Power consumption; Gas – Liquid transport in cells; Transfer resistances; Mass transfer coefficients and their role in scale – up of equipment.

Unit 3
Bioreactors: Batch and continuous types; High performance bioreactors; Downstream processes and effluent treatment: Recovery and purification of products, different unit operations in down streaming with special reference to membrane separations; Extractive fermentation; Anaerobic treatment of effluents; Typical industrial examples for downstream processing and effluent disposal.

Text book(s)
J. E Bailey and D. F. Ollis, "Biochemical Engineering Fundamentals", McGraw Hill, International Edition, 2nd Edition, New York, 1986.

Reference Book(s)
J. M. Lee, "Biochemical Engineering", 1st Edition, Prentice Hall, 1992
H. W. Blanch and D.S.Clark, "Biochemical Engineering", 2ndEdition,CRC Press, 1997.

M.L.Shuler and F. Kargi , "Bioprocess Engineering Basic Concepts", Prentice Hall of India,2002.
D Mukesh and N.G. Sathyanarayana, "Biochemical Engineering", PHI Learning Pvt. Ltd., 2007

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

19CHE442	PETROLEUM REFINING AND PETROCHEMICAL TECHNOLOGY	L-T-P-C: 3-0-0-3

Prerequisite:

Introduction to Chemical Engineering, Material Balance, Energy Balance and Thermodynamics, Chemical Technology, Principles of Heat Transfer, Principles of Mass Transfer

Course Objectives

To understand the design, operations and flow sheet of modern petroleum refinery and various petrochemicals unit.

Course Outcomes

CO1: Understand the concepts of various physical and chemical processes in modern refinery
CO2: Ability to understand the overview and block diagrams of various operations involved in fractionation of crude oil
CO3: Analyze the design, operations and flow sheet of various units in fractionation of crude oil
CO4: Develop and analyze the flow sheets of various petrochemicals processes

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2						2				3		
CO2	3	2	2						2				3		
CO3	3	2	2	2		1	1		2				3	2	
CO4	3	2	2			1	1		2				3	2	

Syllabus

Unit 1
Petroleum refining: Crude oil distillation process – thermal conversion processes. Conventional thermal cracking – vis-breaking and design variables of vis-breaking – coking: Fluid coking, flexi coking, delayed coking and hardware considerations – catalytic conversion processes-fluid catalytic cracking with special reference to catalyst and reactor design configurations – hydro-treating, hydrodesulphurization and hydro-cracking – Reforming: process, catalyst, reactor design configuration – alkylation – isomerization – lube oil manufacturing process, solvent – de-asphalting, solvent de-waxing and hydro finishing – production of PET, waxes and bitumen.

Unit 2
Petrochemical technology: Petrochemical industry overview, primary raw materials for petrochemicals, first generation petrochemicals – hydrocarbon intermediates and their production, non-hydrocarbon intermediates, olefin production, processing of olefins C_4& C_5 cut from steam cracking and fluid cracking.

Unit 3
Aromatics production, second generation petrochemicals from: methane and synthesis gas derivatives, ethylene and ethylene derivatives, propylene and propylene derivatives, C4 and C5 derivatives, aromatics – benzene, toluene and xylene derivatives – third generation petrochemicals – polymers, elastomers, polyurethanes and synthetic fiber.

Texbook(s)
Ram Prasad, "Petroleum Refining Technology", Khanna Publishers, Delhi, 2000.
J.H. Gary, G.H. Handwerk and M.J.Kaiser, "Petroleum Refining Technology and Economics", 5th Edition, CRC Press, New York, 2007.
G.D. Hobson and W. Pohl, "Modern Petroleum Technology", 6th Edition, Wiley, New York, 2000.
B.K. BhaskaraRao, "A Text on Petrochemicals", Khanna Publishers, New Delhi, 2008.
Reference(s)

R.A. Meyers, "Handbook of Petroleum Refining Processes", 2nd Edition, McGraw Hill, New York, 1996.
J.A. Moulijin, M. Makkee and A. Van Diepen, "Chemical Process Technology", Wiley, New York, 2001.
I.D. Mall, "Petrochemical Process Technology", Macmillan India Ltd, New Delhi, 2007.
Sami Matar and Lewis F Hatch, "Chemistry of Petrochemical Processes", Gulf Publishing Company, Houston, Texas, 2000.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes and Assignments.

19CHE443	PROCESS INSTRUMENTATION	L-T-P-C: 3-0-0-3

Pre-Requisite(s): None

Course Objectives

The objective of the course is to provide an introduction to the field of Instrumentation covering process variables and the various instruments used to sense, measure, transmit and control these variables.

