Curriculum Structure and Detailed Syllabus

Bachelor of Technology
in
Chemical Engineering
(Semester 1st to 8th)

(Applicable for the Batch of 2024-2028)

Haldia Institute of Technology

An Autonomous Institute, NAAC Accredited Grade 'A' Institute, NBA Accredited Department

Approved by: All India Council for Technical Education (AICTE)

Affiliated to: Maulana Abul Kalam Azad University of Technology, West Bengal (Formerly Known as - WBUT)

Haldia, Purba Medinipur, West Bengal, India, 721657

Vision and Mission of the Department (Chemical Engineering):

Vision: To become an internationally reputed department of higher learning for the growth and development of chemical and allied process industries to address the related problems.

Mission:

- To inculcate students with a strong fundamental knowledge to meet the needs of a rapidly changing technological environment in process development and equipment design.
- To carry out vibrant interdisciplinary research program that can creatively shape the undergraduates and graduates to address the needs of chemical engineering profession in particular and society in general.
- To develop leadership qualities to solve scientific and environmental challenges keeping in mind the safety and ethical concerns.

List of Program Outcomes (POs)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: 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.

PO3: 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.

PO4: 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.

PO5: 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.

PO6: 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.

PO7: 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.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: 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.

PO11: 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.

PO12: 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.

List of Program Specific Outcomes (PSOs)

PSO1: Function professionally as an engineer to solve problems by applying acquired knowledge in chemical and allied field.

PSO2: Designing an environment friendly system for effective reaction, separation and purification and other operations in various processes with proper safety measures using modern engineering tools individually or in a team.

PSO3: Practicing engineering with professional ethics for the benefit of society with proper communication to the community.

List of Program Educational Objectives (PEOs)

PEO1: To produce graduates with a strong foundation and understanding of the fundamental principles of science and engineering enabling graduates to pursue their careers as practicing chemical engineers in Chemical and Allied Engineering Industries.

PEO2: To produce graduates who are prepared to pursue their post-graduation and research in the emerging and allied areas of Chemical Engineering.

PEO3: To provide students with opportunities to integrate with multidisciplinary teams to develop skills with professional integrity and ethics to implement professional leadership.

Curriculum

B. Tech First year (Semester I)

Theory Papers

Sl no.	Course code	Course title	Hours/week L: T:P	Credit	Marks
1	BS-M 101	Mathematics-I	3-1-0	4	100
2	BS-PH 101	Physics	3-1-0	4	100
3	ES-EE 101	Basic Elec. & Electronics Engineering	3-1-0	4	100
4	ES-BT 101	Biology for Engineers	2-0-0	2	100
Total				**14**	400

Practical/Sessional papers

Sl no.	Course code	Course title	Hours/week L: T:P	Credit	Marks
1	BS-PH 191	Physics Lab	0-0-3	1.5	100
2	ES-EE 191	Basic Elec. & Electronics Engineering lab	0-0-3	1.5	100
3	ES– ME 191	Workshop Practice	0-0-3	1.5	100
Total				**4.5**	300

Extra Curricular Activity

Sl no.	Course code	Course title	Hours/week L: T:P	Credit	Marks
1	AU-101	NSS	0-0-2	0.0	--
Total				0.0	--

B. Tech First year (Semester II)

Theory Papers

Sl no.	Course code	Course title	Hours/week L: T:P	Credit	Marks
1	BS-M 201	Mathematics-II	3-1-0	4	100
2	BS- CH 201	Chemistry	3-1-0	4	100
3	ES-CS 201	Programming for problem-solving	3-1-0	4	100
4	HS-MC 201	Values & Ethics	2-0-0	2	100
5	HM-HU 201	English Language and Technical Communication	2-0-0	2	100
Total				**16**	500

Practical/Sessional papers

Sl no.	Course code	Course title	Hours/week L: T:P	Credit	Marks
1	BS-CH 291	Chemistry Lab	0-0-3	1.5	100
2	ES-CS 291	Programming for Problem Solving Lab	0-0-3	1.5	100
3	ES-ME 292	Engineering Drawing	0-0-3	1.5	100
4	HM-HU 291	English Language and Technical Communication Lab	0-0-2	1.0	100
Total				**5.5**	400

B. Tech Second year (Semester III)

Theory Papers

Sl no.	Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 301	Fluid Mechanics	3-1-0	4	100	4
2	Professional core Courses	PC-CHE 302	Numerical Methods in Chemical Engineering	3-0-0	3	100	3
3	Professional Core Courses	PC-CHE 303	Chemical Process Calculations	3-0-0	3	100	3
4	Professional Core Course	PC-CHE 304	Energy and its Utilization	3-0-0	3	100	3
5	Engineering Science Courses	ES-CHE 301	Materials Science	3-0-0	3	100	3
6	Humanities and Social Science Courses	HM-HU 301	Economics for Engineers	3-0-0	3	100	3
Total					19	600	19

Practical/Sessional papers

Sl no.	Categories	Course code	Course title	Hours/week L: T: P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 391	Fluid Mechanics Laboratory	0-0-3	1.5	100	3
2	Professional Core Courses	PC-CHE 392	Numerical Methods in Chemical Engineering Laboratory	0-0-3	1.5	100	3

3	Professional Core Courses	PC-CHE 393	Energy Engineering Laboratory	0-0-3	1.5	100	3
4	Foundation Course	SI-CHE 391	Emergence of Chemical Engineering	0-0-3	1.5	100	3
Total					6	400	12

B. Tech Second year (Semester IV) Theory Papers

Sl no.	Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 401	Heat Transfer	3-1-0	4	100	4
2	Professional core Courses	PC-CHE 402	Chemical Engineering Thermodynamics	3-1-0	4	100	4
3	Professional Core Courses	PC-CHE 403	Solid and Fluid – Particle Processing	3-0-0	3	100	3
4	Professional Core Courses	PC-CHE 404	Mass Transfer I	3-1-0	4	100	4
5	Humanities and Social Science Courses	HM-HU 401	Principles of Management	3-0-0	3	100	3
6	Mandatory Non Credit Course	MC-CHE 401	Environmental Science	2-0-0	0	100	2
Total					18	600	20

Practical/Sessional papers

Sl no.	Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 491	Heat Transfer Laboratory	0-0-3	1.5	100	3
2	Professional Core Courses	PC-CHE 492	Solid and Fluid– Particle Processing Laboratory	0-0-3	1.5	100	3
Total					3	200	6

B. Tech Third year (Semester V) Theory Papers

SL No.	Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 501	Transport Phenomena	3-1-0	4	100	4
2	Professional Core Courses	PC-CHE 502	Chemical Reaction Engineering	3-1-0	4	100	4
3	Professional Core Courses	PC-CHE 503	Mass Transfer II	3-1-0	4	100	4
4	Professional Elective Courses	PEC-CHE 501	Core Elective I	3-0-0	3	100	3
5	Open Elective Courses	OEC-CHE 501	Open Elective I	3-0-0	3	100	3
6	Mandatory Non-Credit Course	MC-CHE 501	Constitution of India	2-0-0	0	100	2
Total					18	600	20

Practical/Sessional papers

SL No.	Categories	Course code	Course title	Hours/ week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 591	Chemical Reaction Engineering Laboratory	0-0-3	1.5	100	3
2	Professional Core Courses	PC-CHE 592	Mass Transfer Laboratory	0-0-3	1.5	100	3
3	Professional Core Courses	PC-CHE 593	Process Equipment Design and Drawing-I	0-0-3	2	100	3
Total					5	300	9

Core Elective I	PEC–CHE 501A	PEC–CHE 501B	PEC–CHE 501C
Name of the Subject	Food Technology	Fertilizer Technology	Petrochemical Technology

B. Tech Third year (Semester VI) Theory Papers

SL No.	Categories	Course code	Course title	Hours/ week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 601	Chemical Process Technology	3-1-0	4	100	4
2	Professional Core Courses	PC-CHE 602	Instrumentation and Process Control	3-1-0	4	100	4
3	Professional Elective Courses	PEC-CHE 601	Core Elective II	3-0-0	3	100	3
4	Professional Elective Courses	PEC-CHE 602	Core Elective III	3-0-0	3	100	3
5	Open Elective Courses	OEC-CHE 601	Open Elective II	3-0-0	3	100	3
Total					17	500	17

Core Elective II	PEC-CHE 601A	PEC-CHE 601B	PEC-CHE 601C
Name of the Subject	Project Engineering	Nanoscience and nanotechnology	Polymer Science and Engineering

Core Elective III	PEC-CHE 602A	PEC-CHE 602B	PEC-CHE 602C
Name of the Subject	Biotechnology and Biochemical Engineering	Advanced Separation Processes	Industrial Pollution Control

Practical/Sessional papers

Sl no.	Categories	Course code	Course title	Hours/ week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Core Courses	PC-CHE 691	Process Equipment Design and Drawing-II	0-0-3	2	100	3
2	Professional Core Courses	PC- CHE 692	Instrumentation and Process control lab	0-0-3	1.5	100	3
3	Seminar	SEM-CHE 691	Term Paper and Technical Seminar	0-0-3	1.5	100	3
Total					5	300	9

- Students will undergo an Industrial Internship after 6th Semester Examination for a period 6 weeks and that will be evaluated during 7th Semester Examination as the Paper code SI-CHE 791.

B. Tech Fourth year (Semester VII) Theory Papers

Sl no.	Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/week
1	Professional Elective Courses	PEC-CHE 701	Core Elective IV	3-0-0	3	100	3
2	Open Elective Courses	OEC-CHE 701	Open Elective III	3-0-0	3	100	3
Total					6	200	6

Core Elective IV	PEC–CHE 701A	PEC–CHE 701B	PEC–CHE 701C
Name of the Subject	Modern Tools and Their Design Aspects	Computational Fluid Dynamics	Safety and Hazards Analysis in Industries

Practical/Sessional papers

Sl no.	Categories	Course code	Course title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	Project-1	PROJ-CHE 791	Project Work/ Research Internship	0-0-20	6	100	20
2	Industrial Internship	SI-CHE 791	Industrial Internship	0-0-40	3	100	40
3	Professional Core Course	PC-CHE 791	Techno-Economic Evaluation of Industrial Processes	0-0-3	2	100	3
Total					11	300	63

B. Tech Fourth year (Semester VIII) Theory Papers

Sl no.	Categories	Course code	Course title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	Open Elective Courses	OEC-CHE 801	Open Elective IV	3-0-0	3	100	3
Total					3	100	3

Practical/Sessional papers

SL No.	Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/week
1	Project-II	PROJ-CHE 891	Project Work & Report Making.	0-0-32	8	100	32
3	Grand Viva	GV-CHE 891	Grand Viva		2	100	
Total					10	200	32

Open Electives offered by the Department of Chemical Engineering

Categories	Broad name	Name of the subject	Subject code
Open Elective courses	Open Elective I	Materials for Engineering Applications	OEC– CHE 501A
		Renewable energy	OEC– CHE 501B
	Open Elective II	Cryogenic Engineering	OEC– CHE 601A
		Bioreactor Design	OEC–CHE 601B
	Open Elective III	Advanced Food Processing and Food Preservation Technologies	OEC–CHE 701A
		Industrial Total Quality Management	OEC– CHE 701B
		Additive Manufacturing	OEC– CHE 701C
	Open Elective IV	Statistical Quality control	OEC– CHE 801A
		Operation Research	OEC – CHE 801B

Total credit

Semester	Theory	Practical/sessional	Total
First	14	4.5	18.5
Second	16	5.5	21.5
Third	19	6	25
Fourth	18	3	21
Fifth	18	5	23
Sixth	17	5	22
Seventh	6	11	17
Eighth	3	10	13
		Total Credit	**161**

<u>Honours papers for the first, second, third, and fourth year of Chemical Engineering</u>.

***For <u>Honours</u>* <u>in B.Tech</u> (as per the New guideline of AICTE/MAKAUT), <u>total of 20 credits are</u> required over <u>four years</u> in the following way:**

For first year: 8 credits. For the second year: 4 credits. For the third year: 4 credits. For the fourth year: 4 credits

A student in 1st year has to cover courses from at least three (03) skills:

1. Computer Programing with Python
2. Soft skill
3. Ethics

A student in second, third, and fourth year of Chemical engineering has to cover courses from the following list of MOOCS:

MOOCs for Chemical Engineering

Sl. No.	Course Name	Duration (Week)	Credit	Name of the platform	Link
1	Electrochemical Technology in Pollution Control	8	2	Swayam/ NPTEL	https://swayam.gov.in
2	Environmental Quality monitoring and Analysis	12	3	Swayam/NPTEL	https://swayam.gov.in
3	Optimization in Chemical Engineering	12	3	Swayam/NPT EL	https://swayam.gov.in
4	Soft Nano Technology	8	2	Swayam/NPT EL	https://swayam.gov.in
5	Plastic Waste Management	8	2	Swayam	https://swayam.gov.in
6	aste to Energy Conversion	8	2	Swayam	https://swayam.gov.in
7	Sustainable Management of Biodiversity	12	3	Swayam	https://swayam.gov.in
8	Multiphase flows	8	2	NPTEL	
9	Computational Fluid Dynamics	12	3	NPTEL	
10	Process Control-Design, Analysis andAssessment	12	3	NPTEL	
11	Advanced Thermodynamics	12	3	NPTEL	

12	Computer Aided Applied Single Objective Optimization	8	2	NPTEL	
13	Data Science for Engineers	8	2	Swayam	https://swayam.gov.in/nd1_noc19_cs60/preview
14	Introduction to Industry 4.0 and Industrial Internet of Things	12	3	Swayam/NPT EL	https://swayam.gov.in
15	Data Analytics with Python	12	3	Swayam/NPT EL	https://swayam.gov.in
16	BMDATA SCIENCE	12	3	Coursera	https://www.coursera.org
17	Data Analysis and Presentation Skills: the PwC Approach Specialization	12	3	Coursera	https://www.coursera.org
18	Machine Learning with Python	12	3	Coursera	https://www.coursera.org
19	Data Processing Using Python	12	3	Coursera	https://www.coursera.org
20	Advanced Data Science with IBM Specialization	8	2	Coursera	https://www.coursera.org
21	Data Science: Foundations using R Specialization	12	3	Coursera	https://www.coursera.org
22	Python for Data Science and AI	8	2	Coursera	https://www.coursera.org
23	Data Science: Statistics and Machine Learning Specialization	12	3	Coursera	https://www.coursera.org
24	Python and Statistics for Financial Analysis	4	1	Coursera	https://www.coursera.org
25	Applied Machine Learning in Python	12	3	Coursera	https://www.coursera.org

26	Machine Learning, ML	12	3	Coursera	https://www.coursera.org
27	Fuzzy Sets, Logic and System Application	12	3	NPTEL	
28	Machine Learning	8	2	NPTEL	
29	Introduction to Machine Learning	12	3	NPTEL	
30	An Introduction to Artificial Intelligence	12	3	NPTEL	
31	Artificial Intelligence: Knowledge Representation and Reasoning	12	3	NPTEL	
32	Data Science for Engineers	8	2	NPTEL	
33	Introduction to Internet of Things	12	3	NPTEL	
34	Infrared Spectroscopy for Pollution Monitoring	4	2	Swayam	https://swayam.gov.in/nd1_noc19_ee66/preview
35	Technologies For Clean And Renewable Energy Production	8	4	Swayam	https://swayam.gov.in/nd1_noc19_ch26/preview
36	Introduction to Deep Earth Science	5	3	Edx	https://www.edx.org/course/introduction-to-deep-earth-science
37	Basic Analytical Chemistry	6	3	Edx	https://www.edx.org/course/basic-analytical-chemistry
38	Air Pollution – a Global Threat to our Health	3	2	Coursera	https://www.coursera.org/learn/air-pollution-health-threat
39	Demand and Supply Analytics	12	6	Edx	https://www.edx.org/course/demand-and-supply-analytics

40	Introduction to Engineering and Design	3	2	Edx	https://www.edx.org/course/introduction-to-engineering-and-design
41	Bio-refinery: From Biomass to Building Blocks of Bio-based Products	7	4	Edx	https://www.edx.org/course/biorefinery-from-biomass-to-building-blocks-of-biobased-products-2
42	Water quality and the biogeochemical engine	13	6	Edx	https://www.edx.org/course/water-quality-and-the- biogeochemical-engine
43	Programming for the Internet of Things Project	4	2	Coursera	https://www.coursera.org/learn/internet-of-things- project
44	Introduction to the Internet of Things	12	6	Swayam	https://swayam.gov.in/nd1_noc19_cs65/preview
45	Artificial Intelligence (AI)	12	6	Edx	https://www.edx.org/course/artificial-intelligence-ai
46	Introduction to Machine Learning (IITM)	12	6	Swayam	https://swayam.gov.in/nd1_noc19_cs53/preview
47	INTRODUCTION TO CYBER SECURITY	12	6	Swayam	https://swayam.gov.in/nd2_nou19_cs08/preview
48	Introduction to the Internet of Things (IoT)	6	3	Edx	https://www.edx.org/course/introduction-to-the-internet-of-things-iot-1
49	Programming for everybody(getting started with Python)	4	2	COURSERA	https://www.coursera.org/learn/python
50	A life of happiness and fulfillment	4	2	COURSERA	https://www.coursera.org/learn/happiness

51	JAVA for Android	4	2	COURSERA	https://www.coursera.org/learn/java-for-android
52	Effective problem-solving and decision making	4	2	COURSERA	https://www.coursera.org/learn/problem-solving
53	Introduction of philosophy	4	2	COURSERA	https://www.coursera.org/learn/philosophy
54	High Stakes Leadership: Leading in Times of Crisis	4	2	COURSERA	https://www.coursera.org/learn/high-stakes-leadership
55	Institutional Online Course	16	4	INSTITUTE	

All of the MOOCs courses are to be taken from any MOOCs platform as per the following scheme of credit points. There would not be any concept of a fixed basket anymore. However, during choosing courses in the online platform students would essentially avoid the courses taught/offered through the curriculum in the offline / classroom mode.

For NPTEL/ Swayam platform: Credit points as specified in the platform

For other MOOCs platforms like Coursera, edX, Udemy, Simple Arnett, the following guideline is followed

Courses of 4 weeks to 7 weeks: 1 credit point, Courses of 8 weeks to 11 weeks: 2 credit point, Courses of 12 weeks to 15 weeks: 3 credit point Courses of 16 weeks or more: 4 credit point

Detailed Syllabus, B. Tech Second year, Semester I

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
BS-M 101	Mathematics-I	3-1-0	**4**	**100**	**4**

Total Lecture: 56 L

Course Objectives:

- Providing the core concepts of higher Engineering Mathematics and describing the techniques, this works as an essential tool to solve the problems in their field of applications.
- To provide an overview of Differential Equations, Laplace Transform and Complex Analysis to engineers.

COURSE CONTENTS

Module-1 [10 L]

Matrix & Determinant:

Elementary row and column operations over a matrix; Rank of a matrix; Rank and nullity; System of linear equations and its consistency; Cayley-Hamilton theorem; Eigen values and Eigen vectors; Diagonalization of matrices.

Module-2 [12 L]

Differential Calculus & Integral Calculus:

Leibnitz's Theorem; Rolle's Theorem, Mean value theorem, Taylor's and Maclaurin's theorems with remainders; Improper integrals; Beta and Gamma functions and their properties; Convergence of improper integrals. Differentiation under integral sign.

Module-3 [10 L]

Sequence and Series:

Basic concept of Convergence of sequence and series; Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test (statements and related problems on these tests), Rabbe's test; Alternating series; Leibnitz's Test (statement only); Absolute convergence and Conditional convergence.

Module-4 [12 L]

Calculus of function of several variables:

Introduction to functions of several variables; Limit and continuity, Partial derivatives, Homogeneous functions and Euler's theorem up to three variables, Chain rules, Differentiation of implicit functions,

Total differentials and their applications, Jacobians up to three variables Maxima, minima; Saddle points of functions; Lagrange Multiplier method and their applications; Concept of line integrals, Double and triple integrals.

Module-5 [12 L]

Vector Calculus:

Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar point function, divergence and curl of a vector point function,

Directional derivative. Related problems on these topics. Green's theorem, Gauss Divergence Theorem and Stoke's theorem (Applications only, proofs not required).

Course Outcomes (COs)

CO1: Represent, solve and formulate systems of linear equations, which are fundamental in engineering for modelling various physical problems; eigen values /eigen vectors to understand dynamic behavior of systems and analyze their stability, multivariate statistics system analysis.

CO2: Arrange and assess knowledge of characteristics of function at intermediate points, continuity pertaining to proper and improper integrals leading to convergence, convergency of sequence and series.

CO3: Model complex systems with several variables to understand their interactions; comprehend optimization in multidimensional spaces.

CO 4: Describe, analyze and compose physical phenomena that involve quantities with both magnitude and direction amalgamated with the concept of gradient, divergence, and curl to ascertain how quantities change in space and time.

Learning Resources:

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India.
2. B.S. Grewal (S. Chand & Co.), Engineering Mathematics.
3. John Bird, Higher Engineering Mathematics (4th Edition, 1st Indian Reprint 2006, Elsevier).
4. S. S. Sastry, Engineering Mathematics (PHI, 4PthP Edition, 2008).
5. M.C. Potter, J.L. Goldberg and E.F. Abonfadel, Advanced Engineering Mathematics, 3E: (OUP), Indian Edition.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
BS-PH 101	Physics	3-1-0	**4**	**100**	**4**

Total Lecture: 56 L

Course Objectives

- To introduce the rudimental and relevant concepts of physics to different branches of Engineering and Technology.
- To compile all the knowledge acquired from the course and to apply in industry, academia and research keeping in the mind about ethical awareness and impact in the field of environmental (pollution), social (legal) and safety.

COURSE CONTENTS

Module-1 [10 L]

Oscillations and Waves: Harmonic Oscillation -Simple Harmonic Motion –Damped Oscillation - Relaxation time& log decrement. Forced oscillation – Electromechanical Analogy between Mechanical Oscillator with Electrical circuit – Mechanical Impedance - Transient and Steady state oscillations – Resonance - Bandwidth – Quality factor - Sharpness of Resonance.

Module -2 [12 L]

Optics

Wave Optics: Interference–- Superposition of waves, Division of wave front and division of amplitude, Interference in parallel and wedge-shaped film-Thin film Interference, Newton's rings - determination of wave length and thickness.

Diffraction– Fresnel and Fraunhofer diffraction - Single Slit, Double Slit and Garting (Qualitative discussion only)

Polarization – Introduction – States of Polarization – Brewster's law–Malus Law – Phase Retardation Plate.

Lasers– Characteristics of Laser –Spontaneous and Stimulated Emission-Population Inversion-Classification of Laser - construction and working -Einstein's coefficients – Example of Gas Laser (He-Ne), Solid state laser (Ruby) and LED and p-n junction semiconductor lasers- Quantum well Lasers (concept only) -Applications of Laser.

Module -3 [12 L]

Electromagnetism, Dielectric and Magnetic Properties of Material

Basic Electromagnetism- Gradient of a Scalar function, Divergence and Curl of Vector field, Vector Integration –Line, surface and volume integration - Divergence and Stoke's Theorem- Maxwell's equations of Electromagnetism.

Dielectric Properties- Dielectric polarization – Polar and Non-polar dielectric, Electronic, Ionic, Orientational and Space charge polarization (Qualitative overview) - Application of dielectric materials

Magnetic Properties- Introduction**,** Classification (Dia, Para, Ferro) of magnetic materials – Curie temperature – Hysteresis – hard and soft magnetic materials –Applications of Magnetic materials-Superconductivity (only concepts)

Module -4 [12 L]

Quantum Mechanics: Blackbody Radiation –Planck's Radiation law, Compton Effect, Dual Nature of Matter – De' Broglie hypothesis – Heisenberg's Uncertainty Principle – Group velocity and Phase velocity, Wave function – Postulates of Quantum Mechanics – Quantum Mechanical operator –Eigen function and Eigen value - Schrödinger's time dependent and time independent wave equation-Particle in 1D box –Particle in 3D box – Concept of degeneracy-Stationary Perturbation (Concepts Only)

Module -5 [10 L]

Statistical Mechanics: Phase Space (μ- and Γ- phase space) – Macro states and Microstates – Density of States -Statistical Ensemble and Thermodynamic Probability-Classical Statistical systems (Maxwell - Boltzmann statistics) and quantum statistical systems (Fermi-Dirac and Bose-Einstein Statistics) and their applications.

Course Outcomes (COs)

CO1: Represent, solve and formulate the phenomena of Simple Harmonic Motion, Damped & Forced oscillations and realize the problem of simple mechanical systems and their electrical analogy.

CO2: Understand and correlate interference, diffraction, polarization of light and analyze the mechanism of LASER along with their applications.

CO3: Use the knowledge of vector calculus to describe and analyze electromagnetic fields and apply them in dielectric and magnetic properties of matter.

CO4: Formulate principles of quantum mechanics to analyze radiation and to solve problems of particle in infinite potential well with the concept of wave function. In abreast a student must compose statistical methods and probability theory to study the behaviour of systems consisting of a large number of particles.

Learning Resources:

1. M. R. Spiegel, Vector Analysis.

2. N. K. Bajaj, Waves and Oscillation.
3. David Halliday, Robert Resnick Jearl Walker, Principles of Physics, 10ed, Wiley.
4. A .K. Ghatak, Optics, McGraw Hill Education India Private Limited.
5. J. R. Taylor, C.D. Zafiratos and M. A. Dubson, Modern Physics for Scientists and Engineers, 2nd Ed., Pearson (2007).
6. J. J. Sakurai, Modern Quantum Mechanics, Cambridge University Press.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES-EE 101	Basic Elec. & Electro. Engg.	3-1-0	4	100	**4**

Total Lecture: 56 L

Course Objectives

- To introduce the basic concepts of electrical and electronics engineering

COURSE CONTENTS

DC Circuits: (10 L)

Introduction to circuit elements; independent and dependent current and voltage sources; Kirchhoff's laws; mesh and node analysis; source transformations; network theorems: Superposition Theorem, Thevenin's and Norton's Theorem, Maximum power transfer theorem; star-delta transformation

AC Circuits: (12 L)

Production of alternating voltage, RMS and average values for different wave shapes, Concept of phasor, phasor representation of circuit elements; analysis of series and parallel AC circuits; concept of real, reactive and apparent powers; resonance in RLC series and parallel circuits; balanced three phase circuit: voltage, current and power relations for star and delta arrangement; analysis of balanced and unbalanced circuits; three phase power measurement using three- wattmeter and two-wattmeter methods.

