B.Tech in
Chemical Engineering

Faculty of Engineering

Revised in June 2015

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Vision of the Institute

To be a global leader in the delivery of engineering education, transforming individuals to become

creative, innovative, and socially responsible contributors in their professions.

Mission of the Institute:

1. To provide best-in-class infrastructure and resources to achieve excellence in technical education,
2. To promote knowledge development in thematic research areas that have a positive impact on society, both nationally and globally,
3. To design and maintain the highest quality education through active engagement with all stakeholders –students, faculty, industry, alumni and reputed academic institutions,
4. To contribute to the quality enhancement of the local and global education ecosystem,
5. To promote a culture of collaboration that allows creativity, innovation, and entrepreneurship to flourish, and
6. To practice and promote high standards of professional ethics, transparency, and accountability.

Vision of the Department

To be recognized nationally and internationally for excellence in teaching and research in chemical engineering & materials science, integrated with, and practicing, social responsibility and value systems.

Mission of the Department

The department strives for a passionate and committed drive towards continuous improvement in

- the delivery, standards, and currency of education,
- administration efficiency,
- socially beneficial scientific research to create new processes, products, methods, materials, or systems that impact and are beneficial to society, and
- Meeting and exceeding the needs of the stakeholders and Amrita Vishwa Vidyapeetham.

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 associatedethics, 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.

Program Outcomes (POs)

The Program Outcomes are defined by National Board of Accreditation. Engineering graduates will be able to:

- **Engineering Knowledge** : Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
- **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
- **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
- **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
- **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
- **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
- **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
- **Ethics** : Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
- Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

- **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
- **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
- **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

Semester I					
Cat.	**Code**	**Course Title**	**L-T-P**	**Cr**	**ES**
HUM	15ENG111	Communicative English	2 0 2	3	A
SCI	15MAT111	Calculus and Matrix Algebra	2 1 0	3	B
ENGG	15CSE100	Computational Thinking and Problem Solving	3 0 2	4	D
SCI	15PHY100/	Physics /			
	15CHY100	Chemistry	3 0 0	3	C
SCI	15PHY181/	Physics Lab. /			
	15CHY181	Chemistry Lab.	0 0 2	1	L1
ENGG	15MEC180/	Workshop A/			
	15EEE180	Workshop B	0 0 2	1	L2
ENGG	15MEC100	Engineering Drawing - CAD	2 0 2	3	E
HUM	15CUL101	Cultural Education I	2 0 0	2	F
			Total	**20**	

Semester II					
Cat.	**Code**	**Course Title**	**L-T-P**	**Cr**	**ES**
SCI	15MAT121	Vector Calculus and Ordinary			
		Differential Equations	3 1 0	4	B
SCI	15CHY100/	Chemistry/			
	15PHY100	Physics	3 0 0	3	C
ENGG	15CSE102	Computer Programming	3 0 0	3	D
ENGG	15CHE111	Introduction to Chemical Engineering	3 0 0	3	A
ENGG	15CHE112	Material Balances	3 1 0	4	E
SCI	15CHY181/	Chemistry Lab. /			
	15PHY181	Physics Lab.	0 0 2	1	L1
ENGG	15EEE180/	Workshop B/			
	15MEC180	Workshop A	0 0 2	1	L2
ENGG	15CSE180	Computer Programming Lab.	0 0 2	1	L3
HUM	15CUL111	Cultural Education II	2 0 0	2	F
			Total	**22**	

Semester III					
ENGG	15CHE201	Energy Balance and Thermodynamics	3 0 2	4	A
ENGG	15CHE202	Fluid Mechanics	3 1 0	4	C
ENGG	15CHE203	Mechanical Operations	3 0 0	3	D
SCI	15CHY245	Instrumental Methods of Analysis	3 0 0	3	E
SCI	15MAT204	Transforms and Partial Differential Equations	2 1 0	3	B
HUM		Humanities Elective I	2 0 0	2	H
ENGG	15CHE281	Fluid Mechanics Lab.	0 0 2	1	L1
ENGG	15CHE282	Mechanical Operations Lab.	0 0 2	1	L2
HUM	15AVP201	Amrita Values Programme I	1 0 0	1	F
			Total	**22**	

Semester IV					
ENGG	15CHE211	Chemical Engineering Thermodynamics	3 0 0	3	A
ENGG	15CHE212	Chemical Technology	4 0 0	4	B
ENGG	15CHE213	Process Heat Transfer	3 1 0	4	C
SCI		Science Elective	3 0 0	3	D
HUM		Humanities Elective II	2 0 0	2	H
ENGG	15CHE285	Chemical Engineering Instrumentation Lab.	1 0 2	2	L1
ENGG	15CHE286	Chemical Technology Lab.	0 0 2	1	L2
HUM	15SSK221	Soft Skills I	1 0 2	2	G
HUM	15AVP211	Amrita Values Programme II	1 0 0	1	F
			Total	**22**	

Semester V					
ENGG	15CHE301	Chemical Reaction Engineering I	3 0 0	3	A
ENGG	15CHE302	Diffusional Mass Transfer Operations	3 1 0	4	C
ENGG	15CHE303	Statics and Strength of Materials	3 1 0	4	E
HUM	15ENV300	Environmental Science and Sustainability	3 0 0	3	D
SCI	15MAT214	Probability and Statistics	2 1 0	3	B
ENGG	15CHE381	Heat Transfer Lab.	0 0 2	1	L1
ENGG	15CHE382	Strength of Materials Lab.	0 0 2	1	L2
HUM	15SSK321	Soft Skills II	1 0 2	2	G
PRJ	15CHE391	Project Based Learning - Phase I		1	P1
ENGG	15CHE390	Live-in-Lab**		[3]	P2
			Total	**22 [+3]**	

Semester VI					
ENGG	15CHE311	Chemical Reaction Engineering II	3 0 0	3	A
ENGG	15CHE312	Equilibrium Staged Operations	3 1 0	4	C
ENGG	15CHE313	Materials Technology	3 0 0	3	D
ENGG	15CHE314	Process Dynamics and Control	3 1 0	4	E
SCI	15MAT302	Numerical Methods	2 0 2	3	B
ENGG	15CHE385	Chemical Reaction Engineering Lab.	0 0 2	1	L1
ENGG	15CHE386	Mass Transfer Lab.	0 0 2	1	L2
HUM	15SSK331	Soft Skills III	1 0 2	2	G
PRJ	15CHE396	Project Based Learning – Phase II		2	P1
			Total	**23**	

Semester VII					
Cat.		**Course Title**	**L-T-P**	**Cr**	**ES**
ENGG	15CHE401	Process Design and Integration	3 0 0	3	A
ENGG	15CHE402	Process Equipment Design and Drawing	2 0 2	3	B
ENGG	15CHE403	Transport Phenomena	3 1 0	4	C
ENGG		Elective I*	3 0 0	3	E
HUM		Management Elective	3 0 0	3	D
ENGG	15CHE481	Chemical Process Control Lab.	0 0 2	1	L1
ENGG	15CHE482	Computer Aided Design Lab.	1 0 2	2	L2
PRJ	15CHE495	Project Phase I		2	P1
ENGG	15CHE490	Live-in-Lab**		[3]	P2
			Total	**21 [+3]**	

Semester VIII					
Cat.		**Course Title**	**L-T-P**	**Cr**	**ES**
ENGG		Elective II*	3 0 0	3	E
ENGG		Elective III*	3 0 0	3	D
PRJ	15CHE499	Project Phase II		10	P
			Total	**16**	
			TOTAL	**168**	

ELECTIVES

15CHY232	Biomaterials Science
15CHY244	Green Chemistry and Technology
15CHE431	Biochemical Engineering
15CHE432	Chemical Process Modelling and Simulation
15CHE433	Environmental Engineering for Process Industries
15CHE434	Interfacial Science and Engineering
15CHE435	Material Characterization and Spectroscopic Methods
15CHE436	Modern Separation Methods
15CHE437	Nanoscience and Nanotechnology
15CHE438	Petroleum Refining and Petrochemical Technology
15CHE439	Polymer Composites
15CHE440	Polymer Materials – Structure Property Relations
15CHE441	Polymer Processing
15CHE442	Process Instrumentation
15CHE443	Process Intensification
15CHE444	Safety and Hazard Management in Chemical Industries
15CHE445	Solar Energy

MANAGEMENT ELECTIVES

15CHE470	Fundamentals of Management
15CHE471	Managerial Economics and Accounting
15CHE472	Project Engineering of Process Plants

SCIENCE ELECTIVES (3 0 0 3)

15CHY231 Advanced Polymer Chemistry

15CHY232 Biomaterials Science

15CHY233 Catalytic Chemistry

15CHY234 Chemistry of Advanced Materials

15CHY235 Chemistry of Engineering Materials

15CHY236 Chemistry of Nanomaterials

15CHY237 Chemistry of Toxicology

15CHY238 Colloidal and Interfacial Chemistry

15CHY239 Computational Chemistry and Molecular Modelling

15CHY241 Electrochemical Energy Systems and Processes

15CHY242 Environmental Chemistry

15CHY243 Fuels and Combustion

15CHY244 Green Chemistry and Technology

15CHY245 Instrumental Methods of Analysis

15CHY246 Medicinal Organic Chemistry

15CHY247 Modern Polymer Composites

15CHY248 Organic Reaction Mechanisms

15CHY249 Organic Synthesis and Stereochemistry

15CHY250 Polymer Materials and Properties

15CHY251 Polymers for Electronics

15CHY252 Solid State Chemistry

15CHY331 Batteries and Fuel Cells

15CHY332 Corrosion Science

15PHY230 Advanced Classical Dynamics

15PHY233 Biophysics and Biomaterials

15PHY234 Introduction to Computational Physics

15PHY238 Electrical Engineering Materials

15PHY239 Electromagnetic Fields and Waves

15PHY240 Electronic Material Sciences

15PHY241 Lasers in Material Processing

15PHY243 Microelectronic Fabrication

15PHY245 Nuclear Energy – Principles and Applications

15PHY247 Photovoltaics

15PHY248 Physics of Lasers and Applications

15PHY250 Quantum Physics and Applications

15PHY251 Thin Film Physics

15PHY331 Astronomy

15PHY333 Concepts of Nanophysics and Nanotechnology

15PHY335 Medical Physics

15PHY338 Physics of Semiconductor Devices

15PHY532 Astrophysics

15PHY535 Earth's Atmosphere

15PHY536 Earth's Structure and Evolution

15PHY540 Nonlinear Dynamics

15PHY542 Optoelectronic Devices

HUMANITIES ELECTIVES

15CUL230	Achieving Excellence in Life - An Indian Perspective	2 0 0 2
15CUL231	Excellence in Daily Life	2 0 0 2
15CUL232	Exploring Science and Technology in Ancient India	2 0 0 2
15CUL233	Yoga Psychology	2 0 0 2
15ENG230	Business Communication	1 0 2 2
15ENG231	Indian Thought through English	1 0 2 2
15ENG232	Insights into Life through English Literature	1 0 2 2
15ENG233	Technical Communication	1 0 2 2
15ENG234	Indian Short Stories in English	1 0 2 2
15FRE230	Proficiency in French Language (Lower)	1 0 2 2
15FRE231	Proficiency in French Language (Higher)	1 0 2 2
15GER230	German for Beginners I	1 0 2 2
15GER231	German for Beginners II	1 0 2 2
15GER232	Proficiency in German Language (Lower)	1 0 2 2

15GER233	Proficiency in German Language (Higher)	1 0 2 2
15HIN101	Hindi I	1 0 2 2
15HIN111	Hindi II	1 0 2 2
15HUM230	Emotional Intelligence	2 0 0 2
15HUM231	Glimpses into the Indian Mind - the Growth of Modern India	2 0 0 2
15HUM232	Glimpses of Eternal India	2 0 0 2
15HUM233	Glimpses of Indian Economy and Polity	2 0 0 2
15HUM234	Health and Lifestyle	1 0 2 2
15HUM235	Indian Classics for the Twenty-first Century	2 0 0 2
15HUM236	Introduction to India Studies	2 0 0 2
15HUM237	Introduction to Sanskrit Language and Literature	2 0 0 2
15HUM238	National Service Scheme	2 0 0 2
15HUM239	Psychology for Effective Living	2 0 0 2
15HUM240	Psychology for Engineers	2 0 0 2
15HUM241	Science and Society - An Indian Perspective	2 0 0 2
15HUM242	The Message of Bhagwad Gita	2 0 0 2
15HUM243	The Message of the Upanishads	2 0 0 2
15HUM244	Understanding Science of Food and Nutrition	1 0 2 2
15JAP230	Proficiency in Japanese Language (Lower)	1 0 2 2
15JAP231	Proficiency in Japanese Language (Higher)	1 0 2 2
15KAN101	Kannada I	1 0 2 2
15KAN111	Kannada II	1 0 2 2
15MAL101	Malayalam I	1 0 2 2
15MAL111	Malayalam II	1 0 2 2
15SAN101	Sanskrit I	1 0 2 2
15SAN111	Sanskrit II	1 0 2 2
15SWK230	Corporate Social Responsibility	2 0 0 2
15SWK231	Workplace Mental Health	2 0 0 2
15TAM101	Tamil I	1 0 2 2
15TAM111	Tamil II	1 0 2 2

Evaluation Pattern

50:50 (Internal: External) (All Theory Courses)

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

80:20 (Internal: External) (Lab courses and Lab based Courses having 1 Theory hour)

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

70:30(Internal: External) (Lab based courses having 2 Theory hours/ Theory and Tutorial)

Theory- 60 Marks; Lab- 40 Marks

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

65:35 (Internal: External) (Lab based courses having 3 Theory hours/ Theory and Tutorial)

Theory- 70 Marks; Lab- 30 Marks

Assessment	Internal	External
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.

Letter Grade	Grade Point	Grade Description
O	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0.00	Fail

Grades O to P indicate successful completion of the course

$$CGPA = \frac{\sum (C_i x Gr_i)}{\sum C_i}$$

Where

C_i = Credit for the i^{th} course in any semester

Gr_i= Grade point for the i^{th} course

Cr. = Credits for the Course

Gr. = Grade Obtained

15ENG111 COMMUNICATIVE ENGLISH 2 0 2 3

OBJECTIVES: *To make the students communicate their thoughts, opinions, and ideas freely and naturally; to make them understand the different styles in communication; to make the students understand the aesthetics of reading and writing; to bring in a spirit of enquiry; to motivate critical thinking and analysis; to help them ruminate on human values.*

Unit 1

Reading: Different styles of communication – Reading Comprehension - critical thinking and analysis – Note-making – Any two pieces from the text.

Unit 2

Writing: Prewriting techniques - Kinds of paragraphs - basics of continuous writing.

Grammar & Usage: Parts of Speech, Tenses, Concord, Phrasal Verbs, Modal Auxiliaries, Modifiers (Workbook) - Any two pieces from the text.

Unit 3

Practical sessions (Listening & Speaking): Introduction to English pronunciation including minimal pairs and word stress – differences between British and American English – Listening comprehension and Note-taking - Any two pieces from the text.

Activities: Short speeches, seminars, quizzes, language games, debates, and discussions, Book Reviews, etc.

Text: *Language through Reading: Compilation by Amrita University for internal circulation*

Poems:

i. The Poplar Field by William Cowper
ii. Telephone Conversation by Wole Soyinka

Prose:

i. Higher Mathematics by R. K. Narayan
ii. Wings of Fire by Abdul Kalam (Part III.11)

Short Stories:

i. Best Investment I Ever Made by A. J. Cronin
ii. Death of an Indian by Krishna Charan Das

Language through Practice: Compilation by Amrita University for internal circulation

Outcomes:

CO 1: Demonstrate competency in all the four linguistic skills viz, listening, speaking, reading and writing.

CO 2: Apply different styles of communication in professional context.

CO 3: Take part in different planned & extempore communicative activities.

CO 4: Interpret and Discuss facts and information in a given context.

CO 5: Develop an appreciation for human values.

CO –PO Mapping:

	PO6	PO7	PO8	PO9	PO10	PO12
CO1					3	2
CO2				2	3	2
CO3					3	
CO4					3	
CO5			2			

15MAT111 CALCULUS AND MATRIX ALGEBRA 2 1 0 3

Unit 1

Calculus

Graphs: Functions and their Graphs. Shifting and Scaling of Graphs.

Limit and Continuity: Limit (One-Sided and Two-Sided) of Functions. Continuous Functions, Discontinuities, Monotonic Functions, Infinite Limits and Limit at Infinity.

Unit 2

Differentiation and its Applications: Derivative of a function, non- differentiability, Intermediate Value Property, Mean Value Theorem, Extreme Values of Functions, Monotonic Functions, Concavity and Curve Sketching, Integration: Definite Integrals, The Mean Value Theorem for definite integrals, Fundamental Theorem of Calculus, Integration Techniques.

Unit 3

Matrix Algebra

Review: System of linear Equations, linear independence

Eigen values and Eigen vectors: 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 Iterative Methods for the Solution of Linear Systems, Power Method for Eigen Values and Eigen Vectors.

Outcomes:

CO1: Understand the basic concepts of functions, limits, continuity, derivatives and analyze them.

CO2: Apply the concept of differentiability to find the extreme values of the given function and analyze the derivatives to sketch the graph of the given function.

CO3: Recall the terms, facts and basic concepts of definite integrals and the techniques of obtaining antiderivatives.

CO4: Understand the notion of eigenvalues and eigenvectors, analyze the possibility of diagonalization and hence compute a diagonal matrix, if possible.

CO5: Apply the knowledge of diagonalization to transform the given quadratic form into the

principal axes form and analyze the given conic section.

CO6: Understand the advantages of the iterative techniques and apply it to solve the system of equations and finding eigenvectors.

CO –PO Mapping:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	1	-	-
CO2	1	3	1	-	-	-	-	-	-	-	-	0	-	-
CO3	3	0	0	-	-	-	-	-	-	-	-	1	-	-
CO4	3	2	0	-	-	-	-	-	-	-	-	0	-	-
CO5	2	3	1	-	-	-	-	-	-	-	-	0	-	-
CO6	3	0	0	-	-	-	-	-	-	-	-	0	-	-

TEXTBOOKS:

1. *'Calculus', G. B. Thomas Pearson Education, 2009, Eleventh Edition.*
2. *'Advanced Engineering Mathematics', Erwin Kreyszig, John Wiley and Sons, 2015, Tenth Edition.*

REFERENCE BOOKS:

1. *'Calculus', Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rd Edition, 2002.*
2. *'Advanced Engineering Mathematics', by Dennis G. Zill and Michael R. Cullen, second edition, CBS Publishers, 2012.*

15CSE100 COMPUTATIONAL THINKING AND PROBLEM SOLVING 3 0 2 4

Unit 1

Basics: Introduction, Information and data, Data encoding. Logic: Boolean logic, Applications of propositional logic.

Unit 2

Problem Solving and Algorithmic Thinking: Problem definition, Logical reasoning, Problem decomposition, Abstraction. Flowcharting, Name binding, Selection, Repetition, Modularization. Data organization: List and Arrays. Simple algorithms, comparison of performance of algorithms.

Unit 3

Problem Solving Techniques: Factoring and Recursion Techniques, Search and Sort techniques, Text processing and Pattern matching.

Outcomes:

CO1: Apply computational thinking principles and algorithmic building blocks to understand, define, and solve problems

CO2:Design algorithms and implement solutions for problems

CO3:Represent, organize, manipulate and interpret data

CO4:Trace computational states and analyse techniques/ strategies for given solutions

CO-PO Mapping:

CO/PO	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	-	-	-	-	-	-	-	-	-

TEXTBOOKS:

1. *David Riley and Kenny Hunt, Computational Thinking for Modern Solver, Chapman & Hall / CRC, 2014*
2. *R. G. Dromey, "How to solve it by Computer", PHI, 2008*

15CHY100 CHEMISTRY 3 0 0 3

Unit 1

Chemical Bonding

Review of orbital concept and electronic configuration, electrovalency and ionic bond formation, ionic compounds and their properties, lattice energy, solvation enthalpy and solubility of ionic compounds, covalent bond, covalency, orbital theory of covalency - sigma and pi bonds - formation of covalent compounds and their properties. Hybridization and geometry of covalent molecules - VSEPR theory - polar and non-polar covalent bonds, polarization of covalent bond - polarizing power, polarisability of ions and Fajan's rule, dipole moment, percentage ionic character from dipole moment, dipole moment and structure of molecules - co- ordinate covalent compounds and their characteristics, molecular orbital theory for H2, N2, O2 and CO, metallic bond - free electron, valence bond and band theories, weak chemical bonds – inter and intra molecular hydrogen bond - van der Waals forces.

Unit 2

Thermodynamic Parameters

Stoichiometry - mole concept, significance of balanced chemical equation - simple calculations - Conditions for occurrence of chemical reactions - enthalpy, entropy and free changes - spontaneity – Thermochemistry - heats of reactions - (formation, combustion, neutralization) - specific heats - variation of enthalpy change with temperature - Kirchhoff' relation (integrated form) - bond enthalpy and bond order
- Problems based on the above.

Kinetics

Review of molecularity and order of a reaction, rate law expression and rate constant - first, second, third and zero order reactions, pseudo-first order reactions (pseudo-unimolecular reactions) - complex reactions - equilibrium and steady state approximations - mechanism of these reactions - effect of temperature on reaction rates - Arrhenius equation and its significance, Michaelis Menden kinetics-enzyme catalysis.

Unit 3

Electrochemistry

Electrolytes - strong and weak, dilution law, Debye-Huckel theory, faraday's laws, origin of potential, single electrode potential, electrochemical series, electrochemical cells, Nernst equation and its application, reference electrodes - SHE, Ag/AgCl, Calomel.

Photochemistry

Photochemistry, laws of photochemistry - Stark-Einstein law, Beer-Lamberts law, quantum efficiency-determination, photochemical processes - Jablonsky diagram, internal conversion, inter-system crossing, fluorescence, phosphorescence, chemiluminescence and photo sensitization, photo polymerization.

Outcomes:

CO 1: Understand the fundamental concepts of chemistry to predict the structure and properties of engineering materials
CO 2: Develop analytical skills to evaluate the cause, feasibility and course of chemical reactions
CO 3:Design and apply the idea of cutting edge area of chemistry to solve engineering related problems

CO –PO Mapping:

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

REFERENCE BOOKS

Physical chemistry, Puri and Sharma Inorganic chemistry,
Puri and Sharma

15PHY100 PHYSICS 3 0 0 3

Unit 1

Review of Classical Physics and dual nature of Waves /particle Review of Kinematics, Force, Newton's Laws, Linear Momentum, Work, Energy, Power, Angular Motion - Kinematics and Mechanics, Angular momentum Torque, Conservation laws (linear and angular).

Particle properties of waves: Photoelectric effect, quantum theory of light, X-ray diffraction, Compton effect, pair production. Wave properties of particles: Waves, De Broglie waves, Group velocity and phase velocity, uncertainty principle.

Unit 2

Atomic Structure and Quantum Mechanics

Atomic Structure: Various models of atom, Atomic Spectra, Energy Levels, Correspondence Principle, Nuclear Motion, Atomic Excitation, and Rutherford Scattering.

Quantum Mechanics: Introduction - wave equation - Schrodinger's equation (time dependent and independent) - expectation values, operators, Eigen value (momentum and energy) – 1D potential box (finite and infinite) - tunnel effect - harmonic oscillator.

Unit 3

Statistical Mechanics and Solid State Physics

Statistical Mechanics: Classical Distribution - Maxwell's Boltzmann-Molecular energies of an ideal gas - most probable speed. Quantum Statistics - Bose-Einstein and Fermi-Dirac. Applications - Black Body Radiation, Specific heat of solids, free electrons in metals, Electron energy.

Solid State Physics: Types of solids, Crystallography, Bonds- Ionics, Covalent, and Van der Waals, Band Theory and energies, Semiconductor Devices, and Superconductivity.