Course Outcome

CO1: Understand the principles behind the process instrumentation for measurement of temperature, pressure, density, concentration etc.
CO2: Perform Gauge R&R Analysis and test the suitability of an instrument for a given process.
CO3: Develop a working model of an instrument for measuring temperature and pressure separately.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	3	-	-	-	-	-	-	-	3	3	2
CO2	3	3	-	-	3	-	-	-	3	2	1	-	3	2	2
CO3	3	3	-	-	3	-	-	-	3	2	1	-	3	2	2
CO4	3	3	3	-	-	-	-	-	-	-	-	-	3	3	1

Syllabus

Unit 1
Introduction, general principles of measurement, classification of instruments , elements of an instrument, direct and inferential measurement;Static and dynamic characteristics of instruments,errors in measurements &error analysis; Classification of sensors and transducers, amplifier signal conditioner, signal isolation, transmission, display, data acquisition modules, interfaces, recording. Control centre, instrumentation diagram.

Temperature measurement : Expansion thermometers - constant-volume gas thermometer, pressure spring thermometer, volumetric and pressure thermometers; Thermoelectric temperature measurement - Thermoelectricity, industrial thermocouples; Resistance thermometers -industrial resistance thermometers, null-bridge resistance thermometers, deflectional resistance thermometers; Radiation temperature measurement - radiation pyrometers, photoelectric pyrometers and optical pyrometers.

Unit 2
Measurement of pressure and vacuum: Pressure, vacuum and head; liquid column manometers - U-tube type, well type and inclined type, micromanometers; Low pressure measurement - kenetometer, McLeod gage, thermal conductivity gauge; Barometer method for atmospheric pressure measurement; pressure measurement using bourdon tube, flat and corrugated diaphragms, and capsules; Measurement of pressure in corrosive fluids using liquid seal and diaphragm seal. Hydrostatic type, Elastic Element type, Electrical Type and other type of instruments like McLeod Gauge, Thermocouple gauge, Knudson Gauge, Ionization Gauge.

Flow measurement : Variable area and variable head flow meters, volumetric and mass flow rate meters, linear velocity measurement systems, anemometers;Measurement of Head and Level: Density and specific gravity - constant volume hydrometer, air pressure balance method, gas density detector and gas specific gravity measuring system; Level measurement : pressure type , resistance & capacitance type, sonic & ultrasonic, thermal type level meters, level measurement in open vessels and in pressure vessels, solid level detectors.

Unit 3

Viscometers: Redwood, Saybolt, Engler, Cup and Cone type, Rheo & other types of viscometers; Composition analysis -Gas analysis by thermal conductivity, analysis of moisture in gases (humidity), psychrometer method, hygrometer method, dew point method for moisture analysis in gases, measurement of moisture solids; pH measurement;Gas analysis by thermal conductivity, polarography & chromatography; Composition analysis using spectroscopic methods; Online instrumentation in modern plants

Text Book(s)
Jain R.K., Mechanical and Industrial Measurements, Khanna Publishers, 2010

Reference(s)
Ernest O. Doebelin, "Measurements systems Application & design", McGraw Hill Publishing, 1990.
T. G. Beckwith, R.D. Marangoni and J. H. Lienhard, "Mechanical Measurements", 6th Edn, Prentice Hall, 2006.
Eckman D.P., Industrial Instrumentation, Wiley Eastern
Patranabis, D., "Principles of Industrial Instrumentation" 2nd Edition, Tata McGraw Hill, New Delhi.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE444 POLYMER MATERIALS – STRUCTURE PROPERTY RELATIONS L-T-P-C : 3- 0- 0-3

Pre-Requisite(s): Engineering Chemistry - I

Course Objectives

To make the students aware of the relationship between structure, properties and application of different polymers so as to equip them with the ability of prediction of properties based on structure and hence material selection, substitution of economical and best performing polymer for particular applications.

Course Outcome

CO1: Given the chemical structure of a monomer(s) and a polymerization mechanism, be able to predict other properties
CO2: Understand differences in terms of polymerization mechanism and product of a) free radical versus coordination addition polymerization and b) bulk, solution, suspension and emulsion addition polymerization.
CO3: Knowledge of chemical structure, properties and selection of material for end use applications
CO4: Ability to "cost" plastics products, including life cycle analysis with the appropriate design of a "plastics part"

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	2	2	-	-	-	-	2	2	0	1
CO2	3	2	2	-	2	-	2	-	-	-	-	2	-	2	2
CO3	3	3	2	-	2	2	3	-	-	-	-	2	3	0	2
CO4	3	3	3	2	2	-	-	-	3	-	-	2	0	2	2

Syllabus

Unit 1
Structure of polymers – thermoplastic – thermoset, rubber - Linear, branched, crosslinked, and network polymers - Homochain and hetero atomic chain polymers - Copolymers - Linear and cyclic arrangement - Prediction of polymer properties, group contribution techniques, topological techniques- Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Mechanical properties - Stress-strain properties of polymers - Effect of polymer structure on modulus of elasticity, tensile strength, flexural strength, impact strength, yield strength, fracture toughness - Crazing in glassy polymers - Ductile brittle transition. Effect of additives on mechanical properties of polymers - Creep, stress relaxation, and fatigue.