Magnetic circuits: (12 L)

Analogy between electric and magnetic circuits; series and parallel magnetic circuits; operating principles of electrical appliances: single-phase transformer and rotating machines (3-φIM); tests and performance of single-phase transformer.

Electronic Devices: (12 L)

Semiconductor, p-n junction diode: V-I characteristics of diode, Operation of Bipolar Junction Transistor, CB and CE configuration, Transistor as a switch, Basic concepts of FET.

Operational Amplifier Circuits: (10 L)

The ideal operational amplifier, the inverting, non-inverting amplifiers, Op-Amp Characteristics, Applications of Op-amp summing amplifier, differentiator and integrator.

Course Outcomes (COs)

CO1: Remember the concepts of different theorems for electrical, magnetic circuit and semiconductor physics of the device.

CO2: Understand the concepts of basic laws of electricity, network theorems, magnetic circuits, electronics circuit and its applications.

CO3. Apply relevant theorems and concepts to provide efficient solutions of electrical and electronic circuit and machine related problems.

CO4. Assess the efficiency and performance of electrical and electronic systems, making recommendations for improvements based on design specifications, operational constraints, and real-world performance data.

Learning Resources:

1. Hughes, E., Smith, I.M., Hiley, J. and Brown, K., Electrical and Electronic Technology, Prentice Hall (2008) 10th ed.

2. Nagrath, IJ. and Kothari, D.P., Basic Electrical Engineering, Tata McGraw Hill (2002).

3. Boylestad, R.L. and Nashelsky, L., Electronic Devices & Circuit Theory, Perason (2009).

4. Chakraborti, A., Basic Electrical Engineering, Tata McGraw-Hill (2008).

5. Del Toro, V., Electrical Engineering Fundamentals, Prentice-Hall of India Private Limited (2004).

6. David Bell, Electronics Devices and Circuits, Oxford Publications (2009).

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES-BT 101	Biology for Engineers	2-0-0	2	100	**2**

Total Lecture: 24 L

Course objectives:

- To familiarize the students with the basic biological concepts and their engineering applications.
- To provide the students with an insight of how biological systems can be redesigned as substitute products for natural systems.
- To motivate the students to develop the multidisciplinary vision of biological engineering

COURSE CONTENTS

Introduction to Biological Sciences (7 L)

Introduction to Biology: Science and comparison with other disciplines. Differences between Science & Engineering and Biologist & Biological Engineer.

The concept of biomimicry and its modern-day applications. The interdisciplinary nature of biological sciences.

Diversity of the living world, Taxonomy, Nomenclature, Taxonomic hierarchy, Biological classification.

Cell: Basic unit of life - Prokaryotes and Eukaryotes, Cell theory.

Biomolecules (7 L)

Introduction to Biomolecules: Sources, Structure, Characteristics and functions of the biomolecules (Carbohydrates, Proteins, Lipids and Nucleic acids).

Enzymology: Properties of enzymes, Enzyme structure, Classification and functions, Mechanism of enzyme reaction, Enzyme activity, Factors affecting enzyme activity.

Introduction to Metabolism in biological systems

Molecular aspects of life (7 L)

Molecular basis of Information Transfer: Central dogma, Replication, Transcription, Genetic code, Translation.

Immunity to Infection - Innate and Acquired immunity, Organs and cells of the immune system, Classification of antibodies. Microbes as Infectious Agents: Examples from human diseases

Biology and its Industrial Applications (7 L)

Applications of Biology: Agriculture, Medicine, Industry, Environment, Bio-robotics, 3D bio-printing, Biosensors, Bioinformatics etc. New generation bio-fabricated products and future challenges

Course Outcomes (COs):

CO1: Remember and understand the biological concepts from an engineering perspective

CO2: Understand the classification, structure and functions of various Biomolecules

CO3: Perception of the various biomolecular aspects of life

CO4: Apply and implement biological principles for the development of next generation technologies

Learning Resources:

1. Gabi Nindl Waite, Lee Waite, Applied Cell and Molecular Biology for Engineers, McGraw-Hill Education, 2007.

2. Arthur T. Johnson, Biology for Engineers, Second Edition, CRC Press, 2019.

3. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, ―Biology: A global approach, Pearson Education Ltd, 2014.

4. G. S. Stent and R. Calendar, ―Molecular Genetics, Freeman and company, 1978.

Web Reference:

NPTEL: https://onlinecourses.nptel.ac.in/noc19_ge31/preview

Practical/Sessional papers

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
BS-PH 191	Physics Lab	0-0-3	1.5	100	**3**

Periods: 42 P

Course Objectives

- To provide exposure to the students with hand on experience for data acquisition, precession, statistical data analysis, graph plotting calculation of fundamental quantities and error estimation of different fundamental physics experiments relevant to various engineering discipline.

All students have to perform total 10 experiments taking at least one from Optics, Electricity & Magnetism, Quantum Mechanics, Miscellaneous experiments and Innovative experiment sections. (One Innovative experiment is mandatory)

List of Experiments

Optics Experiments

1. Determination of dispersive power of the material of a prism
2. Determination of wavelength of a monochromatic light by Newton's ring
3. Determination of wavelength of a monochromatic light by Fresnel's bi-prism
4. Determination of wavelength of the given laser source by diffraction method
5. Determination of numerical aperture, angle of acceptance and bending energy losses of an optical fiber

Electricity & Magnetism Experiments

1. Determination of thermo electric power of a given thermocouple.
2. Determination of specific charge (e/m) of electron by J.J. Thompson's method.
3. Determination of dielectric constant of a given dielectric material.
4. Determination of Hall coefficient of a semiconductor by four probe method.

5. Determination of resistance of ballistic galvanometer by half deflection method and study of variation of logarithmic decrement with series resistance.

6. Determination of unknown resistance using Carey Foster's bridge

7. Study of Transient Response in LR, RC and LCR circuits using Exp EYES

8. Generating sound from electrical energy using Exp EYES

Quantum Physics Experiments

1. Determination of Stefan-Boltzmann constant.

2. Determination of Planck constant using photocell.

3. Determination of Lande-g factor using Electron spin resonance spectrometer.

4. Determination of Rydberg constant by studying Hydrogen spectrum.

5. Determination of Band gap of semiconductor.

6. To study current voltage characteristics, load response, areal characteristic and spectral response of a photovoltaic solar cell.

Miscellaneous Experiments

1. To determine the moment of inertia of a body about an axis passing through its centre of gravity.

2. Determination of modulus of rigidity of the material of a rod by static method

3. Determination of rigidity modulus of the material of a wire by dynamic method

4. Determination of Young's modulus of elasticity of the material of a bar by the method of flexure

5. Determination of bending moment and shear force of a rectangular beam of uniform cross-section

6. Determination of coefficient of viscosity by Poiseuille's capillary flow method

7. Measurement of wavelength and velocity of Ultrasonic wave by using Ultrasonic Interferometer**.**

Innovative Experiments

1. Studies on Bandgap measurement of thin film using UV-VIS spectrophotometer.

2. Basic UV-VIS absorbance study of organic dyes.

3. Basic UV-VIS study of nano-particles (NPs) and quantum dots (Q Dots).

4. Basic photoluminescence study of organic dyes.

5. Basic photoluminescence study of nano-particles (NPs) and quantum dots (Q Dots).

6. Studies on Basics of Vacuum system and Vacuum measurements.

7. Fabrication of RC and LC Filters.

Course Outcomes (COs)

CO1: Describe and understand the working formulas, uses of instruments, and apparatus used in diverse experiments.

CO2: Apply theoretical concepts to effectively execute experiments and record experimental data.

CO3: Analyze experimentally collected data, validate it through calculations, graphical representation, and error estimation, while adhering to necessary precautions.

CO4: Integrate acquired knowledge and apply it across various engineering disciplines.

Learning Resources

1. C.L. Arora, B.Sc. Practical Physics.
2. Harnam Singh and Dr. P.S. Hemne, B.Sc. Practical Physics.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES-EE 191	Basic Elec. & Electronics Engineering laboratory	0-0-3	1.5	100	**3**

Course objectives:

- To understand the concept of circuit laws and network theorems and apply them to laboratory measurements.

42 P

Name of the Experiments:

1. Network theorems: Thevenin, Norton and Superposition
2. AC series circuit
3. Three phase power measurement
4. Magnetic circuit: tests on transformer
5. Resonance in AC circuit
6. pn-junction diode characteristics
7. Diode use as rectifies.
8. BJT characteristics.
9. FET characteristics.
10. OPAMP Application (Adder, Subtractor and Amplifier)

Course Outcomes (COs):

CO1: Understand the use of various electrical measuring devices

CO2: Practice different types of wiring and devices connections keeping in mind technical and economical safety issues.

CO3: Evaluate and judge whether the solutions obtained are correct and matches the required parameters and characteristics.

CO4: Choose the proper type and specification of measuring procedure and measuring instruments for different industrial/commercial/domestic applications.

CO5: Familiarize with different active and passive electronic and electrical components, Trainer Kit, Function Generator, CRO and different measuring equipments and apply network theorems on DC and AC networks

Text Books:

1. D.P Kothari & I.J Nagrath, TMH, Basic Electrical engineering, Second Edition.
2. V.N Mittle & Arvind Mittal, TMH, Basic Electrical Engineering, Second Edition.
3. Nath & Chakraborti, Basic Electrical Engineering.
4. Surinder Pal Bali, Electrical Technology, Vol-I,Vol-II, Pearson Publication.
5. B.L. Theraja, A.K.Theraja, A Text Book of Electrical Technology, Vol. I & II, S. Chand & Company.

Reference Books:

1. Vincent Del Toro, Prentice-Hall, Electrical Engineering Fundamentals.
2. H. Cotton, Advance Electrical Technology, Reem Publication.
3. R.A. Natarajan, P.R. Babu, Basic Electrical Engineering, Sictech Publishers.
4. N.K. Mondal, Dhanpat Rai, Basic Electrical Engineering.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES–ME 191	Workshop Practice	0-0-3	1.5	100	**3**

42 P

Course Objectives

• To gives the basic working knowledge required in various engineering-based constructions, function, use and application of different working tools, equipment, and machines as well as the technique of manufacturing a product from its raw material.

[Before practice, background lectures will be delivered on the topics. Tool specifications and their materials will be described. Brief reports on the work done will be submitted by the students and

evaluation will be made on the basis of examination of the report and viva, conducted by the teachers.]

Theory

1. Carpentry (Wood Working): Timber, Seasoning and Preservation, Plywood and Plyboards, Carpentry Tools, Engineering applications. Different Joints

2. Metal Joining: Definitions of welding, brazing and soldering processes, and their applications. Oxy-acetylene gas welding process, equipment and techniques. Types of flames and their applications. Manual metal arc welding technique and equipment. AC and DC welding, electrodes, constituents and functions of electrodes. Welding positions. Types of weld joint. Common welding defects such as cracks, slag inclusion and porosity.

3. Bench work and Fitting: Tools for laying out, chisels, files, hammers, hand hacksaw, their specifications and uses.

4. Metal Cutting: Introduction to machining and common machining operations. Cutting tool materials, geometry of cutting tool, cutting fluid. Definition of machine tools, specification and block diagram of lathe, shaper, milling, drilling machine and grinder. Common lathe operations such as turning, facing and chamfering and parting. Difference between drilling and boring. Use of measuring instruments like micrometer / verniercaliper.

5. Tin Smithy: Sheet metal introduction, tools and operations, Shearing and Bending of sheets, types of joints

Jobs to be made in the Workshop

Group A **(**6 P)

Carpentry Shop: T-Lap joints and Dovetail joints

Group B (6 P)

a. Gas Welding practice on mild steel flat/sheet (up to 3mm thick)

b. Lap joint by Gas Welding (up to 3mm thick)

c. Manual Metal Arc Welding practice (up to 5mm thick)

d. square butt joint by MMA Welding

e. Lap joint by MMA Welding

Group C

Fittings work: Sawing and Finishing by Filing. (6 P)

Group D

a. Jobs on lathe with turning, facing, chamfering and parting operations (6 P)

b. Job on shaper and milling machine for finishing two sides of a job (6 P)

c. Drilling of holes of size 5- and 12-mm diameters on the jobs / External threads making by dies, Tap size drill hole/ hand tapping operations (6 P)

Group E

Smithy - making simple products on sheet metal (6 P)

Learning Resources

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.

2. Kalpakjian S. and Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.

3. Gowri P. Hariharan and A. Suresh Babu, "Manufacturing Technology – I" Pearson Education, 2008.

4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.

5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Course Outcomes (COs)

CO1: Train the students in metal joining process like welding, soldering, etc

CO2: Impart skill in fabricating simple components using sheet metal

CO3: Cultivate safety aspects in handling of tools and equipment.

CO4: Define, describe and determine the types and nature of the physical parameters like cutting speed, feed, depth of cut etc applied on mechanical manufacturing systems.

CO5: Classify and explain the effects of the above physical parameters as applied on mechanical manufacturing systems for proper comprehension.

CO6: Develop the collective skill and potentiality and leadership quality to work in a group or team.

Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/Week
AU 101	NSS	0-0-2	0.0	--	**2**

Periods: 28 P

Course Objectives

- To create awareness for women's education, old age education saving of girl child. Medical issue-blood donation and Thalassemia test.
- To realize, synthesize, and evaluate their personal readiness for leadership by group work, communicating effectively and to overcome & eliminate different constraints those may arises in their academic and daily life.

1. **Creating Awareness in Social Issues**

Blood Donation Camp, Road Safety Awareness, Poster Competition (Saving of Girl child, saving of water and fuel for future, Pollution and control, Global warming, Equal education for girls),Thalassemia awareness Programme, Eye Check-Up Camp.

2. **Participating in Mass-Education Programme**

   a. Poster Presentation on Education for All
   b. Elocution competition, SA writing on education for all
   c. National Education Day celebration (11th Nov)

3. Proposal for Local Slum Area Development

   a. Road and Costal Side Cleaning Programme
   b. Local Hospital Area Cleaning Programme (with collaboration Haldia Minicipality)
   c. Campus Cleaning Programme

4. Environmental Awareness Programme

   a. Resource Conversation (By Poster Competition)
      (i) Water
      (ii) Energy
   b. Poster Competition on Global warming
   c. Plantation Programme (5th September)
   d. Fire Safety Awareness Programme (With Haldia Fire Station)

5. Relief and Rehabilitation work during Natural Calamities

Course Outcomes (COs)

CO1. To Create awareness for women's education, old age education saving of girl child. Medical issue-blood donation and Thalassemia test.

CO2. To Realize, synthesize, and evaluate their personal readiness for leadership by group work, communicating effectively and to overcome & eliminate different constraints those may arises in their academic and daily life.

CO3. To Define and correlate different kind of social, cultural and ethical issue in light of saving of girl child, women education, saving of fuel. Manifest an ethics and service to the nation as a fundamental duty by organizing seminar symposia, workshop, essay writing, poster presentation etc.

CO4. To Apply problem solving skills by taking on volunteer and community service in their professional and social life and show interest to think about eco-friendly projects for the betterment of the society.

Detailed Syllabus, B. Tech Second year, Semester II

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
BS-M 201	Mathematics-II	3-1-0	4	100	**4**

Total Lecture: 56 L

Course Objectives

- Providing the core concepts of higher Engineering Mathematics and describing the Techniques, this works as an essential tool to solve the problems in their field of applications.
- To provide an overview of Differential Equations, Laplace Transform and Complex Analysis to engineers.

Module -1 [12 L]

Ordinary differential equations (ODE)- Linear and non-linear differential equations, Bernoulli's equation. General solution of ODE of first order and higher degree (different forms with special reference to Clairaut's equation). Solvable for x, solvable for y, solvable for p. Second order and first degree: General linear ODE of order two with constant coefficients, Method of variation of parameters, Cauchy-Euler equations. Simultaneous linear differential equations.

Module -2 [10 L]

Basics of Graph Theory: Graphs, Digraphs, Weighted graph, Connected and disconnected graphs, Complement of a graph, Regular graph, Complete graph, Subgraph, Walks, Paths, Circuits, Euler Graph, Matrix representation of a graph, Adjacency and incidence matrices of a graph, Graph isomorphism, Bipartite graph. Shortest path and Dijkstra's algorithm. Floyd-Algorithm. Trees and Spanning Trees.

Module -3 [12 L]

Laplace Transform: Introduction to integral transformation, functions of exponential order, Definition and existence of LT (Initial and final value theorems with applications, proofs not required), LT of elementary functions, Properties of Laplace Transformations, Evaluation of sine, cosine and exponential integrals, periodic and step functions using LT.

Definition and properties of inverse LT, Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of initial value problem using LT.

Module -4 [12 L]

Complex Variable: Complex functions, Concept of Limit, Continuity and Differentiability. Analytic functions, Cauchy-Riemann Equations (statement only). Sufficient conditions for a function to be analytic. Harmonic function and Conjugate Harmonic function, related problems. Construction of

Analytic functions, Milne Thomson method etc. Conformal mappings, Bilinear transformation and its applications.

Complex Integration: Concept of simple curve, closed curve, smooth curve & contour. Some elementary properties of complex Integrals. Line integrals along a piecewise smooth curve. Cauchy's theorem (statement only). Cauchy's integral formula and its applications.

Module -5 [10 L]

Zeros and Singularities of an Analytic Function & Residue Theorem.

Zero of an Analytic function, Singularities of an analytic function. Different types of singularities. Poles. Examples on determination of singularities and their nature. Series of complex valued functions, Taylor's series, Laurent's series.

Residue, Cauchy's Residue theorem (statement only) and its applications, evaluation of definite integrals: $\int_0^{\infty} \frac{\sin x}{x} dx, \int_0^{2\pi} \frac{d\theta}{a+b\cos\theta+c\sin\theta}, \oint_C \frac{P(z)}{Q(z)} dz$ (elementary cases, P(z) & Q(z) are polynomials of 2nd order or less).

Course Outcomes (COs)

CO1: Comprehend and solve ODE as a mathematical tool necessary to model, analyze, design complex problems in engineering practice.

CO2: Get acclimatize and propose graph as powerful framework for modelling and analyzing complex systems of interconnected components to predict connectivity and reliability of networks.

CO3: Describe, analyze and compose LT as a mathematical tool for analyzing linear systems, solving differential equations, performing frequency domain analysis, and designing systems with desired performance characteristics.

CO4: Solve problems which are impossible to solve with real variables alone by encompassing contour integration, series expansions, singularities and the residue theorem for solving integrals, differential equations and inverse problems.

Learning Resources

1. Miller & Freund R.A.Johnson, Probability and Statistics for Engineers, Prentice Hall of India.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern.
3. V. K. Balakrishnan, Graph Theory, Schaum's Outline, TMH.
4. B.S. Grewal, Engineering Mathematics, S. Chand & Co.
5. Daniel A. Murray, Introductory Course in Differential Equations, Longmans & Green.
6. N. Deo, Graph Theory, Prentice-Hall of India.
7. Sahajahan Ali Mollah, Numerical Analysis and Computational Procedures, Books & Allied Ltd.
8. Gupta & Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons.

9. Murray R. Spiegel, Schaum's Outlines: Laplace Transforms.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
BS- CH 201	Chemistry	3-1-0	4	100	**4**

Total Lecture: 56 L

Course Objective

- To develop the interest among the students regarding chemistry and their applications in engineering
- To develop confidence among students about chemistry, how the knowledge of chemistry is applied in technological field.

COURSE CONTENTS

Module I (10 L)

Thermodynamics (5 L): First Law of Thermodynamics (general discussion, and numerical), Second Law, Engine; Carnot's Cycle; Entropy, Entropy change; Entropy of system/surrounding/Universe; Free Energy, Free energy expression; Gibbs-Helmholtz equation; Clausius-Clapeyron equation; TdS relationship, Maxwell relationship.

Electrochemistry and Corrosion (5 L): Cell construction; Primary and Secondary Cell; Nernst Equation (without derivation); Relationship with ΔG, ΔH and ΔS; Standard Hydrogen Electrode (SHE), pH of Cell; Fuel Cell (Hydrogen fuel), Batteries (Lithium-ion battery).

Electrochemical theory of corrosion, Types of corrosion (dry, wet), Rust formation, Pitting corrosion, Crevice corrosion, Galvanic series, Stress corrosion cracking, Caustic embrittlement, Prevention from Corrosion (Electroplating, Anodization, Biofilm coatings) Sacrificial anode, Passivation.

Module II (8 L)

Atomic structure (4 L): Bohr's atomic model-Sommerfeld's extension of atomic structure; Electronic configuration and Quantum numbers; Shapes of s, p, d, f orbitals - Pauli's exclusion principle - Hund's Rule of maximum multiplicity- Aufbau principle. Atomic emission and absorption spectra, line and band spectra; Hydrogen spectrum (Numerical only); de-Broglie's theory; Heisenberg's uncertainty principle – wave nature of electron – Schrodinger wave equation (No derivation). Eigen values and Eigen functions.

Chemical bonding and Coordination Chemistry (4 L): Theory of Chemical Bonding, Molecular orbital and Bond order of H2, N2, He2, O2, N2, CO, HF. Pi-molecular orbital of ethylene and

butadiene. Crystal field theory of coordination compounds- magnetism, spin and orbital contribution: d-d transitions, C-T transition, Colour (w.r.t. MnO4-, and CrO42-).

Module III (10 L)

Stereochemistry (5 L): Stereoisomerism; concept of chirality and optical activity (up to two carbon atoms); elements of symmetry (plane and centre); interconversion of Fischer and Newman representations; threo and erythro, D and L, CIP Rules: R/S (up to 2 chiral carbon atoms), E/Z nomenclature. Conformational analysis of ethane, n-butane.

Green Chemistry Approach to Organic Reactions (5 L): Green chemistry Principle, oxidation of p-Xylene to PTA, Jones Oxidation, Use of KMnO4; Reduction reactions of organic compounds using NaBH4, LAH. Some name reactions: Wittig reaction), Suzuki, and Heck Coupling, Synthesis of Immidazolium salt (1-Methyl immidazole with Chloro pyridine.

Module IV (7 L)

Organic Spectroscopy:

UV-Vis Spectroscopy (3 L): Types of electronic transitions, chromophores and auxochromes; Bathochromic and Hypochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); application of Lambert-Beers law (no derivation, only numerical), Absorbency and Transparency, Woodward's Rules for calculation of λmax for conjugated diene, relative positions of λ_{max} considering conjugative effect, solvent effect. Fluorescence, phosphorescence (Jablonski diagram) and their application.

IR Spectroscopy (2 L): Introduction; modes of molecular vibrations (fundamental and nonfundamental); IR active/inactive molecules.

NMR Spectroscopy (2 L): Basic principles of Proton Magnetic Resonance; NMR active molecules; equivalent and non-equivalent protons with example; chemical shift.

Module V (12 L)

Chemical Kinetics (6 L): Rate equation; Activation Theory; Collision Theory; Transition state theory; Consecutive reaction (explanation and example only, derivation not required); Homogeneous and Heterogeneous Catalysis; Enzyme Catalysis; Michaelis Menten equation.

Polymer (6 L): Introduction, Molecular weight of Polymers (number average, weight average), Polymerization processes (addition and condensation polymerization), Mechanism of addition polymerization. (w.r.t polyethylene), Poly dispersity index (PDI), degree of polymerization, stereo-regularity of polymer (tacticity). Synthesis and use of Polyethylene, Polypropylene, Bakelite and PET. Synthesis of rubber, Vulcanization of rubber. Conducting polymers (Polyaniline, polythiophene). Polymer and Environment; Biodegradable polymers (Poly lactic acid, Polyurethane).

Module VI (9 L)

Water Treatment (4 L): Hardness of water, Water treatment (surface and waste), Alkalinity, Scale-sludge, Phosphate Conditioning and its application to Boiler and Laundry, Reaction involved in DO analysis, BOD and COD analysis.

Elementary Chemical Biology (3 L): Origin of Life and Chemical Elements; Trace and Ultrarace elements and their importance; Biological system and roles of metal ions (with special reference to function of Fe in Haemoglobin and Myoglobin and Cu to Hemocyanin). Heavy metal Toxicity of Hg, As, Pb, Cd.

Some commonly used drug molecules (2 L): Synthesis, Structure and use of Aspirin, Paracetamol and Metronidazole, and structure and use of Fluoroquinolone, penicillin, cis-platin, doxorubicin

Course Outcomes (COs)

CO1: Formulate the concept of work, energy and their interchangeability, thermodynamic parameters, cells and batteries, gradual deterioration of materials by chemical or electrochemical reactions in the environment, to substantiate respective engineering fields of applications.

CO2: Comprehend the physical and chemical properties of materials, such as strength, conductivity and durability, from the knowledge of atomic and molecular structure, bonding and reactivity; by understanding reaction rates.

CO3: Arrange and assess the structure and conformation of molecules to identify the substances by using various spectroscopic techniques, and also to correlate the molecular structure and properties of polymers to substantiate with the concept of polymerization reactions, encompassing the views of its applications.

CO4: Synthesize some selective molecules efficacious on biological systems and also to study the essence of water treatment processes to remove contaminants and pollutants, assessing the environmental impact.

Learning Resources

1. P.C.Rakshit, Physical Chemistry Sarat Book House.
2. S. Pahari, Physical Chemistry New Central Book Agency.
3. P. W. Atkins, & Paula, J. de Atkins', Physical Chemistry, Oxford University Press.
4. J. D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley India Pvt. Ltd.
5. F.A. Cotton, G. Wilkinson, and P.L. Gaus, Basic Inorganic Chemistry 3rdEd.; Wiley India.
6. J. E. Huheey, E. A. Keiter, & R. L. Keiter, Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
7. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, Second edition, Oxford University Press.
8. S. Sen Gupta, Reaction Mechanisms in Organic Chemistry, Oxford University Press.
9. L. Finar, Organic Chemistry (Volume 1) Pearson Education.