Outcomes:

CO1: Understand, Comprehend and acquaint with concepts of Modern Physics
CO2: Analyze and solve (idealized and quasi practical) physics problems pertaining to various concepts of Modern Physics
CO3: Apply concepts of Modern Physics to solve engineering problems that needs ideas from Modern Physics

CO –PO Mapping:

CO/ PO	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PO13	PSO 1	PSO 2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
CO2	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TEXTBOOK:

"Concept of Modern Physics", Arthur Beiser, Tata-McGraw Hill, edition.

REFERENCE BOOK:
"Principles of Physics" by Halliday, Resnick and Walker, 9th edition

15CHY181 CHEMISTRY LAB. 0 0 2 1

1. Acid base titration (double titration)
2. Complexometric titration (double titration)
3. Redox (permanganimetry) titration (double titration)
4. Conductometric titration
5. Potentiometric titration
6. Ester hydrolysis

Outcomes:

CO1:Develop analytical skills for the determination of water quality parameter

CO2:Understand the electrochemical principles of conductance and electrode potentials and its application in analytical science

CO3:Develop analytical skills in the determination of rates of chemical reactions and its application

CO4:Learn the basics of redox reaction and applying it for quantitative determination.

CO5:Create skills to convert basic chemical reactions to analytical application.

CO –PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	3	3	1	-	-	-	-	-	-	-	-	-
CO2	3	3	1	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-
CO5	3	3	1	-	-	-	-	-	-	-	-	-

15PHY181 PHYSICS LAB. 0 0 2 1

Young's Modulus – Non Uniform Bending Newton's Rings
Laser - Determination of Wavelength and Particle Size Determination Spectrometer
Carey Foster's Bridge Rigidity Modulus - Tensional Pendulum Viscosity of Liquid by Stokes's method Ultrasonic Interferometer Hysteresis – B H curve

Outcomes:

CO1: Prepare for the lab experiment and perform individually a wide spectrum of experiments.

CO2: Present experimental data in various appropriate forms like tabulation, and plots.

CO3: Analyze, Interpret and Summarize experimental results.

CO4: Communicate clearly understanding of various experimental principles, instruments/setup, and procedure.

CO –PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PSO3
CO1	-	1	-	-	1	-	-	-	2	1	-	-	-	-	-	-
CO2	-	2	-	2	-	-	-	-	-	-	1	-	-	-	-	-
CO3	-	3	1	-	-	-	-	-	1	1	-	-	-	-	-	-
CO4	-	-	-	-	1	-	1	-	1	3	-	-	-	-	-	-

15MEC180 WORKSHOP A 0 0 2 1

1. Product Detailing 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.

2. Pneumatics and PLC Workshop

Study of pneumatic elements - Design and assembly of simple circuits using basic pneumatic elements - Design and Assembly of simple circuits using Electro-pneumatics.

Study of PLC and its applications - Simple programming using ladder diagrams.

3. Sheet Metal Workshop

Study of tools and equipments - 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 and painting practice.

4. (a) Welding Workshop

Study of tools and equipments - Study of various welding methods - Arc welding practice and demonstration of gas welding and cutting.

(b) Demo and practice Workshop

Fitting: Study of tools, practice in chipping, filing and making joints. Carpentry: Study of tools, planning practice and making joints

Outcomes:

CO1: Dismantle and assemble various products.

CO2: Design and simulate pneumatic and electro-pneumatic circuits.

CO3: Fabricate sheet metal objects.

CO4: Perform arc welding and soldering.

CO-PO Mapping:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	1	-	-	-	-	-	-	2	1	-	1
CO 2	2	2	1	-	1	-	-	-	2	1	-	1
CO 3	2	2	-	-	-	-	-	-	2	1	-	1
CO 4	2	1	-	-	-	-	-	-	2	1	-	1

REFERENCE:

Concerned Workshop Manual

15EEE180 WORKSHOP B 0 0 2 1

Part A – Electronics

Identification of electronic components (Passive and Active)
Study of measuring instruments (Voltmeter, Ammeter and Multimeter) Measurement and theoretical Verification of series and parallel combination of resistors and capacitors
Calibration of CRO and measurements of signal parameters (RMS, maximum value, peak value, time and frequency)
Calibration of function generator using CRO Soldering practice

Part B – Electrical

1. Study on power supply and protective devices
2. Study on tools and electrical accessories
3. Study on sources of light
4. Study on energy efficiency
5. Study on water pump
6. Study on house hold appliances:
7. Iron box
8. Fan
9. Refrigerator
10. Air conditioner
11. House wiring I – Glow an incandescent lamp using SPST switch
12. House wiring II – Glow a fluorescent lamp using SPST switch
13. House wiring III – Operate a fan and an incandescent lamp using two independent SPST switch
14. House wiring IV – Operate a fluorescent lamp and a 3 pin socket using two independent SPST switch

15. House wiring V – Staircase wiring
16. House wiring VI – Godown wiring

Outcomes:

CO1: Understand electrical safety measures and identify electrical tools, electronic components and their symbols.

CO2: Understand electric laws using simulation studies and detect failures in electrical and electronic circuits.

CO3: Build/Solder and test, residential wiring/Electronic circuits and measure electrical parameters.

CO4: Estimate the materials required for wiring a building.

CO –PO Mapping:

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

15MEC100 **Engineering Drawing CAD I** **2 0 2 3**
(Pre-Requisite: Nil)

Objectives:

1. To develop drawings using Bureau of Indian Standards (BIS)
2. To communicate effectively through drawings
3. To enhance visualization skills, which will facilitate the understanding of engineering systems.

Keywords:

Coordinate system**,** Orthographic projections, Isometric projections

Contents:

Introduction, Drawing Instruments and their uses, Layout of the Software, standard tool bar/menus, navigational tools. Co-ordinate system and reference planes. Creation of 2 dimensional environment. Selection of drawing size and scale. Commands and Dimensioning.

Orthographic Projections: Introduction, Planes of projection, reference line. Projection of points in all the four quadrants. Projection of straight lines, Projection of Plane Surfaces, and Projection of Solids in first angle projection system.

Outcomes:

CO1: Understand the fundamental principles of first angle and third angle projections.

CO2: Dimension and label the drawings as per standards.

CO3: Construct the drawings by choosing appropriate line type.

CO4: Visualize and construct projections of line and lamina when inclined to one reference plane and both reference planes.

CO5: Visualize and construct solid entities in its simple position and when inclined to one reference plane. CO6: Construct the drawings using computer aided design and drafting software package

CO –PO Mapping:

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

TEXTBOOK:

Bhat N. D. and Panchal V. M, "Engineering Drawing Plane and Solid Geometry" , 42e, Charoatar Publishing House, 2010

REFERENCES:

1. *James D. Bethune, "Engineering Graphics with AutoCAD", Pearson Education, 2014*
2. *K. R. Gopalakrishna, "Engineering Drawing", 2014, Subhas Publications*
3. *Narayan K. L. and Kannaiah P, Engineering Drawing, SciTech Publications, 2003*

15CUL101 CULTURAL EDUCATION I 2 0 0 2

Unit 1

Introduction to Indian Culture; Introduction to Amma's Life and Teachings; Symbols of Indian Culture.

Unit 2

Science and Technology in ancient India; Education in Ancient India; Goals of Life

- Purusharthas; Introduction to Vendanta and Bhagavat Gita.

Unit 3

Introduction to Yoga; Nature and Indian Culture; Values from Indian History; Life and work of Great Seers of India.

Outcomes:

CO1: Be introduced to the foundational concepts of Indian culture and heritage, will be able to understand the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma‟s life a

CO2: Understand the foundational concepts of Indian civilization like purusharthas, law of karma, etc, which contributes towards personality growth.

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:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	-	-	-	-	-	-	2	-	1	-	3	-	-
CO2	-	-	-	-	-	-	1	1	3	2	-	3	-	-
CO3	-	-	-	-	-	-	1	2	3	1	-	3	-	-
CO4	-	-	-	-	-	-	3	3	3	3	-	3	-	-
CO5	-	-	-	-	-	-	1	1	3	3	-	3	-	-

TEXTBOOKS:

1. *The Glory of India (in–house publication)*
2. *The Mother of Sweet Bliss (Amma's Life & Teachings)*

15MAT121 VECTOR CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS 3 1 0 4

Unit 1

Vector Differentiation: Vector and Scalar Functions, Derivatives, Curves, Tangents, Arc Length, Curves in Mechanics, Velocity and Acceleration, Gradient of a Scalar Field, Directional

Derivative, Divergence of a Vector Field, Curl of a Vector Field. (Sections: 9.4, 9.5, 9.6, 9.9, 9.10, 9.11)

Vector Integration: Line Integral, Line Integrals Independent of Path. Green's Theorem in the Plane (Sections: 10.1, 10.2, 10.3, 10.4).

Unit 2

Surface Integral: Surfaces for Surface Integrals, Surface Integrals, Triple Integrals – Gauss Divergence Theorem, Stoke's Theorem. (Sections: 10.5, 10.6, 10.7, 10.9)

First Order Differential Equations: First Order ODE, Exact Differential Equations and Integrating Factors (Sections 1.1and 1.4).

Unit 3

Second Order Differential Equations: Homogeneous and non-homogeneous linear differential equations of second order (Review), Modelling: Free Oscillations, Euler-Cauchy Equations, Solution by Undetermined Coefficients, Solution by the Method of Variation of Parameters (Sections 2.1, 2.2, 2.4, 2.5, 2.6, 2.7, 2.10).

System of Order Differential Equations: Basic Concepts and Theory, Constant Coefficient systems – Phase Plane method, Criteria for Critical Points, Stability. (Sections 4.1 – 4.4).

Outcomes:

CO 1: Able to understand, and interpret the concepts.

CO 2: Able to apply the concept and understand them

CO 3: Able to understand and implement the concepts in application oriented problems.

CO 4: Able to understand and analyze the and apply the knowledge of diagonalization of matrices to transform the given quadratic form.

CO5: Able to understand the basic concepts and apply them in modeling the first order ODEs.

CO6: Able to understand and apply methods of undetermined coefficients and variation of parameters to solve second order ODEs.

CO –PO Mapping:

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

TEXTBOOK:

'Advanced Engineering Mathematics', Erwin Kreyszig, John Wiley and Sons, Tenth Edition, 2015.

REFERENCE BOOKS:

1. *'Advanced Engineering Mathematics', Dennis G. Zill and Michael R. Cullen, second edition, CBS Publishers, 2012.*
2. *'Calculus', G. B. Thomas Pearson Education, 2009, Eleventh Edition.*
3. *'Calculus', Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rd Edition, 2002.*

15CSE102 Computer Programming 3 0 0 3

Objectives:

1. The course intends to familiarize the students with the structured programming paradigm.
2. The course aims to provide necessary skills to students to apply the structured programming principles to solve problems

Contents:

Unit 1:

Introduction to C language: Structure of a C program, comments, Data types, variables, constants, data input and output statements, input assertions; expressions and evaluation. Functions: inter function communication, standard functions, scope. Selection: two way selection, multi-way selection. Repetition: concept of loop, loop invariant, pretest and posttest loops, initialization and updating, event and counter controlled loops. Recursion: recursive definition, recurivse solution, designing recursive functions, limitations of recursion.

Unit 2:

Files and streams, file input output, Arrays –1D numeric, searching and sorting, 2D numeric arrays, problems with matrices. Pointers: introduction, compatibility, arrays and pointers, Dynamic memory allocation, arrays of pointers, pointer arithmetic.

Unit 3:

Strings: fixed length and variable length strings, strings and characters, string input, output, array of strings, string manipulation functions, sorting of strings. Enumerated types, Structres: structure vs array comparison, complex structures, structures and functions, Union, binary input output, command line arguments.

Outcomes:

CO1: Understand the structured programming constructs: data types (primitive and compound), control and recursion thereby to understand a given program

CO2: Understand and analyze a given program by tracing, identify coding errors and debug them

CO3: Apply structural programming constructs appropriately for given problem scenarios

CO4: Develop computer programs that implement suitable algorithms for problem scenarios and applications

CO-PO Mapping:

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

TEXTBOOK:

Behrouz A. Forouzan and Richard F. Filberg, "Computer Science A structured programming approach using C", Third Edition, Cengage Learning, 2006.

REFERENCES:

1. *Brian W. Kernighan, Dennis M. Ritchie, "The C Programming Language", Second Edition, Prentice Hall, 1988.*
2. *Eric S. Roberts, "Art and science of C", Addison Wesley, 1995.*
3. *Jeri Hanly and Elliot Koffman, "Problem solving and program design in C", Fifth Edition, Addison Wesley (Pearson), 2007.*

15CHE111 INTRODUCTION TO CHEMICAL ENGINEERING 3 0 0 3

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; types of chemical engineering problems (mainly rate, equilibrium and design).

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.

Course Outcomes

CHE111.1	Understand various fields to which chemical engineers have been contributed and Identify the role of a modern Chemical Engineer.
CHE111.2	Convert the batch process of a chemical production into a continuous process
CHE111.3	Convert units of physical quantities from one system to another
CHE111.4	Understand the skeleton of Chemical Engineering curriculum
CHE111.5	Develop simple mathematical equations of a process using conservation principles and solve them using suitable mathematical techniques
CHE111.6	Develop a process flow diagram for a given process based on the requirements and analyze the equipment required
CHE111.7	Follow ethics in Chemical Engineering discipline
CHE111.8	Perform profitability and safety analysis of a given process

CO-PO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CHE 112.1	3	3	2										2		
CHE 112.2	3	3	3										3	1	
CHE 112.3	3	3	2										3	1	
CHE 112.4	3	3	3	1									2	2	

TEXTBOOKS & REFERENCES:

7. *K. A. Solen and J. N. Harb, "Introduction to Chemical Engineering – Tools for Today and Tomorrow", 5th Edition, Wiley, 2011.*
8. *S. Pushpavanam, "Introduction to Chemical Engineering", Prentice Hall India, 2012.*

15CHE112 MATERIAL BALANCES 3 1 0 4

Unit 1

Chemical engineer vs. Chemist, Careers in chemical engineering, Chemical engineering industries; 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, Process flowsheets and components; Case studies.

Representing streams: Dimensions and unit conversions, Conversion factors, Dimensional consistency, Dimensionless numbers in chemical engineering; Representing compositions of mixtures and solutions: Binary and tertiary mixtures, Graphical representation, 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; Drying; Liquid-Liquid Extraction; Absorption; Distillation; Recycle, Bypass, and Purge

Unit 3

Combustion: Orsat analysis, Proximate and ultimate analyses of coal; Single-pass and overall conversions; Oxidation of sulphur compounds; Reactions involving phosphorus; Reactions involving nitrogen; Reactions involving chlorine; Extraction of metals from ores; Hydrogenation, hydration, and oxidation; Electrochemical reactions; Recycle, Bypass, and Purge involving reactions

Representing processes: Creating Flowsheets; Degree of freedom analysis of flowsheets; Material balance involving multiple unit operations; Modular and overall equation-solving approaches; Case studies involving industrial flowsheets.

Course Outcomes

CHE112.1 Understand the fundamental concepts of stoichiometry and identifying process variables and properties and develop systematic problem solving skills

CHE112.2 Ability to make and solve material balance equations on unit operations and processes

CHE112.3 Ability to perform material balances with chemical reactions

CHE112.4 Ability to perform material balances involving multiple unit operations

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CHE 112.1	3	3	2										2		
CHE 112.2	3	3	3										3	1	
CHE 112.3	3	3	2										3	1	
CHE 112.4	3	3	3	1									2	2	

TEXTBOOKS:

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

REFERENCES:

1. *Himmelblau, D. M., Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall Inc., New York, 2003*
2. *Felder, R. M. and Rousseau, R. R., Elementary Principles of Chemical Processes, 3rd Edition, John Wiley & Sons, New York, 2000*
3. *Hougen, O. A., Watson, K. M., and Ragatz, R.A., Chemical Process PrinciplesPart I, CBS Publishers, 1973*

15CSE180 Computer Programming Lab. 0 0 2 1

Objectives:

- The laboratory intends to provide hands-on experience on the structured programming paradigm.
- This laboratory facilitates students to apply the structured programming principles to solve problems

Contents:

Solving simple problems with operators, programs on conditional control constructs, programs on loops (while, do-while and for), programs using user-defined functions and library functions, programs on files, arrays (single and multi-dimensional), programs using DMA, programs on strings, structures.

Outcomes:

CO1: Develop solutions for problems systematically using structured logic approach.

CO2: Develop computer programs for a given problem scenario.

CO3: Make use of the programming constructs effectively while developing computer programs.

CO4: Develop modular solutions for a given scenario.

CO-PO Mapping:

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

TEXT BOOKS/REFERENCES:

Behrouz A. ForouzanComputerand ScienceRichardAStructured ProgrammingF.Filberg, Approach"Third Edition, Cengage Learning, 2007.

15CUL111 CULTURAL EDUCATION II 2 0 0 2

Unit 1

1. Relevance of Sri Rama and Sri Krishna in this Scientific Age
2. Lessons from the Epics of India
3. Ramayana & Mahabharata

Unit 2

4. Who is a Wise Man?

5. A Ruler's Dharma
6. The Story of King Shibi

Unit 3

7. Introduction to the Bhagavad Gita
8. Bhagavad Gita – Action without Desire

Unit 4

9. Role and Position of Women in India
10. The Awakening of Universal Motherhood

Unit 5

Patanjali'sAstanga -Yoga System for Personality Refinement

11. Examples of Heroism and Patriotism in Modern India

Outcomes:

CO1: Get an overview of India and her contribution to the world in the field of science and literature

CO2: Understand the foundational concepts of ancient Indian education system and practices associated with them

CO3 : Learn the important concepts of Vedas, Bhagavad-Gita and Yogasutras and their relevance to daily life

CO4 : Familiarize themselves with the inspirational characters and anecdotes from the epics and Indian history

CO5 : Gain a rational understanding of the underlying principles of Indian spirituality

CO-PO Mapping:

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

TEXTBOOKS:

Common Resource Material II (in-house publication)

Sanatana Dharma - The Eternal Truth (A compilation of Amma's teachings on Indian Culture)

3. *Lewis, W. K., Radash, A. H., and Lewis, H. C., Industrial Stoichiometry, McGraw Hill Book Inc., New York, 1995.*

15CHE201 ENERGY BALANCE AND THERMODYNAMICS 3 0 2 4

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, W ork, 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 – Clayperon equation, Clausius-Clayperon equation, Watson equation, Trouton's rule, Kistyakowsky 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 flowsheets – 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.

Course Outcomes

CHE201.1 Understand the basic thermodynamic definitions, laws and P-v-T behaviour of fluids

CHE201.2 Ability to apply fundamental concepts of thermodynamics to engineering applications and energy analysis using property tables

CHE201.3 Understand the energy transfer by mechanical work, by heat and energy balance in unit operations

CHE201.4 Understand the energy analysis of gas cycles, thermodynamic efficiencies and the concept of entropy

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 201.1	3	3											2		
CHE 201.2	3	3	1	2									3		
CHE 201.3	3	3	2										3	2	
CHE 201.4	3	3	2	1									3	2	

TEXTBOOKS:

1. *Narayanan, K. V., and Lakshmikutty, B., Stoichiometry and Process Calculations, Prentice Hall India, New Delhi, 2009*
2. *Cengel, Y. A., and Boles, M. A., Thermodynamics: An Engineering Approach, 7th Special Indian Edition, McGraw Hill India, New Delhi, 2011*
3. *Rao, Y. V. C., Chemical Engineering Thermodynamics, Universities Press, 1997*

REFERENCES:

1. *Murphy, R. M., Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw Hill International Edition, New York, 2007*
2. *O'Connell, J. P., and Haile, J. M., Thermodynamics: Fundamentals for Applications, Cambridge University Press, Cambridge, 2005*

15CHE202 FLUID MECHANICS 3 1 0 4

Unit 1

Elementary concepts – density, specific weight, specific gravity, viscosity – dynamic and kinematic viscosity – surface tension, capillarity, vapour pressure, compressibility – Compressible and incompressible fluids; Concept of gauge and absolute pressure, measurement of pressure using manometers of different types. Hydrostatic force on plane and curved surfaces, center of pressure; buoyancy and stability of submerged and floating bodies;

Flow types - Unsteady, Steady and non-uniform, laminar and turbulent flows – Reynolds number; Ideal flow – rotational and irrotational, stream function, potential function – Velocity vectors; Path line, streak line and stream line; Derivation of continuity and momentum equation for steady three dimensional flows - Application of one dimensional steady flow; circulation and vorticity; Laminar flow between parallel plates – Taylor-Coutte flow and Poiseulle flow; Flow in closed conduits Laminar flow through circular pipe – Shear stress and velocity profiles; pressure gradient, Hagen-Poiseulle's equation; Power required to overcome pressure drop; Velocity profile in turbulent flows;

Two dimensional flows - Boundary layer; Boundary layer equation; Blasisus solution for boundary layer flow; boundary layer separation and its control.

Unit 2

Bernoulli's and Euler's equations; Application of Bernoulli's equations to flow meters - Pitot tube, Nozzle, Venturi meter and Orifice meter; Coefficient of discharge for flow meters and velocity measurement;

Concept of friction and friction factor from drag on a flat plate; Friction loss in laminar and turbulent flows, Darcy-Weisbach equation, Moody chart; Minor losses
– Pipe fittings and pipe networks, equivalent length for pipe in pipe fittings;

Flow past immersed bodies – drag and lift, drag and lift coefficients, flow though beds of solids, one dimensional motion of particle through fluid, terminal velocity, indered settling, Fluidization – Conditions for onset of fluidization, Hydraulic radius of porous medium, Porous medium Reynolds number, minimum fluidization velocity; Pressure drop through porous media for spherical and non-spherical particles – Ergun equation; Types of fluidization;

Unit 3

Applications Transportation of fluids – pipes, fittings, valves; Pump terminology – Suction and Delivery heads, Suction lift, Cavitation, Net positive suction head and Power requirement; Positive displacement

pumps – Reciprocating pump and gear pump; Rotary pumps - Centrifugal Volute pump, Pressure raise in centrifugal pump; Pump characteristics;

Significance of dimensionless numbers; Dimensional analysis and model testing – Bucking ham pi-theorem; Application of dimensionless analysis - Flow through pipe, Settling of particles in a fluid, Centrifugal pump, Reynolds and Froude numbers and their use in model testing;

Course Outcomes

CHE202.1 Understand basic properties of fluids, stress-strain relationship in fluids, classify their behavior and establish force balance in static systems

CHE202.2 Analyze fluid flow problems in different configurations with the application of the momentum and energy equations. Understand principles and functioning of flow metering devices and apply Bernoulli equation to determine the performance of flow-metering devices.

CHE202.3 Analyse fluid behaviour in fixed bed systems, compute power requirement in fixed bed system and determine minimum fluidization velocity in fluidized bed.

CHE202.4 Determine and analyze the performance aspects of fluid machinery specifically for centrifugal pump and reciprocating pump. Develop dimensionless groups that help in scale-up and scale-down of fluid flow systems.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 202.1	3	3	2	2									3	3	1
CHE 202.2	3	3	3	2									3	3	1
CHE 202.3	3	3	3	2									3	3	1
CHE 202.4	3	3	3	2									3	3	1

TEXTBOOK AND REFERENCE BOOKS:

1. Noel de Nevers, Fluid Mechanics for Chemical Engineers, McGraw Hill Inc., 1991

2. Cengel Y. A., and Cimbala J. H, Fluid Mechanics: Fundamentals and Applications, McGraw Hill

Publishers, 3rd Ed., 2013

3. *Holland F. A., and Bragg R., Fluid Flow for Chemical Engineers, Butterworth Heinmann, 2nd Ed., 2002*
4. *Ron Darby, Chemical Engineering Fluid Mechanics, Marcel Dekker Inc., 2nd Ed., 2001*
5. *Frank M. White, Fluid Mechanics, MeGraw Hill Inc., 4th Ed., 2011*

15CHE203 MECHANICAL OPERATIONS 3 0 0 3

Unit 1

Properties and handling of particulate solids- characteristics of solid particles, standard screen series, mixed particle size and screen analysis; Screening: Theory of screening, Effectiveness and Capacity of screens, Screening equipment: stationary screens and grizzlies, gyrating screens, vibrating screens and other industrial screens like trammels, etc. 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): Factors affecting comminution, comminution laws: Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption, Size reduction equipments: Primary crusher – Jaw crusher, Gyratory crusher, Secondary crusher – Roll crusher (both smooth roll & toothed roll) its selection and capacity, Grinder – Construction and operation of Hammermill, Ball mill, Rod mill, Attrition mill, Agitated mill and their materials suitability, Ultra-fine grinder – Fluid energy mill, Cutting machines: knife cutters, Close 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.