Unit 2

Thermodynamic and transition properties - Transition temperature in polymers, glass transition (T_g), melt transition (T_m), relationship between T_g and T_m - other transitions like β-transitions, upper and lower glass transition temperatures - Prediction of Tg and T_m of polymers by group contributions. Calorimetric properties - Heat capacity, specific heat, latent heat of crystallization and fusion, enthalpy and entropy - Calculation of heat capacities of polymers.

Electrical and optical properties - Effect of polymer structure on dielectric constant, power factor, dissipation factor, and loss factor - effect of frequency of voltage and temperature on dielectric properties - Prediction of molar polarization and effective dipole moment. Effect of additives on electrical properties of polymers.

Unit 3

Optical properties - Effect of polymer structure on optical properties - clarity, transparency, haze, transmittance, reflectance, and gloss - Prediction of refractive indices of polymers by group contributions.

Chemical Properties - Cohesive energy, cohesive energy density, solubility parameter, determination of solubility parameter of polymers - Prediction of solubility parameter -Effect of polymer structure on solubility in solvents and oils - Influence of structure in prediction of flame retardancy, water repellency - Chemical resistance of polymers - Polymer toxicity.

Text Book(s)

J. A. Brydson, "Plastics Materials" Butterworth- Heinemann – Oxford, 7th Edition,, London, 1999

Maurice Morton, "Rubber Technology", 3rd Ed, Kluwer Academic Pub, Dordrecht, Netherlands, 1999

Manas Chanda and Salil K. Roy, "Plastics Technology Handbook", CRC Press, Atlanta, 2007

Reference(s)

D.W. Van Krevelenand P.J. Hoftyzer, "Properties of Polymer", 3rd Edition Elsevier Scientific Publishing Company Amsterdam – Oxford – New York. 1990.

Jozef Bicerano, "Prediction of Polymer Properties", Second Edition, Marcel Dekker Inc.New York, 1995.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports

19CHE445 SAFETY AND HAZARD MANAGEMENT IN CHEMICAL INDUSTRIE L-T-P-C: 3-0-0-3

Prerequisite: Introduction to Chemical Engineering, Mechanical Operations, Chemical Technology

Course Objectives

To understand the importance of safety in workplace and undertake various hazard and operability studies.

Course Outcomes

CO1: Identifying the typical sources of risks in a process plants by hazard identification and examination of case studies
CO2: Evaluate the workplace to determine occupational safety and health hazards
CO3: Select appropriate control methodologies to prevent hazards in industries
CO4: Undertake a Hazard and Operability Studies (HAZOP)

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2			2						3	2	2
CO2	3	3	3	2			2						3	2	2
CO3	3	3	3	3			2						3	2	2
CO4	3	3	3	3			2		2				3	3	2

Syllabus

Unit 1
Hazard identification: General hazards of plant operation toxic hazards, fire and explosions – hazards. Transport of chemicals with safety unforeseen deviations, emergency management, planning for safety, selecting a basics of safety – preventive and protective measures, safety based on emergency, relief systems, safety based on containment operational safety procedural instructions – routine checks, process and product changes, safety checks, checklist for safety, leaks and detection.

Unit 2
Hazards of plant operation: Toxic hazards, fire and explosion hazards, reaction hazards, literature calculations & explosions screening, normal reaction, gas evolution, characterizing runaway, control and mitigation of gas emanations, absorption with chemical reaction, health and environmental effects. Special problem of developing countries, safety gadgets, dispersions, degree of hazards, disposals, hierarchy of options, threshold limits, laws of safety, accident reporting.

Unit 3
Storage, central handling safety, unintentional spills, runoff emits, containment economics, waste disposal and environmental protection, incineration, alternatives. Risk analysis, evaluation, mitigation, Hazop, Hazan, definition, probability quantification – risk, engineering, clean technology, initiatives, standards, emergency handling, accident investigation, legislation, nil-risk quantification methods. Case histories of accidents, examples of hazards assessment, examples of use of Hazan, explosion hazards in batch units, technical process, documentation for hazardous chemicals, format and methods.

Text book(s)
A. K. Rohatgi, "Safety handling of Hazardous Chemicals", J.K. Enterprises, Mumbai, 1986.
S.K.Shukla, "Enviro Hazards and Techno Legal Aspects", Shashi Publications, Jaipur, 1993.
G.L. Wells and R.M.C. Seagrave, "Flow sheeting for safety", Institution of Chemical Engineering, London, 1977.

Reference(s)
T. Kletz, "Learning from Accidents", 3rd Edition, Gulf Professional Publishing, London, 1988.

J. Barton and R. Rogers, "Chemical Reaction Hazards – A Guide to Safety", Institution of Chemical Engineering, Gulf Professional Publishing, London, 1997.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes and Assignments.