10. R. N. Morrison, & R. N. Boyd, Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. D. Nasipuri, Stereochemistry of Organic Compounds, Wiley Eastern Limited.
12. E. L. Eliel, & S. H. Wilen, Stereochemistry of Organic Compounds, Wiley: London, 1994.
13. Sharma, Industrial Chemistry (including Chemical Engineering), GOEL Publishing House.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES-CS 201	Programming for problem-solving	3-1-0	4	100	**4**

Total Lecture: 56 L

Course Objectives

- To introduce students to the field of programming using language.
- To enhance their analyzing and problem-solving skills.

COURSE CONTENTS

Module 1 [16 L]

Unit 1: **Introduction to Programming (6 L)**

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) Overview of Number system and its conversion: Binary, Octal & HEX

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.

From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code

Unit 2: **Arithmetic expressions and precedence** (**4 L**)

Unit 3: **Conditional Branching and Loops** (**6 L**)

Writing and evaluation of conditionals and consequent branching; Iteration and loops

Module 2 [14 L]

Unit 1: **Arrays (6 L)**

Arrays (1-D, 2-D), Character arrays and Strings

Unit 2: **Basic Algorithms (8 L)**

Searching algorithm (Linear & Binary search), Basic Sorting Algorithms (Bubble, Selection), notion of order of complexity through example programs (no formal definition required)

Module 3 [12 L]

Unit 1: **Function (6 L)**

Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Unit 2: **Recursion (6 L)**

Recursion, as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Tower of Hanoi problem.

Module 4 [14 L]

Unit 1: **Structure & Union** (**5 L**)

Basic concepts of Structures & Union; Array of Structures, Structure-Union comparison with implementation.

Unit 2: **Pointers (5 L)**

Concept of pointers, Pointer arithmetic, array of pointers, passing pointer to function, function returning pointer, Array-pointer relationship-basic idea.

Unit 3: **File handling (4 L)**

Basic idea about read, write, append in file operation. Sample file creating and reading a file.

Course Outcomes (COs)

CO1: Understand and remember the basic concepts of C programming.

CO2: Apply control structures such as loops and conditionals to develop and solve problems.

CO3: Apply concept of array, strings, pointers for efficient data storage and manipulation.

CO4: Design complex data structures and manage file operations.

Learning Resources

1. R. S. Salaria, Computer Concepts and Programming in C, Khanna Publishers .
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.
3. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
HS-MC 201	Values & Ethics	2-0-0	2	100	**2**

Total Lecture: 28 L

Course objectives:

- To find out how ethics guides one’s moral action and judgments.

- How the value system in work culture builds a sustainable organization.
- To students explore the essence of personal, social and environmental responsibility and Global Warming.
- To gain an insight about the impact of moral philosophies in business activities, wellbeing and promoting peace and harmony.

COURSE CONTENTS

Understanding Values & Ethics (8 L)

Ethics, Ethical values, Moral values, Virtue theory, Civic virtue, Empathy, Trustworthiness, Harmony, Maslow's need hierarchy theory, Societal values, Aesthetic values, Value spectrum of a good life, Value education, Changing value system in contemporary society

Professional Ethics (6 L)

Ethical principles in Workplace, Ethical Leadership, Good corporate governance, Corporate social responsibility, Role of CSR in enhancing brand reputation

Engineering Ethics and Global Issues (6 L)

Ethical duties and responsibilities of an engineer, Conflict between business deal and professional ideal, Whistle blowing, Environmental and Sustainability Ethics, Research Ethics, Bio-Ethics.

Indian Knowledge System (8 L)

Introduction and Importance of Indian Knowledge System, Indian Knowledge System – Contribution to the world- Zero and Decimal System, Ayurveda medicine, Philosophical concepts of the four Vedas, Yoga, etc. Psychological aspects of Health and wellness, Knowledge Triangle.

Course Outcomes (COs):

CO1: Recognize the professional Code of Ethics and to remain committed to it.

CO2: Integrate ethical vision while implementing Technologies and Management to create harmony at workplace.

CO3: Categorize and calculate the moral reasoning and to lessen the moral dilemma in decision making.

CO4: Imbibing moral values through philosophy propounded by the Indian Knowledge System and formulating the spectrum of quality life in the 21st Century.

Learning Resources:

1. B. Mahadevan, IIM Bengaluru, Textbook on IKS.

2. A. Mishra, W. Biswas, A Giri, Ethics, Values and Indian Ethos, New Age publishers, 2022.

3. Kapur K and Singh A. K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of Sankaracharya, Central Chinmay Mission Trust, Bombay, 1995.

4. Reshmi Ramdhoni, Ancient Indian Culture and Civilisation, Star Publication, 2018.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
HM-HU 201	English Language and Technical Communication	2-0-0	2	100	**2**

Total Lecture: 28 L

Course Objectives

- To acquire language skills
- To develop linguistic and communicative competencies for Engineering students.
- To study academic subjects more effectively using the theoretical and practical components of English syllabus, and hence will develop study skills and communication skills in formal and informal situations.

COURSE CONTENTS

Module 1: Theories of Communication [6 L]

Theories and Principles of Communication: Definition, Process, Model (Linear model, Interactive model and Transactional model), Types of Communication – Verbal and Non- verbal communication, Flows of communication

Barriers to communication

Workplace/ Business Communication which can have the following items:

a). Scope of Oral Communication

b). Oral Business Communication: Introducing oneself in a professional setup - brevity, context, understatement, body language –

Task: Introducing others - introducing a junior professional to a senior professional, introducing an employee to a customer, introducing a colleague from your firm to an employee of another firm.

c). Telephone (audio and video) communication: choice of words, body language, paralinguistic elements of speech, enunciation, brevity, clarification, effective closure

Module 2: Applied Grammar [7 L]

Common Errors in English

- Subject-verb agreement

- Tenses
- Noun-pronoun agreement
- Articles and Prepositions
- Misplaced or dangling modifiers
- Redundancies
- Cliché

Transformation of Sentences

- Active and Passive voice
- Direct and Indirect speech
- Degrees of Comparison
- Use of phrases and clauses in sentences
- Synthesis of Sentences: Simple, Complex and Compound

Module 3 Vocabulary Building [3 L]

The concept of word formation: Compounding, Backformation, Clipping and Blending

Root words from foreign languages and their use in English

Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.

Synonym, antonym, phrasal verbs, one word substitution and standard abbreviation

Module 4 Basic Writing Skills [4 L]

Documenting: definition, meaning, basic concept of documenting (print and online media), types of technical documents

Importance of proper punctuation

Writing Drafts and Revising: drafting, drafting process, first draft, revising, writing the final draft

Editing and Proofreading: types of editing, editing process, proofreading, differences between editing and proofreading

Techniques for writing precisely

Module 5 Professional Writing Skills [8 L]

Technical Report Writing: Types and formats

Comprehension, Précis and Expansion Writing, Essay Writing, Writing Statement of Purpose and Project Proposals. Business Letters; Cover letter & CV

Office Correspondence:

- Notice
- Agenda

- Minutes
- Circular
- E-mail

Course Outcomes (COs)

CO1: Apply the basic principles, types and prominent methods and models of communication.

CO2: Synthesize flawless sentence structures incorporating tense, active and passive voices, degrees of comparison, transformation of sentences and speech indices.

CO3: Cultivate strategies for mastering vocabulary, etymology, phrasal verbs, idioms and other tools to enhance sentence coherence.

CO4: Develop essential skills for drafting, documenting, editing and proofreading technical work to hone writing and correspondence skills.

Learning Resources

1. Debashis Bandyopadhyay and Malathy Krishnan, Connect: A Course in Communicative English, Cambridge University Press. 2018.
2. Sanjay Kumar and Pushp Lata, Communication Skills, Oxford University Press. 2015.
3. Nira Konar, Communication Skills for Professionals, Prentice Hall of India 2nd edition, New Delhi, 2011.
4. Wren and Martin, High School English Grammar.
5. S.Prasad & K.P.Thakur, Common Errors in English, Bharti Bhhawan Publishers.
6. R.C. Sharma and Krishna Mohon, Business Correspondence and Report Writing, Tata McGraw-Hill Publishing company Ltd., New Delhi.
7. McCarthy, English Vocabulary in Use.
8. E. Sureshkumar and P. Sreehari, Communicative English, Orient Blackswan , 2007.
9. Jeremy Comfort, Speaking Effectively**,** Developing Speaking Skills for Business English, Cambridge University Press, 1994
10. Michael Swan, Practical English Usage, OUP. 1995.
11. F.T. Wood, Remedial English Grammar, Macmillan.2007.

Practical/Sessional papers

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
BS-CH 291	Chemistry Lab	0-0-3	1.5	100	**3**

Periods: 42 P

Course Objective

- To be able to design, carry out, record and analyze the results of chemical experiments.
- To demonstrate creative and independent thinking in both learning and work environments.
- To be able to use modern instrumentation and classical techniques, to design experiments and to properly record the results of their experiments.
- The students will be able to understand the safety features in chemistry lab and MSDS.

Name of the Experiments

1. Standardization of NaOH solution with standard Oxalic acid solution.
2. Standardization of $KMnO_4$ solution by standard Oxalic acid solution
3. Conductometric and pH- metric titration for determination of strength of a given HCl solution against a standard NaOH solution.
4. Determination of the partition coefficient of a substance between two immiscible liquids.
5. Determination of chloride ion in a given water sample by Argentometric method (using chromate indicator solution)
6. Determination of dissolved oxygen present in a given water sample.
7. Complexometric titration for determination of calcium and magnesium hardness of water.

Course Outcomes (COs)

CO1: Demonstrate the preparation and standardization of secondary standard solutions by using primary standard solutions employing conventional titration methodology.

CO2: Assess the concentration, purity and impurity of chemical substances correlating with potentiometric acid vs. base titration in view of industrial applications.

CO3: Apply the Nernst's distribution law to determine partition coefficient of a substance between two immiscible liquids.

CO4: Implement and validate experimental methods of chloride ion, dissolved oxygen and hardness estimation for water quality assessment.

Learning Resources

1. A. I. Vogel, Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.

2. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Curse in Practical Chemistry, New Central Book Agency; 3rd edition.

3. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.

4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
5. H. T. Clarke, A Handbook of Organic Analysis (Qualitative and Quantitative), Fourth Edition, CBS Publishers and Distributors (2007).
5. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES-CS-291	Programming for Problem Solving Laboratory	0-0-3	1.5	100	3

Course Objectives

- To formulate and test simple algorithms for arithmetic and logical problems, execute the programs and correct syntax and logical errors for implementing conditional branching, iteration and recursion.

The laboratory should be preceded or followed by a tutorial to explain the approach or algorithm to be implemented for the problem given

Tutorial 1: Problem solving using computers, Variable types and type conversions

Lab1: Familiarization with programming environment; Simple computational problems using arithmetic expressions

Tutorial 2: Branching and logical expressions:

Lab 2: Problems involving if-then-else structures

Tutorial 3: Loops, while and for loops:

Lab 3: Iterative problems e.g., sum of series

Tutorial 4: 1D Arrays: searching, sorting:

Lab 4: 1D Array manipulation

Tutorial 5: 2D arrays and Strings

Lab 5: Matrix problems, String operations

Tutorial 6: Functions, call by value:

Lab 6: Simple functions

Tutorial 7: Recursion, structure of recursive calls

Lab 7**:** Recursive functions

Tutorial 8: Numerical methods (Root finding, numerical differentiation, numerical integration):

Lab 8: Programming for solving Numerical methods problems

Tutorial 9: Pointers, structures and dynamic memory allocation

Lab 9: Pointers and structures

Tutorial 10: File handling:

Lab 10: File operations

Course Outcomes (COs)

CO1: Demonstrate the ability to write. Compile and execute basic C program.

CO2: Develop algorithms and solve problems using control structures.

CO3: Implement programs that utilize array, string, pointers for storage, memory access and manipulation.

CO4: Use structures and unions to create, manipulate complex data type and perform file operational for reading and writing data.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
ES-ME 292	Engineering Drawing	0-0-3	1.5	100	**3**

Periods: 42P

Course Objectives

- To teach students to communicate using **graphic** techniques.
- To accomplish the principles and standards of mechanical **drawing** and dimensioning.

[Sessional work should be completed in the class. Problems sheet will be provided. Students should attempt to solve the problems given in the Problem Sheet. Home assignments will be given. Evaluation will be made on the basis of seasonal work and viva-voce examination.]

Scales (3P)

Plain scales, Diagonal scales, Vernier scales

Geometrical Construction and Curves (3P): Conic Section: Parabola, Hyperbola, Ellipse

Projection of Points, Lines, Surfaces (9P): Orthographic Projection – First angle and third angle projection More no. of problems should be practiced in first angle projection. Projection of lines inclined to the planes Projection of surfaces Pentagon, Hexagon

Projection of Solids (12P): Cube, Pyramid, Prism, Cylinder, Cone, Frustums

Isometric View and Isometric Projection (6 P): Prism, Pyramid, Cylinder, Cone and examples of simple solid objects / models.

Sectional Views of Solids, True Shape of a Section (6 P)

Development of Surfaces (3 P): Cube, Prism, Cylinder, Truncated Cone

Learning Resources:

1. Pradeep Jain, Ankita Maheswari, A.P. Gautam, Engineering Graphics & Design, Khanna Publishing House.
2. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House.
3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication.
4. Shah, M.B. &Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
6. Corresponding set of CAD Software Theory and User Manuals.

Course Outcomes (COs)

CO1: To represent pictorially different elements and components using basic engineering drawing guidelines.

CO2: To gain significance of scaling pertinent to engineering drawing problems. The incumbents should also have knowledge about analytical curves and their relevance to understand different higher level mechanical engineering problems.

CO3: To understand the concept of projections for 1D, 2D and 3D object representation.

CO4: To develop an idea and ability to view complex interior sections of a solid object, and they will also be able to analyze and explain how different surfaces are generated when a solid object is cut along a plane and its surfaces are stretched out.

CO5: To draw isometric to orthographic views and vice versa.

CO6: To apply comprehensive knowledge to develop the surface of a solid.

Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
HM-HU 291	English Language and Technical Communication Laboratory	0-0-2	1.0	100	**2**

Periods: 28 P

Course Objectives

- To provide advanced skills of Technical Communication in English through various activities performed in the Language Lab Practice Sessions to 1st Semester U.G. students of Engineering and Technology.
- To instil confidence in them so that they can competently communicate in English language in all spheres.
- To make them efficient enough to communicate about day-to day events and experiences of life, comprehend lectures delivered in English, read and understand relevant materials written in English and also to write grammatically correct English.
- To make them capable of shedding their fear of communication and public speaking.

List of Experiments

1. Developing active 'Listening Skill' and its sub skills through Language Lab Audio device; (Listening to conversations, passages, stories, news bulletin, speeches by famous personalities – Listening for general and specific information etc.,) (3P)
2. Developing 'Speaking Skill' and its sub skills; (Interpersonal Communication, Oral Debate – Extempore – Speech Presentation– Conversational Practice – Face to Face / Telephonic Conversation) (5P)
3. Developing 'Reading Skills' and its sub skills through reading excerpts from plays, poetry, news and various technical/non technical passages using Visual / Graphics/Diagrams /Chart Display etc. and using Literary text(s): The Kabuliwallah by R. N. Tagore and The Night Train at Deoli by Ruskin Bond (4P)
4. Developing 'Writing Skill' and its sub skills by using Language Lab Audio –Visual input; Practice Sessions (Analytical essay writing, dialogue writing, story writing, etc.) (5 P)
5. Pronunciation: Basic Rules (with emphasis on Accent Neutralisation) Organs of Speech (2P)
6. Introducing 'Group Discussion' through audio –Visual input and acquainting them with key strategies for success; GD practice sessions (unstructured and structured) (6 P)
7. SWOT analysis (3 P)

Learning Resources:

1. Nira Konar: English Language Laboratories, A Comprehensive Manual, PHI Learning Pvt. Ltd.
2. Dr. D. Sudharani: Manual for English Language Laboratory. Pearson Education (WB edition),2010.
3. Board of Editors: Contemporary Communicative English for Technical Communication, Pearson Longman, 2010.

4. T. Balasubramanian, A Textbook of English Phonetics for Indian Students, Macmillan India Ltd.
5. E. Sureshkumar and P. Sreehari, Communicative English, Orient Blackswan , 2007.
6. Jeremy Comfort, Speaking Effectively**,** Developing Speaking Skills for Business English, Cambridge University Press , 1994.
7. Diane Hacker, Pocket Style Manual, Bedford Publication, New York, 2003. (ISBN 0312406843).

Course Outcomes (COs)

CO1: Construct English sentence structures with (neutralized accents) appropriate grammar rules and vocabulary.

CO2: Enhance pronunciation, intonation and language fluency by utilizing language laboratory resources.

CO3: Build active listening ability to respond effectively in various real-life situations.

CO4: Develop real life communication skills by taking part in language laboratory activities to mitigate various industrial communication needs.

Detailed Syllabus, B. Tech Second year, Semester III

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
Professional Core Courses	**PC–CHE 301**	**Fluid Mechanics**	**3-1-0**	**4**	**100**	**4**

Course Objectives:

This course prepares the student to:

- Introduce the mechanics of fluids (fluid statics and fluid dynamics), forces on fluids, hydrostatic forces on submerged bodies relevant to Chemical Engineering operations.
- Recognize, Eulerian and Lagrangian descriptions of flow, flow visualization, integral analysis involving mass and momentum balances, Bernoulli equation, flow through pipes and ducts, application of Hagen-Poiseullie equation.
- Illustrate the Navier-Stokes equation, viscous flows, skin and form friction, lubrication approximation, potential flows, and boundary layer theory. Turbulence and turbulent flows, fluidization
- To know about the flow measuring instruments, flow transportation-pumps, blowers and compressors, conservation of mass, linear and angular momentum in differential form.

Contents:

Module I

Introduction to fluids, Types of fluid, Newtonian and non–Newtonian fluid, Continuum hypothesis, Terminologies of fluid flow, velocity–local, average, maximum, flowrate–mass, volumetric, velocity field; dimensionality of flow; flow visualization –streamline, path line, streak line, stress field; viscosity; Newtons's law of viscosity, Reynold's number—its significance, laminar, transition and turbulent flows: Boundary layer concept, Prandtl boundary layer, compressible and incompressible flows.

Blasius solution, Boundary layer separation. Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition, Spectral nature of turbulence,

Fluid statics - pressure distribution, Manometry, Forces on submerged bodies (planar and curved), Buoyancy, Rigid body motion (translation and rotation) Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices –manometer, U-tube, inclined-tube, inverted U-tube manometer. Kinematics of fluid, Basic laws for a system; relation of system derivatives to the control volume formulation. **(14)**

Module II

System and control volume approaches, Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Turbulent flow. The flow of incompressible fluid in a circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, the relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor; head loss; friction factor-Fanning and Darcy, Moody diagram. Major and minor losses; Pipe fittings and valves, schedule no, equivalent diameter

conservation of mass; continuity equation, momentum balance equation-Introduction to Navier Stoke's and Euler's Equation. momentum correction factor. Flow- Eulerian and Lagrangian descriptions. Kinematic decomposition of flow motion.

Flow measurement, Transportation of fluids - Introduction; hydraulic coefficient, the general equation for internal flow meters; Orifice meter; Venturimeter; Weirs, the concept of area meters: Rotameter; Local velocity measurement: Pitot tube. Mass flow meter, Notches and weirs – Rectangular, Triangular, trapezoidal.

(14)

Module III

Differential analysis: mass and momentum balances, Navier-Stokes equation, unidirectional flow, viscous flow, Stokes law, Skin drag, and pressure drag , Introduction; the concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body; packed bed; the concept of Sphericity; Ergun equation, modified friction factor Potential flow, Potential function, Introduction; different types of fluidization; minimum fluidization velocity; governing equation; industrial uses.

(14)

Module IV

Fluid moving machines: Introduction; Basic classification of pumps: Non-Mechanical Pumps—acid egg, steam jet, ejector, air lift pump, Mechanical pump: Centrifugal pumps-cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification, efficiency, Characteristic curves for centrifugal pumps, Compressible flows, fan, blower, and compressor.

(14)

Total: 56 (L+T)

Text Book:

1) Unit operations of Chemical Engineering: McCabe, Smith and Harriot, TMH,6thEdn.
2) S.S. Rattan, Fluid Mechanics, Khanna Publishing House, New Delhi 2018
3) O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005

Reference Books:

1) Introduction to Fluid Mechanics. R.W.Fox, P.J. Pritchard and A.T. McDonald, Johnwiley
2) Fluid Mechanics, A.K. Mohanty, PHI
3) M. White, Fluid Mechanics, 8thEdition, Tata-McGrawHill,2016.
4) V.Gupta and S.K.Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011
5) Transport Process and Unit Operations: Geankoplis, 3rdEdn.PHI
6) Principles of Unit Operations: Foustand Wenzel, Wiley,1980

Course Outcomes:

After this course, students should be able to:

CO1: Understand the fundamental properties of fluid and their characteristics, laws of fluid Mechanics, and their applications. Concepts of Boundary Layer Theory, fluid kinetics and fluid dynamics.

CO2: Establish the Euler‘s Equation and Bernoulli‘s equation in fluid mechanics. Concept and applicability of Navier Stoke‘s Equation

CO3: Analyze the flow over immersed bodies, the concept of drag and lift. Principle of the packed column, the importance of fluidization bed; minimum fluidization velocity; pneumatic conveying and their industrial applications.

CO4: Understand and develop the concept of flow-measuring devices and their industrial applications. fluid moving machinery, pumps, their working principles and industrial applications.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional core courses	**PC–CHE 302**	**Numerical Methods in Chemical Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Introduce students to numerical methods used to solve engineering problems, in particular chemical engineering problems, using numerical methods and computer programming.
- Fundamentals of numerical methods/algorithms to solve systems of different mathematical equations (e.g. linear/ nonlinear algebraic equations, ordinary / partial differential equations), will be introduced.
- Enable students to write their own computer programs using programming languages like C and commercial software like Matlab. Hands-on experience will be provided to apply these computer programs to solve problems in different areas of chemical engineering e.g. fluid flow, heat and mass transfer, chemical reaction engineering etc. Practical classes are to involve solving actual chemical engineering problems through computer programming and coding.

Contents:

Module I

Introduction, Approximation and Concept of Error & Error Analysis. Inherent, rounding of errors, absolute errors, relative errors.

Linear Algebraic Equations:

Direct Method: Gauss elimination, Gauss Jordon, LU decomposition and matrix inversion, Iterative Method: Gauss Jacobi, Gauss-Siedel method. Chemical engineering problems involving solution of linear algebraic equations. **(10L)**

Module II

Root finding methods for solution on non-linear algebraic equations: Bisection, Newton Raphson and Secant methods, Error criterion. Chemical engineering problems involving solution of nonlinear equations.

Interpolation and Approximation: Newton's forward and backward interpolation, Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression, Newton's divided difference. **(12L)**

Module III

Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, Chemical engineering problems involving numerical differentiation and integration

Ordinary Differential Equations: Euler method, Modified Euler method, Huen's method, Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs. **(10L)**

Module IV

Introduction to Partial Differential Equations:

Characterization of PDEs, Laplace equation, Heat conduction / diffusion equations, explicit, implicit, Crank-Nicholson method. **(10L)**

Total: 42 L

Text Books:

1. S. K. Gupta, Numerical Methods for Engineers, New Academic Science,2012.
2. R. S. Salaria, Numerical Methods, Khanna Publishing House,2018
3. S. C. Chapra & R. P. Canale, Numerical Methods for Engineers with Personal Computer Applications, Mc Graw Hill Book Company, 1985.

Reference Books:

1. R. L. Burden & J. D. Faires, Numerical Analysis,7th Ed., Brooks Coles, 2000.
2. P Ahuja, Introduction to Numerical Methods in Chemical Engineering, PHI, 2010
3. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1978.
4. W. H. Presset. al., Numerical Recipes in C: The Art of Scientific Computing,3rd Edition, Cambridge University Press, 2007.

Course Outcomes:

Students will be capable of

CO1: Understanding the consequences of finite precision and the inherent limits of the numerical methods considered.

CO2: Implementing the various types of numerical methods for solving different types of engineering problems in consideration of the mathematical operations involved, accuracy requirements and available computational resources.

CO3: Evaluating the modern scientific problems using different numerical techniques.

CO4: Compiling the numerical techniques for the solution of integration, linear equations,

ordinary differential equations, interpolations etc.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
Professional Core Courses	**PC– CHE 303**	**Chemical Process Calculations**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Understand and apply the basics of calculations related to the material flow in the processes with andwithout reaction.
- Understand and apply the basics of calculations related to energy flow in the processes.
- Serve as a basis for all further chemical engineering courses that are part of the curriculum.

Contents:

Module I

Dimensions and units, physical quantities in chemical engineering, Dimensionless groups, Dimensional homogeneity, Dimensional analysis, Buckingham‘s pi theorem and its application, Data fittings in semi log and log-log graph. Concept of mole, mole fraction, weight fraction, average molecular weight, Compositions of mixtures of solids, liquids, and gases. Specific gravity scales.

(10)

Module II

Material Balance without Chemical Reaction: ―Basis‖ of calculations, material balance problems on mixing, crystallization, absorption, extraction, distillation, drying, etc.

Humidity and Saturation, various humidity terms like a molar, absolute, relative & percentage saturation,humid heat, humid volume, dry bulb temperature, dew point, humidity chart, and its use.

(10)

Module II

Material Balance with chemical reaction: Concept of stoichiometry, limiting reactant, excess reactants and inert, fractional and percentage conversion, fractional yield and percentage yield, selectivity, combustion, and related problems.

Material Balances with recycling, bypass, and purging. **(12)**

Module IV

The fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine Equation, Cox chart, Duhrixng‘s plot, Raoult's slaw, Henry‘s law and related numerical problems, Watson equation, Troutons rule, Kistyakowsky equation.