Course Outcomes

CHE203.1 To develop basic knowledge on particle technology and analyze particle size and shape with deeper understanding on different particle diameters

CHE203.2 To develop understanding on various size reduction operations and mechanical separations with basic understanding on size reduction laws and principles

CHE203.3 To understand various ways of storing , handling solids and agitation of solids in chemical industries

CHE203.4 To apply and analyze appropriate unit operations for separation of solids from solids and separation of solids from liquids

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 203.1	2	3	2	1									1	1	2
CHE 203.2	3	3	2	2									3	3	3
CHE 203.3	2	2	2	3									2	2	2
CHE 203.4	3	3	3	3									3	3	3

TEXTBOOKS:

1. *W. L. McCabe, J. C. Smith, and P. Harriot, "Unit Operations in Chemical Engineering, 6th Edition, McGraw Hill, 2001.*
2. *W. L. Badger and J. T. Banchero, "Introduction to Chemical Engineering", Tata McGraw Hill, 1997.*
3. *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:

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

15CHY245 INSTRUMENTAL METHODS OF ANALYSIS 3 0 0 3

Unit 1

Error Analysis and Sampling: Accuracy - Precision - Classification of Errors - Minimization of errors - Standard deviation - Coefficient of variance - F-test - t-test - Significant figures. Sampling - Basis of sampling, Sampling and physical state - Safety measures of sampling.

Separation Techniques: Brief out line of column, paper and thin layer chromatography - Ion exchange methods - principle and application – HPLC.

Unit 2

Gas chromatography - principle and applications – gel chromatography.

Electroanalytical techniques: Potentiometry - Potentiometric titration - determination of equivalence point - acid base, complexometric, redox and precipitation titrations - merits and demerits. Voltammetry - Cyclic voltammetry - basic principle and application - Polarography - introduction - theoretical principles - migration current - residual current - half wave potential - instrumentation - analytical applications.

Unit 3

Spectro-chemical techniques: UV-VIS spetrophotometry - principle - Beer's Law application - photometric titration - single and double beam spectrophotometer - instrumentation of IR - sample handling - IR applications - H - NMR - Instrumentation and applications - principle - instrumentation - applications of atomic absorption spectroscopy.

Thermal and Diffraction techniques: Principles and applications of DTG - DTA - DSC - X-ray - Electron Diffraction Studies - SEM, TEM.

Course Outcome

CO01: To develop an understanding of principle and working of the range of instrumental methods in analytical chemistry

CO02: To provide an understanding and skills in contemporary methods of separation and appropriate selection of instruments for the successful analysis of chemical compounds

CO03: To impart skills in the scientific method of planning, conducting, reviewing, reporting experiments and problem solving in chemical analysis.

TEXTBOOKS:

1. *Willard H W, Merritt J R, "Instrumental Methods of Analysis", 6th edition, Prentice Hall, (1986).*
2. *Skoog Douglas A, West Donald, "Fundamentals of Analytical Chemistry", 7th edition, New York Addison, Wesley, (2001).*

REFERENCES:

1. *"Vogel's Textbook of Quantitative Chemical Analysis", 5th edition, ELBS, (1989).*
2. *Kaur. H, "Instrumental Methods of Chemical Analysis", Goel Publisher, (2001).*

15MAT204 TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS 2 1 0 3

Unit 1

Laplace Transform: Laplace Transforms, Inverse Transforms, Linearity, Shifting, Transforms of Derivatives and Integrals, Differential Equations, Unit Step Function, Second Shifting Theorem, Dirac's Delta Function. Differentiation and Integration of Transforms.

Unit 2

Convolution, Integral Equations, Partial Fractions, Differential Equations, Systems of Differential Equations. (Sections: 6.1 to 6.7)

Fourier Series: Fourier series, Half range Expansions, Parseval's Identity, Fourier Integrals, Fourier integral theorem. Sine and Cosine Integrals. (Sections: 11.1 - 11.3)

Unit 3

Fourier Transforms: Sine and Cosine Transforms, Properties, Convolution theorem. (Sections: 11.1 -11.3, 11.7-11.9)

Partial Differential Equations: Basic Concepts, Modeling; Vibrating String, Wave Equation, Separation of Variables, Use of Fourier Series, Heat Equation; Solution by Fourier Series. (Sections: 12.1-12.5)

Course Outcomes

15MAT204.CO1	Understand the concepts of Laplace and Fourier transforms and its properties to transform a function from time domain to the frequency domain.
15MAT204.CO2	Obtain the Laplace and Fourier transform and its inverse transform of impulsive, discontinuous and some complicated periodic signals.
15MAT204.CO3	Solve the initial value problems' using Laplace and Fourier transforms on signals arising by changing over to frequency domain.
15MAT204.CO4	Define the Fourier series for periodic functions and determine the Fourier coefficients
15MAT204.CO5	Understand the formation of partial differential equations and apply some standard methods to obtain its solutions.
15MAT204.CO6	Apply Fourier series technique to solve the heat, wave and Laplace equations.

TEXTBOOK:

Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Ninth Edition, 2012.

REFERENCE BOOKS:

1. *Advanced Engineering Mathematics by Dennis G. Zill and Michael R. Cullen, second edition, CBS Publishers, 2012.*
2. *Larry C. Andrews and Bhimson. K. Shivamoggi, The Integral Transforms for Engineers, Spie Press, Washington, 1999.*
3. *J. L. Schiff, The Laplace Transform, Springer, 1999.*

15CHE281 FLUID MECHANICS LAB. 0 0 2 1

Bernoulli's equation for steady flow - verification of energy conservation principle; Determination of coefficient of discharge of flow measuring devices like venturimeter, orificemeter, rotameter; Pipe friction studies- losses in fittings - friction factor; Flow through annular and helical coil pipes - coefficient of friction; Performance characteristics of centrifugal and reciprocating pumps; Flow through packed columns

– fluidization - pressure drop in the column; Terminal settling velocity.

Course Outcomes

CO Code	Course outcome statement
15CHE281.1	To develop ability to do experiments in fluid flow meters such as venturi, orifice and rotameter
15CHE281.2	To handle and operate reciprocating and centrifugal pumps
15CHE281.3	To develop ability to conduct experiments in packed column, helical coil and annular flow pipe
15CHE281.4	To perform experiments to calculate friction loss in pipe flow and drag coefficients

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
15CHE281.1	3	3	3	3				2	3	2			3	3	3
15CHE281.2	3	3	3	3				2	3	2			3	3	3
15CHE281.3	3	3	3	3				2	3	2			3	3	3
15CHE281.4	3	3	3	3				2	3	2			3	3	3

15CHE282 MECHANICAL OPERATIONS LAB. 0 0 2 1

Calculating Specific Surface Area and Particle Size using Sieve Analysis, Screen Effectiveness, Verifying crushing laws and energy consumption in Jaw Crusher, Ball mill and Drop weight Crusher, Determining reduction ratio in Roll Crusher, and Drop Weight Crusher, Solid Separation in Cyclone Separator, Calculation thickener area using batch sedimentation experiment, Determining Specific Cake resistance and filter medium Resistance in Filter Press, and Leaf Filter.

Course Outcomes

CHE282.1	To learn particle analysis of complex heterogeneous mixtures using sieve analysis and familiarise on the different ways of calculating particle diameters and specific surface area
CHE282.2	To understand screen analysis and effectiveness of screen
CHE282.3	To familiarise on the various size reduction mechanisms and equipment and investigating the energy consumption using empirical laws
CHE282.4	To understand separation of solids from liquids and gases

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	P O 10	P O 11	P O 12	PSO 1	PSO 2	PSO 3
CHE28 2.1	2	3	2	2									1	2	2
CHE28 2.2	2	3	2	2									1	2	2
CHE28 2.3	3	3	3	2									3	3	3
CHE28 2.4	3	3	3	3									3	3	3

15AVP201 / AMRITA VALUES PROGRAMME I / 1 0 0 1
15AVP211 AMRITA VALUES PROGRAMME 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.

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.

Outcomes:

CO1: Appreciate the significance of *Rāmāyaṇa* as an *itihāsa,* and important aspects of *Bālakāṇḍa*.

CO2: Understand the family values and ideal human relationships portrayed in the *Ayodhyakāṇḍa* and *Aranyakāṇḍa* of *Rāmāyaṇa*.

CO3: Understand *dharma* and its nuances, emphasizing its applicability in an individual's life through *Kishkindhakāṇḍa* and *Sundarakāṇḍa* of Ramayana.

CO4: Appreciate the triumph of *dharma* over *adharma* through *Yuddhakāṇḍa*of *Rāmāyaṇa*

CO5: Appreciate the spiritual values from *Rāmāyaṇa* in resolving personal and social conflicts through varied effective presentations of important episodes of the *Rāmāyaṇa*

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	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	-	-

15CHE211 CHEMICAL ENGINEERING THERMODYNAMICS 3 0 0 3

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 factors 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 Co-efficient models; Multi-component VLE – K-factor approach; Thermodynamic consistency of VLE data.

Criterion for liquid-liquid equilibrium; Estimation of distribution co-efficient 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.

Course Outcomes

CHE211.1	Students will understand thermodynamic definitions, ideal, non ideal gases, equations of state, gas mixtures and mixture rules
CHE211.2	Understand ideal and non ideal solutions, criterion for vapor liquid equilibrium(VLE),binary and multi-component VLE and criterion for liquid-liquid equilibrium
CHE211.3	Ability to estimate the feasibility of chemical processes and predict the criterion for chemical reaction equilibria
CHE211.4	Analyze homogeneous gas phase reactions , gas-liquid reactions and conversion calculations in chemical reactions

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 211.1	3	3											3	1	
CHE 211.2	3	3	1	1									3	2	
CHE 211.3	3	3	2										3	1	
CHE 211.4	3	3	1										3	1	

TEXTBOOK AND REFERENCE BOOKS:

1. *Y. V. C. Rao, Chemical Engineering Thermodynamics, 1st Ed., 2001*
2. *J. P. O'Connell and J. M. Haile, Thermodynamics: Fundamentals for Applications, Cambridge University Press, 2005*
3. *Yunus A. Cengel, Thermodynamics: An Engineering Approach, 7th Ed., 2010*

15CHE212 CHEMICAL TECHNOLOGY 4 0 0 4

Unit 1

Chemical processing, the role of a chemical engineers in process industries, importance of block diagrams and flow charts, unit operations, unit processes, process utilities and economics, industrial safety and pollution, outline of plant and equipment design, process control and instrumentation; Chlor-Alkali: Definition of electrochemistry, manufacture of soda ash by solvay process, manufacture of chlorine & caustic soda by diaphragm cell, advantages & disadvantages of diaphragm & comparison with mercury cell. Cement: Definition of cement &portland cement, process description, raw material, flow sheet & major engineering problems associated with the dry processes for manufacturing of portland cement; Glass & Ceramics: Definition and general composition of glass, raw material, methods of manufacture, special glasses - fused silica and high silica glass; Ceramics – properties, classification, manufacturing process; Types of refractories and manufacturing processes; kilns. Inorganic Acids: Flow sheet, raw materials, industrial applications, and engineering problems for Sulfuric acid (includes production of Sulfur) and Hydrochloric acid. Soap & Detergent industry: Continuous hydrolysis & saponification process, flow sheet for continuous process, for fatty acids, soap & glycerine; types of surface active agents, different constituents of detergent, manufacturing process of detergent (sulfonation and sulfation and compounding of detergent). Vegetable Oils: Extraction methods, hydrogenation of vegetable oils,

general methods of production; Pulp & Paper Industry: Kraft process for pulp manufacture, Fourdrinier and Cylinder Machine processes for paper manufacture, and paper finishing;

Unit 2

Fertilizer Industry: mixed and direct-application fertilizers, NPK value, granulation, Haber process for Ammonia synthesis; Petroleum Refining Industry: Constituents of petroleum, products of refining, processing or refining; Petrochemicals Industry: Unit operations, chemical conversions, manufacture of petrochemicals, reactions producing petrochemicals; Paints & Varnishes: Brief description of requirements for surface coatings, simple flow sheet of paint coatings, simple flow sheets of paint manufacturing process, varnishes & their applications; Dyes and Intermediates: Raw materials, important cyclic intermediates, chemical conversions, structure and classification of dyes.

Unit 3

Polymers & Plastics Industries: Definitions, types of polymers, classifications, polymerization reactions, manufacture of PE,PP, PVC; Phenolic and epoxy resin. Rubber Industries: Natural and synthetic rubber, rubber compounding, rubber fabrication, latex compounds, and rubber derivatives; Pharmaceutical: Classification, alkylation, condensation and cycliztaion, dehydration, halogenations, oxidation, sulfonation, amination. Fermentation process; Manufacture of antibiotic - Penicillin, Streptomycin and Erythromycin; Biologicals. Food industry: Types of processing (refining & milling, canning, concentration, freezing, drying, pasteurization); Sugar: Manufacture and refining of cane sugar, decolorization, bagasse, beet sugar.

Course Outcomes

CHE212.1 Understand the role of Chemical Engineers in chemical processing, plant location considerations and manufacture of various chemical products

CHE212.2 Analyze and understand the significance of unit processes and equipment involved in manufacture of organic and inorganic chemical products.

CHE212.3 Understand the production sequences and manufacturing processes involved in selected chemical process industries

CHE212.4 Develop knowledge to propose a process flow diagram with enhanced process parameters for improved performance in chemical process industries

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 212.1	1	2	3			3	3	3			2		1	2	3
CHE 212.2	3	3	3	2									3	3	3
CHE 212.3	3	3	3	2		2	3	3			2		3	3	3
CHE 212.4	3	3	2	3		2	3	3			2		3	3	3

TEXTBOOKS:

1. *C. E. Dryden, "Outlines of Chemicals Technology", 2nd Edition, Edited and Revised by M. Gopala Rao and M. Sitting, Affiliated East–West Press, 1993.*
2. *M. B. Hocking, "Handbook of Chemical Technology and Pollution Control", 3rd Edition, Academic Press, 2005.*
3. *G. I. Austin, "Shreve's Chemical Process Industries", 5th Edition, Tata McGraw Hill, Singapore, 1990.*

REFERENCES:

1. *Martin B. B. Hocking, "Handbook of Chemical Technology and Pollution", 3rd Edition, Academic Press, 2006.*
2. *M. Bickford, "Kirk-Othmer - Concise Encyclopedia of Chemical Technology", (2-volume set), 4th Edition, Wiley-Interscience, 1999.*

15CHE213 PROCESS HEAT TRANSFER 3 1 0 4

Unit 1

Modes of heat transfer – Fourier's law of heat conduction and applications; Thermal conductivity measurement; Steady state conduction with variable area; Heat transfer coefficient & film theory; Heat transfer in extended surfaces; Heat Transfer to Fluids without phase change: Concepts of heat transfer by convection – Natural and forced convection; Correlations for the calculation of heat transfer coefficients.

Unit 2

Analogies between transfer of momentum and heat – Reynold's analogy, Prandtl and Colburn analogies; Heat Transfer to Fluids with Phase Change – heat transfer from condensing vapors, drop wise film wise condensation, film condensation on vertical surface and horizontal tube bank; Heat transfer to boiling liquids – mechanism of boiling of saturated liquids; Heat exchangers – shell & tube, double pipe, flow

patterns, construction and operational features, theory & calculations, energy balances and effectiveness.

Unit 3

Heat exchanger design procedure – Effectiveness - NTU Method – Chart for different configurations; Theory of Evaporation; evaporator types; single effect and multiple effect evaporation; evaporator design considerations; Radiation heat transfer – Emissive power, Black body radiation, Emissivity, Stefan–Boltzman law, Planck's law, radiation between surfaces.

Course Outcomes

CHE213.1 Ability to understand conduction, convection, and radiation heat transfer modes

CHE213.2 Ability to estimate value of heat transfer coefficient for systems with and without phase change

CHE213.3 Ability to understand and solve the coupled heat transfer and fluid dynamics problems

CHE213.4 Design and analyze the performance of heat exchangers

CHE213.5 Design and analyze the performance of evaporators

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 213.1	3	3	2	2			2						3	3	1
CHE 213.2	3	3	3	2			2						3	3	1
CHE 213.3	3	3	3	3			2						3	3	1
CHE 213.4	3	3	3	2			1						3	3	1
CHE2 13.5	3	3	3	2			1						3	3	1

TEXTBOOKS:

1. *Binay K. Dutta, "Heat Transfer – Principles and Applications", PHI Learning Pvt. Ltd., 2001.*
2. *W. L. McCabe, J. C. Smith and P. Harriot, "Unit Operations in Chemical Engineering", 6th Edition, McGraw Hill, 2001.*
3. *J. P. Holman, "Heat Transfer", 8th Edition, McGraw Hill, 1997.*

REFERENCES:

1. F. P. Incropera, "Fundamentals of Heat and Mass Transfer", 6th Edition, Wiley, 2006.

2. J. M. Coulson, and J. F. Richardson, "Chemical Engineering Vol. 1", 4th Edition, Asian Books Private Limited, India, 1998.

15CHE285 CHEMICAL ENGINEERING INSTRUMENTATION LAB . 1 0 2 2

Measurements – Units and Dimensions, Unit Conversions, Significant Figures, Uncertainty in Measurements: Standard Error, Standard Deviation, Sampling and Confidence Intervals; Rating an Instrument – Interval, Range, Resolution, Sensitivity, Detection Limit, Repeatability, Reproducibility, Accuracy and Precision; Graphical Representation of Data – Scatter Plots, Linear, Log-Linear and Log-Log Plots, 3D and Contour Plots, Bar Charts

Pressure Measurement (Two Experiments) – Atmospheric, Gauge, Differential, Vacuum, Barometric Pressure, Static vs. Dynamic Pressure; U-tube Manometer, Capsule Gauge, Thermal Gauge, Capacitive Gauge, Ion Gauge; Safety: Pressure Regulator, Relief Valves, Rupture Disks, Pressure Test and Leak Test;

Temperature Measurement (Two Experiments) – Wet Bulb, Dry Bulb Temperatures and Dew Point; Thermometers, Thermistors, Resistance Temperature Devices (RTD), Thermocouples, Thermopiles, Pyrometers;

Flow Measurement (Two Experiments) – Positive Displacement, Differential Pressure, Variable Area, Mass Flow, Oscillatory, Ultrasonic Flow Meters; Orifice Meters, Venturi Meters, Compressible Flow, Pitot Tubes, Rotameters, Hot Wire Anemometers, Coriolis Flow Meters;

Analysis of Solids and Powders (One Experiment) – Bulk and Particle Density; Particle Size and Size Distribution – Sieve Analysis, Diffraction, Microscopy;

Concentration and pH in Gases and Liquids (One Experiment) – pH Meters, Introduction to Chromatography, Mass Spectrometry, Refractometry, Spectroscopy

Course Outcomes

CHE285.1 Understand the principles behind the process instrumentation for measurement of temperature, pressure, density, concentration etc.,

CHE285.2 Perform Gauge R&R Analysis and test the suitability of an instrument for a given process.

CHE285.3 Develop a working model of an instrument for measuring temperature and pressure separately.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE285.1	3				3								3	3	2
CHE285.2	3	3			3				3	2	1		3	2	2
CHE285.3	3	3			3				3	2	1		3	2	2

TEXTBOOKS / REFERENCES:

1. *G. S. Patience, "Experimental Methods and Instrumentation for Chemical Engineers", Elsevier, 2013.*
2. *V. R. Radhakrishnan, "Instrumentation and Control for the Chemical, Mineral and Metallurgical Processes", Allied Publishers Pvt. Ltd., 1997.*
3. *AlokBarua, "Fundamentals of Industrial Instrumentation", Wiley India, 2011*

15CHE286 CHEMICAL TECHNOLOGY LAB. 0 0 2 1

1. Estimation of the percentage of nitrogen in urea by Kjeldahl's method
2. Determination of the percentage of available chlorine in the given sample of bleaching powder.
3. Determination of acid value and iodine value of different oils (any two)
4. Estimation of saponification value of different oils (any two)
5. Determination of alkalinity and Total fatty matter by Soap analysis (any two)
6. Analysis of Flash point of a given oil (any two)
7. Determination of viscosity by red wood viscometer
8. Estimation of silica and moisture content in cement analysis.
9. Determination of sucrose content in the given sample of sugar
10. Analysis of the percentage of ash and lactose content in the given milk sample.

Course Outcomes

CHE286.1 Understanding the theoretical concepts by way of doing lab experiments

CHE286.2 Exposure for how the factors are affecting the experiments

CHE286.3 Able to understand the evaluation of material/product performance

CHE286.4 Work in a team to perform laboratory experiments and exposure for team work

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE286.1	3	3		1	2				3	2			3	3	1
CHE286.2	3	2		2	3				3	3			3	2	3
CHE286.3	2	3		3	2				2	2			2	3	3
CHE286.4	3	3		3	3				3	2			3	3	2

15SSK221 SOFT SKILLS I 1 0 2 2

CO#	Course Outcomes	Programme Outcomes
1.	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.	PO8, PO9, PO10, PO12
2.	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.	PO9, PO10, PO12
3.	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.	PO2, PO4
4.	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	PO10, PO12

5.	Verbal: At the end of the course, the students will have the ability to understand the nuances of English grammar and apply them effectively.	PO10, PO12
6.	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.	PO9, PO10, PO12

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.

TEXTBOOKS:

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

REFERENCES:

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

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

15CHE301 CHEMICAL REACTION ENGINEERING I 3 0 0 3

Unit 1

Elementary reactions - Rate equation and rate law, temperature dependency of rate of reaction (rate

constant) – Arrhenius, Collision and Transition State theories.

Non-elementary reactions, mechanisms of non-elementary reactions – the pseudo steady state hypothesis (PSSH).

Analysis of Batch Reactor Data – Integral and Differential analysis of data, rate parameter estimation using least square analysis and curve fitting.

Unit 2

Design / performance equations for homogeneous and Isothermal systems – Batch, mixed flow and tubular reactors; size comparison of different reactors for single reactions; Rate parameter estimation using experimental data from various reactors.

Combination of reactors for a single reaction; Mixed Flow Reactors in Series; Combined Reactors in Series – Plug flow followed by mixed flow and vice versa. Parallel reactors – feed distribution in parallel reactor configuration; Auto catalytic reactions - Recycle reactors, Optimization of recycle ratio.

Unit 3

Multiple reactions – series, parallel and series-parallel reactions; Conversion and Selectivity; Reactor design for series reactions; Reactor design for parallel reactions; Reactor design for Series-parallel reactions;

Adiabatic reactions; heat of reaction as a function of temperature; Temperature as a function of Conversion and vice versa; Cooling / heating requirements in near-isothermal operation; Effect of temperature on conversion and selectivity in multiple reactions;

Course Outcomes

CHE301.1 Estimate rate parameters rate constant, order, pre-exponential factor and activation energy from experimental data obtained from batch, mixed flow and plug flow reactors.

CHE301.2 Analyze the effect of parameters such as temperature, pressure etc., on reaction and reactor performance.

CHE301.3 Develop reaction mechanisms for non-elementary reactions based on experimentally determined rate

CHE301.4 Design and optimize reactors for single and multiple homogeneous reactions for required conversion, productivity and selectivity.

CHE301.5 Optimize recycle ratio for autocatalytic reactions

CHE301.6 Develop the relation between temperature and conversion for adiabatic reactions to operate them near isothermal.

CO-PO Mapping

CO Code	PO1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE301.1	3	2	3	2	3								3	2	
CHE301.2	3	3	3	3	3								3	3	3
CHE301.3	3			3									3	3	3
CHE301.4	3	3	3										3	3	3
CHE301.5	3	3	3		3								3	3	3
CHE301.6	3	3	3		3								3	3	3

TEXTBOOK AND REFERENCE BOOKS:

1. *Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley, 2004*
2. *Scott H. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall of India, 2000*
3. *G. F. Froment and K. B. Bischoff, Chemical Reactor Analysis and Design, 2nd Edition, John Wiley, 1990*

15CHE302 DIFFUSIONAL MASS TRANSFER OPERATIONS 3 1 0 4

Unit 1

Molecular diffusion in fluids, Fick's Law of diffusion, steady state diffusion under stagnant and laminar flow conditions. Diffusivity measurement and estimation, multi-component diffusion, diffusion in solids and its applications, eddy diffusion, mass transfer coefficients, theories of mass transfer, analogy equations, application of empirical correlations to known geometry suchas flat plates, wetted wall columns.Concept of mass transfer coefficients, inter phase mass transfer, two film theory, relationship between individual and overall mass transfer coefficients. Mass transfer in fluidized bed, flow past solids and boundary layers.Equipments for countercurrent and concurrent mass transfer operations.

Unit 2

Absorption and stripping – Gas liquid equilibria, Raoults and Henry's laws,Solubility of gases in liquid, choice of solvent; Material balance in countercurrent andconcurrent absorption and stripping, L/G ratio,absorption factor; Equipment for absorption, Graphical and analytical methods for tray column,

packed columns for absorption: rate based designs, HTU, NTU and HETP concepts, absorption with chemical reaction. Humidification and dehumidification: vapour liquid equilibria, theory of wet-bulb temperature and adiabatic saturationtemperature, Lewis relation, Lewis relation, psychometric chart, humidification and dehumidification equipments, enthalpy transfer concepts – temperature profiles in humidifier and dehumidifiers theory. Classification and design of cooling towers.

Unit 3

Drying: Solid-gas equilibria, mechanism of drying, drying curves, modes ofdrying operations, classification of dryers, industrial dryers for batch and continuous drying, time of drying in batch operation, estimation of size of rotary dryer based on rate concept.Crystallization:Equilibrium, theories of crystallization, purity, yield, energy requirements, kinetics of crystallization – nucleation and growth; population balance model, MSMPR crystallizer, crystallisation equipment.

Course Outcomes

CHE302.1 Understand fundamental concepts in mass transfer

CHE302.2 Ability to solve systems consisting of diffusion and convection

CHE302.3 Ability to estimate value of mass transfer coefficient for different systems involving fluid flow

CHE302.4 Design and analyze the performance of absorbers, humidifier, and crystallizer

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 302.1	3	3	3	3									2	2	2
CHE 302.2	3	3	3	3									2	2	2
CHE 302.3	3	3	3	3									2	2	2
CHE 302.4	3	3	3	1									3	3	3

TEXTBOOKS:

1. R. E. Treybal, Mass Transfer Operations, 3rd Edn. McGraw Hill 1981.

2. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, PHI Learning Private Ltd,

2013

REFERENCES:

1. *J. D. Seader, Ernest J. Henley, Separation Process Principles, 2nd Edition, Wiley India, 2011*
2. *Coulson, J. M. and Richardson, J. F. Chemical Engineering Vol. II, 4th Edn., Asian Books Pvt. Ltd. India. 1998.*
3. *McCabe, W. L. Smith, J. C. and Harriot, P. "Unit Operations in Chemical Engineering, 6th Edn, McGraw Hill Edn, 2001.*
1. *J. R. Welty, C. E Wicks, G. L. Rorrer and R. E. Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2000.*
2. *Foust, A. S. Wenzel, L. A. Clump, C. W. Naus, L., and Anderson, L. B. 'Principles of Unit Operations', 2nd Edn. Wiley, 1980.*
3. *Geankoplis, C. J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2004.*

15CHE303 STATICS AND STRENGTH OF MATERIALS 3 1 0 4

Unit 1

Principles of statics: Introduction to vector approach - free body diagram - forces in plane and space - concurrent forces - resolution of forces - equilibrium of particle. Statics of rigid bodies in two and three dimensions - moment of force - rigid body equilibrium - support reactions. Centroid and centre of gravity; Centroids of lines, areas, volumes and composite bodies - Second moment of area - polar moment of inertia - mass moment of inertia.

Unit 2

Simple Stresses and Strains: Hooke's law - Elastic limit linear strain - lateral strain - Analysis of varying sections - bars of composite sections – Thermal stresses. Shear force and bending moment; Different types of support conditions and loads - Cantilever – simply supported – Over hanging beams, point loads, uniformly distributed loads - Theory of Simple bending; flexural formula.

Unit 3

Torsion of circular sections; Derivation of torsional formula – Assumptions made Power transmitted – Solid and hollow shafts. Complex stress; principal stresses and principal planes - principal strains – graphical method. Thin Shells; Thin cyclindrical 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.

Course Outcomes

CHE303.1 To understand the vectorial and scalar representation of forces and moments and to develop simple mathematical model for engineering problems and carry out static analysis.

CHE303.2 To analyse & solve rigid body equilibrium problems using free-body diagrams and accurate equilibrium equations

CHE303.3 To gain a fundamental understanding of the concepts of stress , strain and moduli by applying it to solids subjected to elastic deformation

CHE303.4 To analyze statically determinate axial members, torsional members, and beams to determine axial forces, torque, shear forces, and bending moments.

CO-PO Mapping

CO Code	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 303.1	3		3										2	3	
CHE 303.2	2	2											3	1	
CHE 303.3	3	3	3	3										3	
CHE 303.4	3	3	3	3									2	3	3

TEXTBOOKS:

1. R. C. Hibbeler, "Statics and Mechanics of Materials" Prentice Hall, 2013.

2. F. W. Cheng, "Statics and Strength of Materials", McGraw Hill India, 2013.

REFERENCES:

1. *F. P. Beer, E. R. Johnston & D.Mazurek, "Vector Mechanics for Engineers: Statics", McGraw-Hill Higher Education, 2012.*
2. *J. M. Gere and B. J. Goodno, "Mechanics of Materials", CL Engineering, 2012.*

15ENV300 ENVIRONMENTAL SCIENCE AND SUSTAINABILITY 3 0 0 3

Unit 1

State of Environment and Unsustainability, Need for Sustainable Development, Traditional conservation systems in India, People in Environment, Need for an attitudinal change and ethics, Need for Environmental Education, Overview of International Treaties and Conventions, Overview of Legal and Regulatory Frameworks.

Environment: Abiotic and biotic factors, Segments of the Environment, Biogeochemical Cycles, Ecosystems (associations, community adaptations, ecological succession, Food webs, Food chain, ecological pyramids), Types of Ecosystems – Terrestrial ecosystems, Ecosystem Services, Economic value of ecosystem services, Threats to ecosystems and conservation strategies.

Biodiversity: Species, Genetic & Ecosystem Diversity, Origin of life and significance of biodiversity, Value of Biodiversity, Biodiversity at Global, National and Local Levels, India as a Mega-Diversity Nation (Hotspots) & Protected Area Network, Community Biodiversity Registers. Threats to Biodiversity, Red Data book, Rare, Endangered and Endemic Species of India. Conservation of Biodiversity. People's action.

Impacts, causes, effects, control measures, international, legal and regulatory frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil / land degradation / pollution

Unit 2

Linear vs. cyclical resource management systems, need for systems thinking and design of cyclical systems, circular economy, industrial ecology, green technology. Specifically apply these concepts to: Water Resources, Energy Resources, Food Resources, Land & Forests, Waste management.

Discuss the interrelation of environmental issues with social issues such as: Population, Illiteracy, Poverty, Gender equality, Class discrimination, Social impacts of development on the poor and tribal communities, Conservation movements: people's movements and activism, Indigenous knowledge systems and traditions of conservation.

Unit 3

Common goods and public goods, natural capital / tragedy of commons, Cost benefit analysis of development projects, Environment Impact Assessment (EIA), Environment Management Plan (EMP), Green business, Eco-labeling, Problems and solutions with case studies.

Global and national state of housing and shelter, Urbanization, Effects of unplanned development case studies, Impacts of the building and road construction industry on the environment, Eco-homes / Green buildings, Sustainable communities, Sustainable Cities.

Ethical issues related to resource consumption, Intergenerational ethics, Need for investigation and resolution of the root cause of unsustainability, Traditional value systems of India, Significance of holistic value-based education for true sustainability.

Outcomes:

ENV300.1	CO1: Integrate facts and concepts from ecological, physical and social sciences to characterize some common socio-environmental problems.
ENV300.2	CO2: Develop simple integrated systems and frameworks for solving common interconnected socio-environmental problems.
ENV300.3	CO3: Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.
ENV300.4	CO4: Identify the ethical underpinnings of socio-environmental issues in general.

CO-PO Mapping:

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ENV 300.1		1		1		2	3			2		1			
ENV 300.2	1		1				3			2		1			
ENV 300.3							3	2	1	2		1			
ENV 300.4							3	3		2		1			

15MAT214 PROBABILITY AND STATISTICS 2 1 0 3

Unit 1

Probability Concepts: Review of probability concepts - Bayes' Theorem.

Random Variable and Distributions: Introduction to random variable – discrete and continuous distribution functions - mathematical expectations – moment generating functions and characteristic functions. Binomial, Poisson, Geometric, Uniform, Exponential, Normal distribution functions (MGF, mean, variance and simple problems) – Chebyshev's theorem

Unit 2

Sampling Distributions: Distributions of Sampling Statistics, Chi-square, t and F distributions (only definitions and use). Central Limit Theorem.

Theory of estimation: Point Estimation, Unbiased estimator - Maximum Likelihood Estimator - Interval Estimation.

Unit 3

Testing of Hypothesis: Large and small sample tests for mean and variance – Tests based on Chi-square distribution.

Course Outcomes

15MAT214.1	Understand the basic concepts of probability and probability modeling.
15MAT214.2	Gain knowledge about statistical distributions and their properties
15MAT214.3	Get in-depth knowledge about statistical distributions and their real time applications.
15MAT214.4	Understand some approximation theorems on probability and distributions.
15MAT214.5	Know the importance of estimating the parameters of probability models.
15MAT214.6	Ability to make decisions under uncertainties using statistical testing of hypotheses

TEXTBOOK:

Douglas C. Montgomery and George C.Runger, Applied Statistics and Probability for Engineers, (2005) John Wiley and Sons Inc.

REFERENCE BOOKS:

1. J. Ravichandran, "Probability and Random Processes for Engineers", First Edition, IK International,

2015.

2. *Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition (2007), Pearson Education Asia.*
3. *Sheldon M Ross, Introduction to Probability and Statistical Inference, 6th Edition, Pearson.*
4. *A. Papoulis, and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", Fourth Edition, McGraw Hill, 2002.*

15CHE381 HEAT TRANSFER LAB. 0 0 2 1

Thermal conductivity of solid materials, transient heat conduction, electrical analogies, natural convection, forced convection, heat transfer in pool boiling, condensation heat transfer, steady and un-steady state heat transfer through submerged coils in agitated vessels. Radiation heat transfer, characteristics and efficiency of heat transfer equipments such as heat exchangers, jacketed pans and evaporators.

Course Outcomes

CHE381.1 Design of experiment based on theoretical concepts studied in classroom.

CHE381.2 Understanding of concept of heat transfer coefficient and its determination for various systems under different convection conditions.

CHE381.3 Understanding of operation and design concepts of heat exchangers

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE381.1	3	3	3					3	3	2	1		3	1	3
CHE381.2	3	2	1					3	1	1	1		3	1	3
CHE381.3	3	2	3					3	2	1	1		3	1	3

15CHE382 STRENGTH OF MATERIALS LAB. 0 0 2 1

Tensile test on metals and wires - determination of tensile strength, modulus of elasticity, percentage elongation; Hardness tests - Rockwell, Brinell hardness number; Impact test - Izod and Charpy - impact strength, energy and modulus estimation: Compression test; Torsion test on shafts - determination of Shear stress and modulus of rigidity; Static bending test – fibre stress at limit of proportionality, resilience, modulus of elasticity; Fatigue test - S-N curves; Deflection test on beams; Double shear test.

Course Outcomes

CHE382.1 To gain fundamental knowledge on the mechanical behaviour of materials when subjected to tensile, impact and bending loads.

CHE382.2 Familiarization of the experimental methods to determine the mechanical properties like strength, modulus, hardness, toughness and stiffness of materials

CHE382.3 Develop ability to work in groups and document results as reports

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CHE382.1	3	3							1				3	3	3
CHE382.2	3	3	3	3					2				2	3	2
CHE382.3									3						

15SSK321 SOFT SKILLS II 1 0 2 2

CO#	Course Outcomes	Programme Outcomes
1.	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.	PO9, PO10, PO11, PO12
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.	PO10, PO11, PO12
3.	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.	PO2, PO4
4.	Verbal: At the end of the course, the students will have the ability to relate, choose, conclude and determine the usage of right vocabulary.	PO10, PO12
5.	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.	PO10, PO12
6.	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.	PO9, PO10, PO12

CO-PO Mapping

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

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.

TEXTBOOKS:

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

REFERENCES:

1. *Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova*

2. *More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.*
3. *The BBC and British Council online resources*
4. *Owl Purdue University online teaching resources*

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

15CHE390 / 15CHE490 LIVE-IN-LAB. 3 cr

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 fourth semester or sixth semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth or seventh semester. The objectives and projected outcome of the project should be reviewed and approved by the Dept. chairperson and a faculty assigned as the project guide. On completion of the project, the student shall submit a detailed project report. The report shall be evaluated and the students shall appear for a viva-voce test on the project.

15CHE311 CHEMICAL REACTION ENGINEERING II 3 0 0 3

Unit 1

Steps in heterogeneous reactions – bulk diffusion, internal diffusion, adsorption, desorption and surface reaction; Rate expressions for different steps in heterogeneous systems; Thiele modulus and effectiveness factor.

Flow regimes in Gas-Solid and Liquid-Solid systems; Estimation of overall mass transfer coefficient in heterogeneous systems; Design of packed-bed, fluidized bed, slurry and trickle bed reactors;

Unit 2

Relative rates of reaction and mass transfer in non-catalytic reactions in Gas-liquid reactions – Hatta number; Effect of gas solubility on rate of reaction;

Models for fluid-solid reactions: Progressive conversion model and Shrinking core model; Rate controlling steps in fluid-solid non-catalytic systems; Reactor design for non-catalytic reactions.

Unit 3

Non-ideal mixing in reactors; Estimation of mean residence time distribution and dispersion in mixing vessels using tracer studies; Dispersion model and Tanks-in Series model.

Course Outcomes

CHE311.1 Develop rate expressions for different steps in heterogeneous catalytic and non-catalytic reactions

CHE311.2 Identify the rate limiting step in heterogeneous reactions

CHE311.3 Design catalysts for pore diffusion control / elimination

CHE311.4 Analyze the effect of parameters on heat and mass transfer in heterogeneous systems

CHE311.5 Design reactors for Gas-Solid & Liquid-Solid catalytic and non-catalytic reactions

CHE311.6 Analyze the effect of non-ideal mixing in reactors on mean residence time and reactor performance

CHE311.7 Estimate kinetic rate parameters using experimental data from multi-phase reactors

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 311.1	3	3											3		2
CHE 311.2		3		3									3		
CHE 311.3				3									3		3
CHE 311.4				3									2	3	3
CHE 311.5			3		3										3
CHE 311.6				3									3		
CHE 311.7					3									3	

TEXTBOOK AND REFERENCE BOOKS:

1. *Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John-Wiley & Sons Inc., 1999*
2. *Scott H. Fogler, Elements of Chemical Reaction Engineering, 3rd Edition, PHI Limited, 2004*
1. *Peter Harriot, Chemical Reactor Design, Marcel and Dekker Inc., 2003*
2. *Froment, Bischoff and De Wilde, Chemical Reactor Analysis and Design, 3rd Edition, John-Wiley & Sons Inc., 2011*
3. *Hugo A. Jakobsen, Chemical Reactor Modeling: Multiphase Reactive Flows, Springer-Verlag, 2008*

15CHE312 EQUILIBRIUM STAGED OPERATIONS 3 1 0 4

Unit 1

Design of mass transfer equipment based on the concept of equilibrium stage;

Distillation: vapor-liquid equilibria, Raoults 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.

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.

Unit 3

Leaching: Solid-liquid equilibria; Equipment – batch and continuous types; Calculation of number of stages.

Adsorption and Ion exchange: Theories of adsorption of gases and liquids; Principle of ion exchange; Equipment for batch and continuous operation; Design calculations for adsorption and for ion exchange resins.

Miscellaneous separation processes: Introduction to membrane separation process; Solid and liquid membranes; Reverse osmosis; Electrodialysis.

Course Outcomes

15CHE312.1 Develop a strong conceptual understanding of various mass transfer processes

15CHE312.2 Understand general design and operations of mass transfer equipments

15CHE312.3 Analyze chemical engineering operations involving mass transfer equipments

15CHE312.4 Ability to solve problems involving staged mass transfer processes such as distillation, extraction, adsorption, absorption and leaching.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
15CHE 312.1	3	2	2						2				3		
15CHE 312.2	3	2	2						2				3	2	
15CHE 312.3	3	3	2						2				3	2	
15CHE 312.4	3	3	3	2					2				3	2	

TEXTBOOKS:

1. R. E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.

2. J. D. Seader and E. J. Henley, Separation Process Principles, 2nd Edition, Wiley, 2005.

REFERENCES:

1. J. M. Coulson and J. F. Richardson, "Chemical Engineering Vol. II", 4th Edition, Asian Books Pvt. Ltd, India, 1998.

3. W. L. McCabe, J. C. Smith and P. Harriot, "Unit operations of Chemical Engineering", 6th Edition,

McGraw Hill, International Edition, 2001.

15CHE313 MATERIALS TECHNOLOGY 3 0 0 3

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 matempering – Austempering – Hardenability and its testing – TTT diagram – Surface hardening of steels – carburising, nitriding, induction hardening. Effect of alloying elements on steel - Non-ferrous alloys – copper-aluminum – Magnesium, nickel and zinc-Composite materials – Ceramics.

Course Outcomes

CHE313.1	To understand the structure, directions, planes and directions in polycrystalline materials
CHE313.2	To understand the different types of deformation and mechanical behavior of materials
CHE313.3	To create awareness on the various test methods for the selection of materials for specific applications
CHE313.4	To gain fundamental knowledge on the construction of phase diagrams for alloy systems
CHE 313.5	To analyze the various heat treatment processes and the corresponding changes in the structure and properties of metals and alloys

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 313.1	3	2											2		
CHE 313.2	2	2	3										2		
CHE 313.3	3	3	3	3									3	3	
CHE 313.4	2	3	3	2									3	2	2
CHE 313.5	2	2	2	2										3	3

TEXTBOOKS:

3. R. Balasubramaniam, "Callisters Materials Science and Engineering", Wiley, 2013.

4. W F Smith, J Hashemi, R Prakash, "Materials Science and Engineering", McGraw Hill 2008.

REFERENCES:

1. L H Van Vlack, Elements of Materials Science and Engineering, Pearson India 2008

2. D. R .Askeland, P. P Fulay, W. J .Wright,The Science and Engineering of Materials, CL Engineering 2012

15CHE314 PROCESS DYNAMICS AND CONTROL 3 1 0 4

Unit 1

Laplace transformation, transform of standard functions, derivatives and integrals; Open–Loop systems, first order systems: concept of transfer functions, transient response for standard input functions, physical examples of first order systems, first order systems in series, linearization and its application in process control, second order systems and their dynamics, transportation lag.

Unit 2

Closed loop control systems, development of block diagram for feedback control systems, servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic and electronic controllers; transient response of closed – loop control systems; stability of control systems:Routh-Hurwitz criterion, root locus diagrams.

Unit 3

Frequency response of closed – loop systems,control system design by frequency response techniques, bode diagram and stability criterion, tuning of controller settings.Introduction to advanced control systems - cascade control, Feed-forward control; Control of chemical processes.

Course Outcomes

CHE314.1 Understand the necessity for process control in chemical process plants and apply basic principles to dynamic modelling, developing transfer functions and system behaviour study to various input functions.

CHE314.2 Develop block diagram and utilize control algorithms to design and analyse transient response of control schemes for various configurations.

CHE314.3 Analyse stability of control Systems and tuning of process controllers.

CHE314.4 Application of control systems in chemical processes.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 314.1	3	3	3	3		1							3	3	1
CHE 314.2	3	3	3	3									3	3	3
CHE 314.3	3	3	3	3	2								3	3	3
CHE 314.4	3	3	3	2									3	3	1

TEXTBOOKS:

M.D. Coughanowr, "Process Systems Analysis and Control - 2nd Edn., McGraw Hill, New York, 1991.

N. G. Stephanopoulos, "Chemical Process Control", 8th Edn, Prentice Hall of India. 2009.

REFERENCE BOOKS:

1. Dale E. Seeborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle, Process Dynamics and Control, 3rd Edition, John Wiley and Sons, 2011

2. Peter Harriot, Process Control, Tata McGraw Hill, 2008

15MAT302 NUMERICAL METHODS 2 0 2 3

Unit 1

Review of Errors: Accuracy and Precision, round-off error and truncation error. (Sec. 2.2-2.4)

Roots of Transcendental and Polynomial Equations: Bisection method, Iteration methods based on first degree equation, Rate of convergence, System of nonlinear equations. (Sec. 4.2, 4.3, 5.1-5.3, 5.5)

Review of Matrix Algebra: Systems of Equations, Eigenvalues and Eigen vectors.

Solution of System of Linear Algebraic Equations: Gauss Elimination and Gauss Jordan Methods. Iteration Methods. Eigenvalues and Eigenvectors: Jacobi Method for symmetric matrices and Power Method for arbitrary matrices. (Sec. 8.2, 8.7, 10.2, 22.2)

Unit 2

Interpolation and Approximation: Lagrange and Newton interpolation for unequal intervals, Finite difference operators, Interpolating polynomials using finite differences. (Sec. 13.1 – 13.4, 13.6)

Unit 3

Review of Ordinary Differential Equations:

Solutions of Ordinary Differential Equations: Initial value problems - Single step methods - Taylor Series Method, Second , Third and Fourth order Runge Kutta Methods. (Sec. 20.1 – 20.3, 21.2)

Lab. - Implementation of these methods: MATLAB or EXCEL or Free and Open Source Software (FOSS) tools like R-programming and Scilab.

Course Outcomes

15MAT302.1	Understand and apply different numerical methods to solve algebraic, transcendental equations and system of nonlinear equations
15MAT302.2	Understand and apply power method, Jacobi method to find eigenvalues and eigenvectors
15MAT302.3	Understand and apply concept of interpolation and inverse interpolation
15MAT302.4	Understand and implementation of methods Taylors series, Euler method, modified Euler method and RK methods to solve ODE
15MAT302.5	Implementation of numerical methods using MATLAB and writing efficient well documented MATLAB codes and present numerical methods in an informative way.

TEXTBOOK:

Steven Chapra and Raymond Canale, Numerical Methods for Engineers, McGraw Hill, 2007.