Energy balance: Heat capacities, estimation of heat capacities, calculation of enthalpy changes, Kopp's rule. Energy balances with chemical reaction: Heat of reaction, the heat of combustion, heat of formation, Calorific values, Hess's Law, and related problems of various chemical processes.

(10)

Total: 42 (L+T)

Text Books:

1. Bhatt, B.I., Vora, S.M., "Stoichiometry", Fourth Edition, Tata McGraw Hill Publishing Company Ltd, 2004.
2. Hougen, O. A., Watson, K. M., Ragatz, R. A., ―Chemical Process Principles, Part-I Material& EnergyBalances‖, Second Edition, CBS Publishers & Distributors, 2004
3. Venkataramani, V., Anantharaman, N., Begum, K.M.MeeraSheriffa, "Process Calculations", SecondEdition, Prentice Hall of India.
4. Sikdar, D. C., "Chemical Process Calculations”, Prentice Hall of India.
5. Narayanan K.V., Lakshmikutty B., “Stoichiometry and Process Calculations”, 2nd edition, Prentice Hall of India.

Course outcomes:

Students completing the course will have the ability in

CO1: Remembering & understanding the process parameters/ variables involved in any processing unit of Chemical processing industries or its allied sectors, to **list** and **relate** the process variables and then **label** them on block diagram/ simple flow diagram of processing unit.

CO2: Applying the knowledge and concepts of mass balance or energy balance computation to **select** the basis of solution of the specific problem and then to **identify** the important key components for **solving** the chemical process engineering problems under certain processing conditions.

CO3: Analyzing to **compare** and **simplify** the appropriate techniques, then **evaluating** the exact solutions of complex chemical engineering problems with an understanding of the limitations, laws and regulations related to economic, environmental, ethical, health issues.

CO4: Creating in aspects of ability to **invent,** and **adapt** the modified techniques with an understanding of engineering and management principles, and also to engage as individual or

as a team member independently in profession for life-long learning in the broad context of technological changes.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
Professional Core Course	**PC–CHE 304**	**Energy and its Utilization**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Introduce the different conventional and alternative energy sources and their utilization technologies, relevant to Chemical Engineering operations.
- Introduce students to various sources of energy and their classification.
- It also introduces students to the various potential sustainable sources for future and their technologies.

Contents:

Module I

Introduction: Conventional (fossil energy) and non-conventional (alternative energy) resources & reserves. Solid Fuels: Biomass, Wood, and Charcoal. Formation of Coal, Classification & Rank of Coal, Peat, Lignite, Sub-Bituminous coal, Bituminous coal, Anthracite coal, Cannel & Bog head coal.

Properties and beneficiation: Physical Properties of Coal, Proximate & Ultimate Analysis of Coal, Cleaning, Washing & Storage of Coal. Utilization of Coal. Carbonization, Combustion, excess air calculation, etc. **(10)**

Module II

Liquid Fuels: Constitution of petroleum, theory of the formation of crude petroleum oil. Characterization of crude oil & petroleum fuels. Operation and flow sheet of crude distillation plant. Atmospheric Distillation, Vacuum Distillation, Cracking— Thermal & catalytic cracking, reforming processes, coking, vis-breaking, Process of a typical Indian refinery.

Parameters and testing logistics of petroleum products—Octane no.; Cetane no.; Aviation fuel, Power no.; Pour point; Smoke point; Char point; Cloud point; Flash point; Fire point; Aniline point and Diesel index.

Derivation of Liquid fuel from coal: Bergius and Fischer Tropsch process. Introduction to other Synthetic Liquid Fuels.

(12)

Module III

Gaseous Fuels: Classification of gaseous fuel; Physico-chemical principles, Calorific Value, Wobbes index, and flame speed. Flow sheet & operation of Producer gas, Water gas, Carburetted water gas, oil gas, and coke-oven gas, blast furnace gas, Natural Gas and LPG. Coal Bed Methane. Aerobic & Anaerobic Digestion Principles and Operation of Aerobic & Anaerobic Digestors, Bio gas: generation and management & flowsheet with special

reference to waste utilization.
(10)

Module IV
Solar Energy: Devices for measurement of solar flux. Different types of Solar collectors (Flat plate, parabolic, concentric & heliostat), Utilization of Solar Energy- For room heating, water heating other industrial uses -solar Pond, Photovoltaic cells, Chemical storage, etc.
Geothermal Energy & Wind Energy: Utilization of Geothermal Energy; Operating principles of different types of Wind Energy Mills, Energy from Ocean, Tydal, Biomass, Fuel Cell, Hydrogen, etc.
Nuclear energy: Sources of Nuclear fuels, Indian scenario; Introduction to Nuclear reactions and power generation by nuclear reactors. **(10)**

Total: 42 (L+T)

Text Books:
1. Fuels & Combustion: Dr. Samir Sarkar, Orient Longmans
2. Elements of Fuels. Furnace and Refractories: O. P. Gupta

References Books:
1. Non-conventional energy sources, G. D. Rai Khanna Publishers
2. Non-Conventional Energy Resources, D.S. Chauhan and S. K. Srivastava, New Age International Publishers.
3. Fundamentals of Renewable Energy Systems, D. Mukherjee and S. Chakrabarti, New Age International Publishers.
4. Fuel and Combustion: Sharma S. P. and Chandra Mohan

Course Outcomes:
Students will be capable of:
CO1: Understanding the basic concepts of conventional and alternative energy, energy consumption pattern in both India and worldwide.
CO2: Applying the properties, exploration, processing and utilization of solid, liquid, and gaseous energy sources.
CO3: Analyzing the engineering aspects in the field of coal and crude oil's exploration and processing in a refinery.
CO4: Analyzing the importance of renewable energy sources and their utilization such as solar, wind, hydro, geothermal, ocean thermal, fuel cell, nuclear energy, etc.

Categories	Course Code	Course Title	Hours/Week L: T: P	Credit	Marks	Total contact hours/week
Engineering Science Courses	ES – CHE 301	Materials Science	3-0-0	3	100	3

Course objectives:

The main focus of the course is to

- Give the students a basic introduction to the different classes of materials relevant to engineering in general, and specifically to Chemical Engineering.
- Relate the underlying molecular structure of the materials to their physical and chemical properties, and their processing and performance characteristics.
- Apply numerical solutions with clear insight into the basis for the selected solution for properties and characteristics of the given material using materials property data.

Module I:

Introduction to materials; atomic structure of materials; bonding between atoms like metallic bonding, ionic bonding, covalent bonding, Vander Waals bond; role of materials selection in design, structure-property-processing-performance relationships; crystal geometry: crystal co-ordinate system, classification of crystals and lattices; miller indices of directions and planes, inter-planer spacing, Bragg's law, introduction to experimental techniques of XRD for material characterization.

(11L)

Module II:

Metals and alloys: packing of atoms inside solids, close-packed structures, 3-D close packing of equal hard spheres, HCP and CCP structure, c/a ratio of an ideal HCP crystal, strength and properties of materials: plastic deformation, Corrosion: basic concepts and forms of corrosion, corrosion mechanism and prevention, protective materials and coating.

(11L)

Module III:

Solid solutions: interstitial and substitutional solid solutions; structure of allotropes (carbon based), ionic solids, semi-crystalline materials: classification, structure and configuration of glass, ceramics, polymers and copolymers; imperfections/defects in solids: vacancies, interstitial, dislocations: types and characteristics of dislocations, free surface, grain boundary, stacking faults, equilibrium concentration of vacancy.

(10L)

Module IV:

Basics of phase diagrams- phases and components, uses of phase diagrams, solidification and structure of metals, equilibrium phase diagrams of binary alloys; composition of phases in the 2–D phase region: tie line rule, relative amount of two phases region; eutectic systems: Pb-Sn phase diagram; Gibbs phase rule, Iron-Carbon phase diagram; phase transformation, T-T-T diagram.

(10L)

Total: 42 L

Text books:

1. William F. Smith, Javad Hashemi and Francisco Presuel-Moreno, Foundations of Materials Science and Engineering (7th edition, 2022)
2. Lawrence H. Van Vlack, Elements of Material Science and Engineering, Pearson Education. (6th edition, 2002).
3. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited, (6th Edition, 2015).
4. Lakhtin, Engineering Physical metallurgy; MIR publishers. (1st edition, 2005).

Reference books:

1. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
2. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley Publisher.
3. B. S., Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.
4. Ray, Sridhar & Abraham. Extraction of non ferrous metal, EWP
5. L. Von Bogdandy and H.J. Engell, The Reduction of Iron Ores, Springer-Verlag, NY.
6. Callister R Subramaniam., Material Science and Engineering, Wiley, 2 nd Edition, 2014.

Course Outcomes:

Students will be capable of

CO1: Understanding the basics of atomic structure, crystal geometry, and various mechanical properties of materials.

CO2: Analyzing the classification of hard and soft materials, including polymers, glass, ceramics, and composites, their characterization, properties, and engineering applications.

CO3: Applying phase diagram basics to interpret equilibrium phase diagrams, solidification, and phase transformations in alloys.

CO4: Analyzing corrosion principles, types, and control strategies, along with principles of solid solutions, allotropes, and semi-crystalline materials to understand engineering material structures.

Categories	Course Code	Course Title	Hours / Week L: T:P	Credit	Marks	Total contact hours/week
Humanities and Social Science Courses	**HM–HU 301**	**Economics for Engineers**	**3-0-0**	**3**	**100**	**3**

Pre-requisites: Analytical and mathematical skills

Course Objectives:

1. Understand basic economic concepts and their relevance to engineering decision-making.
2. Apply economic principles to analyse engineering projects and assess their feasibility.
3. Develop skills in cost estimation, project evaluation, and risk analysis and gain insights into the economic implications of engineering decisions on society and the environment.

Course Outcomes (CO):

CO1 Students will recall and explain fundamental concepts of engineering economics.

CO2 Students will apply economic principles and techniques to analyze engineering projects and make informed decisions based on economic criteria.

CO3 Students will analyze project cost structures, estimate costs using appropriate methods, and evaluate cost-effectiveness of the engineering projects using NPV, IRR, BCR etc.

CO4 Students will integrate economic sustainability considerations into engineering design and decision-making processes by assessing project risk through sensitivity analysis.

Content:

Module I

Introduction to Engineering Economy: Origin of Engineering Economy, Principles of Engineering Economy, Role of Engineers in Decision Making **(8)**

Module II

Time Value of Money: Introduction to Time Value of Money, Simple Interest, Compound Interest, Nominal Interest rate, Effective Interest rate, Continuous Compounding, Economic Equivalence, Development of Interest Formulas, The Five Types of Cash flows, Single Cash flow Formulas, Uneven Payment Series, Equal Payment Series

Methods of comparison of alternatives: NPV, Profitability Index or Benefit Cost Ratio, Payback Period Method, Equivalent Worth Methods, Present Worth Method, Future Worth Method, Annual Worth Method, Rate of Return Methods (IRR and ARR) **(14)**

Module III

Engineering Costs & Estimation: Elements of cost (Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental

Costs, Cash Costs vs Book Costs, Life-Cycle Costs) and cost estimation models (Per-Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve), Concept of Revenue, Break even analysis, Cost sheet.

(10)

Module IV

Inflation And Price Change: Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In Engineering Economic Analysis, Cash Flows that inflate at different Rates. **(10)**

Total: 42 L

References:

1. Donald Newnan, Ted Eschembach, Jerome Lavelle: Engineering Economics Analysis, OUP
2. R. Paneer Seelvan: Engineering Economics, PHI
3. Sullivan and Wicks: Engineering Economy, Pearson
4. John A. White, Kenneth E. Case, David B. Pratt : Principle of Engineering Economic Analysis, John Wiley
5. James L. Riggs, David D. Bedworth, Sabah U. Randhawa: Economics for Engineers 4e, Tata Mc Graw - Hill

Practical Papers:

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional core courses	**PC–CHE 391**	**Fluid Mechanics Laboratory**	**0-0-3**	**1.5**	**100**	**3**

Course Objectives:

The objective of this course is to

- Impart practical knowledge in verification of principles of fluid flow in determining flow regimes and measuring discharge, velocity, pressure of fluid flow.

- Develop skills of the students in fluid mechanics through bridging between the theoretical concepts and working practices for attaining the competency in practical applications
- Develop skills for working in the industry and conducting research & development activities.

At least eight experiments are to be performed

Experiments:

1. Pipe line assembling and a layout drawing.
2. Experiments on Reynolds Apparatus for visualization and determination of flow regimes.
3. Verification of Bernoulli's Principle experimentally.
1. Calibration of an Orifice meter.
2. Calibration of a Venturi meter.
3. Calibration of a Rotameter.
4. Determination of co-efficient of Pitot tube and construction of velocity profile across the cross section of pipe.
5. Determination of co-efficient of Discharge for different types of weirs.
6. Determination of pressure drop for flow through packed bed and verification of Ergun equation.
7. Experiment on fluidization techniques and determination of
    a. Minimum fluidization velocity;
    b. Pressure drop profile
8. Determination of the efficiency of a centrifugal pump.

Text Books:

1. P Pritchard P.J. Fox and McDonald's Introduction to Fluid Mechanics, John Wiley &Sons Inc., 8th edition, 2011.

2. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

3. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical Engineering (Volume 2), Butterworth-Heinemann, 5th edition, 2002.

Reference Books:

1. Jain A.K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, 1998.

2. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition, 2010.

Course Outcomes:

Students will have the ability in

CO1: Recalling the basics of fluid mechanics to **relate** with relevant engineering instruments/equipment.
CO2: Applying the fundamental knowledge of fluid mechanics through experimental.
CO3: Analyzing the working of various fluid mechanics instruments/ equipment.
CO4: Evaluating the performance of the instruments/ equipment by comparing the results with established values and **developing** the skill of presenting the results in form of written reports.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	PC–CHE 392	Numerical Methods in Chemical Engineering lab	0-0-3	1.5	100	3

Course Objective:

- This course focuses on the use of modern computational and mathematical techniques in chemical engineering. Starting from a discussion of linear systems as the basic computational unit in scientific computing, this course introduces methods for solving sets of numerical linear, nonlinear algebraic equations.
- This course also discusses about the ordinary differential equation's solution technique.
- It introduces computational and mathematical methods for the solution of multi-scale chemicalengineering problems.

Contents:

1. Introduction to use of computers for numerical calculations
2. Matrix Multiplication using C language.
3. Matrix Multiplication using MATLAB.
4. Solution of linear algebraic equations using direct method (Gauss elimination etc.)

5. Solution of linear algebraic equations using indirect method (Gauss-Siedel etc.)
6. Solution of a non-linear equations using bracketing and open-end method (Newton-Raphson and Secant) method.
7. Newton's Forward and Backward Interpolation, Lagrange Interpolation.
8. Numerical integration: Trapezoidal Rule, Simpson 's1/3 rule and 3/8 rule.
9. Solving of ODEs by using Euler's method.
10. Solving of ODEs by using Runge-Kutta method.
11. Solution of simple PDEs

Text Books:

1. S.K. Gupta, Numerical Methods for Engineers, New Academic Science, 2012.
2. R.S. Salaria, Numerical Methods, Khanna Publishing House,2018.

Reference Books:

1. S.C. Chapra & R.P. Canale, Numerical Methods for Engineers with Personal ComputerApplications, Mc Graw Hill Book Company, 1985.
2. R.L. Burden & J.D. Faires, Numerical Analysis,7th Ed., Brooks Coles, 2000.
3. K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons,1978.
4. W.H. Presset. al., Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition,Cambridge University Press, 2007.

Course outcomes:

Students will be able in

CO1: Defining the methodologies to handle engineering problems numerically.

CO2: Understanding the pertinent parameters of different engineering problems using suitable methods.

CO3: Applying a preferable method to handle the different engineering problem.

CO4: Differentiating the engineering problem critically.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
Professional Core Courses	**PC– CHE 393**	**Energy Engineering Laboratory**	**0-0-3**	**1.5**	**100**	**3**

Course Objectives:

The objective of this course is to

- Impart working knowledge
- develop skills of the students in Energy Engineering through bridging between the theoretical concepts and working practices for attaining competency in practical applications
- Develop skills for working in the industry and conducting research & development activities.

At least eight experiments are to be performed Experiments:

1. Proximate analysis of Coal:
   (a) Determination of moisture content of Coal under Proximate analysis.
   (b) Determination of volatile matter of Coal under Proximate analysis.
   (c) Determination of ash content of Coal under Proximate analysis.
2. Determination of carbon residue of fuel oil using Conradson Apparatus.
3. Determination of the aniline point of fuel oil.
4. Determination of moisture content of fuel oil by Dean & Stark apparatus.
5. Atmospheric Distillation of a petroleum product.
6. Determination of Flash Point & Fire Point of oil by Abel apparatus.
7. Determination of Flash Point & Fire Point of oil by closed-cup Pensky Martin apparatus.
8. Determination of kinematic viscosity of oil by Redwood Viscometer I and II.
9. Determination of calorific value of gaseous fuel by Junker's apparatus.
10. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.
11. Determination of vapor pressure of petroleum product using Reid apparatus.
12. Experiments on Non-conventional Energy Sources using Solar Cookers/ Flat Plate Collectors/ Bio Gas Reactor
13. Analysis of a gaseous mixture by Orsat apparatus
14. Determination of viscosity by Ostwald Viscometer

Course outcomes:

After completion of this course, the students will be capable of

CO1: Understanding the principles and techniques involved in the determination of moisture content, volatile matter, and ash content of coal through Proximate analysis.

CO2: Applying appropriate laboratory techniques to determine the aniline point, carbon residue of fuel oil using the Conradson apparatus, and moisture content of fuel oil using the Dean & Stark apparatus.

CO3: Analyzing the results from atmospheric distillation of petroleum products, Flash Point & Fire Point determination, kinematic viscosity measurement, calorific value determination, and vapor pressure analysis to assess fuel quality and characteristics.

CO4: Evaluating the performance and reliability of various energy lab apparatus including Abel, Pensky Martin, Redwood Viscometer, Junker's, Bomb Calorimeter, Reid, Orsat, and Ostwald Viscometer.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
Foundation Course	SI-CHE 391	Emergence of Chemical Engineering	0-0-3	1.5	100	3

Objectives:

The objective of this course is to

- Provide knowledge about a basic overview of chemical engineering field
- Expose different chemical manufacturing operations in a plant to the students
- Make the students aware about the importance of industry-institute interaction

Description:

Students will be exposed to different aspects of chemical engineering like, history of chemical sciences and emergence chemical engineering, different types of chemical industries etc. and their functioning through in house discussions and lectures/workshops by industry personnels, and industrial visit by students.

Contents:

Module I **10 L**

Interrelationship between Chemistry / Engineering Chemistry and Chemical Engineering.

Unit Operations and unit processes involved in Chemical Engineering - an overview.

Chemical Industries - scope of a chemical engineer, different features & characteristics of chemical Industries. Physical separation /transformation and chemical transformation during raw material to product formation.

Module II **12 L**

Batch and continuous processes, Role of thermodynamics and kinetics in chemical transformation. Process flow sheet presentation.

Different dimensionless groups and their use in chemical engineering. Conversion of units.

Sources of information and data for calculating different physical properties of components, Group contribution method in estimating different physical properties like density, heat capacity etc.

Basic ideas / features of some useful equipments /units involved in the chemical process like, pump, blowers, compressors, ejector, economizer, boiler, knockout drum, barometric condenser, stripper etc. pump selection, pipe size selection, tubes, fittings, and valves.

Module III **10**

L

Outlines of different unit processes like nitration, hydrogenation, halogenation etc., involved in chemical process industries.

Outlines of unit operations involved in separating multiphase systems - distillation, filtration, crystallization, absorption, adsorption, extraction, leaching, evaporation, drying etc.

Module IV **10**

L

Plant layout. Pollution consideration and occupational safety aspects. Plant Utilities.

Process Data Representation and Analysis - interpolation and extrapolation, curve-fitting and least squares method, fitting a line to scattered data.

Total lectures: 42

Text Books

1. Coulson & Richardson's chemical engineering , vol VI, by R. K. Sinnott
2. Introduction to Chemical Engineering by S.K.Ghosal, S.K.Sanyal and S. Dutta, Tata Mc Graw Hill Publishing Company Limited, New Delhi

Course Outcomes:

Students will have the ability in:

CO1: Understanding the relation among chemical science, engineering, and technology

CO2: Remembering the different features of chemical operations in industries

CO3: Applying the knowledge during interaction with industry experts

CO4: Analyzing the gathered knowledge during exposer to different components to industries

Detailed Syllabus, B. Tech Second year, Semester IV

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	PC–CHE 401	Heat Transfer	3-1-0	4	100	4

Course Objectives:

This course prepares the student:

- To understand the Basic Concepts of Heat Transfer in Conduction, Convection and Radiation.
- To apply the heat transfer concepts in designing the heat exchanging equipment like Heat exchangers & Evaporators, condensers etc.
- To design and rating of Heat exchanging equipment with and without Phase Change.

Contents:

Module I

Heat Transfer Fundamentals: Modes of heat transfer, thermal conductivity, thermal diffusivity and heat transfer coefficient; Differential equations of heat transfer. Conductive heat transfer – Fourier's law, compound resistance in series, General heat conduction equation, Insulation, critical insulation thickness. Lumped system analysis, significance of Biot and Fourier number, use of transient temperature chart application of one and two dimensional steady state heat transfer problems, concept of heat transfer from extended surfaces, **(14)**

Module II

Convective heat transfer - natural and forced convection; Dimensional analysis; forced convection in system of simple geometries (plate, cylinder etc.), Dittus - Boelter Equation, Thermal boundary layer, Physical Interpretation of different Dimensionless groups; Coefficient of thermal expansion, Grashoff and Rayleigh number; Reynolds, Prandtl and Colburn Analogy; Wilson Equation, Analysis of free convection in hot vertical plate, and over cylinder,

Concept of LMTD, LMTD correction factor, dirt factor, Individual and overall heat transfer coefficient.

Design aspects of Double pipe and Shell & Tube Heat Exchangers heat exchangers, construction and design procedure of shell and tube heat exchanger-Kern's method, effectiveness-NTU method, construction aspects in brief.

(18)

Module III

Basics of Heat transfer with phase change - Introduction to boiling, Leidenfrost Phenomenon, Hysteresis, Mechanism of nucleate boiling, pool and forced convection boiling, Introduction to condensation, Drop wise and film wise condensation, Film condensation on vertical surface, Nusselt equation, Condensation outside horizontal and vertical tube bank. Design aspects of Condensers, Re-boilers and Evaporators. Types of evaporators,

Evaporation: classification, capacity, Steam economy, Boiling point elevation (Duhring rule), Material and energy balance of single effect evaporator, Design procedure of single effect evaporator, Introduction to multiple effect evaporator: Forward feed, Backward feed, Mixed

feed, Parallel feed evaporator.

(12)

Module IV

Introduction to Radiative heat Transfer, Black body radiation, Plank‘s distribution law, Monochromatic emissive power, Wein‘s displacement law, Kirchoff‘s law, Emissivity of solids, Concept of gray body, Radiation between surface, View factor, Radiation shield, Absorption and emission in gaseous medium, Design aspects of Furnaces. **(12)**

Total: 56 (L+T)

Text Books:

1. B. K. Dutta, Heat Transfer–Principles and Applications 2nd Edition
2. W.J. McCabe, J .Smith, P.Harriot, Unit Operations of Chemical Engineering, Sixth Edition, Mc Graw Hill (2005)
3. J.P. Holman,S.Bhattacharya,HeatTransfer,10thEd.,TataMcGraw-Hill (2011).

Reference Books:

1. Er. R. K. Rajput, Heat and Mass Transfers, S. Chand Publications
2. Bejan, A., A.D. Kraus, Heat Transfer Handbook, John Wiley(2003).
3. D.Q. Kern, Process Heat Transfer, Tata-Mc GrawHill (1997).
4. R. Welty, C.E. Wicks, R.E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed., Wiley (2007).

Course outcomes:

Students will be able to

- Understand the overall concept about the conductive, convective and radiative heat transfer for their Engineering applications.
- Apply their knowledge for designing of double pipe and shell and tube Heat Exchangers based on TEMA classification
- Analyze the concept and design of finned tube heat exchangers and other compact heat exchanging equipment like condenser, re-boiler etc.
- Utilize the overall concept of heat transfer for classification and designing of different type Evaporators for the industrial application.

Categories	Course Code	Course Title	Hours/Week L: T: P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC–CHE 402**	**Chemical Engineering Thermodynamics**	**3-1-0**	**4**	**100**	**4**

Course Objectives:

This course prepares the student about the

- Introduction of basic principles and applications of laws of thermodynamics, and phase equilibrium.
- General concepts of fugacity and its applications, activity coefficient, and vapor liquid equilibrium
- Overview of reaction equilibrium and process to evaluate the equilibrium constant at different parametric conditions in real application purposes.

Contents:

Module I

Introduction- scope of thermodynamics, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Reversible process; Constant P, V, T processes; Mass and energy balances for open systems. Heat effects.

PVT behavior; Equation of State-Ideal gas law, van der Waals, virial and cubic equations of state, etc.; Reduced conditions & corresponding states theories; **(16)**

Module II

Second Law of Thermodynamics: Entropy; Entropy changes of an ideal gas; Thermodynamic property of fluids, Maxwell relations, The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. Concept of free energy.

Thermodynamic analysis of steam power plants; Rankine cycle; internal combustion engine, Otto engine; Diesel engine; Jet engine. **(12)**

Module III

Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties. Vapor-liquid equilibrium (VLE): phase rule, simple models for VLE –Raoults law; Bubble point, dew point, Flash calculations, etc.

Non ideal solutions: The non- ideal solution and the residual and excess properties. Definition of fugacity and fugacity coefficient of pure species and species in solution, Activity and activity coefficient. Gibbs Duhem equations. **(16)**

Module IV

Liquid phase properties from VLE, Models for excess Gibbs free energy, heat effects and property change on mixing. VLE by modified Raoult's law; VLE from K-value correlations; Bubble point, dew point, Flash calculations.

Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multi reaction equilibria. Phase rule for reacting system.

(12)

Total: 56 (L+T)

Text Books:

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, "Introduction to Chemical Engineering Thermodynamics," 8th edition, McGraw-Hill International Edition,2005.
2. K. V. Narayanan, "A text book of Chemical Engineering Thermodynamics," 2nd edition, PHI, 2013.

References Books:

3. Y.V.C. Rao, "Chemical Engineering Thermodynamics", University Press, Hyderabad,1997.

Course outcomes:

Students should be able in

CO1 Understanding the basic concepts and related laws of thermodynamics, its application in closed and open system.

CO2 Applying the concepts of heat engine and heat pump / refrigerator, refrigeration and other cycles and also the properties of non-ideal gases and liquids in open and closed system.

CO3 Analyzing the concept of fugacity, activity, the Raoult's law, the bubble point, dew point and flash calculation and Chemical Reaction Equilibria.

CO4 Evaluating the application of solution thermodynamics, Chemical Reaction Equilibria, and solve different thermodynamic problems involving equilibria of different phases.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact Hours/Week
Professional Core Courses	**PC– CHE 403**	**Solid and Fluid Particle Processing**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Develop basic concept of properties of particle and mixture along with its storage and transportation.
- Understand of various mechanical operations like Screening, Size reduction & Enlargement, Filtration, Sedimentation, Agitation and Mixing used in Chemical Process Industries.
- Make them well acquainted with fundamental theory, calculations, and various types of equipment used in Chemical Process Industries related to Mechanical Operations.

Contents:

Module-I

Introduction to solid particles, Characteristics of solid particles: Particle size, shape, and their distribution, Relationship among shape factors and particle dimensions, Concept of Sphericity, Measurement of surface area. Properties of solid mixture. Introduction to nanoparticles: properties, characterization, synthesis methods, applications.

Screening, various screen series and Differential and cumulative method of screen analysis. industrial screens - grizzly, gyratory and vibratory screens, revolving screens, trammels, capacity and effectiveness of screens, magnetic separation, electrostatic separation.

(12)

Module – II

Principle of comminution, Types of crushers, grinders & disintegrators for coarse and intermediate & fine grinding. Energy & power requirement for size reduction, laws of crushers & work index, close & open circuit grinding, feed control, mill discharge and removal & supply of heat in wet grinding. Size enlargement– objectives, methods and equipment used in industries.

Storage of solid, Types of flow in solid discharge and various problems. Types of Mechanical & pneumatic conveying system.

(12)

Module – III

Concept of sedimentation, terminal settling velocity, batch settling test and free & hindered settling, Flocculation, types of thickener & thickener area calculation, batch & continuous settling chambers and sorting of classifiers. Centrifugal settling process, cyclone and principle of centrifugal sedimentation.

(10)

Module – IV

Types of filtration, requirements of filter media and filter aids. Principle of cake filtration, constant pressure & constant rate filtration, Batch & continuous filtration equipment – filter

press, leaf filter, cartridge filter & rotary drum filter. Centrifugal filtration, design of cyclones and hydro-cyclones. **(8)**

Total: 42 (L)

Text Books:

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.
2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.

Reference Books

3. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester; New York, 2008.
4. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.
5. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.
6. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties, and Applications, 2nd Ed., Wiley, 2013.

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

CO1: Describe basic concept of Mechanical Operations used in chemical process industries.

CO2: Classify and Explain solid-solid, solid-fluid related operations identifying methods for measuring performance of equipment.

CO3: Examine the factors affecting on solid handling related operations with respects to the sustainable development of process industries.

CO4: Design and troubleshooting of Industrial equipment related to Mechanical Operations.

Categories	Course Code	Course Title	Hours / Week L: T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC–CHE 404**	**Mass Transfer I**	**3-1-0**	**4**	**100**	**4**

Course Objectives:

The general objectives of Mass Transfer I for the undergraduate students are -

- To learn the fundamental concepts of mass transfer principles and to apply those concepts to real engineering problems.
- To impart knowledge on the basic principles of operation of the major mass transfer equipment/devises, their design and operation under optimum conditions.
- To design mass transfer equipment involved in separation processes like absorption, distillation, humidification and dehumidification.

Contents:

Module I

Diffusion and Mass Transfer: General principles of convective and diffusive mass transfer process in fluids; Measurement of diffusivity; multi-component diffusion; Diffusion through a variable area. Mass-transfer coefficients; Dimensionless groups in mass transfer; Diffusion in solids. Theories of mass transfer (Film theory, Penetration theory, Surface renewal theory); Inter-phase mass transfer theory; overall and local mass transfer coefficients.

(14)

Module II

Equipment for Gas-Liquid Operations: Selection of equipment for mass transfer operation.

Gas Absorption and stripping (Binary system, isothermal operation): Introduction; Equilibrium data representation, Design of a packed tower; Minimum liquid-gas ratio; Estimation of number of stages in a tray tower; HETP.

(14)

Module III

Distillation: vapor-liquid equilibrium; relative volatility, azeotropism, steam distillation; Single stage flash distillation; Simple distillation (Rayleigh Equation), Continuous multistage fractionation, Number of trays by McCabe-Thiele method, Minimum Reflux, Introduction to Ponchon-Savarit method; Azeotropic, Extractive distillation, Vacuum distillation, Introduction to Multicomponent Distillation.

(16)

Module IV

Humidification & Dehumidification Operations: Principles of Humidification & Dehumidification; adiabatic saturation curve, wet bulb temperature line, Psychrometric chart and its use, Types of cooling towers, Design calculations of cooling towers, Make up water calculation of cooling tower, Dehumidifier design concept, Adiabatic humidifier.

(12)

Total: 56 (L+T)

Text books

1. R.E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983.
2. Binay K. Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007
3. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, 1993.

Reference books:

1. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill International Edition,
2. Coulson, J. M., Richardson, J. F., Backhurst, J. R., & Harker, J. H., Chemical Engineering, Volume 1 & 2, 6th Edition
3. Sieder J.D., Ernest J.Henley. Separation Process Principles (2011).
4. A.P. Sinha, Parameswar De, Mass Transfer Principles and Operations, PHI Learning Pvt. Ltd., India, 2012

Course Outcomes:

Students will have the ability in

CO1: Understanding the basics of mass transfer operations.
CO2: Applying the principles of mass transfer for transfer coefficients, rate equations and transfer unit.
CO3: Analysing working of various mass transfer equipment of distillation, absorption and humidification.
CO4: Designing mass transfer equipment of distillation, absorption and humidification.

Categories	Course code	Course title	Hours/week L: T:P	Credit	marks	Total contact hours/ week
Humanities and social science courses	**HM – HU-401**	**Principles of Management**	**3-0-0**	**3**	**100**	**3**

Pre-Requisites: Basics of industrial aspects

Course Objectives:

- To help the students gain understanding of the functions and responsibilities of

managers

- To provide them tools and techniques to be used in the performance of the managerial job
- To enable them to analyze and understand the environment of the organization
- To help the students to develop cognizance of the importance of management principles

Course Outcomes (CO):

CO1 Learning the basic concepts, principles and practices of management and exploring the roles and skills required for managers

CO2 Generating ideas to effectively plan, organize, lead and control varied managerial operations.

CO3 Understand the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities

CO4 Application of management knowledge to diagnose and solve organizational problems and develop optimal managerial decisions that would help implementing new technology in the area of finance, marketing and operations to bring in effectual outcomes.

Contents:

Module I

Basic concepts of management: Definition - Essence, Functions, Roles, Level.

Functions of Management: Planning - Concept, Nature, Types, Management by objectives. **(10)**

Module II

[OB & HR]

Organization Structure: Concept, Structure, Centralization, Decentralization, Span of Management, Organizational Effectiveness.

People Management: Overview, Recruitment & Selection, Training & Development, Stress Management, Communication, Motivation, Leadership, Team Effectiveness **(10)**

Module III

Economics & Finance]

Economic: Factors affecting Production, Types of Markets, Financial Function & Goals

Decision making: Concept, Nature, Process, Tools & techniques.

[Marketing]

Customer Management: Market Planning & Research, Marketing Mix, Advertising & Brand Management. **(12)**

Module IV

[Operations & Technology Management]

Operations & Technology Management: Role of Operations Management, Logistics & Supply Chain Management, TQM, Kaizen & Six Sigma, MIS.

[Entrepreneurship]

Introduction to Entrepreneurship: Starts ups, Prospects & Challenges, Sustaining business Management and Society: Concept, External Environment, CSR, Corporate Governance, Ethical Standards. **(10)**

Total: 42 L

Text and References Books:

1. Principles of Management- Competencies, Processes & Practices - Bhat, A & Kumar, A (OUP).
2. Essentials for Management - Koontz, H. Tata McGraw Hill (TMH)
3. Fundamentals of Management – Robbins, S., M. Coulter & M, Cenzo, D. Pearson
4. Principles of Management and Administration, Bose, D.C. Prentice Hall of India
5. Principles of Management – Tripathi, P.C., Reddy, P.N. & Bajpai, A., McGraw Hill

Categories	Course Code	Course Title	Hours/Week L: T: P	Credit	Marks	Total contact hours/week
Mandatory Non-Credit Course	**MC–CHE 401**	**Environmental Science**	**2-0-0**	**0**	**100**	**2**

Course Objectives:

1. To study about environment and ecologies
2. To evaluate the influence of human activities on the environment, such as pollution, deforestation, and habitat destruction, using scientific methods and data analysis.

3. To explore strategies and practices that indorse sustainable resource management, renewable energy adoption, and conservation efforts to address environmental challenges.

Contents:

(a) Awareness Activities **(14)**

i) Small group meetings about water management, promotion of recycle use, generation of less waste, avoiding electricity waste
ii) PPT/model presentation focusing on awareness
iii) Poster making event
iv) Video or short movie making event
v) Story or poem writing on the specific environmental issue and posting through online platform

(b) Actual Activities **(14)**

i) Plantation
ii) Cleanliness drive
iii) Drive for segregation of waste
iv) To live some big environment at least for a week or so to understand this work
v) To know about the different varieties of plants
vi) Shutting down the fans and Acs of the campus for an hour or so

Total: 28 (L)

Reference Books:

1. Text book of Environmental Studies, Erach Bharucha, University Press
2. Environmental Studies, M P Poonia & SC Sharma, Khanna Publishing House
3. Environmental Studies, Rajagopalan, Oxford University Press

Course Outcomes:

At the completion of course, Students will have the ability in:

CO1: Understanding the basic reasons of air pollution, water pollution, solid waste management, process plant safety, hazardous chemicals and its adverse effects on environment.

CO2: Applying the theoretical information to control pollutions as well as its impact on public health, safety and environment.

CO3: Analyzing the framework of potential methodologies in different field of application related to different environmental issues.

CO4: Evaluating the pertinence of technologies with respect to environment as well as health, safety and industrial hazards.

Practical

Categories	Course Code	Course Title	Hours/Week L: T: P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC–CHE 491**	**Heat Transfer Laboratory**	**0-0-3**	**1.5**	**100**	**3**

Course objectives:

This laboratory course aims to

- Understand the various forms of heat transfer and their applications in real life problems.
- Develop skill of the budding chemical engineers in safe handling of major heat transfer equipment/devices, in close observation of their operation by giving training by hands of the students on the primary or basic heat transfer devices.
- Develop analytical ability in correlating the performance of the devices with their operational conditions. Another objective is to motivate them to learn to team work in the stage of their laboratory circumstances/mini-pilot processing plant.

The list of laboratory experiments: (at least eight experiments are to be conducted)
Experiments:

1. Determination of thermal conductivity of metal bar.
2. Determination of thermal conductivity of insulating material used inside a lagged pipe apparatus.
3. Determination of thermal conductivity of insulating powder in a spherical metallic bowl.
4. Determination of heat transfer coefficient in forced convection of air in a tube and to study theeffect of air velocity on heat transfer coefficient.
5. Determination of emissivity of an unknown test surface in radiation heat transfer.
6. Determination of overall heat transfer coefficient in Parallel flow / Counter current double pipeheat exchanger.
7. Determination of surface and overall heat transfer coefficients in film wise and drop wise condensation.
8. Determination of internal thermal resistance of two test metal bodies by calculating Biot Number during unsteady state heat transfer.
9. Determination of Stefan-Boltzmann constant using ($dT/d\theta$) from temperature vs. time plot in radiation heat transfer.
10. Determination of overall heat transfer coefficient and efficiency of Shell & Tube heat exchanger.
    Determination of capacity and economy for single effect evaporator

Materials used during experimentation:
Laboratory manual

Reference books:

1. Process Heat Transfer: D Q Kern
2. Heat Transfer: Principles and Applications: B. K Dutta

Course Outcomes:

At the completion of this course, students will have the ability in

CO1: Remembering and **understanding** the previously learned basic science & engineering concepts in the heat transfer operations to **interpret** the experimental data.
CO2: Applying the fundamental knowledge of experimented heat transfer operations and basic principles for that heat transfer device to **solve** experimental problem.
CO3: Analyzing the experimental condition to **develop** and **simplify** the solution techniques for solving any problem primarily in different way as per requirement in new situation.
CO4: Evaluating the key properties / parameters from the experimentation to **assess** & **justify** the real process in comparison with ideal process and finally to **develop** the skill of presenting the results in form of written reports.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional core courses	PC–CHE 492	Solid and Fluid–Particle Processing Laboratory	0-0-3	1.5	100	3

Course Objectives:

The objective of this course is to

- Impart working knowledge in Particle and fluid –Particle Processing
- Develop skills of the students in the Particle and fluid – particle Processing laboratory through bridging between the theoretical concepts and work practices for attaining competency in practical applications
- Develop skills for working in the industry and conducting research & development activities.

At least eight experiments are to be performed:

1. Verification of Rittinger‘s Law and determination of grind ability index of a drop weight crusher for agiven granular solid sample.
2. Determination of reduction ratio and capacity of a laboratory scale _Ball Mill‘.
3. Estimation of capacity and reduction ratio of a batch Hamme Mill‘.

4. Determination of average particle size of a given solid sample using a sieve shaker by (i)Random Sampling (ii) Coning and quartering.
5. Determination of overall effectiveness of a sieve shaker for a given solid sample of unknown size.
6. Estimation of Mixing Index at different times and power consumption for fluid mixing for differentrotational speeds of the impeller.
7. Determination of rate of sedimentation for given slurry by plotting interface height vs. Time.
8. Design of a continuous thickener by conducting a batch sedimentation test for a given sedimentationduty.
9. Determination of specific cake resistance ' a ' and filter medium resistance 'Rm' by filtering a slurryusing plate and frame filter press.
10. Estimation of ' α ' (specific cake resistance) and ' R_m' by filtering slurry using a batch centrifugal filter.
11. Determination of the recovery percentage of coal in froth from coal-sand mixture by using Froth Floatation Technique.

Text/Book of reference:

1. Mc.Cabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7thedition, 2017.

Course Outcomes:

Students will be able in

CO1: Memorizing and understanding the fundamentals of particle and fluid particle processing by doing the experiment in hand through teamwork.

CO2: Understanding the importance of various equipment of particle and fluid particle processing used in process industries by applying its working principle through experiment.

CO3: Analyzing the principles of particle and fluid particle processing for designing various size reduction equipment, size separation, filtration, mixing and conveying types of equipment.

CO4: Justifying between the professional ethics and responsibility in aspects of safety and environmental protection during experimental work.

Detailed Syllabus, B. Tech Third year, Semester V

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week

Professional Core Courses	**PC– CHE 501**	**Transport Phenomena**	**3-1-0**	**4**	**100**	**4**

Course Objectives:

- This course will highlight coupling between three transport phenomena with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems.
- The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid- state heat conduction, forced and free convection, binary diffusion with or without chemical reaction.

Contents:

Module I

Introduction to Transport Phenomena, Formulation of transport problems from nature. Concept of unified approach to Momentum, Heat and Mass Transport through Transport Phenomena Assumptions of Transport phenomena; Similarity of Mass, Momentum and Energy transfer, Diffusivities, Transport Theorem. Vector and Tensor Analysis: Basic concepts Basics of momentum transport: Euler/ Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor. **(12)**

Module II

Shell momentum balances, Falling film Flow, Flow of Newtonian or Non- Newtonian fluid through a circular tube, Flow of Newtonian or Non- Newtonian fluid through annulus, Flow of two adjacent immiscible fluids, Flow of a film on outside of circular tube, Creeping flow around a sphere. Equations of change, dimensional analysis, applications to isothermal flow of Newtonian & non-Newtonian fluids. **(14)**

Module III

Basics of energy transport, conductive, convective and viscous dissipation energy fluxes.

Shell energy balance and boundary conditions – Heat conduction with electrical, nuclear, viscous and chemical heat source, Heat conduction through composite walls, Heat conduction in fins, Heat conduction from a sphere to stagnant fluid. Equations of change for non-isothermal systems, dimensional analysis, and applications to steady- state conduction and convection. **(16)**

Module IV

Basics of mass transport, mechanisms, and mass and molar fluxes. Shell mass balance and boundary conditions – Diffusion through stagnant gas film, Diffusion in a falling film, Diffusion with heterogeneous chemical reaction, Equations of Continuity for binary mixture,

simplification of general equation for special cases. Derivation of equation of continuity for A binary mixture and its application to convection- diffusion problems.

Unsteady-state momentum, heat and mass transport, formulation of basic equations and similarity transform method. **(14)**

Total: 56 (L+T) Text Books:

1. R. B. Bird, W. E. Stewart, and E. S. Lightfoot. Transport Phenomena, 2nd ed.,Wiley India Pvt. Ltd., 2002.
2. Transport Processes and Unit Operations, C. J. Geankoplis, Prentice Hall, III Edition,1993.
3. Welty, C. E. Wicks, R. E. Wilson, and G. L. Rorrer. Fundamentals of Momentum, Heat, and Mass Transfer. 5th ed., Wiley India Pvt. Ltd., 2007.

Reference Books:

1. W.M. Deen, Analysis of Transport Phenomena, Oxford University Press,1998.
2. Transport Phenomena, R.S. Brodkey and H.C. Herskey, Mc.Graw Hill,1988.
3. W.J. Thompson, Introduction to Transport Phenomena, Prentice Hall,2000.

Course Outcomes:

On completion of the course, students would be familiar in

CO1: Understanding the fundamental relations between the conservation laws in heat, mass and momentum. Interpret the importance of analogies between transport operation.

CO2: Solving the transport problems by applying shell balance methods.

CO3: Analyzing the technique to formulate and solve one-dimensional transport problems by using the conservation equations.

CO4: Formulating simple multi-dimensional transport problems. Evaluating the equation of changes from conservation laws for momentum, energy and mass transport. Dimensional analysis, Equations of Continuity to develop various transfer model and solving Chemical Engineering real problems concern with transport phenomena.

Categories	Course Code	Course Title	Hours / Week L: T:P	Credit	Marks	Total contact hours/ week
Professional Core Courses	**PC–CHE 502**	**Chemical Reaction Engineering**	**3-1-0**	**4**	**100**	**4**

Course Objectives

This course prepares the student to gain knowledge on:

- Basic Concepts of Kinetics and Rate Laws and Design and Rating of Ideal Reactors Interpretation of Rate data and Design and Rating of Reactors involving multiple reactions
- Basic Concepts of Catalysis, Kinetics and Mechanistic aspects of Catalysts, Design and Rating of Catalytic Reactors
- Analysis of Non-ideal flow Behavior in Reactors

Contents:

Module I

Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity, Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory Analysis and correlation of experimental kinetic data - data collection & plotting, differential and integral method of analysis **(14)**

Module II

Ideal reactors –Sizing and analysis of ideal batch, mixed flow (CSTR), plug flow, semi- batch and recycle reactors -solving design equations for constant and variable density systems, graphical interpretation, reactors in series and parallel

Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions **(14)**

Module III

Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterization of catalysts. Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the catalyst, catalyst characterization. Kinetics of solid catalyzed gas phase reaction

Laboratory reactors for catalytic gas solid reactions. Design concepts. **(14)**

Module IV

Mass transfer, Diffusion and Chemical reactions in catalysts. Effects of external mass transfer and heat transfer, Effectiveness factor. Design aspects of catalytic reactors.

RTD theory and analysis of non-ideal reactors **(14)**

Total: 56 (L+T)

Text Books:

1. Elements of Chemical Reaction Engineering, 4th.Edition, H.Scott Fogler, Prentice Hall
2. Chemical Reaction Engineering, 2nd. & 3rd.editions, O. Levenspiel: Wiley Eastern Ltd.

References:

1. Chemical Reactor Analysis and Design Fundamentals, J.B. Rawlings and J.G. Ekerdt. Nob Hill Publishing.
2. Chemical Engineering Kinetics, 3rd. Edition, J.M.Smith, MGH.
3. Chemical Engineering Kinetics and Reactor Design, C.G.Hill, Wiley

4. The Engineering of Chemical Reactions, 2nd.Edition, L. D. Schmidt, Oxford
5. Experiments in Catalytic Reaction Engineering, J.N. Berty, Elsevier.

Course outcomes

Students will be able in

CO1: Understanding the kinetic data analysis to get the kinetic rate expressions for different types of reactions.

CO2: Applying the performance equation of different types of reactors for sizing the reactors

CO3: Analyzing the use of catalyst in the design of different heterogeneous reactors

CO4: Evaluating the effect of non-ideality in the performance of different reactors

Categories	Course code	Course title	Hours/week L: T:P	Credit	marks	Total contact hours/week
Professional core courses	**PC –CHE 503**	**Mass Transfer II**	**3-1-0**	**4**	**100**	**4**

Course Objectives:

The general objectives of Mass Transfer II for the undergraduate students are -

- To learn the fundamental concepts of some major Mass transfer operations and to apply those concepts to real engineering problems.
- To impart knowledge on the basic principles of operation of the major mass transfer equipment/devises.
- To apply the design principles for mass transfer devices/equipment.

Contents:

Module I Liquid-liquid Extraction: Introduction; Equilibrium data representation; selectivity and choice of solvent; Stage-wise contact; Method of calculation for single stage, Multistage Cross-current and Counter-current operation by graphical methods; Extraction efficiency; Types of extraction Equipment.

(14)

Module II

Leaching: Introduction to leaching; Factors affecting the rate of leaching; Equilibrium data representation; Method of stage calculation; Introduction to Supercritical Fluid Extraction; Leaching Equipment.

Adsorption: Introduction; Nature of adsorbents; Equilibrium data representation; Design of Fixed bed Adsorber - Break-through curves, Determination of time required to reach breakthrough point, length of unused bed; Equipment. Biosorption and biochar basics with applications.

(16)

Module III

Drying: Introduction; theory and mechanism of drying; drying equilibria and drying rate curve; classification and selection of dryers; Calculation of rate of drying and time of drying for batch and continuous dryers; Introduction to freeze drying.

Crystallization: Introduction to crystallization; Mass transfer theory of crystallization; Batch and continuous Crystallizers; Design calculations for crystallizers.

(14)

Module IV

Membrane Separation Process: Membrane separation basics; classification of membrane separation processes; Different types of membranes including ionic membrane, reactive membrane and Liquid membrane; Dialysis, Electrodialysis, Pervaporation, microfiltration, ultrafiltration, nanofiltration, reverse Osmosis, Gas permeation, membrane fouling and cleaning.

(12)

Total: 56 (L+T)

Text books

1. R.E. Treybal, Mass Transfer Operations,3rd Edition, Mc Graw Hill,New Delhi,1983.
2. Binay K. Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007
3. C.J. Geankoplis, Transport Processes and Unit Operations,3rd Ed., Prentice Hall, India, 1993.

Reference books:

1. W. L. Mc Cabe, J.Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill International Edition,
2. Coulson, J.M., Richardson, J.F., Backhurst, J.R, & Harker, J.H., Chemical Engineering, Volume 1 & 2, 6th Edition
3. Sieder J.D., Ernest J.Henley. Separation Process Principles (2011).

4. A.P. Sinha, Parameswar De, Mass Transfer Principles and Operations, PHI Learning Pvt. Ltd., India, 2012

Course Outcomes:

Students will have the ability in

CO1: Recalling the basics of mass transfer theory and understanding the principles of Liquid-liquid extraction, leaching, drying, adsorption, crystallization and membrane separation.
CO2: Calculating process parameters of these mass transfer processes.
CO3: Analysing working of various mass transfer equipment of drying, adsorption, crystallization and membrane separation.
CO4: Designing mass transfer equipment of extraction, leaching, adsorption, etc.

Core Elective I	PEC–CHE 501A	PEC–CHE 501B	PEC–CHE 501C
Name of the Subject	Food Technology	Fertilizer Technology	Petrochemical Technology

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	PEC–CHE 501A	Food Technology	3-0-0	3	100	3

Course Objectives:

This course prepares the student to:

* Understand the physicochemical properties and nutritional qualities of food constituents.

* Understand the requirements, CCPs and the extent of processing needed for different foods, and their preservation until consumption.

* Develop idea in identifying and detecting contamination and adulteration, and designing a plant setup for their prevention.

* Develop idea to choosing an effective mode of processing for a food by restoring its nutritional and sensory qualities.

Contents:

MODULE I

Chemistry of foods: Carbohydrates, proteins, lipids, vitamins and minerals- chemistry and nutritional quality; biological value, NPU, PER of proteins, properties of water, water

activity, food pigments, flavours and additives, enzymes, physical, chemical and biochemical changes of foods during harvesting, storage and processing.

Food microbiology: Different microbes and cellular morphology, microbial growth curve, pure culture, media preparation, agar plating and slant preparation, gram staining, shake flask, CFU, serial dilution, spoilage microorganisms in different food products including milk, fish, meat, egg, cereals and their products, food pathogens and microbial toxins.

(10)

MODULE II

Thermal and non-thermal processing of foods: Pasteurization, sterilization, appertization, retort types, aseptic packaging, D value, z value, F value, TDT curve, canning, irradiation, HPP, ultrasound, microwave, HI-PEF, ohmic heating, membrane separation, freezing and cold preservation. minimal processing, CA and MA storages, Advantages, limitations and product defects in **d**ifferent types of processing.