REFERENCE BOOKS:

1. *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.*
2. *C. F Gerald and P. O Wheatley, Applied Numerical Analysis, 7th edition, Addison Wesley, 2009.*
3. *Rizwan Butt, Introduction to Numerical Analysis Using MATLAB, Jones and Bartlett Publisher, 2010.*
4. *Abdelwahab Kharab, Ronald B, An Introduction to Numerical Methods: A MATLAB Approach, Third Edition, CRC Press, 2012.*

15CHE385 CHEMICAL REACTION ENGINEERING LAB. 0 0 2 1

Lecture on RTD studies; Study of kinetic expressions for first and second order reactions,kinetic studies in batch reactor, Semi batch reactor, Sono batch reactor, CSTR, PFR, Combined reactor in series,RTD study in CSTR in series, RTD study in a PFR.

Course Outcomes

CHE385.1	Evaluate the kinetic parameters for a given reaction from the experimental data obtained from different reactors
CHE385.2	Design reactors using experimentally obtained kinetic parameters and performance equation for a specified conversion
CHE385.3	Determine conversion in various reactors and compare it with the theoretical value
CHE385.4	Estimate the mean residence time and mixing behavior based on RTD studies

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE385.1	3	3			1				3	3			3	1	3
CHE385.2	3	3			1				3	3			3	1	3
CHE385.3	3	3			1				3	3			3	1	3
CHE385.4	3	3			1				3	3			3	1	3

15CHE386 MASS TRANSFER LAB. 0 0 2 1

Measurement of Diffusion coefficient, measurement of mass transfer coefficient, Concentration profile, Wetted wall column, Ternary Liquid-liquid Equilibrium, Leaching, Extraction in packed and plate columns. Steam distillation, Simple distillation, Distillation in packed columns. Absorption Isotherms Drying rate measurements. Characteristics and Efficiency of mass transfer equipments.

Course Outcomes

CHE386.1 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

CHE386.2 Understand the basic principles of distillation and conduct simple, steam and packed bed distillation experiments.

CHE386.3 Understand the basic principles of leaching and conduct co-current single stage ,multistage leaching and counter current leaching

CHE386.4 Understand the principles of adsorption and determine the amount of adsorbate on the surface of adsorbent and interpret through adsorption isotherms

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE386.1	3	2	2						3	2			3	2	
CHE386.2	3	2	2						3	2			3	2	
CHE386.3	3	2	2						3	2			3	2	
CHE386.4	3	2	2						3	2			3	2	

15SSK331 SOFT SKILLS III 1 0 2 2

CO#	Course Outcomes	Programme Outcomes
1.	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.	PO9, PO10, PO12
2.	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 ca positive attitude and courteous communication.	PO8, PO9, PO10, PO12
3.	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.	PO2, PO4
4.	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.	PO10, PO12
5.	Verbal: At the end of the course, the students will have the ability to decide, conclude, identify and choose the right grammatical construction.	PO10, PO12

6.	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.	PO9, PO10, PO12

CO-PO Mapping:

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

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.

TEXTBOOKS:

1. *A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.*
2. *Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.*
3. *Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.*
4. *The Hard Truth about Soft Skills, by Amazone Publication.*
5. *Data Interpretation by R. S. Aggarwal, S. Chand*
6. *Logical Reasoning and Data Interpretation – Niskit K Sinkha*
7. *Puzzles – Shakuntala Devi*
8. *Puzzles – George J. Summers.*

REFERENCES:

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

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

15CHE396 PROJECT BASED LEARNING - PHASE - II 2 cr

Students will apply the concepts that they have studied in Project Based Learning - I, and proceed with executing the project as per plan. The instructor provides guidance through tutorial classes to help the students to master problem solving and analytical aspects. There will be requirement of literature review report, two mid-project reports and a final report, each of which will be used towards course evaluation.

Course Outcomes

CHE396.1 Ability to construct detailed process flow chart

CHE396.2 Understand aspects of equipment, process, and plant design & economics

CHE396.3 Ability to prepare a detailed project report for set up of a chemical plant

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO3
CHE396.1	3	1	3	1	2		2			1			3	2	1
CHE396.2	3	3	3	2			2						1	3	3
CHE396.3	1									3					3

15CHE401 ROCESS DESIGN AND INTEGRATION 3 0 0 3

Unit 1

Chemical process design process, Hierarchy of chemical process design and integration, Newdesign vs. retrofit, approaches, Heuristics for process design. Conceptual Process Synthesis – Diagrams for understanding chemical processes, Structure and hierarchical synthesis of flow sheets.

Reactor Network Synthesis - Reactor type and conditions 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 equipments.

Course Outcomes

CHE401.1 Understand the concepts and hierarchy of chemical of process design. Apply heuristics to process design. Synthesize flow sheets.

CHE401.2 Use knowledge of reaction type and kinetics to identify performance criterion, optimum reactor configurations, conditions and reactor networks.

CHE401.3 Apply heuristics and thermodynamic principles to separation system synthesis - distillation columns sequencing for ideal and non-ideal mixtures.

CHE401.4 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

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 401.1	3	3	3	1			1						3	3	3
CHE 401.2	3	3	3	3	1								3	3	3
CHE 401.3	3	3	3	3	1								3	3	3
CHE 401.4	3	3	3	3	1		1						3	3	3

TEXTBOOK:

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

REFERENCES:

1. *Warren D. Seider, J. D. Seader, Daniel R. Lewin, Soemantri Widagdo, Product and Process Design Principles: Synthesis, Analysis and Design, 3rd Edn, Wiley, 2010*
2. *Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, 3rd Edn, Pearson Education, 2008*

3. *Biegler, L. T., Grossmann, I. E., and Westerberg, A. W. "Systematic Methods for Chemical Process Design", Prentice-Hall, 1997.*
4. *Douglas, J. M. "Conceptual Design of Chemical Processes", McGraw Hill, 1988.*
5. *Harry Silla, Chemical Process Engineering Design and Economics, Marcel Dekker, Inc., New York, 2003*

15CHE402 PROCESS EQUIPMENT DESIGN AND DRAWING 2 0 2 3

Design and drawing of chemical engineering equipments – hydrodynamic design, process design, mechanical design and drawing of the following equipments:

Unit 1
Pressure Vessels, Storage Tanks, Heat exchangers, Condensers.

Unit 2
Evaporators, Dryers, Cooling towers, Crystallizers.

Unit 3
Absorption columns, Distillation columns, Extraction columns, Reactors.

Course Outcomes

CHE402.1 Knowledge of basics of process equipment and important parameters of process equipment design

CHE402.2 Able to process design of pressure vessels, shell and tube heat exchanger and condenser

CHE402.3 Able to process design of storage vessels, evaporator, packed bed absorption column and crystallizer.

CHE402.4 Able to process design of sieve tray distillation column, reactor, dryer and cooling tower

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 402.1	3	2	2						1				3	3	1
CHE 402.2	2	2	3			1			2				3	3	1
CHE 402.3	2	2	3			1			2				3	3	1
CHE 402.4	2	2	3			1			2				3	3	1

TEXTBOOKS:

1. *M. V. Joshi and V. V. Mahajan, "Process Equipment Design", 3rd Edition, MacMillan India Ltd., 1996.*
2. *J. M. Coulson and J. F. Richardson, "Chemical Engineering Vol. 6", Asian Books Pvt Ltd, India, 1998.*

REFERENCES:

1. *R. H. Perry, D. W. Green and J. O. Maloney, "Perry's Chemical Engineers Handbook", 7th Edition, 1997.*
2. *S. D. Dawande, "Process Design of Equipments", Central Techno Publications, Nagpur, 2000.*
3. *"Indian Standard Specifications", IS: 2712-1998; IS: 2825-1969; IS: 3233-1965; IS: 4049-1996; IS: 4179-1967;IS: 4503-1967; IS: 4865-1968 Indian Standards Institution, New Delhi.*
4. *S. Tickoo, "AUTOCAD 2000", Galgotia Publications, New Delhi, 2001.*
5. *D. Kern, "Process Heat Transfer", McGraw Hill, 1999.*

15CHE403 TRANSPORT PHENOMENA 3 1 0 4

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.

Course Outcomes

15CHE403.1 Understanding of mechanism of various transport processes like momentum, heat and mass transport

15CHE403.2 Develop shell balances for steady flow through various geometries in momentum, heat and mass transport problems

15CHE403.3 Analyze chemical engineering industrial problems along with their appropriate boundary conditions for momentum, heat and mass transport problems

15CHE403.4 Ability to develop steady and time dependent solutions with their limitations for momentum, heat and mass transport problems.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
15CHE 403.1	3	2	2	2					2				3	2	
15CHE 403.2	3	2	2	2					2				3	3	
15CHE 403.3	3	3	2	2					2				3	3	
15CHE 403.4	3	3	3	3					2				3	3	

TEXTBOOK:

R. B. Bird, W. E. Stewart and E. W. Lightfoot, "Transport Phenomena", 2nd edition, John Wiley, 2002.

REFERENCES:

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

15CHE481 CHEMICAL PROCESS CONTOL LAB. 0 0 2 1

Calibration of temperature, pressure and flow measuring instruments, Dynamics of first order, second order, interacting and non-interacting systems, Control valve characteristics, Study of control systems involving temperature, pressure, flow and level, Study advanced control strategies and Controller tuning.

Course Outcomes

CHE481.1 Understand the dynamic response of first and second order systems, first order systems in series in interacting and non-interacting manner different input functions and evaluate system parameters

CHE481.2 Understand the types of control valves, temperature measuring devices and their characteristics

CHE481.3 Analyse the response of control systems (level, flow, pressure etc) in different control configurations and control parameter settings, perform tuning of control configurations

CHE481.4 Understand and analyse the dynamic response of advanced control configurations

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CHE481.1	3	3		3	3				3	3			3	3	3	
CHE481.2	3	3		3	3				3	3			3	3	3	
CHE481.3	3	3		3	3				3	3			3	3	3	
CHE481.4	3	3		3	3				3	3			3	3	3	

15CHE482 COMPUTER AIDED DESIGN OF CHEMICAL PROCESS LAB. **1 0 2 2**

Introduction to Aspen PLUS/ HYSYS; Thermodynamic 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, Equilibrium reactors and their combinations); Simulation of Distillation, Absorption and Extraction columns;

Case study set up and Sensitivity analysis.

Course Outcomes

CHE482.1 Understand the basic structure of a process simulation software
CHE482.2 Formulate governing equations for a process based on conservation principles and analyze degrees of freedom for a stream, equipment and process
CHE482.3 Develop and simulate a process flow sheet based on given problem statement
CHE482.4 Perform case studies for a chemical process

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE482.1	3	3			3				3				3	3	2
CHE482.2	3	3			3				3				3	3	2
CHE482.3	3	3			3								3		
CHE482.4	3	3			3		3						3	2	

15CHE495 PROJECT PHASE I **2 cr**

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.

Course Outcomes

15CHE495.1 Create a set up through proper design and investigate the system using the engineering knowledge acquired

15CHE495.2 Estimate and manage the cost and time of the project

15CHE495.3 Present the project with clarity and ethics in both oral and written mode

15CHE495.4 Develop a team and effectively participate in the team to execute the project

15CHE495.5 Support the environmental , social and engineering discipline through the project

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
15CHE495. 1	3	3	3	3	3								3	3	3
15CHE495. 2											3		3	3	
15CHE495. 3								3	3	3			3		3
15CHE495. 4									3				3		3
15CHE495. 5						3	3					3	3		3

15CHE499 PROJECT PHASE II 10 cr

Setting up of the experimental work (hardware/software), carrying out the experimental work, carrying out material characterization if required, analysis of the results, discussion and interpretation of the results, validation of the hypothesis, and reporting project outcome in the approvedformat.

Presentation of the work / findings to the faculty for review and feedback three times during the semester.

The final project will be evaluated by expert panel consisting of internal and external examiners.

Course Outcomes

15CHE499.1 Create a set up through proper design and investigate the system using the engineering knowledge acquired

15CHE499.2 Estimate and manage the cost and time of the project

15CHE499.3 Present the project with clarity and ethics in both oral and written mode

15CHE499.4 Develop a team and effectively participate in the team to execute the project

15CHE499.5 Support the environmental , social and engineering discipline through the project

CO-PO Mapping

CO Code	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PS O2	PS O3
15CHE499.1	3	3	3	3	3								3	3	3
15CHE499.2											3		3	3	
15CHE499.3								3	3	3			3		3
15CHE499.4									3				3		3
15CHE499.5						3	3					3	3		3

ELECTIVES

15CHE431 BIOCHEMICAL ENGINEERING 3 0 0 3

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 equipments.

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.

Course Outcomes

CHE431.1 Understand the basics of biomolecules and microbes to study different biochemical reactions.

CHE431.2 Study the basic concepts and kinetics of enzyme and immobilized enzyme

CHE431.3 Design and analyze the bioreactors

CHE431.4 Understand the downstream processing and industrial bioreactors

CO-PO Mapping

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CHE 431.1	1	1					1						1	1	1
CHE 431.2	2	2					1						3	2	1
CHE 431.3	3	3	3				1						3	3	2
CHE 431.4	3	3	3				1						3	3	3

TEXTBOOK:

1. *E Bailey and D. F. Ollis, "Biochemical Engineering Fundamentals", McGraw Hill, International Edition, 2nd Edition, New York, 1986.*

REFERENCE BOOKS:

1. *J. M. Lee, "Biochemical Engineering", 1st Edition, Prentice Hall, 1992*
2. *H. W. Blanch and D. S. Clark, "Biochemical Engineering", 2nd Edition, CRC Press, 1997.*
3. *M. L.Shuler and F. Kargi, "Bioprocess Engineering Basic Concepts", Prentice Hall of India, 2002.*
4. *D Mukesh and N. G. Sathyanarayana, "Biochemical Engineering", PHI Learning Pvt. Ltd., 2007*

15CHE432 CHEMICAL PROCESS MODELING AND SIMULATION 3 0 0 3

Unit 1

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 modelling.

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.

Unit 2

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.

Triple effect evaporator; Binary distillation: continuous and batch columns; Multicomponent distillation: Underwood-Gilliland model; Gas absorption into a laminar liquid jet; Tray tower absorption: Kremser-Brown-Sauders equation, rigorous models; Reactive absorption in a wetted wall column; Multistagecountercurrent liquid-liquid extraction.

Unit 3

Selected Systems from the following: Multiple steady states and Stability: Isothermal and Non-isothermal CSTR; Temperature control in a non-isothermal PFR; Packed bed reactor; Polymerization: Bulk and Suspension polymerization; Membrane separation – Cross flow and reverse osmosis; Activated sludge

process – secondary bioreactor; Pyrolysis of plastic; Chemical vapor deposition; Continuous, multicomponent distillation column; Dry flue gas desulfurization; Ball mill; Rotary kiln.

Course Outcomes

CHE432.1 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.

CHE432.2 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.

CHE432.3 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.

CHE432.4 Derive mathematical models for basic chemical engineering unit - lumped, distributed, and staged - operations and processes. Solve the models either by analytical techniques or set up a solution by numerical techniques.

CHE432.5 For a complex chemical system, construct a mathematical model in general terms, perform a dimensional analysis to understand interactions between competing phenomena, identify controlling physics, and reduce the model to simpler cases.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 432.1	3	3	2	3		1	2		3			3	3	3	3
CHE 432.2	3	3	3	3		1	1					3	3	3	3
CHE 432.3	3	3	3	3		1	1					3	3	3	3
CHE 432.4	3	3	3	3	3	1	1					3	3	3	3
CHE 432.5	3	3	3	3		1	2					3	3	3	3

TEXTBOOK / REFERENCE:

1. W. L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd Edition,

McGraw Hill, 1996.

2. *C. L. Smith, R. W. Pike and P. W. Murrill, Formulation and Optimization of Mathematical Models, International Textbook Company, USA, 1970.*
3. *L. T. Biegler, E. I. Grossman and A. W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, 1997.*

15CHE433 ENVIRONMENTAL ENGINEERING FOR PROCESS INDUSTRIES 3 0 0 3

Unit 1

W ater 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 equipments. 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; valueextraction 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.

Course Outcomes

CHE433.1 To develop basic knowledge on water pollutants and wastewater characteristics

CHE433.2 To understand various unit operations and unit processes involved in wastewater treatment

CHE433.3 To design and apply specific treatment methods for effluents of various chemical process industries

CHE433.4 To design and apply specific treatment methods for air pollutants of various chemical process industries

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 433.1	2	1	2	1									1	2	3
CHE 433.2	3	2	2	3		3	3	3			3		3	3	3
CHE 433.3	3	3	3	3		3	3	3			3		3	3	3
CHE 433.4	3	3	3	3		3	3	3			3		3	3	3

TEXTBOOKS / REFERENCES:

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

1995.

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

15CHE434 INTERFACIAL SCIENCE AND ENGINEERING 3 0 0 3

Unit 1

Introduction – colloids, surfaces and interfaces, Colloids - classifications and characterizations. Colloids - preparation and purification methods - Surfaces and interfaces – definitions, description of different surface and interfaces, applications of interfacial engineering - Surface, interfacial tensions and measurement of interfacial tension using different methods - Surface properties.

Attractive forces and van der Waals interactions - Columbic forces and ionic, dipole interactions. Van der Waals forces in polar and non-polar media - Electrostatic and Electrokinetic theories.

Source of interfacial formation and electrical double layer (EDL) - Helmholtz model, Gouy-Chapmanmodel, Debye–Hückel theory on EDL, EDL thickness - Surface potential, Zeta potential, pH effects, calculations - Electroosmosis and Electrophoresis, types, applications.

Unit 2

Capillary theories, Capillary driving forces in liquid–fluid systems, Solid–Liquid– Fluid Systems: The Effect of Contact Angle - Capillary Flow and Spreading Processes, coefficients, petroleum recovery, measurement of capillary driving forces - Surface tension gradients, marangoni flow, contact angle hysteresis, dynamic contact angles, Practical capillary systems – wetting in fibers, water proofing, wicking process and detergency.

Adsorption – Gibbs surface excess, adsorption equation for Solid-Fluid interfaces, Gibbs adsorption isotherm – Physisorptionvs Chemisorption, Thermodynamic considerations, heterogeneous catalysis.

Catalytic poisons, promoters and adsorption isotherms at S-V interfaces, Langmuir, Freundlich, BET adsorption isotherms and surface area calculations, adsorption at S-L interfaces - Adsorption isotherms in solid–liquid systems, nature of the adsorbent surface, environmental effects - Colloidal stability –

Coagulation, flocculation, mechanism for colloidal formation.

Unit 3

Colloidal behaviour, Lennard–Jones 6–12 potential, attractive forces, sources of colloidal stability, critical coagulation concentration -Coagulation kinetics - fast and slow, Smoluchowski equation, DLVO theory, reversible flocculation.

Emulsions - formation, emulsification methods-Emulsifiers and Stabilizing agents, types, functions.

HLB number, PIT and Application of HLB and PIT in Emulsion Formulation - Association colloids - vesicles, micelles and membranes -Surfactant solubility, krafft temperature, and cloud point - Surfactant liquid crystals, micelles, micelle formation – Critical micelle concentrations (CMC) - factors affecting CMC, additives - Vesicles and bilayer membranes – definitions, applications.

Optical properties - Light scattering, turbidity, light scattering theories - Scattering by small particles, large particles, Rayleigh, Debye and Mie scattering of particles - Foams, Aerosols, Foam stability and microfoams - Rheological properties of colloidal dispersions - viscosity, newtonian and non-newtonian fluids, Electroviscous effects.

Course Outcomes

CHE434.1 Understand the fundamental theories associated with the surface and interface properties

CHE434.2 Understand the surface and interfacial phenomena of thin film coatings and colloids

CHE434.3 Analyze the role of surface and interface properties in the processings of different industrial products, intermediates and raw materials

CHE434.4 Design of new product formulations with superior surface and interface properties

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 434.1	1	2	1	1	2		2						2	1	
CHE 434.2	3	2	1	1	2		2						2	1	
CHE 434.3	3	3	1	1	1		1						3	2	
CHE 434.4	3	2	3	2	1		1						1	3	

REFERENCE / TEXTBOOKS:

1. *Drew Myers, Surfaces, Interfaces, and Colloids: Principles and Applications. 2nd Ed., Wiley-VCH, 1999*
2. *D. J. Shaw, Colloid & Surface Chemistry, 4th Edition, Butterworth-Hienemann, 2003,*
3. *Intermolecular and Surface Forces, Jacob N. Israelachvili, Academic Press, 1992*

15CHE435 MATERIAL CHARACTERIZATION AND SPECTROSCOPIC METHODS 3 0 0 3

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.

Course Outcomes

15CHE435.1 Understand the fundamental principles behind the individual characterization methods which are included in the curriculum.

15CHE435.2 Analyze, interpret and present observations from the different characterization methods.

15CHE435.3 Assess which methods of characterization are appropriate for different material / requirement/ condition/ problems.

15CHE435.4 Able to evaluate the uncertainty of observations and results from the different characterization methods.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE435.1	3	3	2									2	2		1
15CHE435.2	3	2	2				2						2	2	2
15CHE435.3	2	2	2	2	3					2		2	2	1	
15CHE435.4	2	2	2	3									2		2

REFERENCE / TEXTBOOKS:

1. *Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods 2013, Wiley VCH; ISBN-10: 3527334637, ISBN-13: 978-3527334636.*
2. *B D Cullity and S R Stock, Elements of X-ray diffraction, 3rd Ed., Prentice Hall 2001*
3. *K P. Menard Dynamic mechanical analysis: A practical introduction, CRC press, 1999*

15CHE436 MODERN SEPARATION METHODS 3 0 0 3

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 Equipments - Other Techniques: Supercritical Fluid Extraction, Oil Spill Management; Industrial Effluent Treatment by Modern Techniques. Reactive Extraction, Reactive Distillation.

Course Outcomes

CHE436.1 Ability to design multi component distillation columns with multiple feed streams

CHE436.2 Describe the the structure,characteristics and operational features of different types of synthetic membranes and membrane modules

CHE436.3 Explain the characteristic features,applications, limitations and advantages of separation operations like filtration, reverse osmosis, electrodialysis,pervaporation, gas separation and chromatographic separations

CHE436.4 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

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 436.1	2	3	2		2								2	2	
CHE 436.2	3		2										3		
CHE 436.3	3	2	2		2		1						3	2	
CHE 436.4	3		2				1						3		

REFERENCES:

- *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.*
- *J. M. Coulson and J. F. Richardson, "Chemical Engineering - Volume 2", 5th Edition, Butterworth-Heinemann, 2002.*
- *Y. Osada and T. Nakagawa, "Membrane Science and Technology", Marcel Dekker, 1992.*
- *Relevant journal publications.*

15CHE437 NANOSCIENCE AND NANOTECHNOLOGY 3 0 0 3

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 - Carbon nanotubes and fullerenes: Formation and properties of nanotubes, fullerenes, characterizations and their applications in electronics and energy storage.

Molecular switches –monomolecular in solutions, on surfaces (electron, pH and light driven switches).

Unit 3

Micro/ Nanoelectronics (Nanowires: transistors, LEDs, Lasers, photodetectors).

Nano-Bio Technology (Lipid and lipid templates, selfassembled monolayers, biological computing, Protein Engineering, biosensors, drug delivery, PDT), Social implications of nanotechnology.

Course Outcomes

15CHE437.1 Understanding of length scale concepts, top-down and bottom-up preparation methods of nanomaterials and nanostructures

15CHE437.2 Demonstrate the principles of processing and characterization methods of nanomaterials and nanoensembles

15CHE437.3 Apply the electron and scanning probe microscopes to characterize and to manipulate different nanostructures and nanodevices.

15CHE437.4 Evaluate and analyze the electrical, mechanical and thermal properties of nanostructured metals and semiconductors, quantum dots and carbon nanotubes

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE437.1	2	1	2		2										
15CHE437.2	1	1	2	1	2								1	1	
15CHE437.3	2	2	2	2	3								2	2	1
15CHE437.4	3	2	2	2	2								3	2	

REFERENCE / TEXTBOOKS:

1. *Massimiliano Di Ventra, Stephane EvoyandJames R. Heflin, Jr, "Introduction to Nanoscale Science and Technology" Kluwer Academic Publishers, 2004*
2. *T. Pradeep, Nano: The Essenstials / Understanding Nanoscience and Nanotechnology, Tata Mcgraw Hill Publishing Company Limited, 2007*
3. *Cristian Contescu, Karol Putyera, DekkerEncyclopaedia of Nanoscience and Nanotechnology, 2nd Edition, CRC Press Publications, 2009, ISBN 978 0 8493 9639 7 (six volume set)*

15CHE438 PETROLEUM REFINING AND PETROCHEMICAL TECHNOLOGY 3 0 0 3

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 C4& C5 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.

Course Outcomes

15CHE438.1 Understand the concepts of various physical and chemical processes in modern refinery
15CHE438.2 Ability to understand the overview and block diagrams of various operations involved in fractionation of crude oil
15CHE438.3 Analyze the design, operations and flow sheet of various units in fractionation of crude oil
15CHE438.4 Develop and analyze the flow sheets of various petrochemicals processes

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
15CHE 438.1	3	2	2						2				3		
15CHE 438.2	3	2	2						2				3		
15CHE 438.3	3	2	2	2		1	1		2				3	2	
15CHE 438.4	3	2	2			1	1		2				3	2	

TEXTBOOKS:

1. *Ram Prasad, "Petroleum Refining Technology", Khanna Publishers, Delhi, 2000.*
2. *J. H. Gary, G. H. Handwerk and M. J. Kaiser, "Petroleum Refining Technology and Economics", 5th Edition, CRC Press, New York, 2007.*
3. *G. D. Hobson and W. Pohl, "Modern Petroleum Technology", 6th Edition, Wiley, New York, 2000.*
4. *B. K. Bhaskara Rao, "A Text on Petrochemicals", Khanna Publishers, New Delhi, 2008.*

REFERENCES:

1. *R. A. Meyers, "Handbook of Petroleum Refining Processes", 2nd Edition, McGraw Hill, New York, 1996.*
2. *J. A. Moulijin, M. Makkee and A. Van Diepen, "Chemical Process Technology", Wiley, New York, 2001.*
3. *I. D. Mall, "Petrochemical Process Technology", Macmillan India Ltd, New Delhi, 2007.*
4. *Sami Matar and Lewis F Hatch, "Chemistry of Petrochemical Processes", Gulf Publishing Company, Houston, Texas, 2000.*

15CHE439 POLYMER COMPOSITES 3 0 0 3

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, polyimides, 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 behaviour 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 layup, 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.

Course Outcomes

CHE439.1	Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure
CHE439.2	Able to explain how interfacial bonding may be achieved between matrices and reinforcement and parameters affecting composite properties
CHE439.3	Able to select suitable matrices and reinforcement of composites for suitable application including biodegradable green composites
CHE439.4	Able to analyze the mechanics of the composite materials including theoretical calculation based on mathematical models

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3
CHE 439.1	3	2									2	1	3	2	
CHE 439.2	3	3	3										2		1
CHE 439.3	1		3			2	3			2	2		2	2	
CHE 439.4			3	3	2						2	2	3	2	3

TEXTBOOKS:

1. *B. Astrom, "Manufacturing of Polymer Composites", CRC Press, 1997.*
2. *P K Mallick, "Fiber-Reinforced Composites: Materials, Manufacturing, and Design", CRC Press, 2007.*

REFERENCES:

1. *F. C. Campbell (Ed), Manufacturing processes for advanced composites, Elsevier, 2004.*
2. *S T Peters (Ed.), "Handbook of Composites", Springer, 1998.*

15CHE440 POLYMER MATERIALS - STRUCTURE PROPERTY RELATIONS 3 0 0 3

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 (Tg), melt transition (Tm), relationship between Tg and Tm - other transitions like ß-transitions, upper and lower glass transition temperatures - Prediction of Tg and Tm 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.

Course Outcomes

15CHE440.1 Given the chemical structure of a monomer(s) and a polymerization mechanism, be able to predict other properties

15CHE440.2 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.

15CHE440.3 Knowledge of chemical structure , properties and selection of material for end use applications

15CHE440.4 Ability to "cost" plastics products, including life cycle analysis with the appropriate design of a "plastics part"

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE440.1	3	2	2		2	2	2					2	2		1
15CHE440.2	3	2	2		2		2					2		2	2
15CHE440.3	3	3	2		2	2	3					2	3		2
15CHE440.4	3	3	3	2	2				3			2		2	2

TEXTBOOKS:

1. *J. A. Brydson, "Plastics Materials" Butterworth- Heinemann – Oxford, 7th Ed., London, 1999*
2. *Maurice Morton, "Rubber Technology", 3rd Ed, Kluwer Academic Pub, Dordrecht, Netherlands, 1999*
3. *Manas Chanda and Salil K. Roy, "Plastics Technology Handbook", CRC Press, Atlanta, 2007*

REFERENCE BOOKS

1. *D. W. Van Krevelen and P. J. Hoftyzen, "Properties of Polymer", 3rd Edition Elsevier Scientific Publishing Company Amsterdam – Oxford – Newyork. 1990.*
2. *Jozef.Bicerano, "Prediction of Polymer Properties", Second Edition, Marcel Dekker Inc. New York, 1995.*

15CHE441 POLYMER PROCESSING 3 0 0 3

Unit 1

Physical Basis of Polymer Processing – Mixing - distributive and dispersive mixing equipments. 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 – Sharskin-Die swell.

Unit 2

Injection Moulding – Principles - Moulding Cycle - Reciprocating Screw 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 - Trouble shooting – 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 - Layup 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.

Course Outcomes

15CHE441.1 Understand the fundamental background to the processing of polymeric materials like flow behaviour and mixing of additives

15CHE441.2 Comprehend the practical and theoretical basis of injection moulding and extrusion and their offshoot processes.

15CHE441.3 Familiarize a wide range of polymer processing operations like compression and transfer moulding, rotational moulding, blow moulding, thermoforming and assembling techniques.

15CHE441.4 Develop capability for selecting an appropriate processing method for the conversion of polymer feed to products.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE441.1	3	1			1								2		1
15CHE441.2	2	3			2							3	3		3
15CHE441.3	2	3			2							3	3		3
15CHE441.4	1	3			3							3	3		3

TEXTBOOKS:

1. *B. Strong, "Plastics: Materials and Processing", Prentice Hall, 2012.*
2. *D. H. Morton-Jones," Polymer Processing", Chapman & Hall, 1989.*

REFERENCES:

1. *C. A. Harper (Ed), "Handbook of Plastic Processes", John and Wiley 2006.*
2. *M. L. Berins (ed.), "Plastics Engineering Handbook of The Society of The Plastics Industry", Springer, 2012.*

15CHE442 PROCESS INSTRUMENTATION 3 0 0 3

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 acquisitionmodules, 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 opticalpyrometers.

Unit 2

Measurement of pressure and vacuum: Pressure, vacuum and head; liquid column manometers - U-tube type, well type and inclined type, micromanometers; Lowpressure 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 Neleod 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 ofmoisture 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;On line instrumentation in modern

plants.

Course Outcomes

15CHE442.1 Gain knowledge about general principles of measurement, measurement methods employed in industrial processing and manufacturing and various elements of instrumentation

15CHE442.2 Understand the static and dynamic characteristics of instruments, gain knowledge of calibration methods of instruments and processes and perform error analysis.

15CHE442.3 Acquire knowledge of the operating principles, construction & working of temperature measuring devices and gain ability to select the most suitable measuring device based on its performance characteristics

15CHE442.4 Understand the operating principles, construction & working of pressure, flow and level measuring devices.

15CHE442.5 Acquaint with the various latest analytical instruments and online instrumentation and gain knowledge of the working principles of instruments for measuring viscosity, pH, moisture, composition analysis etc

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE442.1	3	2	2										3	1	1
15CHE442.2	3	2	2										3	1	1
15CHE442.3	3	2	2										3	1	1
15CHE442.4	3	2	2										3	1	1
15CHE442.5	3	2	2										3	1	1

TEXTBOOK:

1. Jain R. K., Mechanical and Industrial Measurements, Khanna

REFERENCES:

1. *Ernest O. Doebelin, "Measurements systems Application & design", McGraw Hill Publishing, 1990.*
2. *T. G. Beckwith, R. D. Marangoni and J. H. Lienhard, "Mechanical Measurements", 6th Edn, Prentice Hall, 2006.*
3. *Eckman D. P., Industrial Instrumentation, Wiley Eastern.*
4. *Patranabis, D., "Principles of Industrial Instrumentation" 2nd ed. Tata McGraw Hill, New Delhi.*

15CHE443 PROCESS INTENSIFICATION 3 0 0 3

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-Flo 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 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.

Course Outcomes

15CHE443.1 Identify inefficiencies, and economic pressures and environmental impacts of a process or operation

15CHE443.2 Understand the principles of process intensification

15CHE443.3 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.

15CHE443.4 Choose a variety of process technologies that can be used to intensify reaction kinetics, separations and/or transport phenomena, or that reduce processing cost.

15CHE443.5 Evaluate different process options based on qualitative and quantitative measures to arrive at an optimal process design choice

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE443.1	3	2				2						2	3		3
15CHE443.2	3												3		3
15CHE443.3	3	3	3	3	3							2	3	3	3
15CHE443.4	3	2	3	3		2							3	3	3
15CHE443.5	3	3	3	3	3	3	2				2		3	3	3

TEXTBOOK / REFERENCES:

1. *David Reay, Colin Ramshaw, and Adam Harvey, "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility" Butterworth-Heinemann, 2008*
2. *Frerich J. Keil, "Modeling of Process Intensification", Wiley-VCH, 2007 Relevant journal publications*

15CHE444 SAFETY AND HAZARD MANAGEMENT IN CHEMICAL INDUSTRIES 3 0 0 3

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.

Course Outcomes

15CHE444.1	Identifying the typical sources of risks in a process plants by hazard identification and examination of case studies
15CHE444.2	Evaluate the workplace to determine occupational safety and health hazards
15CHE444.3	Select appropriate control methodologies to prevent hazards in industries
15CHE444.4	Undertake a Hazard and Operability Studies (HAZOP)

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE444.1	3	3	3	2			2						3	2	2
15CHE444.2	3	3	3	2			2						3	2	2
15CHE444.3	3	3	3	3			2						3	2	2
15CHE444.4	3	3	3	3			2		2				3	3	2

TEXTBOOKS:

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

REFERENCES:

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

15CHE445 SOLAR ENERGY 3 0 0 3

Unit 1

Solar energy

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 cell physics

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.

Unit 2

Solar cell fabrication technology

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. Thin film technologies.

Solar Cell Characterization

Characterization of solar cells: IV characteristics, impedance, incident photon-to-current conversion efficiency (IPCE), intensity modulated photovoltage spectroscopy (IMPV), lifetime measurements.

Solar photovoltaic system design
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 troubleshooting.

Unit 3

Emerging Photovoltaic Technologies

Working principle, characterization and applications of: organic solar cells, dye sensitized solar cells, quantum dot solar cells, bulk heterojunction solar cells

SPV applications

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.

Course Outcomes

15CHE445.1 Determine the placement of solar panels based on the daily and yearly movement of the sun in the sky.

15CHE445.2 Explain the basic functioning of photovoltaic cell along with its efficiency, figures of merit and main sources of losses.

15CHE445.3 Describe the main solar cell fabrication methods.

15CHE445.4 Design a simple solar photovoltaic system.

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE445.1	3	2	1	1					2	1					
15CHE445.2	3	2							2	1					
15CHE445.3	2	1							2	1					
15CHE445.4	1	1	2	1			1		2	1					

TEXTBOOKS:

1. *John W Twidell and A D Weir, Renewable Energy Resources, ELBS*
2. *T Bhattacharya, Terrestrial Solar Photovoltaic, Narosa Publishers Ltd, New Delhi*

REFERENCE BOOKS:

1. *Garg H P., Prakash J., Solar Energy: Fundamentals & Applications, Tata McGraw Hill, New Delhi, 1997*
2. *S P Sukhatme, Solar Energy, Tata McGraw Hill*
3. *J F Kreider and Frank Kreith, Solar Energy Handbook, McGraw Hill*
4. *D Y Goswami, Frank Kreith and J F Kreider, Principles of Solar Engineering, Taylor & Francis.*

MANAGEMENT ELECTIVES

15CHE470 FUNDAMENTALS OF MANAGEMENT 3 0 0 3

Unit 1

Introduction - Managers and Management. The historical roots of contemporary management practices - the pre-modern era, classical contributions, human resources approach, the quantitative approach. The Management Environment - A global market place, emphasis on technology, society and managers, entrepreneurship.

Foundations of Planning - Planning in uncertain environments, types of plans, management by objectives. The importance of organizational strategy, strategic framework, quality as a Strategic weapon. Foundations of Decision Making - The decision-making process, making decisions - the rational model, modifications of the rational model. Decision making - a contingency approach, decision-making styles, making decisions in groups.

Unit 2

Basic Organization Designs - The elements of structure, contingency variables affecting structure, organization design applications, learning organization, organization culture.

Managers and the Human resource management process - Employment planning, recruitment and selection, orientation, training, and development, performance management, compensation and benefits, managing change, stress and innovation, change process, organizational change and member resistance, making changes in the organization. Stress - the aftermath of organizational change, stimulating innovation.

Unit 3

Foundations of Individual and Group behaviour - Explaining and predicting behaviour, personality, perception, learning, foundations of group behaviour. Understanding work teams - types of work teams, characteristics of high-performance work teams. Motivating and rewarding employees - motivation and individual needs, early theories of motivation, contemporary theories of motivation. Leadership and Trust - Managers versus leaders, trait theories of leadership, behavioral theories of leadership, contingency theories of leadership, emerging approaches to leadership, contemporary leadership issues, building trust. Communication and Interpersonal skills - understanding communication, communication and Information Technology, developing interpersonal skills.

Foundations of Control - the importance of control, types of control, control implications for managers, the dysfunctional side of control.

Course Outcomes

15CHE470.1 Understand the evolution of management principles and practices
Understand the importance of organizational strategy and principles of decision making processes.

15CHE470.2 Understand basic organization designs and principles of human resource management processes. Understand organizational change and member resistance.

15CHE470.3 Understand the principles of individual and group behavior. Understand theory and principles of motivation. Understand various theories of leadership. Understand the process of communication. Understand types and process of Control.

15CHE470.4 Understand, analyze and design suitable management solutions for a given problem through the Case Studies.

TEXTBOOK:

Stephen P. Robbins, David A. DeCenzo, Sanghamitra Bhattacharya, Madhushree Nanda Agarwal. "Fundamentals of Management" – Pearson Prentice Hall, Sixth Edition

15CHE471 MANAGERIAL ECONOMICS AND ACCOUNTING 3 0 0 3

Unit 1

Introduction to Economics and managerial Decision Making, the Economics of a business, a brief review of important economic terms and concepts; Supply and Demand - market demand, market supply, determinants of supply and demand, short run market changes and long run market analysis, comparative statics analysis, Demand Elasticity - the economic concept of elasticity, the price elasticity of demand, the cross-elasticity of demand, income elasticity, other elasticity measures, elasticity and total revenue; Elasticity of Supply. Applications of elasticity. Marginal utility, the law of diminishing marginal utility.

The theory and estimation of production - the production function, a short-run analysis of total, average, and marginal product, the three stages of production in the short run, long run and the law of diminishing returns, derived demand and the optimal level of variable input usage. Forms of production function.

Unit 2

The Theory and Estimation of Cost - the importance of Cost in managerial decisions, the relationship between production and cost, the short-run cost function, the long-run cost function, economies of scale.

Pricing and output decisions - Competition and market types, pricing and output decisions in perfect competition, selecting optimum output level, competitive market in the long run; Pricing and output decisions in monopoly markets, implications for managerial decision making. Pricing and output decisions in monopolistic competition; oligopoly and market concentration, pricing in oligopolistic market.

Unit 3

Management accounting: Balance Sheet and Profit and Loss account – financial statements, assets, liabilities, and owner's equity, relationship between assets, liabilities and owner's equity, forms of the balance sheet, profit and loss account, relation between balance sheet and profit and loss account. Cost classifications and allocation - nature of cost, historical and future costs, cost classifications in a manufacturing firm, cost concepts for planning and control, cost allocation; cost-volume-profit analysis and operating leverage; Break-even analysis, break-even point, operative leverage.

Capital expenditure planning - nature of investment decisions, investment evaluation criteria, time value of money, net present value method, internal rate of return method, profitability index, payback period, accounting rate of return method, cash flows for investment analysis. Capital budgeting process.

Course Outcomes

15CHE471.1 Understand the economic concepts and principles of Supply and Demand and measures of elasticity and its applications to real world problems. Understand the theory and estimation of production during short run and long run and the law of diminishing returns.

15CHE471.2 Understand the theory and estimation of cost and its importance in managerial decisions. Understand the relationship between production and cost during short run and long run. Understand different types of competition and learn to determine pricing and output decisions as appropriate to the competition

15CHE471.3 Understand financial statements of management accounting and tools for capital expenditure planning

15CHE471.4 Apply the cost analysis methods for measuring enterprise financial performance

REFERENCES:

1. *Paul G. Keat, Philip K. Y. Young, Sreejata Banerjee "Managerial Economics" Economic Tools for Today's Decision Makers – Sixth Edition.*
2. *I M Pandey, "Management Accounting", A Planning and Control Approach, Vikas Publishing*

House Pvt Ltd.,

15CHE472 PROJECT ENGINEERING OF PROCESS PLANTS 3 0 0 3

Unit 1

Scope of project engineering - the role of project engineer - R & D - TEFR - plant location and site selection - preliminary data for construction projects - process engineering – flowdiagrams - plot plans - engineering design and drafting. Planning and scheduling of projects - bar chart and network techniques.

Unit 2

Business and legal procedures: Procurement operations, Organization and operation of procurement department, Procurement procedure, General purchaser-vendor practices, contracts and contractors, project financing, statutory sanctions.

Details of engineering design and equipment selection - design calculations excluded -Vessels, heat exchangers, process pumps, compressors and vacuum pumps, motors and Turbines, other process equipment

Unit 3

Details of engineering design and equipment selection II - design calculations excluded - piping design, thermal insulation and buildings, safety in plant design, plant constructions,start up and commissioning.

Critical path method (CPM) and Programme evaluation and review technique (PERT) in project engineering.

Course Outcomes

15CHE472.1 Understand the role, duties, and scope of project engineering in a manufacturing plant

15CHE472.2 Understand the procurement process, inclusive of its logistics, business, and legal aspects

15CHE472.3 Understand the requirements for design of process equipment, plant facilities, and plant commissioning

15CHE472.4 Be able to assess the safety and effectiveness of the design

CO-PO Mapping

CO Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
15CHE472.1	1		1			1	1	2		2	3		2		
15CHE472.2								2		3	3		2	2	
15CHE472.3			3	1	2	1	2	1			2				3
15CHE472.4			3	2		3		2					2	2	

REFERENCE BOOKS

1. *Peter Watermeyer , Handbook for Process Plant Project Engineers, Wiley, 2002*
2. *Howard F. Rase, M. H. Barrow, Project engineering of process plants, Wiley, 1957*
3. *Peter S. Max &Timmerhaus, Plant design and economics for chemical engineers, Mc Graw Hill, 2002.*
4. *B. C. Punmia & K. K. Khandelwal, Project Planning and Control with PERT & CPM, Firewall Media, 2002*
5. *Srinath L. S., PERT AND CPM, 3rd Edn Affiliated East Press Pvt. Ltd., New York, 2001.*
6. *Perry J. H,"Chemical engineering handbook" 7th ed. McGraw Hill, 1997.*
7. *Ernest E. Ludwig, Applied project engineering and management, Gulf Pub. Co, 1988.*
8. *R K Sinnott, Chemical Engineering Design: Chemical Engineering Design, Chemical Engineering Technical Series, Elsevier, 2014.*

15CHY239 COMPUTATIONAL CHEMISTRY AND MOLECULAR MODELLING 3 0 0 3

Unit 1

Introduction: Stability, symmetry, homogeneity and quantization as the requirements of natural changes - Born - Haber cycle – Energetic – kinetics - Principles of spectra.

Computational techniques: Introduction to molecular descriptors, computational chemistry problems involving iterative methods, matrix algebra, Curve fitting.

Molecular mechanics: Basic theory - Harmonic oscillator – Parameterization - Energy equations - Principle of coupling - Matrix formalism for two masses - Hessian matrix - enthalpy of formation - enthalpy of reactions.

Introduction to Quantum mechanics - Schrodinger equation - Position and momentu - MO formation - Operators and the Hamiltonian operator - The quantum oscillator - Oscillator Eigen value problems - Quantum numbers - labeling of atomic electrons.

Unit 2

Molecular Symmetry: Elements of symmetry - Point groups - Determination of point groups of molecules.

Huckel's MO theory: Approximate and exact solution of Schrodinger equation - Expectation value of energy - Huckel's theory and the LCAO approximation - Homogeneous simultaneous equations - Secular matrix - Jacobi method - Eigen vectors: Matrix as operator - Huckel's coefficient matrix - Wheeland's method - Hoffmann's EHT method - Chemical applications such as bond length, bond energy, charge density, dipole moment, Resonance energy.

Unit 3

Self consistent fields: Elements of secular matrix - Variational calculations - Semi empirical methods - PPP self consistent field calculation - Slater determinants - Hartree equation - Fock equation – Roothaan - Hall equation - Semi empirical models and approximations.

Ab-initio calculations: Gaussian implementations – Gamess - Thermodynamic functions - Koopman's theorem - Isodesmic reactions, DFT for larger molecules - Computer aided assignments/mini projects with softwares - Introduction to HPC in Chemical calculations.

Molecular modelling software engineering - Modeling of molecules and processes - Signals and signal processing in Chemistry - QSAR studies and generation of molecular descriptors - Applications of chemical data mining - Familiarization with open source softwares useful for molecular modeling - Introduction to molecular simulation - M.D. simulation.

Course Outcome

CO01: Get to understand the structure of molecules using symmetry.

CO02: Understanding Quantum mechanical approach to calculate the energy of a system.

CO03: Applying mathematical knowledge and quantum mechanical approach in finding out the characteristics- reactivity, stability, etc., of the molecule.

CO04: To get a brief idea about molecular mechanics based chemical calculations.

CO05: To get an idea about general methodology of molecular modeling.

TEXTBOOKS:

1. *Ramachandran, G Deepa and K Namboori, "Computational Chemistry and Molecular Modeling - Principles and Applications", Springer-Verlag, Berlin, Heidelberg, 2008, ISBN-13 978-3-540-77302-3.*
2. *Donald W Rogers, "Computational Chemistry Using PC", Wiley, (2003).*
3. *Alan Hinchliffe, "Chemical Modeling from atoms to liquids", Wiley, (2005).*

REFERENCES:

1. *James B Forseman and Aeleen Frisch-Gaussian, "Exploring Chemistry with Electronic Structure Method", Inc., Pittsburgh, PA, 2nd edition, (2006).*
2. *A C Philips, "Introduction to Quantum mechanics", Wiley, (2003).*
3. *Wolfram Koch, Max C. Holthausen, "A Chemist's guide to Density Functional Theory", Wiley, VCH, 2nd edition, (2001).*

15CHY241 ELECTROCHEMICAL ENERGY SYSTEMS AND PROCESSES 3 0 0 3

Unit 1

Background Theory: Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler-Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafel plots - exchange current density and transfer coefficients.

Unit 2

Batteries: Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air, zinc-silver oxide batteries; lithium primary cells - liquid cathode, solid cathode and polymer electrolyte types and lithium-ferrous sulphide cells (comparative account).