Fermented foods: Definition of fermentation, fermentation biochemistry, preservation by fermentation, yeast and SCPs, alcoholic beverages, fermentation by moulds and bacteria, pure culture and mixed culture fermentation, fermented vegetables, acetic and propionic acids fermentation. **(10**)

MODULE III

Milk, milk products, fish, meat and poultry: Composition of milk, microbes of milk, LTLT, HTST, UHT pasteurizations, pasteurization indices, lactic acid fermentation, paneer, cheese, curd and ice-cream, processing of fish and meat, curing, rigor mortis, PSE, DFD meats, egg morphology and biochemical changes, preservation of eggs.

Cereals, fruits and vegetables, non-alcoholic bevera**g**es: Postharvest handling and storage of cereals, dry and wet millings of cereals, resistance starch, bakery products, commercial canning of fruits and vegetables, dehydration of fruits, fruit juice, nectar, cordial, jam, jelly, marmalade, pectin- structure, function and extraction; vinegar production, potato products.

(12)

MODULE IV

Oils, oilseeds and pulses processing: Extraction and processing of edible oils, pulses as protein foods, processing of pulses.

Food packaging and food laws: Different types of packaging materials of foods, gas and moisture permeability of packaging materials, tetra pack, HACCP, PFA, FPO, FSSAI, ISO, FDA and EU legislations. **(10)**

Total: 42 (L)

Course Outcomes:

At the completion of this course, students should be able in:

CO1: Remembering the relationship between food, nutrition and health.

CO2: Understanding digestion, absorption, functions and food sources of various nutrients.

CO3: Applying the concept of balanced diets and menu planning.

CO4: Analyzing different methods of cooking and ways to prevent nutrient losses.

Text Books:

1. Textbook of Food Science and Technology – A. Sharma.

2. Fennema's Food Chemistry, Srinivasan Damodaran, Kirk L. Parkin (Eds.), CRC Press.

3. Principles of Food Chemistry, J. M. DeMan, Springer.

4. Harper's Illustrated Biochemistry, Thirty Second Edition, Victor W. Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil, McGraw Hill Professional.

5. Food Processing: Principals and Applications, Ramaswamy, Marcotte, CRC Press.

6. Food Microbiology, W. C. Frazier, D. C. Westhoff, Tata-McGraw Hill Publishing Company.

7. Fundamental of Food Process Engineering, R. T. Toledo, CBS Publishers and Distributors.

8. Milk Processing and Quality Management, A. Y. Tamime (Ed.), Backwell Publishing.

9. Textbook on Meat, Poultry and Fish Technology, Jhari Sahoo, Manish Kumar Chatli, Daya Publishing House.

10. Handbook of Postharvest Technology, Cereals, Fruits, Vegetables, Tea, and Spices, Amalendu Chakraverty, Arun S. Mujumdar, Hosahalli S. Ramaswamy (Eds.), CRC Press.

11. Pulse Foods: Processing, Quality and Nutraceutical Applications, Brijesh K. Tiwari, Aoife Gowen, Brian McKenna, Academic Press.

12. Chemistry and Technology of Oils and Fats, M. M. Chakraborty, Allied Publishers.

13. Food Packaging: Principles and Practice, G. L. Robertson, CRC Press.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC–CHE 501B**	**Fertilizer Technology**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Introduce production of various NPK fertilizers and their importance
- Impart knowledge of bio-fertilizers, fluid fertilizers and controlled release fertilizers
- Identify pollutions involved in fertilizer manufacture and their controlling strategies to maintain the pollution standards.

Contents:

Module I

Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crops. Nutrient contents of fertilizers; Bio-fertilizers, Nutrient-Secondary nutrients and micronutrients;

Fluid fertilizers, Granular fertilizers, Controlled release fertilizers, Slow-release fertilizers. **(10 L)**

Module II

Nitrogenous fertilizers: Feedstock and raw materials for nitrogenous fertilizers. Methods of production of ammonia and nitric acid. Ammonium sulphate, Urea, Ammonium chloride, Ammonium nitrate and Calcium ammonium nitrate, Characteristics and specification, Storage and handling. **(10 L)**

Module III

Phosphatic Fertilizers: Raw materials – phosphate rock, Sulphur, pyrites etc. Processes for the production of sulphuric and phosphoric acids. Phosphatic fertilizers – ground rock phosphate, bonemeal–Single super-phosphate, Triple super-phosphate, thermal phosphates, characteristics and specifications. **(10 L)**

Module IV

Potassic fertilizers: Potassium Chloride, Potassium sulphate, Potassium magnesium sulphate, Potassium hydroxide, Potassium nitrate – Methods of production: their characteristics and specifications.

NPK fertilizers: Urea ammonium phosphate, ammonium phosphate sulphate, Nitro-phosphates, and various grades of NPK fertilizers produced in the country. Pollution from fertilizer industry, Solid, liquid and gaseous pollution control and standards. **(12 L)**

Total: 42 L

Text Books:

1. Hand book of fertilizer technology Association of India, New Delhi,1977
2. Fertilizer Manual, United Nations Industrial Development Organization, United Nations, New York, 1967.

Reference books:

1. Rao G., Sittig M., Dryden's Outlines of Chemical Technology, 3rd ed., East West Press, India, 2010.
2. Austin T. G., Shreve's Chemical Process Industries,5th ed., Tata Mc Graw-Hill Education Pvt. Ltd, USA, 2012.

Course Outcomes:

Students will be able in:

CO1: Understanding the reactions and unit operations steps in manufacturing of various fertilizers.

CO2: Analyzing and applying the fertilizers on the basis of different properties.

CO3: Evaluating engineering problems in fertilizer manufacturing Industries.

CO4: Analyzing appropriate synthesis and handling of the fertilizers.

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC– CHE 501C**	**Petrochemical Technology**	**3-0-0**	**3**	**100**	**3**

Course Objective:

The course attempts to

- Develop individuals with a specialization in petrochemicals and other important fields.
- Give students with the information and skills necessary for flourishing petroleum and petrochemicals-based careers.
- Give the knowledge in petro chemistry and the application of new petrochemical technologies for the growth and problem solving within both the government and the industrial sectors.

Contents:

Module I

Different feed stocks used for Petrochemical Industries and their sources. Impurities in feed stocks and their removal methods. Natural Gas processing. General idea of LNG, CNG, NGL, LPG and their generation. Production and Utilization of Synthesis gas: Production of Methanol from Synthesis gas. Chemicals from Synthesis gas by Oxo synthesis. Production of liquid fuels from Synthesis gas by Fischer Tropsch process. **(10)**

Module II

Name of Major Petrochemical products and their applications. First, Second and Third generation petrochemical products. Production of Ethylene, Propylene, and Butadiene by Naphtha/Gas cracking. Petrochemicals based on Ethylene, Propylene and Butadiene: Like VCM, VAM, Ethylene Oxide, Ethylene Glycol, Ethanol Amines from Ethylene. Acrylonitile, Isopropanol, Propylene oxide, Glycerine, Acrylic acid, Acrolein from Propylene. Production of Butadiene. **(10)**

Module III

Production, Separation and Utilization of Aromatics: - Catalytic Reformation of Naphtha and production of Xylenes. Separation of Xylenes. Isomerization of Meta xylene. Pyrolysis Gasoline hydrogenation and separation of BTX aromatics. Production of Benzene, Toluene, Xylenes from BTX aromatics by distillation. Production of Benzene from Toluene. Uses of xylenes. Alkylation of Benzene. Production of Styrene, Cumene and Phenol. Production of Phthalic Anhydride etc.
(12)

Module IV

Plastomers, Elastomers and Synthetic fibres:- Various methods of polymerization and their mechanisms. Production processes of LDPE, LLDPE and HDPE. Basic difference among the three and their applications. Production of PVC and Polystyrene. Production of Polypropylene. Production of SBR, PBR and Butyl rubber. Production of ABS plastics. Production of Polyamide (Nylon 6 and Nylon 6,6), Polyester and Acrylic fibers. Production of Phenol Formaldehyde resins.
(10)

Total: 42 L

Text Books:

1. Bulk Chemicals from Petrochemicals: B.K.B. Rao, Khanna Publishing House
2. Elements of Petrochemical Engineering, O.P. Gupta, Khanna Publishing House
3. Petrochemical processes: Chauvel, Gulf Publishing

Reference Books:

1. The Petroleum chemicals Industry:R.F. Goldstein and A.L. Waddams.
2. Advanced Petrochemicals: Dr.G.N. Sarkar, Khanna Publishers
3. Introduction to Petrochemicals, Sukumar Maity. Oxford and IBH Publishing Co.

Course Outcomes:

Students will be able in

CO1: Memorizing different petrochemicals products, their properties and reaction fundamentals.

CO2: Explaining the engineering problem during producing petrochemicals product.

CO3: Demonstrating various processes for the petrochemical's product production with consideration of public health, safety and different environmental regulations.

CO4: Comparing different petrochemical products and their processing.

Open Elective I	OEC– CHE 501A	OEC– CHE 501B
Name of the Subject	Materials for Engineering Applications	Renewable Energy

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	OEC – CHE 501A	Materials for Engineering Applications	3-0-0	3	100	3

Course objectives:

The main objective of the course is to

- Understand the classification of various engineering materials, Chemical bond characteristic; the crystalline, non- crystalline materials and different types of crystal structures and their defects. Also, to understand the concept of phase and different type of phase diagrams.
- Give the chemical engineering students a basic concept about the role of a chemical engineer from the characterization of engineering materials to processing them for their significant applicability in core industry and other relevant engineering fields.
- Relate the underlying molecular structure of the materials to their physical and chemical properties, and their processing and performance characteristics in the corresponding engineering aspects.

Module I:

Characterization of engineering materials: structure of engineering materials Determination of mechanical properties: the tensile test, bend testing, statistics of brittle fracture, hardness testing, fracture toughness testing, time-dependent mechanical properties, metals and alloys: general strengthening mechanisms, the effect of processing, families of engineering alloys. **(10 L)**

Module II:

Corrosion -corrosion Principles and types of corrosion, electrochemical reactions, corrosion rate expressions, polarization, passivity, open corrosion potential, linear polarization, stresses corrosion cracking, corrosion prevention: cathodic protection, sacrificial anode methods of corrosion prevention, anti-corrosion coatings.

(10 L)

Module III:

Glasses and ceramics: -types of ceramic, crystal structures and silicate structures, processing of ceramics, mechanical and thermal properties of ceramics; structures and composition of glasses, glass transition temperature, forming methods for glasses; electrometallurgy, surface finishing, selection of materials of constructions: cantilever, pressure vessels, design and corrosion factor for chemical contact, water pipelines, crude oil pipelines

(12 L)

Module IV:

Organic polymeric materials: forming processes for polymers, mechanical properties, polymer degradation; polymer composite materials: various types of engineering composites; factors influencing composite properties; nano-composite materials: nanomaterials classifications depending on location and based on the number of dimensions; approaches for the nanomaterial preparations, nano-fillers, biomaterials:

(10 L)

Total: 42 L

Text books:

1. John W. Martin, Materials for Engineering, Woodhead Publishing Limited, 3rd Edition.
2. M Fontana, Corrosion Engineering, Tata McGraw Hill Education Pvt. Ltd., 3rd Edition, 2010.
3. William F Smith, Javad Hashemi & Ravi Prakash, Materials Science and Engineering In SI Units, Tata McGraw Hill Education Pvt. Ltd., Sixth Edition.
4. O.P. Gupta, Elements of Fuels, Furnaces, & Refractories, Khanna Publishers, 2002.
5. R. Subramaniam, Callister's Material Science and Engineering, Wiley, 2nd Edition, 2014.

Reference books:

1. Brian S. Mitchell, An Introduction to Materials Engineering and Science: For Chemical and Materials Engineers, John Wiley & Sons, Inc., 2004.
2. J.C., Anderson K.D Leaver., P. Leevers & R.D Rawlings., Material Science for Engineers, CRC Press, 5th Edition, 2003.

Course outcomes:

Students will be capable of

CO1: Understanding the fundamental techniques of characterizing engineering materials and various mechanical properties associated with them.

CO2: Analyzing between the structures, properties and formation of various engineering materials including metals, glass, ceramics, organic polymers, composite, nano-composite and bio materials.

CO3: Applying engineering materials selection concepts for appropriate application in chemical and related industries.

CO4: Analyzing the principles and various types of corrosion within the process industry, and implement effective strategies to control corrosion.

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	**OEC–CHE 501B**	**Renewable Energy**	**3-0-0**	**3**	**100**	**3**

Course objectives:

This course prepares the student to:

- Create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last and learn the fundamental concepts about renewable energy.
- Introduce the operating principle of several environmentally friendly energy technologies.
- Identify the material issues relevant to these technologies and to evaluate various operational aspects associated with these technologies.

Contents:

Module I

World energy consumption pattern, trend and future. Sustainability of energy sources, present, past and future. Classifications. World economy and growth aspect related to renewable energy sources.

Area of application of light energy, solar photovoltaic, solar thermal applications and technologies, solar appliances, weather dependency, economics and hazard.

(10)

Module II

Area of application of wind energy, trend and future, solar turbine technologies, technological solutions of technology in weather crisis, economics and hazard.

(10)

Module III

Other types of renewable sources and their scope, Tidal and wave energy, hydrodynamic, geothermal, ocean thermal, nuclear, chemical, biochemical, bio-energy, electrochemical etc., Innovative idea.

(10)

Module IV

Hydrogen energy road map, hydrogen production processes, hydrogen storage and hydrogen transport.

Fuel cell, fuel cell types, fuel cell components, fuel cell design, fuel cell operation and performance. **(12)**

Total: 42 (L)

Reference Books:

1. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, 2004

Course outcomes:

At the completion of this course, students should be able to:

CO1: Memorize the environmental aspects of conventional and non-conventional energy resources.

CO2: Summarize the need of different types of renewable energy resources, historical and latest developments.

CO3: Interpret solar photovoltaic, solar thermal energy, wind energy, geothermal, ocean thermal and others potential sources for the purpose of heating, cooling, desalination, power generation, drying, cooking etc.

CO4: Appraise the performance of various futuristic approaches of exploration of environmentally benign energy sources and appliances.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Mandatory Non-Credit Course	MC– CHE 501	Constitution of India	2-0-0	0	100	2

Course Objectives:

This course prepares the student:

• Sensitization of student towards self, family (relationship), society and nature

• Understanding (or developing clarity) of nature, society, and larger systems, based on human relationships and resolved individuals.

• Strengthening of self-reflection and development of commitment and courage to act.

Contents:

Module -I **(7L)**

Introduction: Constitution' meaning of the term, Indian Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy

Union Government and its Administration: Structure of the Indian Union: Federalism, Centre-State relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha

Module -II **(7L)**

State Government and its Administration Governor: Role and Position, CM and Council of ministers, State Secretariat: Organization, Structure and Functions

Module -III **(7L)**

Local Administration District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Panchayati raj: Introduction, PRI: Zila Panchayat, Elected officials and their roles, CEO Zila Panchayat: Position and role, Block level: Organizational Hierarchy (Different 4. departments),

Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Module -IV **(7L)**

Election Commission Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women

Total: 28 (L)

Text book and Reference books:

1. 'Indian Policy' by Laxmikanth
2. 'Indian Administration 'by Subhash Kashyap
3. 'Indian Constitution' by D.D. Basu

4. ‘Indian Administration’ by Avasti and Avasti

Course Outcomes

At the completion of this course, students will be capable of

CO1: Understanding the Indian Constitution's meaning, sources, historical development, and key features like citizenship, preamble, fundamental rights, duties, etc.

CO2: Applying knowledge of the Indian Union's structure and federalism to analyze the relationship between its government and administration, including key roles and powers.

CO3: Analyzing the structure and functioning of State Government and its administration, including key roles like Governor, Chief Minister, and Council of Ministers

CO4: Evaluating the functioning of local administration, including district, municipal, and panchayati raj institutions, to assess elected and appointed officials' roles in grassroots democracy.

Practical / Sessional papers

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC– CHE 591**	**Chemical Reaction Engineering Laboratory**	**0-0-3**	**1.5**	**100**	**3**

Course Objective:

- Students can get hand on experience in prototype system.
- The students are learning the gap between the theoretical and practical phenomena in terms of outcome or results and learn the safety in handling pilot scale instruments.
- Student‘s knowledge in Prototype system will help them to idea of commercialization

At least eight experiments are to be performed Experiments:

1. Experimental studies on kinetics of a noncatalytic homogeneous liquid phase reaction in an isothermal batch reactor.
2. Experimental studies on kinetics of a homogeneous liquid phase reaction in an isothermal semi batch reactor.
3. Experimental studies on kinetics of a non-catalytic homogeneous liquid phase reaction in a tubular plug flow reactor. (ideal plug flow reactor)
4. Experimental studies on kinetics of a non-catalytic homogeneous liquid phase reaction in a Spiral plug flow reactor.

5. Experimental studies on kinetics of a noncatalytic homogeneous liquid phase reaction in an isothermal CSTR.
6. Experimental studies on RTD in a packed bed reactor using pulse input of tracer and measurement of axial dispersion coefficient.
7. Experimental studies on RTD in a straight tube PFR using pulse input of tracer and measurement of axial dispersion coefficient.
8. Experimental studies on kinetics of hydrolysis of ethyl acetate in presence of acid catalyst in an adiabatic batch reactor.
9. Kinetic studies of sulfonation of toluene in an isothermal batch reactor
10. Kinetic studies on hydrolysis of benzoyl chloride in an adiabatic batch reactor.

Text Books:

1. Elements of Chemical Reaction Engineering, 4th.Edition, H. Scott Fogler, Prentice Hall
2. Chemical Reaction Engineering, 2nd & 3rd editions, O Levenspiel: Wiley Eastern Ltd.

Course outcomes:

The student will be able in

CO1: Understanding and remembering the Steady and unsteady state reactors and study its performance during experiment.

CO2: Explaining all stages of experiment for batch, semi-batch and continuous reactor mode of operation in various ideal reactors and also for non-ideal reactor of RTD experiment. While conducting the experiment, the student will be able to exercise and illustrate tidiness, safety in the laboratory and cleanliness of the lab area.

CO3: Applying the raw data generated in performance equation of reactors, including units in the title of data table for the steady or unsteady state operation and analyzing the data in various ways such as, charts, tables, graphs to compare the results.

CO4: Verifying the efficiency and kinetics of various mode of operation for different reactors.

Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/ week
Professional core courses	**PC –CHE 592**	**Mass Transfer Laboratory**	**0-0-3**	**1.5**	**100**	**3**

Course objectives:

This laboratory course aims to

- Develop skill of the budding chemical engineers in safe handling of major mass

transfer equipment/devices, in close observation of their operation by giving training by hands of the students on the primary or basic mass transfer devices.

- Develop analytical ability in correlating the performance of the devices with their operational conditions.
- Teach student the use of conceptual design method in designing and trouble-shooting industrial mass transport processes.
- Motivate them to learn to team-work in the stage of their laboratory circumstances/mini-pilot processing plant.

The list of laboratory experiments: (at least eight experiments are to be conducted)

1. Experimentation to determine the mass transfer co- efficient for diffusion of water vapor into air(while heating / boiling of bath water under natural convection)
2. Experimentation to determine the diffusivity of volatile organic liquid(CCl_4 / acetone / benzene) while its vapor diffusing in air.
3. Humidity: Experiment to determine the properties of moist air.
4. Experimentation on Rotary Vacuum Dryer to study the drying characteristics curve at differentperiods of drying.
5. Experimentation on Forced Draft Tray Dryer to study the drying characteristics curve at differentperiods of drying.
6. Experimentation on Othmer Still for boiling point diagram and equilibrium diagram of a binaryliquid mixture.
7. Experimentation on simple batch distillation to verify Rayleigh‘s Equation
8. Experimentation on binary distillation in a sieve plate column.
9. Experimentation on batch adsorption (to verify adsorption isotherms).
10. Experimentation on liquid-liquid extraction to determine efficiency of extraction of liquid-liquid mixture using solvent in three stage operation.
11. Experimentation on Absorption in packed column.

Materials used during experimentation:

Laboratory manual

Reference books:

1. J.D Seader, E.J. Henly, Separation Processes and principles, John Willey,2nd edition, 2006

2. Ross Taylor and R. Krishna, Multi component Mass Transfer, John Wiley, New York,1993

Course Outcomes:

At the completion of this course, students will be:

CO1: Recalling and relating the previously learned engineering / basic science concepts or knowledge with the major mass transfer operations.

CO2: Interpreting the experimental data on the basis the fundamentals of experimented mass transfer operations.

CO3: Applying basic design principles for mass transfer equipment to solve primarily any complex mass transfer problem facing in day-to-day life by industry.

CO4: Examining and classifying the causes of technical problem during experimentation in various mass transfer areas.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC– CHE-593**	**Process Equipment Design and Drawing-I**	**0-0-3**	**2**	**100**	**3**

Course Objectives:

The objective of this course is to

- Acquire basic understanding of design parameter, familiarize standard symbols of process flowdiagrams and Learn basic symbols used instrumentation diagrams
- Complete knowledge of design procedures for commonly used process equipment and theirattachments, and to know the selection of material of construction.
- Know detailed dimensional drawings including sectional front view, full top/side view depending onequipment.

Content:

1. Introduction to basic knowledge of flow meter and process design of Orifice meter, Venturi meter,Rotameter. **(4)**
2. Mechanical design, materials of construction, and drawing of Orifice meter/ Venturi meter/Rotameter. (4)

3. Introduction to basic knowledge of Heat exchanger, types of heat exchanger etc. (4)
4. Complete process design and mechanical design of Shell & tube heat exchanger. Introduction to standards, codes and regulations. Selection of material and design of various parts of heat exchanger Detailed design of Shell and tube heat exchanger. (10)
5. Introduction to basic knowledge of Evaporator, types of evaporator etc. **(3)**
6. Process design and mechanical design of Multi-effect evaporator. Introduction to standards, codes and regulations. Selection of material and design of various parts of Evaporator. Detailed Design of Multi effect evaporator. (10)
7. Drawing of Shell & tube heat exchanger and Multi effect evaporator. **(7)**

Text books:

1. Heat Transfer: Principles and Applications – Binay K. Dutta
2. Process Heat Transfer – D.Q. Kern (McGraw-Hill)
3. Process Equipment Design by Lloyd E. Brownell & Edwin H. Young
4. Process Equipment Design by M.V. Joshi

Reference books:

1. Introduction to Chemical Equipment Design: Mechanical Aspects by B.C. Bhattacharya
2. Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus.
3. Chemical Process Equipment: Selection and Design byJames R. Couper.

Course Outcomes:

Student will have the ability in

CO1: Remembering and understanding the standards for the mechanical design of equipment used in the process industry to **demonstrate** and **explain** the general fabrication techniques.

CO2: Applying the useful guide lines and the various principles of designing different process equipment of unit operations.

CO3: Analyzing the probable processing constraints to acquire the ability to **identify** design problems in industrial equipment.

CO4: Evaluating and Creating in aspects of ability to **develop** the skill to represent the process and mechanical design of specific equipment as well as the requisite accessories using engineering drawing tools.

Detailed Syllabus, B. Tech Third year, Semester VI

Categories	Course code	Course title	Hours/week L: T:P	Credit	marks	Total contact hours/week
Professional core courses	PC–CHE 601	Chemical Process Technology	3-1-0	4	100	4

Course Objectives:

The objective of this course is to:

- Introduce about Basic concepts of chemical process technology.
- Study the different process principles and technologies.
- Learn the various operations in any chemical industry.
- Teach the strategies to analyze major engineering problems.

Contents:

Module- I **(14L)**

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of inorganic chemicals, such as: Chlor-alkali Industry for Soda Ash & Brine electrolysis for NaOH, Chlorine manufacturing. Industrial manufacturing process of NH_3, HNO_3 & H_2SO_4, Manufacturing process with flow diagram for Urea, Superphosphate & Mixed fertilizer.

Module –II **(12L)**

Manufacturing of Oil and Soap: Classification of oil. Properties of vegetable oil : acid value, saponification value and iodine value (Definition and Significance). Process description with flow diagram of oil extraction from oil seed. Hydrogenation process of oil.

Raw materials, chemical reaction, process description with flow diagram for manufacturing of soap by continuous process. Cleansing action of soap. Production of detergents.

Module – III **(16L)**

Industrial process with flow diagram for manufacture of Petrochemicals: C1(methanol, formaldehyde, chloromethanes), C2 (ethylene, ethanol, polyethylene, vinyl chloride), C3 (isopropanol, Acetone, cumene, Acrylonitrile), C4 (butadiene via dehydrogenation of

Butane), benzene, toluene, xylene and other petrochemicals (Phenol-by cumene process and styrene-from benzene and ethylene) from these basic building blocks.

Module – IV **(14L)**

Cement: Chemical composition of Portland cement, raw materials, dry and wet process for manufacturing cement clinker, setting and hardening of cement.

Glass: Composition of glass, raw materials, manufacturing method of glass- pot furnace and tank furnace, annealing of glass.

Ceramic: Basic raw materials, white-wares, manufacturing process of porcelain and their forming operations.

Surface Coatings: Types, Compositions, applications & paint-failure and it's remedies.

Total: 56L

Reference Books:

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, Marshall Sittig, East West Press, 1997
3. Chemical Process Technology, O. P. Gupta, Khanna Publishing House,2018 (AICTE Recommended Textbook – 2018)
4. Chemical Project Economics, Mahajani V. V. and Mokashi S M., Mac-Millan India Ltd. 2005
5. Plant Design and Economics for Chemical Engineers, Max Peters, Klaus Timmerhaus, Ronald West, McGraw Hill International Edition, 2013

Course Outcomes:

At the completion of this course, students will be capable of:

CO1: Understanding various manufacturing processes used in chemical process industries

CO2: Analyzing major engineering problems encountered in chemical process industries

CO3: Evaluate the process aspects like yield, by products formed, generation of waste

CO4: Create and apply the concept of problem-solving approach for industrial solutions.