Secondary batteries: ARM (alkaline rechargeable manganese) cells, Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultra thin lithium polymer cells (comparative account). Advanced Batteries for electric vehicles,

requirements of the battery - sodium-beta and redox batteries.

Unit 3

Reserve batteries and Fuel cells: Reserve batteries - water activated, electrolyte activated and thermally activated batteries - remote activation - pyrotechnic materials. Fuel Cells:Principle, chemistry and functioning - carbon, hydrogen-oxygen, proton exchange membrane (PEM), direct methanol (DMFC), molten carbonate electrolyte (MCFC) fuel cells and outline of biochemical fuel cells.

Electrochemical Processes: Principle, process description, operating conditions, process sequence and applications of Electroforming – production of waveguide and plated through hole (PTH) printed circuit boards by electrodeposition; Electroless plating of nickel, copper and gold; Electropolishing of metals; Anodizing of aluminium; Electrochemical machining of metals and alloys.

Course Outcomes

CO01: Understand the fundamental concepts of electrochemistry through electrode potential and reaction kinetics

CO02: Learn the application of the electrochemical principles for the functioning and fabrication of industrial batteries and fuel cells

CO03: Acquire knowledge in solving numerical problems on applied electrochemistry

CO04: Analysis and practical problem solving in fabrication of batteries and fuel cells

CO05: Application of concepts and principle in industrial electrochemical processes

CO06: Evaluation of comprehensive knowledge through problem solving

TEXTBOOKS:

1. *Derek Pletcher and Frank C. Walsh, "Industrial Electrochemistry", Blackie Academic and Professional, (1993).*
2. *Dell, Ronald M Rand, David A J, "Understanding Batteries", Royal Society of Chemistry, (2001).*

REFERENCES:

1. *Christopher M A, Brett, "Electrochemistry – Principles, Methods and Applications", Oxford University, (2004).*
2. *Watanabe T, "Nano-plating: microstructure control theory of plated film and data base of plated film microstructure", Elsevier, Oxford, UK (2004).*

3. *Kanani N, "Electroplating and electroless plating of copper and its alloy", ASM International, Metals Park, OH and Metal Finishing Publications, Stevenage, UK (2003).*
4. *Lindon David, "Handbook of Batteries", McGraw Hill, (2002).*
5. *Curtis, "Electroforming", London, (2004).*
6. *Rumyantsev E and Davydov A, "Electrochemical machining of metals", Mir, Moscow, (1989).*

15CHY243 FUELS AND COMBUSTION 3 0 0 3

Course Objectives:

To provide the basic knowledge about fuels, rocket propellants and explosives.

Unit 1

Fuels - Solid fuels - Classification, preparation, cleaning, analysis, ranking and properties - action of heat, oxidation, hydrogenation, carbonization, liquefaction and gasification.

Liquid fuels – Petroleum - origin, production, composition, classification, petroleum processing, properties, testing - flow test, smoke points, storage and handling.

Secondary liquid fuels - Gasoline, diesel, kerosene and lubricating oils. Liquid fuels - refining, cracking, fractional distillation, polymerization. Modified and synthetic liquid fuels. ASTM methods of testing the fuels.

Unit 2

Gaseous fuels - Types, natural gas, methane from coal mine, water gas, carrier gas, producer gas, flue gas, blast furnace gas, biomass gas, refinery gas, LPG - manufacture, cleaning, purification and analysis. Fuels for spark ignition engines, knocking and octane number, anti knock additives, fuels for compression, engines, octane number, fuels for jet engines and rockets.

Flue gas analysis by chromatography and sensor techniques.

Unit 3

Combustion: Stochiometry, thermodynamics. Nature and types of combustion processes - Mechanism - ignition temperature, explosion range, flash and fire points, calorific value, calorific intensity, theoretical flame temperature. Combustion calculations, theatrical air requirements, flue gas analysis, combustion kinetics – hydrogen - oxygen reaction and hydrocarbon - oxygen reactions.

Rocket propellants and Explosives - classification, brief methods of preparation, characteristics; storage and handling.

Course Outcomes

CO01: Understand the types of fuels and variation in their properties

CO02: Able to analyze the fuel content

CO03: Obtain knowledge in identifying a proper fuel as per the requirement

CO04: Ability to know the preparation and working of propellants and explosives

TEXTBOOK:

Fuels and Combustion, Samir Sarkar, Orient Longman Pvt. Ltd, 3rd edition, 2009.

REFERENCE:

1. *Fuels - Solids, liquids and gases - Their analysis and valuation, H. Joshua Philips, Biobliolife Publisher, 2008.*
2. *An introduction to combustion: Concept and applications - Stephen R Turns, Tata Mc. Graw Hill, 3rd edition, 2012.*
3. *Fundamentals of Combustion, D P Mishra, 1st edition, University Press, 2010*
4. *Engineering Chemistry - R. Mukhopadhyay and Sriparna Datta, Newage International Pvt. Ltd, 2007.*

15CHY244 GREEN CHEMISTRY AND TECHNOLOGY 3 0 0 3

Objectives

1. Understand the principles of green chemistry and its contribution to the development of sustainable products
2. Possess knowledge of the migration from a hydrocarbon-based economy to carbohydrate-based economy

3. Evaluate the deficiencies of traditional process and acknowledge the invent of new processes
4. Distinctly map the culmination of academic research to industrial chemistry

Unit 1

Our environment and its protection, chemical pollution and environmental regulations, environmental chemistry, pollution prevention strategies, challenges to the sustainability of chemical industry, Pollution Prevention Act 1990, USA, Green Chemistry and its 12 principles, toxicity of chemicals, material safety data sheet (MSDS), concept of zero pollution technologies, atom economy, functional toxicity vs non-functional toxicity, alternative solvents, energy minimization, microwave and sonochemical reactions, renewable feed stock, carbon dioxide as a feed stock.

Unit 2

Greener strategies of the synthesis of ibuprofen synthesis, teriphthalic acid etc. phase behaviour and solvent attributes of supercritical CO2, use of supercritical carbon dioxide as a medium chemical industry, use of ionic liquids as a synthetic medium, gas expanded solvents, superheated water, etc. Synthesis of various chemicals from bio mass, polycarbonate synthesis and CO2 fixation, green plastics, green oxidations, etc.

Unit 3

Processes involving solid catalysts – zeolites, ion exchange resins, Nafion/silica nano composites and enhanced activity. Polymer supported reagents, green oxidations using TAML catalyst, membrane reactors. Green chemistry in material science, synthesis of porous polymers, green nanotechnology.

Course Outcomes

CO01: Understand the evolving concept of Green Chemistry and its application to the manufacture of sustainable products

CO02: Appreciate the need for Renewable energy and Feed stock along with carbon sequestration through the fundamentals of Green Chemistry Techniques

CO03: Develop a coherence to evaluate systematic deficiencies in traditional Chemical science process and products

CO04: Undertake a purposeful Journey through the microscopic domain of academic research to the macroscopic domain of Industrial chemistry

REFERENCES:

1. *Hand Book of Green Chemistry and Technology; by James Clarke and Duncan Macquarrie; Blakwell Publishing.*

2. *Anastas, P. T., Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press Inc., New York, 1998.*
3. *Matlack, A. S. Introduction to Green Chemistry Marcel Dekker: New York, NY, 2001.*

15CHY331 BATTERIES AND FUEL CELLS 3 0 0 3

Course Objective:

To provide sound knowledge on the application of electrochemistry in energy storage systems.

Unit 1

Background Theory: Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler-Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafel plots - exchange current density and transfer coefficients.

Unit 2

Batteries: Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air batteries; Lithium primary cells - liquid cathode, solid cathode and lithium-ferrous sulphide cells (comparative account).

Secondary batteries: Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultrathin lithium polymer cells (comparative account). Advanced Batteries for electric vehicles, requirements of the battery - sodium-beta and redox batteries.

Unit 3

Fuel Cells: Description, working principle, anodic, cathodic and cell reactions, fabrication of electrodes and other components, applications, advantages, disadvantages and environmental aspectsof the following types of fuel cells: Proton Exchange Membrane Fuel Cells, alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, direct methanol fuel cells.

Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of

performance – recent developments.

Fuels for Fuel Cells: Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen – clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel.

Course Outcome

CO01: Understand the fundamental concepts of electrochemistry through electrode potential and reaction kinetics

CO02: Learn the application of the electrochemical principles for the functioning and fabrication industrial batteries and fuel cells

CO03: Analysis of practical problem solving in fabricating batteries and fuel cells

CO04: Evaluation of comprehensive knowledge through problem solving

TEXTBOOKS:

1. *Dell, Ronald M Rand, David A J, 'Understanding Batteries', Royal Society of Chemistry, (2001).*
2. *M. Aulice Scibioh and B. Viswanathan 'Fuel Cells – principles and applications', University Press, India (2006).*

REFERENCES:

1. *Kanani N, 'Electroplating and electroless plating of copper and its alloy', ASM International, Metals Park, OH and Metal Finishing Publications,Stevenage, UK (2003).*
2. *Curtis, 'Electroforming', London, (2004).*
3. *F. Barbir, 'PEM fuel cells: theory and practice', Elsevier, Burlington, MA, (2005).*
4. *G. Hoogers, 'Fuel cell handbook', CRC, Boca Raton, FL, (2003).*

15CHY332 CORROSION SCIENCE 3 0 0 3

Unit 1

Basic principles: Free energy concept of corrosion - different forms of corrosion

- Thermodynamic & Kinetic aspects of corrosion: The free energy criterion of corrosion possibility - Mechanism of Electrochemical corrosion - Galvanic and Electrochemical series and their significance.

Corrosion Control: Materials selection - metals and alloys - metal purification - non metallic - changing medium.

Unit 2

Anodic and cathodic protection methods - Coatings - metallic and other inorganic coatings - organic coatings - stray current corrosion - cost of corrosion control methods.

Corrosion protection by surface treatment: CVD and PVD processes - Arc spray - Plasma spray - Flame spray.

Corrosion Inhibitors: Passivators - Vapour phase inhibitor.

Unit 3

Stress and fatigue corrosion at the design and in service condition - control of bacterial corrosion.

Corrosion protection: Automobile bodies – engines – building construction.

Course Outcome:

CO01: Development of skill in identifying the nature and type of corrosion

CO02: Understanding the mechanism of various types of corrosion

CO03: Analysing the problem and find out a solution to combat corrosion in any sort of environment.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	-	-	-	-	-	-	-	-	-	-	3	1	-	-
CO2	-	3	1	2	-	-	-	-	-	-	-	1	1	2	-	-
CO3	-	3	3	3	2	3	3	-	-	-	-	1	3	2	3	-

TEXTBOOKS:

1. *Fontana and Mars G, "Corrosion Engineering", 3rd edition, McGraw Hill, (1987).*
2. *Uhlig H H and Reviees R W, "Corrosion and its Control", Wiley, (1985).*

REFERENCES:

1. *ASM Metals Handbook, "Surface Engineering", Vol. 5, ASM Metals Park, Ohio, USA, (1994).*
2. *ASM Metals Handbook, "Corrosion", Vol. 13, ASM Metals Park, Ohio, USA, (1994).*
3. *Brain Ralph, "Material Science and Technology", CRC Series, Boston, New York.*

15PHY230 ADVANCED CLASSICAL DYNAMICS 3 0 0 3

Unit 1

Introduction to Lagrangian dynamics

Survey of principles, mechanics of particles, mechanics of system of particles, constraints, D'Alembert's principle and Lagrange's equation, simple applications of the Lagrangian formulation, variational principles and Lagrange's equations, Hamilton's principles, derivation of Lagrange's equations from Hamilton's principle, conservation theorems and symmetry properties.

Unit 2

Central field problem

Two body central force problem, reduction to the equivalent one body problem, Kepler problem, inverse square law of force, motion in time in Kepler's problem, scattering in central force field, transformation of the scattering to laboratory system, Rutherford scattering, the three body problem.

Rotational kinematics and dynamics

Kinematics of rigid body motion, orthogonal transformation, Euler's theorem on the motion of a rigid body.

Unit 3

Angular momentum and kinetic energy of motion about a point, Euler equations of motion, force

free motion of rigid body.

Practical rigid body problems

Heavy symmetrical spinning top, satellite dynamics, torque-free motion, stability of torque-free motion - dual-spin spacecraft, satellite maneouvering and attitude control - coning maneuver - Yo-yo despin mechanism - gyroscopic attitude control, gravity-gradient stabilization.

Course Outcomes

CO1 - Able to use the Lagrangian formalism to solve simple dynamical system

CO2- Able to understand Hamiltonian formalism and apply this in solving dynamical systems

CO3- Able to apply Lagrangian formalism in bound and scattered states with specific reference to Kepler's laws and Scattering states

CO4- Able to solve problems in the Centre of Mass frame and connect it to Laboratory Frame of Reference

CO5- Understand and solve problems in rigid body rotations applying of Euler's equations.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	0	0	0	0	0	0	0	1	0	0	0
CO2	3	3	1	1	0	0	0	0	0	0	0	1	0	0	0
CO3	3	3	3	1	0	0	0	0	0	0	0	1	0	0	0
CO4	3	3	3	1	0	0	0	0	0	0	0	2	0	0	0
CO5	3	3	3	2	0	0	0	0	0	0	0	2	0	0	0

TEXTBOOKS:

1. H. Goldstein, Classical Mechanics, Narosa Publishing House, New Delhi, 1980, (Second Edition)

2. H. Goldstein, Charles Poole, John Safko, Classical Mechanics, Pearson education, 2002 (Third Edition)
3. Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier, pp.475 - 543

4. Anderson John D, Modern Compressible flow, McGraw Hill.

REFERENCE BOOKS:

1. D. A. Walls, Lagrangian Mechanics, Schaum Series, McGraw Hill, 1967.

2. J. B. Marion and S. T. Thornton, Classical dynamics of particles and systems, Ft. Worth, TX: Saunders, 1995.

15PHY238 ELECTRICAL ENGINEERING MATERIALS 3 0 0 3

Unit 1

Conducting materials: The nature of chemical bond, crystal structure Ohm's law and the relaxation time, collision time, electron scattering and resistivity of metals, heat developed in a current carrying conductor, thermal conductivity of metals, superconductivity.

Semiconducting materials: Classifying materials as semiconductors, chemical bonds in Si and Ge and it's consequences, density of carriers in intrinsic semiconductors, conductivity of intrinsic semiconductors, carrier densities in n type semiconductors, n type semiconductors, Hall effect and carrier density.

Unit 2

Magnetic materials: Classification of magnetic materials, diamagnetism, origin of permanent, magnetic dipoles in matter, paramagnetic spin systems, spontaneous magnetization and Curie Weiss law, ferromagnetic domains and coercive force, anti ferromagnetic materials, ferrites and it's applications.

Unit 3

Dielectric materials: Static dielectric constant, polarization and dielectric constant, internal field in solids and liquids, spontaneous polarization, piezoelectricity.

PN junction: Drift currents and diffusion currents, continuity equation for minority carriers, quantitative treatment of the p-n junction rectifier, the n-p-n transistor.

Course Outcomes

CO1: To understand the nature of interaction between atoms in crystalline solid materials that determines their dielectric, magnetic and electrical properties.

CO2: Analyze the relation between the macroscopic dielectric constant and the atomic structure of an insulator.

CO3: Fundamental concepts of magnetic fields required to illustrate the magnetic dipoles. This forms the basis to understand the magnetic properties of dia, para, ferro, antiferro and ferri magnetic materials.

CO4: Fundamentals concerned with conduction mechanism in metals and superconductors.

CO5: Understand the basics for classification of materials based on its conductivity, nature of chemical bonds in Si and Ge, carrier density, energy band structure and conduction mechanism in intrinsic and extrinsic semiconductors.

CO-PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	1	1											1	-
CO2	2	2	2										1	-
CO3	2	2	2										2	-
CO4	2	2	2										2	-
CO5	2	2	2					2					1	-

TEXTBOOK:

A J Decker, “Electrical Engineering materials”, PHI, New Delhi, 1957.

REFERENCES:

1. A J Decker, “Solid State Physics”, Prentice Hall, Englewood Cliffs, N J 1957.

2. C Kittel, “Introduction to solid state Physics”, Wieley, New York, 1956 (2nd edition).

3. Allison, Electronic Engineering materials and Devices, Tata Mc Graw Hill

4. F K Richtmyer E H Kennard, John N Copper, “Modern Physics”, Tata Mc Graw Hill, 1995 (5th edition).

15PHY248 PHYSICS OF LASERS AND APPLICATIONS 3 0 0 3

Unit 1

Review of some basic concepts and principle of laser.

Introduction to light and its properties: Reflection, refraction, interference, diffraction and polarization. Photometry – calculation of solid angle. Brewster's law. Snell's law and, its analysis.

Introduction to LASERS: Interaction of radiation with matter - induced absorption, spontaneous emission, stimulated emission. Einstein's co-efficient (derivation). Active material. Population inversion – concept and discussion about different techniques. Resonant cavity.

Unit 2

Properties of LASERS

Gain mechanism, threshold condition for PI (derivation), emission broadening - line width, derivation of FWHM natural emission line width as deduced by quantum mechanics - additional broadening process: collision broadening, broadening due to dephasing collision, amorphous crystal broadening, Doppler broadening in laser and broadening in gases due to isotope shifts. Saturation intensity of laser, condition to attain saturation intensity.

Properties – coherency, intensity, directionality, monochromaticity and focussibility. LASER transition – role of electrons in LASER transition, levels of LASER action: 2 level, 3 level and 4 level laser system.

Unit 3

Types of LASERS

Solid state LASER: (i) Ruby LASER – principle, construction, working and application. (ii) Neodymium (Nd) LASERS. gas LASER: (i) He-Ne LASER - principle, construction, working and application. (i) CO2 LASER - principle, construction, working and application.

Liquid chemical and dye LASERS. Semiconductor LASER: Principle, characteristics,

semiconductor diode LASERS, homo-junction and hetero-junction LASERS, high power semi conductor diode LASERS.

Applications in Communication field:

LASER communications: Principle, construction, types, modes of propagation, degradation of signal, analogue communication system, digital transmission, fiber optic communication.

Applications of LASERS in other fields:

Holography: Principle, types, intensity distribution, applications. laser induced fusion. Harmonic generation. LASER spectroscopy. LASERS in industry: Drilling, cutting and welding. Lasers in medicine: Dermatology, cardiology, dentistry and ophthalmology.

Course Outcomes

CO 1- Understand, Comprehend and acquaint with concepts of NanoPhysics
CO2- To familiarize the material's property changes with respect to the dimensional confinements.
CO3- Acquire knowledge on the modern preparation process and analysis involved in the nanomaterial's research
CO4- To learn about the technological advancements of the nano-structural materials and devices in the engineering applications

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	2												
CO2	2	3												
CO3				3										
CO4						3	2					1		

REFERENCES:

1. William T Silfvast, "Laser Fundamentals", Cambridge University Press, UK (2003).

2. B B Laud, "Lasers and Non linear Optics", New Age International (P) Ltd., New Delhi.

3. Andrews, “An Introduction to Laser Spectroscopy (2e)”, Ane Books India (Distributors).

4. K R Nambiar, “Lasers: Principles, Types and Applications”, New Age International (P) Ltd., New Delhi.
5. T Suhara, “Semiconductor Laser Fundamentals”, Marcel Dekker (2004).

15PHY532 ASTROPHYSICS 3 0 0 3

Unit 1

Historical introduction: Old Indian and western – astronomy - Aryabhatta, Tycho Brahe, Copernicus, Galileo - Olbers paradox - solar system – satellites, planets, comets, meteorites, asteroids.

Practical astronomy - telescopes and observations & techniques – constellations, celestial coordinates, ephemeris.

Celestial mechanics - Kepler’s laws - and derivations from Newton’s laws.

Sun: Structure and various layers, sunspots, flares, faculae, granules, limb darkening, solar wind and climate.

Unit 2

Stellar astronomy: H-R diagram, color-magnitude diagram - main sequence - stellar evolution – red giants, white dwarfs, neutron stars, black holes - accretion disc - Schwartzchild radius - stellar masses Saha–Boltzman equation - derivation and interpretation.

Variable stars: Cepheid, RR Lyrae and Mira type variables - Novae and Super novae. Binary and multiple star system - measurement of relative masses and velocities. Interstellar clouds - Nebulae.

Unit 3

Galactic astronomy: Distance measurement - red shifts and Hubble’s law – age of the universe, galaxies – morphology - Hubble’s classification - gravitational lens, active galactic nuclei (AGNs), pulsars, quasars.

Relativity: Special theory of relativity - super-luminal velocity - Minkowski space - introduction to general theory of relativity – space - time metric, geodesics, space-time curvature. Advance of perihelion of Mercury, gravitational lens.

Cosmology: Comic principles, big bang and big crunch – cosmic background radiation - Nucleo-synthesis - plank length and time, different cosmic models - inflationary, steady state. Variation of G. anthropic principle.

COURSE OUTCOMES (CO):

After completion of the course students should be able to

CO1: Get a broad knowledge of scientific and technical methods in astronomy and astrophysics.
CO2: Apply mathematical methods to solve problems in astrophysics.
CO3: Develop critical/logical thinking, scientific reasoning and skills in the area of modern astrophysics.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3											1		
CO2	2	2												
CO3	1	2												

REFERENCES:

1. "Textbook of Astronomy and Astrophysics with elements of Cosmology", V. B. Bhatia, Narosa publishing 2001.
2. William Marshall Smart, Robin Michael Green "On Spherical Astronomy", (Editor) Carroll, Bradley W Cambridge University Press ,1977
3. Bradley W.Carroll and Dale A. Ostlie. "Introduction to modern Astrophysics" Addison-Wesley, 1996.
4. Bradley W.Carroll and Dale A. Ostlie, "An Introduction to Modern Astrophysics" Addison-Wesley Publishing Company,1996
5. 'Stellar Astronomy' by K. D Abhayankar.
6. 'Solar Physics' by K. D Abhayankar.

HUMANITIES ELECTIVES

15ENG230 BUSINESS COMMUNICATION 1 0 2 2

Course Objectives

To introduce business vocabulary
T o introduce business style in writing and speaking
To expose students to the cross-cultural aspects in a globalised world
To introduce the students to the art of persuasion and negotiation in business contexts

Syllabus

Unit 1:

Business Vocabulary - Writing: Drafting Notices, Agenda, and Minutes - Reading: Business news, Business articles

Unit 2:

Writing: Style and vocabulary - Business Memorandum, letters, Press Releases, reports – proposals – **Speaking**: Conversational practice, telephonic conversations, addressing a gathering, conducting meetings

Unit 3:

Active Listening: Pronunciation – information gathering and reporting **- Speaking**: Cross-Cultural Issues, Group Dynamics, negotiation & persuasion techniques

Activities

Case studies & role-plays

Course Outcomes

CO1 Familiarize and use appropriate business vocabulary and etiquettes in verbal communication in the professional context

CO2 Understand organizational structures, pay structures and performance assessments

CO3 Apply language skills in drafting various business documents and other necessary communications in the business context

CO4 Understand and address cross cultural differences in the corporate environment

CO5 articipate in planned and extempore enactments of various business situations

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO 3	PO4	PO5	PO 6	PO7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1										3		2
CO2									1		1	
CO3										3		
CO4						2						
CO5									2			

Books recommended:

1. Jones, Leo & Richard Alexander. *New International Business English*. CUP. 2003.
2. Horner, David & Peter Strutt. *Words at Work*. CUP. 1996.
3. Levi, Daniel. *Group Dynamics for Teams*. 3 ed. Sage Publications India Pvt. Ltd. New Delhi, 2011.
4. Owen, Roger. *BBC Business English*. BBC. 1996.
5. Henderson, Greta Lafollette & Price R Voiles. *Business English Essentials*. 7th Edition. Glencoe / McGraw Hill.
6. Sweeney, Simon. *Communicating in Business*. CUP. 2000.

15ENG233 TECHNICAL COMMUNICATION 1 0 2 2

Course Objectives:

To introduce the students to the elements of technical style

To introduce the basic elements of formal correspondence

To introduce technical paper writing skills and methods of documentation

To improve oral presentation skills in formal contexts

Syllabus:

Unit 1

Mechanics of writing: Grammar rules – punctuation - spelling rules - tone and style- graphical Representation

Unit 2

Different kinds of written documents: Definitions - descriptions- instructions-recommendations- manuals - reports – proposals; Formal Correspondence: Letter Writing including job applications with Resume

Unit 3

Technical paper writing: Library research skills- documentation style - document editing – proof reading - formatting

Practice in oral communication: Practice in Oral communication and Technical presentations

Course Outcomes:

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

CO1 Understand and use the basic elements of formal correspondence and methods of documentation

CO2 Learn to edit technical content for grammatical accuracy and appropriate tone and style

CO3 Use the library and internet recourses for research purposes

CO4 Demonstrate the ability to communicate effectively through group mock-technical presentations and other activities

Mapping of course outcomes with program outcomes:

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1										3				
CO2										3				
CO3				1										
CO4									3	3				

References

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

2. Anderson, Paul. V. “Technical Communication: A Reader-Centred Approach”. V Edition. Harcourt Brace College Publication, 2003
3. Strunk, William Jr. and White. EB. “The Elements of Style” New York. Alliyan & Bacon, 1999.
4. Riordan, G. Daniel and Pauley E. Steven. “Technical Report Writing Today” VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.

15HIN101 HINDI I 1 0 2 2

To teach Hindi for effective communication in different spheres of life:- Social context , Education, Research & Media.

Syllabus

Unit-1

Introduction to Hindi Language, -National Language, Official Language, link Language etc.. S Introduction to Hindi language , Devanagari script and Hindi alphabet.
Shabda Bhed , Roopanthar ki Drishti se- Bhasha – Paribhasha aur Bhed - Sangya - Paribhasha Aur Bhed- Sangya ke Roopanthar- kriya.

Unit-2

Common errors and error corrections in Parts of Speech with emphasis on use of pronouns, Adjective and verb in different tenses – Special usage of adverbs, changing voice and conjunctions in sentences, gender& number - General vocabulary for conversations in given context –understanding proper pronunciation – Conversations, Interviews, Short speeches.

Unit -3

Poems – Kabir Ist 8 Dohas, Surdas 1st 1 Pada; Tulsidas 1st 1 Pada; Meera 1st 1 Pada

Unit- 4

Letter writing – personal and Formal –Translation from English to Hindi

Unit- 5

Kahani –Premchand : Kafan , Abhilasha, Vidroh, Poos ki rath, Juloos

Course Outcomes:

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

CO1 Gain knowledge about the nature and culture of Hindi language
CO2 Understand the structural aspects of Hindi language
CO3 Apply the knowledge of the grammatical structures to communicate in Hindi
CO4 Analyse the social significance of modern literature.
CO5 Develop the ability to translate a given text to Hindi

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1									**2**	**3**				
CO2									**2**	**3**				
CO3									**2**	**3**				
CO4										**3**				
CO5									**2**					

Text Books :

1. Prem Chand Ki Srvashrestha Kahaniyam: Prem Chand ; Diamond Pub Ltd. New Delhi
2. Vyavaharik Hindi Vyakaran ,Anuvad thaha Rachana : Dr. H. Parameswaran, Radhakrishna publishing House,New Delhi
3. Kamtha Prasad Guru : Hindi Vyakaran, Best Book pub House, New Delhi
4. Poetry : Kavya Ras-Ed: T.V. Basker- Pachouri Press; Mathura

15HIN111 HINDI II 1 0 2 2

Appreciation and assimilation of Hindi Literature - both *drishya* and *shravya* - using the best specimens provided as anthology.

Syllabus:

Unit -1

Kavya Tarang;-Dhumil ke Anthim Kavitha[Poet-Dhumil],Dhabba[Poet-Kedarnath Singh],Proxy[Poet-Venugopal],Vakth[Poet-Arun Kamal],Maachis[Poet-Suneeta Jain].

Unit -2

Communicative Hindi - Moukhik Abhivyakthi

Unit -3

Audio- Visual –Media in Hindi – Movies like Tare Zameen par , Paa, Black etc., appreciation and evaluation . News reading and presentations in Radio and TV channels in Hindi .

Unit -4

Gadya Manjusha – Budhapa , Kheesa, Sadachar ka Thavis

Unit -5

Translation: Theory and Practice - Letter writing: Formal and Personal – Introduction to Hindi Software.

Course Outcomes:

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

CO1	Understand the grammatical structures of Hindi
CO2	and the post modern trends of literature
CO3	e critical thinking and writing skills
CO4	and analyse different literary and audio-visual material
CO5	ndamental knowledge of Hindi in formal and informal writing

Mapping of course outcomes with program outcomes:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2
CO1									**1**	**2**				
CO2									**1**	**2**				
CO3									**1**	**2**				
CO4										**3**				
CO5									**1**	**2**				

Text Books:

1. Kavay Tarang : Dr. Niranjan , Jawahar Pusthakalay , Mathura.
2. Gadya Manjusha: Editor: Govind , Jawahar Pusthakalay , Mathura
3. Prem Chand Ki Srvashrestha Kahaniyam: Prem Chand ; Diamond Pub Ltd. New Delhi

4. Kamtha Prasad Guru : Hindi Vyakaran, Best Book pub House, New Delhi
5. 5.Poetry : Kavya Ras-Ed: T.V. Basker- Pachouri Press; Mathura

15HUM239 PSYCHOLOGY FOR EFFECTIVE LIVING 2 0 0 2

Course Objectives

1. To help students acquire the basic knowledge of behavior and effective living
2. To create an awareness of the hazards of health compromising behaviours
3. To develop and strengthen the tools required to handle the adversities of life

Syllabus

Unit 1

SELF AWARENESS & SELF MOTIVATION
Definition of motivation-Maslow's hierarchy of motivation-Self-analysis through SWOT and Johari window - Importance of self-esteem and Enhancement of self-esteem-techniques and Strategies for self-motivation.

Unit 2

THE NATURE AND COPING OF STRESS
Definition of stress, stressors, eustress, distress-PTSD-stress among college students- stress assessment-coping with stress-progressive muscle relaxation-RET-guided imagery-bio feedback-religious and spiritual way of coping with stress

Unit 3

APPLICATION OF HEALTH PSYCHOLOGY
Health compromising behaviors-smoking and alcoholism-biological and psychological effects of addiction-deaddiction-behavior modifications-CBT in handling problem behavior-cancer risks-AIDS.

Course Outcome

CO 1: Understand the basic concepts of Behavioral Psychology

CO 2: Demonstrate self reflective skills through activities
CO 3: Apply the knowledge of psychology to relieve stress
CO 4: Analyse the adverse effects of health compromising behaviours.
CO 5: Evaluate and use guided techniques to overcome and cope with stress related problems.

CO-PO Mapping

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

Text Book(s)

V.D.Swaminathan&K.V.Kaliappan, Psychology for Effective living-An introduction to Health

Reference(s)

1.S.Sunder. (2002). Textbook of Rehabilitation,2nd edition,Jaypee Brothers,New Delhi.
2.Weiben&Lloyd. (2004). Psychology applied to Modern Life,Thompson Learning,Asia Ltd.

15HUM240 PSYCHOLOGY FOR ENGINEERS 2 0 0 2

Course Objectives

1. To strengthen the fundamental knowledge of human behavior
2. To strengthen the ability to understand the basic nature and behavior of humans in organizations as a whole
3. To connect the concepts of psychology to personal and professional life

Syllabus

Unit 1

PSYCHOLOGY OF ADOLESCENTS

Psychology-definition-scope-adolescence-characteristics-developmental tasks-physical and psychological changes-interests-family relationships-emotions-peer pressure-positive and Negative effects of peer pressure-types of friends-choice of friends

Unit 2

LEARNING, MEMORY AND STUDY SKILLS

Definitions-Classical conditioning-Operant conditioning-Insight learning-reinforcement-its principles and its effects-role of reward and punishment in learning-forgetting-causes-techniques for improving study skills-Mnemonics-Intelligence-Emotional and social intelligence

Unit 3

ATTENTION & PERCEPTION

Definition-types of attention-span of attention-division of attention- factors determining attention-perception-difference between sensation and perception-laws of perception-errors in perception-illusion and hallucination

Course Outcome

CO 1: Understand the fundamental processes underlying human behavior such as learning, motivation, individual differences, intelligence and personality.
CO 2: Apply the principles of psychology in day- to- day life for a better understanding of oneself and others.
CO 3: Apply the knowledge of Psychology to improve study skills and learning methods
CO 4: Apply the concepts of defense mechanisms to safeguard against abusive relationships and to nurture healthy relationships.

CO-PO Mapping

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

Text Book(s)

S.K.Mangal General Psychology,Sterling Publishers Pvt.Ltd.2007

Reference(s)

1.Elizabeth B. Hurlock, Developmental Psychology - A Life span approach,6th edition
2.Cliffordm Organ, Richard King, John Scholper, Introduction to Psychology, Tata McGraw Hill, Pvt Ltd 2004.

15HUM244 UNDERSTANDING SCIENCE OF FOOD AND NUTRITION 1022

Course Objectives:

- To introduce the significance of food, nutrients, locally available food resources, synergic food combinations, good cooking methods and importance of diversity in foods
- To understand nutritional imbalances and chronic diseases associated with the quality of food.
- To gain awareness about the quality of food - Organic food, genetically modified food, adulterated food, allergic food, , food poisoning and food safety.
- To understand food preservation processing, packaging and the use of additives.

UNIT I:

FOOD AND FOOD GROUPS:
Introduction to foods, food groups, Identifying locally available foods and plant nutrients. Nutrients and its variety. Cooking methods, effects of cooking on nutritive value of foods, while preparation and preservation of foods, cooking utensils & instruments. Synergy between foods, Do and Don'ts while cooking. Science behind foods.Food allergies, food poisoning, food safety standards.

UNIT II:

NUTRIENTS AND NUTRITION:
Nutrition through life cycle, RDA intake for all age groups. Nutrition in disease – Malnutrition (under & over), other diseases. Adulteration of foods & Food additives. Packaging and labeling of foods, certification, logo & symbols.

UNIT III:

INTRODUCTION TO FOOD BIOTECHNOLOGY:
Future foods- Organic foods and genetically modified foods, Fortification of foods, bio fortification of foods, value addition of foods, functional foods, nutraceuticals, weaning foods/supplementary.

Processing and preservation of foods, applications of food technology in daily life, and your prospects associated with food industry – Nanoparticles, biosensors, advanced research.

Course Outcome:

CO1: Acquire knowledge about the various food and food groups
CO2: Understand nutritional imbalances and chronic diseases prevailing among different age groups.
CO3: Understand the significance of safe food and apply the food safety standards
CO4: Demonstrate skills of food processing, preservation and packaging methods with or without additives
CO5: Evaluate the quality of food based on the theoretical knowledge of Food and Nutrition

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1		1	1			1	2	1	1	1	1	3
CO 2		1	1			1	1	1	1	1	1	3
CO 3		1	1			1	1	1	1	1	1	3
CO 4		1	1			1	1	1	1	1	1	3
CO 5		1	1			1	2	1	2	1	1	3

Reference Books:

- C. Gopalanetal, **Nutritive Value of Indian Foods**, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, 2017.
- B.SriLakhmi, **Dietetics**, New age international, 2015.
- N, ShakuntalaManay, M. Shadaksharaswamy, **Foods Facts and Principles**, New Age International, New Delhi, 2008.
- Sumati.RMudamri, and M.V.Rajagopal, **Fundamental of foods, Nutrition and Diet Therapy**, New Age International, New Delhi, 2008.

15MAL101 MALAYALAM I 1 0 2 2

Course Objectives:

To teach Malayalam for effective communication in different spheres of life:- Social context , Education, Research & Media

Unit 1

Ancient poet trio:*Adhyatmaramayanam,LakshmanaSwanthanam (Lines: valsasoumitre…*

*mungikidakayal),*Ezhuthachan -Medieval period classics – *Jnanappana(Lines: kalaminnu… vilasangalingane*),Poonthanam.

Unit 2
Modern Poet trio: *EnteGurunathan,* VallatholNarayanaMenon- Critical analysis of the poem.

Unit 3
Short stories from period 1/2/3:*Poovanpazham*-VaikaomMuhammedBasheer-Literary & Cultural figures of Kerala and about their literary contributions.
Unit 4

Literary Criticism: *BharathaParyadanam-VyasanteChiri*–Ithihasa studies-KuttikrishnaMararu-Outline of literary Criticism in Malayalam Literature-Introduction to KuttikrishnaMararu& his outlook towards literature &life.

Unit 5
Error-freeMalayalam: **1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha
Malayalam – Writing-**a**. Expansion of ideas; **b**.PrecisWriting; **c**. Essay Writing; **d**.Letter writing; **e**.RadioSpeech;**f**.Script/Feature/Script
Writing;**g**.NewsEditing;**h**.Advertising;**i.**Editing;j.EditorialWriting;**k**.Critical appreciation of literary works (Any one or two as an assignment).

Course Outcome :

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

CO1	Understand and inculcate philosophical thoughts and practices
CO2	Understand and appreciate the post modern trends of literature.
CO3	Analyse the literary texts and comprehend the cultural diversity of Kerala
CO4	Distinguish the different genres in Malayalam literature
CO5	Demonstrate the ability to effectively communicate in Malayalam

CO-PO Mapping :

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

REFERENCES:

1. Prof. PanmanaRamachandranNair(Edited),*Thunjanpadhanangal*, Current Books, 2012.
2. Prof. G.Balakrishnan Nair,.*JnanappanayumHarinamaKeerthanavum*, N.B.S, 2005.
3..Dr. M.N.Karasseri,*BasheerintePoonkavanam*, D.C.Books, 2008.
4 Prof. M.N.Vijayan, *MarubhoomikalPookkumbol*,D.C.Books, 2010.
5..Prof. M.ThomasMathew,*LavanyanubhavathinteYukthisasthram*, Kerala Sahitya Academy, 2006.
6. Dr. .M.Leelavathy,*KavithaSahityacharitram*, Kerala Sahitya Academy, 1996.
7. ThayattuSankaran, *VallatholNavayugathinteKavi*,VallatholVidyapeetham

15MAL111 MALAYALAM II 1 0 2 2

Course Objectives

- To appreciate the aesthetics and understand the cultural implications in Malayalam Literature
- To enhance creative thinking in Malayalam
- To equip the students to read and write effectively in Malayalam
- To acquire pronunciation skills

Unit1

Ancient poet trio: *Kalayanasougandhikam,(Lines: kallummarangalum… namukkennarikavrikodara),*KunjanNambiar - Critical analysis of his poetry-Ancient Drama: *Kerala Sakunthalam* (Act 1), Kalidasan (Transilated by Attor Krishna Pisharody).

Unit 2

Modern/romantic/contemporary poetry: *Manaswini*, Changampuzha Krishna Pillai –Romanticism – modernism.

Unit 3

Anthology of short stories from period 3/4/5: *NinteOrmmayku*, M.T.Vasudevan Nair-literary contributions of his time.

Unit 4

Partof an autobiography/travelogue: *KannerumKinavum*, Chapter: Valarnnuvarunnoratmavu, V.T.Bhattathirippadu-Socio-cultural literature-historical importance.

Unit 5

Error-free Malayalam-**1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha Malayalam-

Writing-**a**.Expansion of ideas;**b**.PrécisWriting;**c.** Essay Writing; **d**.Letter writing;**e**.RadioSpeech;**f**.Script/Feature/ScriptWriting;**g**.NewsEditing;**h.**Advertising;**i**.Editing; **j**.EditorialWriting;**k**.Critical appreciation of literary works (Any one or two as an assignment).

Course Outcome:

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

CO1	Understand the different cultural influences in linguistic translation
CO2	Identify and appreciate the Romantic elements of modern literature
CO3	Analyze the genre of autobiographical writing
CO4	Critically evaluate the significance of historical, political and socio cultural aspects in literature
CO5	Demonstrate good writing skills in Malayalam

CO-PO Mapping

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

REFERENCES:

1. Prof.P.K.NarayanaPillai.,(SahityaPanchanan), *Vimarsanathrayam,* Kerala Sahitya Academy,2000.

2. Prof.M.P. SankunniNair.,*ChathravumChamaravum,* D.C.Books, 2004.

3.Prof.M.K.Sanu, *Changampuzha: Nakshatrangalude Snehabhajanam*,N.B.S.,1989.

4. Prof.S.GupthanNair,*AsthiyudePookkal*, D.C Books.2005.

5. Prof. PanmanaRamachandranNair,*ThettillathaMalayalam*,*Sariyumthettum etc*., D.C.Book, 2006.

6. Prof.M. Achuthan, *Cherukatha-Innale, innu,* National Book Stall, 1998.

7. Prof.N.KrishnaPillai,*KairaliyudeKatha*,National Book Stall, 2001.

15TAM101 TAMIL I 2 0 0 2

Course Objectives

- To introduce the students to different literature- Sangam literature, Epics, Bhakthi literatureandmodern literature.
- To improve their ability tocommunicate with creative concepts, and also to introduce them to the usefulness of basicgrammaticalcomponents in Tamil.

Syllabus

Unit1

The history ofTamilliterature: Nāṭṭupuṟap pāṭalkaḷ, kataikkaḷ, paḻamoḻikaḷ - ciṟukataikaḷ tōṟṟamum vaḷarcciyum,
ciṟṟilakkiyaṅkaḷ: Kaliṅkattup paraṇi (pōrpāṭiyatu) - mukkūṭaṟ paḷḷu 35.
Kāppiyaṅkaḷ: Cilappatikāram – maṇimēkalai naṭaiyiyal āyvu maṟṟum aimperum – aiñciṟuṅ kāppiyaṅkaḷ toṭarpāṉa ceytikaḷ.

Unit 2

tiṇai ilakkiyamum nītiyilakkiyamum - patiṉeṇkīḻkkaṇakku nūlkaḷ toṭarpāṉa piṟa ceytikaḷ - tirukkuṟaḷ (aṉpu, paṇpu, kalvi, oḻukkam, naṭpu, vāymai, kēḷvi, ceynaṉṟi, periyāraittuṇakkōṭal, viḻippuṇarvu pēṉṟa atikārattil uḷḷa ceytikaḷ.
Aṟanūlkaḷ: Ulakanīti (1-5) – ēlāti (1,3,6). - Cittarkaḷ: Kaṭuveḷi cittar pāṭalkaḷ (āṉantak kaḷippu –1, 4, 6, 7, 8), maṟṟum akappēy cittar pāṭalkaḷ (1-5).

Unit 3

tamiḻ ilakkaṇam: Vākkiya vakaikaḷ – taṉviṉai piṟaviṉai – nērkkūṟṟu ayaṟkūṟṟu

Unit 4

tamiḻaka aṟiñarkaḷiṉ tamiḻ toṇṭum camutāya toṇṭum: Pāratiyār, pāratitācaṉ, paṭṭukkōṭṭai kalyāṇacuntaram, curatā, cujātā, ciṟpi, mēttā, aptul rakumāṉ, na.Piccaimūrtti, akilaṉ, kalki, jī.Yū.Pōp, vīramāmuṉivar, aṇṇā, paritimāṟ kalaiñar, maṟaimalaiyaṭikaḷ.

Unit 5

tamiḻ moḻi āyvil kaṇiṉi payaṉpāṭu. - Karuttu parimāṟṟam - viḻampara moḻiyamaippu – pēccu - nāṭakam paṭaippu - ciṟukatai, katai, putiṉam paṭaippu.

Course Outcomes

CO 1: To understand the Sangam literature
CO 2: To understand the creative literature
CO 3: To understand the literary work on religious scriptures
CO 4: To improve the communication and memory skills
CO 5: To understand the basic grammar components of Tamil language and their usage and applications.
CO 6: Understand creative writing aspects and apply them.

CO-PO Mapping

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

Textbooks:

- http:/Www.tamilvu.trg/libirary/libindex.htm.
- http:/Www.tunathamizh.tom/2013/07/blog0post_24.html
- Mu.Varatarācaṉ "tamiḻ ilakkiya varalāṟu" cāhitya akaṭemi papḷikēṣaṉs, 2012
- nā.Vāṉamāmalai "paḻaṅkataikaḷum, paḻamoḻikaḷum" niyū ceñcuri puttaka veḷiyīṭṭakam, 1980,2008
- nā.Vāṉamāmalai, "tamiḻar nāṭṭuppāṭalkaḷ" niyū ceñcuri puttaka veḷiyīṭṭakam 1964,2006
- poṉ maṇimāṟaṉ "aṭōṉ tamiḻ ilakkaṇam "aṭōṉ papḷiṣiṅ kurūp, vañciyūr, tiruvaṉantapuram, 2007.

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15TAM111 **TAMIL II** **2 0 0 2**

Course Objectives

- To learn the history ofTamilliterature.
- To analyze different styles of Tamil Language.
- To strengthen thecreativity in communication, Tamilbasicgrammar and use of computer on Tamil Language.

Syllabus

Unit 1

The history ofTamilliterature: Nāṭṭupuṟap pāṭalkaḷ, kataikkaḷ, paḻamoḻikaḷ - ciṟukataikaḷ tōṟṟamum vaḷarcciyum,
ciṟṟilakkiyaṅkaḷ: Kaliṅkattup paraṇi (pōrpāṭiyatu) - mukkūṭaṟ paḷḷu 35.
Kāppiyaṅkaḷ: Cilappatikāram – maṇimēkalai naṭaiyiyal āyvu maṟṟum aimperum – aiñciṟuṅ kāppiyaṅkaḷ toṭarpāṉa ceytikaḷ.

Unit 2

tiṇai ilakkiyamum nītiyilakkiyamum - patiṉeṇkīḻkkaṇakku nūlkaḷ toṭarpāṉa piṟa ceytikaḷ - tirukkuṟaḷ (aṉpu, paṇpu, kalvi, oḻukkam, naṭpu, vāymai, kēḷvi, ceynaṉṟi, periyāraittuṇakkōṭal, viḻippuṇarvu pēṉṟa atikārattil uḷḷa ceytikaḷ.
Aṟanūlkaḷ: Ulakanīti (1-5) – ēlāti (1,3,6). - Cittarkaḷ: Kaṭuveḷi cittar pāṭalkaḷ (āṉantak kaḷippu –1, 4, 6, 7, 8), maṟṟum akappēy cittar pāṭalkaḷ (1-5).

Unit 3

tamiḻ ilakkaṇam: Vākkiya vakaikaḷ – taṉviṉai piṟaviṉai – nērkkūṟṟu ayaṟkūṟṟu

Unit 4

tamiḻaka aṟiñarkaḷiṉ tamiḻ toṇṭum camutāya toṇṭum: Pāratiyār, pāratitācaṉ, paṭṭukkōṭṭai kalyāṇacuntaram, curatā, cujātā, ciṟpi, mēttā, aptul rakumāṉ, na.Piccaimūrtti, akilaṉ, kalki, jī.Yū.Pōp, vīramāmuṉivar, aṇṇā, paritimāṟ kalaiñar, maṟaimalaiyaṭikaḷ.

Unit 5

tamiḻ moḻi āyvil kaṇiṉi payaṉpāṭu. - Karuttu parimāṟṟam - viḻampara moḻiyamaippu – pēccu - nāṭakam paṭaippu - ciṟukatai, katai, putiṉam paṭaippu.

Course Outcomes

CO 1: Understand the history of Tamil literature.
CO 2: Apply practical and comparative analyses on literature.
CO 3: Understand thinai literature, literature on justice, Pathinenkeelkanaku literature.
CO 4: Understand the tamil scholars' service to Tamil language and society.
CO 5: Understand components of Tamil grammar and its usage
CO 6: Understand creative writing aspects and apply them

CO-PO Mapping

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

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