Categories	Course code	Course title	Hours/week L: T:P	Credit	marks	Total contact hours/week

Professional Core Courses	**PC–CHE 602**	**Instrumentation and Process Control**	**3-1-0**	**4**	**100**	**4**

Course Objectives:

- To impart knowledge about the various techniques used for the measurement of primary industrial parameters like flow, level, temperature, pressure etc.
- To maintain a process at a desired, constant operating condition (temperature, pressure, composition, etc.) in the face of disturbances.
- To understand the dynamic behavior of the processes and its significance in real-time processes and develop ability in the students to design a control system to meet desired needs for a given process.

Contents:

Module I

Introduction: Principles of measurement. Error Analysis, Static and dynamic characteristics of instruments.

Temperature measurement: Filled system Thermometer, Thermo couples, Resistance Thermometers, radiation and optical pyrometers.

Pressure: Manometers: U tube manometer, inclined limb manometer, Ring balance manometer, elastic deformation: bourdon, bellows, diaphragm and electrical type gauges: strain gauge, piezoelectric, pressure transducers Vacuum gauges: mechanical, electrical and ionization types

Flow: Head flow meters, area flow meters, positive displacement flow meters, mass and magnetic flow meters Level: Direct and inferential type; composition. **(14)**

Module II

Different forcing functions: Step, Impulse, Ramp, Sinusoidal and frequency inputs & their graphical representation, Laplace transform.

First order system; transfer function; response of different forcing functions; two first order systems in series- non- interacting & interacting

Second order system: under- damped, critically damped & over damped, Transportation lag.

Classical feed-back controllers-P, PI, PD, PID & their transfer function, different types of control valves; characteristic curve & transfer function, Development of block diagrams, block diagram reduction techniques.

(14)

Module III

Closed loop response-servo & regulatory control. Block diagram of different chemical process units, open loop & closed loop transfer function, simple models: stirred tank, shell & tube heat exchanger, distillation column, different types of controllers.

Definition of stability, concept of unbound function, Routh stability criterion, Routh Array. **(14)**

Module IV

Introduction to frequency response, Bode stability analysis, Nyquist stability criteria

Controller tuning: Zeigler-Nichol's controller settings, Cohen-Coon tuning.

Introduction to advanced controllers: cascade control, feed forward control, ratio control, Adaptive & digital control. Concept of PLC & DCS. **(14)**

Total: 56 (L+T)

Reference books:

1. D. Patranabis, "Principles of Industrial Instrumentation", Tata McGraw Hill, Publishing Ltd, New Delhi, 1999
2. Process system analysis & Control–D. R. Coughanowr MGH.
3. Chemical Process Control–G. Stephanopoulus PHI.
4. Industrial Instrumentation Fundamentals, A. E. Fribance, McGraw–Hill Education

Course Outcomes:

Students will have the ability in:

CO1: Understanding the basic knowledge on statics and dynamics of process control and measuring instruments, and their behavior.

CO2: Applying the knowledge of different forcing functions and the schemes encountered in operations for first and higher order systems

CO3: Analyzing different types of controllers, control valves, components of a control loop and block diagram of different chemical process units for various mode of control operations

CO4: Evaluating the stability of the control system and controller tuning, frequency response, and other characteristics relevant to process instrumentation and control

Core Elective II	PEC–CHE 601A	PEC–CHE 601B	PEC–CHE 601C
Name of the Subject	Project Engineering	Nanoscience and Nanotechnology	Polymer Science and Engineering

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total Contact hours/week

Professional Elective Courses	**PEC – CHE 601A**	**Project Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

The objective of this course is to:

- Provide a comprehensive knowledge of modern project management principles and practices as they relate to project concept selection, development planning, engineering design, procurement and construction activities for facilities in the industry.
- Improve the concepts of engineering with management principles to oversee the technical engineers working on a specific project.
- Develop technical engineering skills while also building valuable leadership and organizational skills.

Contents:

Module I:

Role of a project engineer, Typical design steps for chemical and biochemical processes. Development of project- Laboratory bench scale experiment to pilot & semi-commercial plant operation, scale up and scale down techniques, pre-design cost estimation, fixed capital and working capital, Manufacturing cost, Feasibility survey, plant location factors, selection of plant site, process design development, plant lay-out. **(10)**

Module II:

Time value of money, simple interest, Nominal & effective interest rates, continuous interest, present worth & discount, Annuities, present worth of an annuity, perpetuities and capitalized cost.

Depreciation**:** Types of depreciation, Depletion, Concepts of service life, Salvage value and Book value; unamortized value, net realizable value, Depreciation calculation by straight line method, Text book and double declining balance method, sum-of-the-years digit method and sinking fund method.

(10)

Module III:

Profitability analysis method: effect of inflation on profitability, Alternative investment, Choices among various alternatives, Replacements, Methods of profitability evaluation for replacements.

Optimum design, Break-even point, Optimum production rate, Optimum conditions in cyclic operations, optimum economic pipe diameters, optimum flow rate, cooling water, optimum reflux ratio.

(12)

Module IV:

Project scheduling: Bar chart, Milestone chart, Concept of network analysis: PERT, CPM, statistical distribution associated with PERT network, earliest expected time, and latest allowable occurrence time calculation, Slack, determination of critical path, concept of float.

(10)

Total: 42 L

Text Books:

1. Plant Design & Economics for Chemical Engineers- By M. Peter & K.D. Timmerhaus, 4rth edn, MGH
2. Chemical Engineering Plant Design - By Himmelblau.
3. PERTCPM, L. S. Srinath, East West Press

Course Outcome:

Students will be able in:

CO1: Defining the basic principles of project engineering and its objectives.
CO2: Explaining the relevant methodologies of project management and parameters.
CO3: Preparing the optimum design parameter.
CO4: Distinguishing among the different case studies of projects as well as criticize network analysis

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact hours/week
Professional Elective Courses	**PEC – CHE 601B**	**Nanoscience and Nanotechnology**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- This course will highlight the fundamentals of nanomaterials along with structure and bonding in solids. Discussion of specific properties of nanomaterials over the bulk scale materials is also included in this course.
- The course will deal with different synthesis approaches of the nanomaterials with

different characterization techniques.

- The course will deal with different applications of nanomaterials in details.

Contents:

Module I

Introduction: Definition, History, What makes nanoscale so different from other length scales, key examples of nanotechnology. Scope of nanotechnology, nanoscale in perspective. Physics of solid state: Structure & Bonding in solids.

Synthesis of nanomaterials: General approaches (Top-down and Bottom-UP), Physical Methods,Chemical Methods, Biological Methods, hybrid methods.

(12)

Module II

Characterization techniques of nanomaterials: Microscopy, Spectroscopy and Diffraction techniques. Some special nano materials: Fullerene, Carbon nanotubes, Nanowires, Quantum dots, Core-shell nanoparticles, Doped nanoparticles.

(10)

Module III

Properties of nanomaterials: Mechanical, Structural, Thermal, Electrical & Optical properties

(10)

Module IV

Applications of nanomaterials: Nanolithography, Nanoparticles as catalyst, Drug delivery, Bio-imaging, Nanomedicines, Sensor applications. **(10)**

Total: 42 L

Text Books:

- NANOTECHNOLOGY: Principles & Practices; Sulabh K. Kulkarni, Capital Publishing Company, Kolkata.
- Nanoscience and Nanotechnology: Fundamentals of Frontiers, M. S. Ramchandra Rao, S. Singh, Wiley, 2013.
- Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley,2007.

Reference Books:

- Principles of nanotechnology: N. Phani kumar; Sci tech, Kolkata.
- Introduction to nanotechnology: Charles P. Poole & Frank Li Owens, Wiley India (p)

Ltd, NewDelhi.

Course outcomes:

On completion of the course, students would be familiar with:

CO1: Understanding fundamentals of nanomaterials and structure and bonding of materials
CO2: Identifying different synthesis approaches of nanomaterials
CO3: Learning characterization techniques of nanomaterials
CO4: Understanding properties of the nanomaterials and its applications

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC–CHE 601C**	**Polymer Science and Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- The main objective of this course is to upgrade the technical skills and knowledge of graduate engineers to be employed in the polymer and related industries such as Electronics, General Manufacturing and Clean Technologies.
- The modules have been carefully selected to equip students with scientific knowledge and technical skills that are in line with current advancements in the field of polymers.
- The modules will also help them to develop their analytical knowledge for benefitting their career in R&D sector.

Contents:

Module I

Basic Concepts: Concepts and classification of polymers, Functionality, Structure and property relationship.

Polymerization Mechanism & Synthesis: Step-growth and chain-growth polymerization; Poly disparity, concept & significance of molecular weight averaging; Bulk, solution, emulsion and suspension polymerization; Comparison of polymerization processes.

(12)

Module II

Polymerization Kinetics: Mechanism and kinetics of poly condensation reactions, Relationship between average functionality, extent of reaction and degree of polymerization. Mechanism and kinetics of free radical chain polymerization, kinetic chain length, and chain transfer reactions, Inhibit ion and retardation, kinetics of copolymerization. **(10)**

Module III

Polymer Rheology: Viscoelastic behavior, Flow curve concept, Melt & solution viscosity; Melting temperature & Glass transition temperature; Melt instability & Melt flow index.
Polymer Degradation: Factors affecting polymer stability; Thermal degradation, mechanical degradation, Chemical degradation, Hydrolysis, oxidative degradation & Ozonolysis; Stabilization.

(10)

Module IV

Polymer Processing: Polymer compounding ingredients; compression, transfer, injection, jet & blow molding; casting; extrusion, calendaring, lamination, spinning & finishing.

(10)

Total: 42 L

Text Books:

1. Text Book of Polymer Science, F.W. Billmeyer, John Wiley, New York
2. Polymer Science & Technology, P.Ghosh, TMC
3. J.R.Fried, Polymer Science and Technology, Prentice-Hall., 3rd Ed., 2014

Reference Books:

1. The elements of Polymer Science & Engineering, Alfred Rudin, Academic Press, 2nd Edition.
2. Introduction to Polymers, R.J. Young, Chapman & Hall, London

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

COs	STATEMENT
CO1	Connect properties of polymeric materials to their structures and explain how different material parameters and external factors affect the mechanical properties.
CO2	Correlate structure-processing-properties relationships for polymers, blends and composites.

CO3 Decide which test methods are suitable for measurement of mechanical & rheological properties.

CO4 Select a suitable processing and manufacturing technique for a given polymer.

Core Elective III	PEC–CHE 602A	PEC–CHE 602B	PEC–CHE 602C
Name of the Subject	Biotechnology and Biochemical Engineering	Advanced Separation Processes	Industrial Pollution Control

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	PEC–CHE 602A	Biotechnology and Biochemical Engineering Technology	3-0-0	3	100	3

Course Objectives:

- Knowledge of this paper helps them competent to analyze problems in fermentation plant and to rectify defects.
- It also helps them to develop bankable project report for development of Biochemical plants and to understand different Biochemical pathway different fermentation process.
- Students can make use of this knowledge in any fermentation industry.

Contents:

Module I

Introduction to industrial microbiology; Production of organic acids (vinegar, lactic acid), Recombinant DNA technology -Process and applications, Enzyme Immobilization-Definition, types, Examples associated with industries Propagation of Baker's and Brewer's yeasts, Production of Single cell protein; Microbial production of vitamins (B_2 and B_{12}), antibiotics (penicillin, streptomycin)

(12)

Module II

Bioreactor design: Mechanism and kinetics (Monod model), Fermentation-types of fermenters, chemostat, chemostat with recycle, turbidostat, PFR, fluidized bed reactor, air lift fermenter, mass transfer in microbial reactors, scale up and scale down of bioprocess.

(10)

Module III

Bio-product recovery: Downstream processing-separation process for cell mass and product, filtration, centrifugation, membrane process (reverse osmosis, ultra filtration, chromatographic separation).

(10)

Module IV

Bioprocess economics, Cost analysis of alcohol production plant, fermentation plant design project, Bio-product regulation.

(10)

Total: 42 L

Text and reference books:

1. Biochemical Engineering Fundamentals: J.E Bailey, DFOlli, MGH
2. Biochemical Engineering: Aiba S; Academia press, N Y
3. Bioprocess Engineering: Basic Concepts,2nd Edition- Michael L. Shulur and Fikret Kargi
4. Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists- Shigeo Katoh and Fumitake Yoshida
5. Principles of Fermentation Technology- Allan Whitaker, Peter F. Stanbury, and Stephen J. Hall

Course Outcomes:

Students will be able to:

CO1: Define and review basic principles of industrial microbiology and biochemical engineering for ethanol, antibiotics, organic acids and allied biochemical through fermentation considering techno-economic feasibility.

CO2: Design and develop processes to address problems and find solutions for various bioengineering plants to optimize production of high value biochemicals.

CO3: Interpret and validate different modelling and simulation strategies for upstream and downstream processing through analysis of data, and synthesis of information for final product stability and functionality, scale-up and sustainability.

CO4: Determine modern techniques like immobilizations, recombinant technologies to formulate and optimize fermentative products for biochemical and allied industries in compliance to legal, ethical and environmental guideline.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC–CHE 602B**	**Advanced Separation Processes**	**3-0-0**	**3**	**100**	**3**

Course objectives:

The goal of this course is -

- To enhance the understanding of membrane separation processes which involves different types of membrane as well as membrane technologies.
- It provides a comprehensive yet concise overview of various membrane separation processes covering the fundamentals as well as recent development of the different products, processes and their relevance to industrial problems.
- To give the students the basic idea about the material of construction, preparation and characterization process.
- Enrich students with mathematical analysis, derivation to solve complex and realistic engineering problems.

Course content:

Module I:

Membrane Separation Process: Types of membranes, properties of membranes. Organic & Inorganic membranes, advantages & disadvantages and applications of various membranes, membrane modules, transport mechanism in membrane process, introduction to liquid membrane, advantages &disadvantages of liquid membrane. **(10)**

Module II:

Ultrafiltration: UF modules, applicability, concentration polarization, basic numerical problems. Reverse Osmosis: Fundamentals of RO, Osmotic pressure, relation between chemical potential & osmotic pressure, factors affecting the performance of RO plant, RO membrane module, membraneage, advantages, disadvantages and application of RO process, Numerical problems. **(10)**

Module III:

Pervaporation: Osmotic Distillation, advantages of pervaporation, temperature drop at membrane interface, application of pervaporation. Chromatographic Separation: Liquid

Chromatography, Liquid-Solid Chromatography, High performance liquid chromatography; Advantages & Disadvantages of Chromatographic Separation.

Electrophoresis: Basic principles, Proteins and amino-acids separation, SDS- PAGE Electrophoresis **(12)**

Module IV:

Gas Separation: Theory of gas separation and permeability, permeability ratio and Knudsen diffusivity, factors affecting permeability, separation factors, application of gas separation process.Dialysis: Theory of Dialysis, mass transfer in Dialysis,

Supercritical fluid extraction: supercritical fluid, supercritical solvent, advantages of SCF extraction,basic techniques in SCF technology. **(10)**

Total: 42 L

Text books:

- J.D. Seader and Ernet J. Henlay; Separation Process Principles.
- Anil K.Pabby, Syed S.H. Rizvi, Ana Maria Sastre: Hand Book of Membrane separations.

Reference books:

- Membrane Separation Processes by Kaushik Nath
- Membrane Handbook by Ho and Sircar.
- Ultrafiltration Handbook by Munir Cheriyan, CRC Press.
- Practical Biochemistry: Principles & Techniques, Wilson & Walker, 5ed. Cambridge Univ. press

Course Outcomes:

Students will be able to

CO1: Remember, understand and identify different membrane separation processes and assess the life time ofmembranes under different process environments.

CO2: Solve and analyze problems to any complex membrane separation processes by applying acquired knowledge, fact, techniques and characterize different types of membranes with the material of construction, advantages and disadvantages of different types of process and its engineering applications.

CO3: Evaluate the modern industrial problems using different separation techniques. Gain knowledge about overall concept of membrane separation processes and mathematical modelling of different types of membranes.

CO4: Compile different membrane separation techniques as well as design or modify structure of membrane as per requirements of process and the chemicals involved.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC–CHE 602C**	**Industrial Pollution Control**	**3-0-0**	**3**	**100**	**3**

Course objectives

- The student is informed about the emissions from chemical industries, and guidelines set by the environmental protection agencies for maintaining clean-air. Standards for the level of pollutants from the industries have been given for subsequent monitoring. For monitoring, the student is required to know the characterization of industrial effluents, BOD, COD, TOC values, methods of determination of these characteristics, for all types of pollutants from all chemical and petroleum industries.
- Having given information about the characterization, the student is made conversant with various methods of treatment- primary as well as tertiary treatments. The course offers latest techniques such as Ion exchange, RO, Ultra filtration, along with the conventional systems already existing.
- Treatment of wastewater (e.g. Processes, Methods and equipment needs) is presented for their subsequent applications.
- Monitoring methods are taught for pollution control. Sampling methods for acquiring samples and their analysis are discussed.
- The student is acquainted with the various control methods and equipment required. They can design the appropriate process and equipment for a given industrial pollutant.

Content

Module–I:

Types of emissions from Chemical industries and Effects of environment, Environment legislation, Type of pollution and their sources, Effluent guidelines and standards. Characterization of effluent streams, Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve mathematical, Controlling of BOD curve.

(10)

Module–II:

Methods of Primary treatments: Screening, Sedimentation, Flotation, Neutralization, and methods of tertiary treatment. Brief studies of Carbon absorption, Ion exchange, Reverse osmosis, Ultra filtration, Chlorination, Ozonation, treatment and disposal. **(10)**

Module–III:

Introduction to waste water treatment, Biological treatment of wastewater, Bacterial and bacterial growth curve, Aerobic processes, Suspended growth processes, Activated aerated lagoons and stabilization ponds, Attached growth processes, Trickling filters, Rotary drum filters, and Anaerobic processes.

(12)

Module–IV:

Air pollution sampling and measurement: Types of pollutant and sampling and measurement, ambient air sampling: Collection of gaseous air pollutants, Collection of particulate air pollutants. Stack sampling: Sampling system, Particulate sampling, and gaseous sampling. Air pollution control methods and equipment: Source collection methods: raw material changes, process changes, and equipment modification. Cleaning of gaseous equipments particulate emission control: Collection efficiency, Control equipment like gravitational settling chambers, Cyclone separators, fabric filters, ESP. Scrubbers and absorption equipment.

(10)

Total: 42 L

Course Outcomes

CO1: Understanding the need of clean environment for sustainable environment.
CO2: Applying the knowledge of reducing pollution levels in the environment.
CO3: Analysing the nature of the Pollutants from the respective industries one can implement the techniques and methods to mitigate it.
CO4: Evaluating the effects of the pollutants on human health, vegetation, and building materials.

Text Book

- Environmental Pollution and Control Engineering, Rao C. S., Wiley Eastern Limited, India, 1993.
- Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. Environmental Engineering, McGraw Hill International (1985).
- Metcalf & Eddy, Wastewater Engineering, Tata McGraw-Hill Education Private Limited (2009).

Reference Books

- Pollution Control in Process Industries, S.P. Mahajan, TMH., 1985.
- Waste Water Treatment, M.Narayana Rao and A.K.Datta, 3rd Edition, Oxford and IHB, 2008.
- Industrial Pollution Control and Engineering, Swamy AVN, Galgotia publications, 2005.
- Masters, G.M., Introduction to Environmental Engineering and Science, Prentice Hall off India, (2008).

- Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern (2010). De Nevers, N., Air Pollution Control Engineering, McGraw-Hill (2000).

Open Elective II	OEC– CHE 601A	OEC– CHE 601B
Name of the Subject	**Cryogenic Engineering**	**Bioreactor Design**

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	**OEC–CHE 601A**	**Cryogenic Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To encourage the dissemination of information concerning low temperature processes, techniques, and bringing all those together in all discipline concern with the application of low temperature technologies.
- To learn about the Thermodynamics, Physics and Chemistry of Combustion.
- To understand the chemical thermal energy conversions in refrigeration system

Contents:

Module I

Introduction: Introduction to Cryogenic Engineering and its applications. Properties of Cryogenic Fluids, Superfluid and Supercritical fluids and also behavioral changes of Solids at low temperatures.

Refrigeration, Liquefaction Refrigeration and Liquefaction Principles: Joule-Thomson Expansion, Isentropic Expansion, Cascade Processes, Ortho-Para hydrogen Conversion, Ultra-Low-Temperature Refrigerators, Thermodynamic Analyses of Systems. **(12)**

Module II

Equipment Associated with Low-Temperature Systems: Heat Exchangers, Compressors, Expanders, Effects of Component Inefficiencies, System Optimization. **(10)**

Module III

Separation and Purification Systems: Ideal Separation of Gases, Characteristics of Mixtures, Principles of Gas Separation & Purification, Air Separation Systems-Cryogenic and non-cryogenic processes (PSA/VSA).

(10)

Module IV

Cryogenic Special: Hydrogen Separation Systems, Helium Separation Systems, Liquefaction of Natural Gas (LNG), Storage and Transfer Systems, Insulation Concepts.

(10)

Total: 42 L

Text Books:

1. K.D. Timmerhaus and T.M. Flynn, Cryogenic Process Engineering, Plenum Press, 1989.
2. M Mukhopadhyay, Fundamentals of Cryogenic Engineering, PHI Learning Pvt. Ltd., New Delhi, 2010.

Reference Books

3. R.F. Barron, Cryogenic Systems, Mc Graw Hill,1985.
4. R.B. Scott, Cryogenic Engineering, Van Nostrand andCo.,1962.

Course Outcomes:

Students will be able to:

CO1: Understand the various cryogenic process principles and behaviours of materials at cryogenic temperatures.

CO2: Apply to solve problems of separation and purification of cryogenic fluids.

CO3: Evaluate eventuality of choosing equipment / materials at cryogenic conditions.

CO4: Create/formulate devices which can smoothly work at cryogenic conditions.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	OEC–CHE 601B	Bioreactor Design	3-0-0	3	100	3

Course Objectives:

This course prepares the student to:

- Introduce about Basic concepts of bioreactor design and study the Bioreactor instrumentation and control
- Teach the Methods and strategies for fermentation control.
- Study the modeling and simulation of fermentation processes

Module-I

Introduction of Bioreactor, Classification of Bioreactor, Enzyme Bioreactor: Free & Immobilized bioreactor and Design equation, Basic features of Bioreactor, Mode of Bioreactor operation.

(10)

Module –II

Batch Bioreactor Design, Measurement of microbial growth (direct method and indirect), Kinetics of cell growth in batch culture, Unstructured distributed models for microbial growth, Growth phases in Batch Culture, Batch growth kinetics, Growth Yields, Product kinetics, Performance Equation of Batch Fermenter.

Fed-batch cultivation, Design and Analysis of Fed-batch bioreactor, Continuous culture, Design of Chemostat (Continuous Bioreactor), Productivity of Chemostat, Multiple CSTR connected in series, Continuous reactor with cell recycle, Model for plug flow reactor.

(12)

Module –III

Bioreactor sensor characterization, Basic control system for operation of Bioreactors: Temperature measurement control, Principles of dissolved oxygen measurement and control, Principles of PH/ redox measurement and control, Foaming and prevention of foam, determination of biomass and application of biosensors.

(10)

Module –IV

Airlift Bioreactors, Design and construction of the airlift – loop reactor, Bubble column reactor, Hydrodynamics, Three – phase flow, Mass transfer in Bioreactor, Theory of mixing, Rheological properties of fermentation fluid, Oxygen transfer.

Study of structured models for analysis of various bioprocesses – Compartmental models, Models of cellular energetics and metabolism, Single cell models, Digital Simulation for Bioreactor process Dynamics, Formulation and Solution of problems by simulations.

(10)

Total: 42 L

Text Book:

1. SCRAGG. A.H, “Bioreactors in Biotechnology”, Ellis Horwood series,1991.

Reference Book:

1. Bailey. J.E, and Ollis. D.F. “Biochemical Engineering Fundamentals” 2nd Edition, Mc Graw–Hill, 1988.

Course Outcomes:

Students will have the ability in:

CO1: Remembering and defining various types of bioreactors, microbial growth, growth yield, microbial culture medium.

CO2: Understanding of microbial cell kinetics in various mode of operations such as batch, fed-batch, continuous culture, their parameter control systems and explain the optimum parameters of operations and arrangement of bioreactors for the bioprocess.

CO3: Applying the microbial growth kinetics in various cultures to solve the problems.

CO4: Analyzing the kinetic data in various cultures to evaluate the productivity, reactor performance, mass and heat transfer correlations to bioreactor design and modern bioengineering equipment.

Practical / Sessional papers

Categories	Course code	Course title	Hours/week L: T:P	Credit	marks	Total contact hours / week
Professional core courses	**PC –CHE 691**	**Process equipment design and drawing-II**	**0-0-3**	**2**	**100**	3

Course Objective:

This course enables students to:

- Integrate all the subjects they have learned and design plant/processes from chemical engineering principles.
- Understand chemical engineering principles applicable to designing chemical engineering equipment like Pressure vessel, Reactor packed and plate columns and supports.
- Implement standard codes for the design of chemical plant equipment and analyze specifications of process equipment and accessories.

Contents:

1. Design and Drawing of a ~~Reactor~~ Pressure vessel (Batch Reactor/PFR /CSTR)

   Introduction to the basic principle of Pressure vessel thickness calculation and reactor operation and its applications. Design of various reactors, introduction to the basic knowledge of different internal accessories of the reactors.

2. Design and Drawing of Distillation column/ Bubble cap tray

Introduction to the basic principles of distillation process and its applications, Design of distillation column with its process design and various parts of column and drawing of internals of distillation column.

3. Design and Drawing of Absorption tower

   Introduction to the basic principles of Absorption process and its applications, Design of Absorption column with its process design and various parts of column and drawing of internals of Absorption tower.

4. Design of supports for vertical and horizontal towers. Mechanical drawing of types of supports.

Each student shall be allotted design problems on sl. no 1,2 & 3 at the beginning of the 6th semester and the student shall carryout complete process and ~~mechanical~~ model design under supervision of a faculty member. The student shall also prepare engineering drawing of the equipment sl. no 1,2, 3 & 4 and submit ~~two copies of~~ the design report (Problem statement, Solution and Drawing sheet) in tied and bound form 7 days before commencement of 6th semester examination. Assessment would be made on the basis of the submitted report, Model and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and class teachers with Head of the Department as Chairman during 6th Semester examination.

Reference Books:

1. Process Equipment Design-Vessel Design-L. E. Brownell &E. H. Young, First Edition.
2. Illustrated Process Equipment Design by S B Thakore, Second edition.
3. Process Equipment Design -M.V. Joshi & V. V. Mahajani, Third edition.
4. Process Equipment Design (Mechanical Aspects) By B. C. Bhattacharya.
5. Mass Transfer Operation-R E Traybal, Mc-Graw Hill

Course outcomes:

Student will be capable of:

CO1: Applying the principles of pressure vessel design, including thickness calculation and reactor operation, to design various reactors, and introduce basic internal accessories knowledge.

CO2: Analyzing distillation process principles to design and draw distillation columns with bubble cap trays, including process design and detailed drawing of column internals.

CO3: Evaluating absorption process principles to design and draw absorption towers, including process design and detailed drawing of tower internals.

CO4: Designing various types of supports for vertical and horizontal towers and producing mechanical drawings for diverse engineering applications.

Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/ week
Professional core courses	**PC–CHE-692**	**Instrumentation and Process Control Lab**	**0-0-3**	**1.5**	**100**	**3**

Course Objectives:

- This laboratory course will help the students to get knowledge about temperature measurement using thermocouple and RTD.
- It also includes study of load cell and dead weight tester.
- The objective also includes liquid level measurement using air-purge method and dynamic study of single and two tank liquid level systems.

Contents:

1. Temperature Measurement using Thermocouple.
2. Study of RTD Characteristics & use in Temperature sensitive bridge.
3. Calibration of pressure gauge by Dead Weight Tester.
4. Study of Load Cell.
5. Liquid-Level Measurement using Air-Purge Method
6. Studies on Characteristics of Pneumatic Pressure Controller (PI Control Valve)
7. Liquid level dynamics-single tank system
8. Dynamics of two tank non-interacting liquid-level system
9. Dynamics of two tank interacting liquid-level system
10. Studies on the Stability and tuning of a Flow Controller
11. Response of a P&PI Controller

Course outcomes: On completion of the course, students would be familiar with:

CO1: Understanding the temperature measurement using thermocouple and RTD, Pressure gauge calibration by dead weight tester, Liquid-level measurement using air-purge method and Dynamic study of single and two tank liquid levels systems.
CO2: Applying the basics for further calculation.
CO3: Analyzing the concepts for further calculations.
CO4: Evaluating the concepts for further calculations.

Categories	Course code	Course title	Hours/week L: T:P	Credit	marks	Total contact hours/Week
Seminar	**SEM–CHE 691**	**Term paper and Technical Seminar**	**0-0-3**	**1.5**	**100**	**3**

Course Objectives:

- The objective of this course is to familiarize the students about seminar presentation along with clear concept of chemical engineering subjects.
- The course will make students much more efficient for industries and for doing market analysis.
- It will also help them to work on a specific project more professionally.

Contents:

Students have to choose a seminar topic according to his/her subject of interest. A thorough report has to be prepared on his/her selected topic. Students have to give seminar presentation on his/her selected topic and have to face question-answer session followed by the seminar. Assessment of the student would be done on the basis of presentation, performance in the question - answer session and the submitted report.

Course outcomes:

Students will have the ability in:

CO1: Understanding the elementary knowledge to give a seminar presentation more professionally and to develop their leadership quality through this process.

CO2: Applying the knowledge to solve problems and discussing innovative solutions supported by evidence and reasoning in the technical seminar.

CO3: Analyzing the significance of complex technical evidence in the literatures, theories, and methodologies relevant to the chosen topic

CO4: Evaluating the strengths and weaknesses of existing concepts, methodologies, and research findings relevant to the chosen topic to assess the validity, reliability, and relevance of information presented in both written and oral forms.

Detailed Syllabus, B. Tech Fourth year, Semester VII

Core Elective IV	PEC–CHE 701A	PEC–CHE 701B	PEC–CHE 701C
Name of the Subject	Modern Tools and Their Design Aspects	Computational Fluid Dynamics	Safety and Hazards Analysis in Industries

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	PEC–CHE 701A	Modern tools and their design aspects	3-0-0	3	100	3

Course Objectives:

- The objective of this course is to introduce the modern tools (software and hardware) and their performances in Chemical Engineering operations.
- The course will introduce students to various case studies of Modern process industry and their business strategies and accidents and the investigation process
- It also introduces students to the step towards modernization of the chemical engineering process through experiences.

Contents:

Module I

Introduction: Basics of Modern process industry and their business strategies, Design, and layout of process industries, Understanding the scope of modernization through continuous assessment for sustainability. **(10)**

Module II

Non- traditional machining processes and the effect of process parameters. Case studies: Case studies on Pumps in process industries. Case studies on valves and pipelines in process industries. Corrosion and the strategies to protect the industrial equipment. Industrial Utilities **(12)**

Module III

Industrial accidents and their causes. Human error behind industrial accidents, mechanical failure behind accidents. Industrial disasters essay. **(10)**

Module IV

Workshop and Interaction with industry **(10)**

Total: 42 L

Reference books:

1. Coulson & Richardson's Chemical Engineering.
2. Introduction to Software for Chemical Engineers, CRC press
3. Software Architectures and Tools for Computer Aided Process Engineering, Volume 11,1st Edition, e**ditors:** Bertrand Braunschweig, Rafiqul Gani

Course Outcomes:

Student will be able to:

CO1: Understand modern software and hardware, non-traditional machining processes and the effect of process parameters

CO2: Differentiate the various traditional and non-traditional machining processes

CO3: Understand industrial operation of different equipment and their maintenance, Plant safety and hazardous

CO4: Demonstrate workshop technology

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	PEC–CHE 701B	Computational Fluid Dynamics	3-0-0	3	100	3

Course Objective:

- To introduce Governing Equations of viscous fluid flows and to introduce numerical modelling and its role in the field of fluid flow and heat transfer
- To enable the students to understand the various discretization methods, solution procedures and turbulence modeling.
- To create confidence in solving complex problems in the field of fluid flow and heat transfer by using high-speed data processing machines.

Contents:

Module I: **(13)**

Introduction to Computational Fluid Dynamics and Principles of Conservation; Basic of Computational Fluid Dynamics: Governing Differential Equations and Finite Difference

Method, CFD Applications, Numerical / Analytical technique.

Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Mathematical classification of partial differential equations, Error Minimization Principles, Boundary conditions: Primary and secondary variables, least square method, Rayleigh-Ritz method

Module II: (10)

Discretization principles: Preprocessing, Solution, Post-processing, Finite Element Method, 3 Finite difference method, Simple Methods – General Methods for first and second order accuracy –Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term. Finite Volume Method for Convection Diffusion Steady one-dimensional convection and diffusion –Central, upwind differencing schemes, Physical consistency, Overall balance, properties of discretization schemes, Power-law

Module III: (10)

Discretization of the Momentum Equation: Primitive variable approach, Staggered grid and Collocated grid, SIMPLE, SIMPLER, PRESTO. Structured Grid generation – Unstructured Grid generation, Mesh generation, Mesh refinement, Green Gauss Node based gradient, cell-based gradient.

Module IV: (9)

Turbulence Model: Turbulence models, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity 2 models, Mixing length model, Turbulent kinetic energy and turbulent dissipation energy, The κ-ε model, Advantages and disadvantages of κ–ε model, More two-equation models: RNG κ-ε model and κ-ω model, Reynolds stress model (RSM), software tools.

Total: 42 L

Text Books:

1. Ghosh Dastidar, P. S., “Computer Simulation of flow and heat transfer”, Tata Mc Graw Hill Publishing Company Ltd., 2017.

2. Versteeg, H.K., and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The finite volume Method”, Pearson Education Ltd, Second Edition, 2007.
3. John David Anderson," Computational Fluid Dynamics: The Basics with Applications ",McGraw Hill, New York

Course Outcomes:

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

CO1: Understanding the basic principles of mathematics and numerical concepts related to fluid dynamics.

CO2: Applying governing equations for a given fluid flow system to solve the numerical.

CO3: Analyzing Finite difference and Finite volume methods for further calculations.

CO4: Evaluating Flow field problems, Turbulence models, and Mesh generation techniques to achieve the defined goal.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	PEC–CHE 701C	Safety and Hazards analysis in Industries	3-0-0	3	100	3

Course objectives:

- To know about Industrial safety programs and toxicology, Industrial laws, regulations and source models
- To understand about fire and explosion, preventive methods, relief and its sizing methods
- To identify and analyse industrial hazards and its risk assessment and control of hazards and risk mitigation

Contents:

Module I: Introduction

Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Windroses, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

(10)

Module II: Tools for hazards identification

HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index, Safety Audits. **(10)**

Module III: Risk analysis concept and methodology
Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number. **(10)**

Module IV: Engineering control of chemical plant hazards
Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England), Bhopal (India), Seveso (Italy), Pasadona (Texas).

(12)

Total: 42 L

Text Books:

- Chemical Process Safety: Fundamentals with Applications: D.A. Crowl and J.F. Louvar, Prentice Hall,1990
- Elements of Hazardous Waste Management, O.P. Gupta, Khanna Publishing House, 2018.
- Industrial Safety, S.C. Sharma, Khanna Publishing House,2018.

References:

- Safety in Chemical Process Industries: O.P. Kharbanda, E.A. Stallworthy, Heinmann Professional Publishing LTD.,1988.
- Hazardous Waste management: C.A. Wentz, MGH.
- Environmental Risks & Hazards, S.L. Cutter, Prentice Hall,1994
- Chemical Process Technology, O.P. Gupta, Khanna Publishing House, 2019. (AICTE Recommended)

Course Outcomes (CO):

Students will be able to:

- **Analyse** the effect of release of toxic substances
- **Determine** the type of risk involved in a chemical plant operation
- **Apply** the industrial laws, regulations and source models.
- **Perform** to prevention of toxic release, fire and explosions.

Open Elective III	OEC– CHE 701A	OEC– CHE 701B	OEC-CHE 701C
Name of the Subject	Advanced food processing and food preservation technologies	Industrial total quality management	Additive Manufacturing

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	**OEC–CHE 701A**	**Advanced food processing and food preservation technologies**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To introduce students about the importance of food processing and preserving food to prevent wastage and losses
- To introduce students about the methods of preservation to increase shelf life of food commodities and retain its overall quality attributes
- To introduce students about the methods of different food processing techniques and value addition.

Contents:

Module I

Introduction to food preservation:

General principle of preservation: Classification of methods used for preservation; need and importance of preservation at domestic and large scale; cause of food spoilage.

Basic concepts of thermal destruction of microorganisms – lethality, D, Z and F values; assessment of adequacy of thermal processing of food processing operations **(10)**

Module II

Pasteurization (definition, time - temperature combination and equipment, application, advantage disadvantage); Sterilization of foods; Blanching (definition, time-temperature combination and equipment, application, advantage disadvantage); Canning definition, equipment, advantage, disadvantage, influence of canning on the quality of food, spoilage of canned foods); retorting process; commercial sterility.

Principles of food freezing, basic working principle and application of different types of freezers, IQF; frozen storage of foods; freeze concentration, refrigerated storage; cold-storage; cold-chain; effect to flow temperature storage on organoleptic and nutritional characteristics of food.

(12)

Module III

Drying and dehydrations, drying phenomenon, factors affecting rate of drying; Sun drying, working principle of batch & continuous driers and their suitability for different foods Freeze drying, effect of drying on organoleptic and nutritional characteristics of food; osmotic dehydration; intermediate moisture foods

Preservation by microbial fermentation (principle, types, applications); Chemical preservatives; Bio-preservation; lactic acid bacteria, antibiotics, Hurdle technology, Principles of preservation by use of sugar and salt, curing, pickling; smoking, Overview of minimal processing.

(10)

Module IV

Novel Non thermal methods: HPP, ultrasonication, ohmic heating, microwave, pulse delectricfield, pulse dlight, cold plasma, ozone. Preservation by ionizing radiations (Sources of radiations, units and doses, Irradiation mechanism, effect on microorganisms and different nutrients; dose requirements for radiation preservation of foods, safe limits. **(10)**

Total: 42 L

Text and Reference Books:

1. Technology of Food Preservation by Desrosier
2. Hand book of Food Preservation. Second Edition edited by.M.Shafiur Rahman. C R C Press
3. Food Science by Potter
4. Fruits and vegetable processing by Cruss
5. Preservation of Fruits &Vegetables by IRRI

Course Outcomes:

Students will be able to:

- Select the various engineering properties of the raw material used in food processing which will be useful to match various food processing techniques.
- Explain the knowledge in different food processing operations involved in various food manufacturing process.
- Identify and transform different processing technology utilizing appropriate food-Preservatives to produce quality food products.
- Analyze the unit operations involved in food technology.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	**OEC – CHE 701B**	**Industrial Total quality management**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To facilitate the understanding of Quality Management principles and process and to train them with various tools and techniques of Quality Management.
- To inculcate the importance of Quality in an organization and to make understood about the ISO Quality systems.
- To make the ward aware of the quality concepts adopted in industry scenario.

Contents:

Module I

Meaning of the term 'Quality': Definition and Concept, Dimensions of Quality, Achievement of Quality, Cost of Quality, Quality-Cost Tradeoff, Methods of Generating Ideas for Quality Improvement

Quality Gurus: William Edwards Deming, Joseph M. Juran, Philip B. Crosby, Karou Ishikawa, Shigeo Shingo, Genichi Taguchi **(10)**

Module II

Total Quality Management: Meaning of TQM, Principles of TQM, Benefits of TQM, Zero Defect, Poka Yoke.

Tools and Techniques of TQM: Cause and Effect (Fishbone) Diagram, Check (Tally) Sheet, Control Charts, Histogram, Pareto Chart, Scatter Diagram, Stratification, Quality Function Deployment, Failure Mode and Effective Analysis, Flow Process Chart, Kaizen, Just-in-Time, Quality Circles.

(10)

Module III

Inspection of Quality: Types of Inspection, Role of Inspection, Acceptance Sampling, Basis of Sampling Inspection, Single, Double and Chain Sampling Plan, Defects and types of Defects, Operating Characteristics (OC) Curve. **(10)**

Module IV

Statistical Quality Control: Objectives/Uses of SQC, Sources of Variation, Control Charts for Variables and Attributes ($\bar{X}$-R Chart, p-Chart, np-Chart, c-Chart), Process Capability, Concept of Six Sigma.

Different Quality Standards: ISO, BS and Bureau of Indian standards, details of ISO 9000 series, ISO 14000 series and SA 8000 and the certification authorities, productivity control management.

Quality in Service Organizations: Characteristics of Services, Differences between Goods and Services **(12)**

Total: 42 L

Text Books:

1. Statistical quality control, Grant, MGH.

References:

1. Total Quality Management- A Practical Approach: H.Lal, New Age International Qualty Circle: S R Udpa.
2. Total Quality Management– A Primer: Sundara Raju S.M., TMH.
3. Fundamentals of Quality Control Improvement, Mitra,PHI
4. TQM - S K Ghosh, Oxford

Course Outcomes:

On successful completion of the course, students will be able to:

CO-1: Conversant with the TQM framework in association to the contribution of Quality Gurus.

CO-2: Grasp the nature and importance of various tools and techniques of TQM and apply them in exceling their workplace.

CO-3: Learn the policies and procedure of various quality standards/certification and their significance while facing external audits.

CO-4: Align TQM in service organization to maintain good public/customer relationship.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	OEC–CHE 701C	Additive Manufacturing	3-0-0	3	100	3

Course Objectives:

- To introduce students the basics of additive manufacturing/rapid prototyping and its applications in various fields, reverse engineering techniques.
- To familiarize students with different processes in rapid prototyping systems.
- To teach students about mechanical properties and geometric issues relating to specific rapid prototyping applications.

Course Content:

Module I

Rapid Prototyping, Overview of Rapid Prototyping. Product development process. Design for Modularity (Manufacturing).

Subtractive versus Rapid Manufacturing. Reverse Engineering: Use of CMM and 3-D Camera for making virtual model.

(10)

Module II

Powder based processes. Extrusion based processes. Sheet Stacking processes. Beam Deposition processes.

3 D printing processes: Basic Process-CAD Model Creation, Conversion to STL format, Slicing the STL File, Layer by layer construction, Clean and finish. **(12)**

Module III

Materials in Rapid Manufacturing. Post-processing concerns. Product costing for Rapid Manufacturing.

Rapid Product Development, CAE and CIM. Stereo-lithography (SLG): Principles, systems, relative advantages an application. **(10)**

Module IV

Selective laser sintering (SLS): Principles, systems, relative advantages and applications. Fused deposition modeling (FDM): Principles, systems, relative advantages and applications. Laminated objects manufacturing (LOM): Principles, systems, relative advantages and applications.3D Inkjet Printing: Principles, systems, relative advantages and applications.

(10)

Total: 42 L

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing by Groover, Prentice Hall.
2. CAD/CAM by M.P. Groover and E.W. Zimmers, Prentice Hall of India.
3. Manufacturing Technology, Radhakrishnan, Scitech

References:

1. Ian Gibson, David W. Rosen, Brent Stucker, “Additive Manufacturing Technologies”, Springer,2009
2. Chua C.K., Leong K.F., and Lim C.S., “Rapid Prototyping: Principles and Applications”, Second Edition, World Scientific Publishers (2003).

Course Outcomes:

Students will be able to:

CO1: Recall geometric transformation techniques commonly used in CAD and recognize common issues in STL files and recall repair algorithms to address them and explain the mathematical concepts behind the representation of curves, surfaces, and solids.
CO2: Implement geometric transformation techniques effectively within CAD software and utilize mathematical models to accurately represent various shapes and structures.
CO3: Analyze different slicing algorithms to determine the most suitable for a given part and assess the efficiency of tool path generation methods in reducing errors and support material usage.
CO4: Design innovative approaches to geometric transformations to achieve specific CAD goals and construct optimized workflows for STL file repair, part orientation, slicing, and tool path generation to streamline additive manufacturing processes.

Practical/Sessional papers

Categories	Course code	Course title	Hours/ week L: T:P	Credit	marks	Total contact hours/week
Project-I	**PROJ–CHE 791**	**Project Work/ Research Internship**	0-0-20	6	**100**	20

Course Objectives:

- To develop the capacity of students in correlating theoretical knowledge into practical systems either to perform creative works or to perform analysis and hence to suggest solutions to problems, pertaining to environmental engineering domain and bring up collaborative learning skills.
- To develop self-directed inquiry and life-long skills.
- To enhance the communication skills of the students by providing opportunities to discuss in groups and to present their observations, findings and report in formal reviews both in oral and written format.

Content:
Project work for B. Tech students has to be allotted to the student at the beginning of 7th semester and this is expected to be completed in the 8thsemester. Each group of students will be required under the supervision of a faculty/ joint supervision of a faculty. The research work has to be carried out by the students themselves occasionally consulting his supervisor(s). Each group of students is expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. The project work is included of identifying particular area of investigation, literature review, preliminary investigation, field excursion, conducting of experiments, numerical modeling to validate

experimental data, interpretation of results and report writing. The course content of 'Project I' is Research topic determination and literature review and preliminary and primary investigation and 'Project II' contain literature review and extensive work and analysis of the project work.

The report of the project work has to be submitted in typed and bound form 7 days before commencement of the 7th semester and 8th semester examination. Assessment would be made on the basis of the submitted report and the presentation & viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee.

Course Outcomes:

Students will have the ability in:

CO1: Remembering the information of document report comprising of summary of literature survey, detailed objectives, project specifications, etc.

CO2: Applying the concept and demonstrating the functionality.

CO3: Analyzing the experimental results in graphical representation.

CO4: Evaluating the chemical engineering parameters, judging the basics knowledge.

Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/ week
Professional Core Course	**SI – CHE 791**	**Industrial Internship**	**0-0-40**	**3**	**100**	**40**

Course Objective:

This course aims to:

- To develop skills and techniques directly applicable to their careers.
- To expose students to real work environment experience gain knowledge in writing report in technical works/projects.
- To enhance the ability to improve students creativity skills and sharing ideas.
- To build a good communication skill with group of workers and learn to learn proper behavior of corporate life in industrial sector.

Contents:

Students will be sent for training to a chemical industry for a period of 4 to 6 weeks after completion of 6th semester examination. After completion of the training, the students will

submit a comprehensive report consisting of general overview of the plant, process description of with process flow diagram, details of different equipment with specifications, process instrumentation and control, product with production capacity, raw materials utility and energy consumed per unit of product**.** Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and training coordinator with Head of the Department as Chairman during.

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

COs	STATEMENT
CO1	Understand and Participate in the projects in industries during his or her industrial training.
CO2	Describe use of advanced tools and techniques encountered in the Process.
CO3	Interact with industrial personnel and follow engineering practices and discipline prescribed in industry.
CO4	Develop awareness about general workplace behavior and build interpersonal and team skills.

Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/ week
Professional Core Course	**PC-CHE 791**	**Techno-Economic Evaluation of Industrial Processes**	**0-0-3**	**2**	**100**	**3**

Objectives:

This course aims to:

- To expose students about the meaning DPR
- To impart knowledge about the analysis of feasibility of any project
- To make understand students about various aspects of a project

Description:

Student will make a sample DPR including economic viability of a project by creating extensive and elaborative outlet of a project which may include different information like, resources, financial, design, social aspects etc. of a plant preferably where the student has under gone industrial internship.

Course Outcomes:
Students will have the ability in:

CO1: Understanding the meaning of detailed project report (DPR).

CO2: Applying the concept of engineering knowledge in feasibility studies

CO3: Analyzing various aspects of projects like, social, economic, technology etc.

CO4: Evaluating the report and taking the final decision.

Detailed Syllabus, B. Tech Fourth Year Semester VIII

Open Elective IV	OEC– CHE 801A	OEC– CHE 801B
Name of the Subject	Statistical quality Control	Operation Research

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	OEC–CHE 801A	Statistical quality control	3-0-0	3	100	3

Course Objectives:

- To teach students statistical quality control ideas and how to apply them to industrial quality control process design and management.
- Major topics include history and overview of the state of the art of quality control methodologies, tools for descriptive and predictive statistical analysis, design and use of various control charts for quality control, process characterization and capability analysis, R&R gauge capability studies, design of experiments, acceptance sampling and continuous improvement.
- The emphasis will be on ensuring that the students gain both a broad perspective of quality control as well as the technical skills necessary to implement quality control in any industrial setting.

Syllabus

Module -1

Introduction: Basic concept of quality control, Conformance, Cost of Quality, Benefits of SQC, modern quality control philosophy.

Total Quality Management (TQM): Concept, Philosophy & Benefits of TQM. Product quality Management, TQM Models, Benchmarking, Kaizen & Kairyo system. **(10)**

Module -2

Quality Assurance: Quality Survey, Quality Inspection Planning, Statistical Process Control (SPC), Quality policy deployment, Error proofing. **(10)**

Module -3

Basic Statistical Concept: Variations, Variables & Attributed data, frequency distribution, Normal curve, Probability & Probability distribution. Binomial distribution. Control charts for variables & attributes. **(10)**

Module -4

Sampling: Methods, Sampling planes, Continuous sampling plan, Standard sampling plan, Selection of sampling plan for normal inspection,

Reliability: Quality & Reliability, Elements, Total Productive Maintenance (TPM), Quality Circle, ISO: 9000 series standards. **(10)**

Total: 42L

Text Books:

1. Montgomery D. C. (2013). Introduction to Statistical Quality Control(7thed.), John Wiley & Sons, Inc.
2. R.C. Gupta, Statistical Quality Control & Quality Management, 9th Edition, Khanna Publishers.

Reference Books:

3. John T. Burr, Elementary Statistical Quality Control, 2ndEdition, 2004, by Taylor & Francis Ltd.
4. Grant E.L. and Leaven worth, Statistical Quality Control, TMH, 2000.
5. IS2500 Standard sampling plan.

Course Outcome

CO1: Understanding the basic concepts underlying statistical quality control and to develop their ability to apply those concepts to the design and management of quality control processes in industries.

CO2: Applying the major topics include history and overview of the state of the art of quality control methodologies, tools for descriptive and predictive statistical analysis.

CO3: Analyzing, designing and usage of various control charts for quality control, process characterization and capability analysis, R&R gauge capability studies, design of experiments, acceptance sampling and continuous improvement.

CO4: Evaluating the gain both a broad perspective of quality control as well as the technical skills necessary to implement quality control in any sustainable industrial setting.

Categories	Course Code	Course Title	Hours/Week L: T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	OEC–CHE 801B	Operation Research	3-0-0	3	100	3

Objective:

1. To comprehend and use operations research methods to analyse and solve your operational challenges in real life.
2. To formulate and apply the techniques of Linear Programming and the extended topics to solve certain optimization problems

Pre-Requisite:

1. Knowledge of probability distributions and statistics, and preferably basic calculus, for learning Simulation.

Module-1

Linear Programming Problem (LPP): Solution of Linear Programming Problems: Solution of LPP: Using Simultaneous Equations and Graphical Method; Definitions: Feasible Solution, Basic and non-basic Variables, Basic Feasible Solution, Degenerate and Non-degenerate Solution, Convex set and explanation with examples Solution of LPP by Simplex Method; Charnes' Big-M Method; Duality Theory. **(12)**

Module-2

Transportation Problem: Basic concept, Different solution methods, Optimality test.

Assignment Problem: Problem formulation, Solution methods, Travelling Salesman Problem.

Game Theory: Introduction; 2-Person Zero-sum Game; Saddle Point; Mini-Max and Maxi-Min Theorems (statement only) and problems; Games without Saddle Point; Graphical Method; Principle of Dominance. **(10)**

Module-3

Network Analysis: Shortest Path: Floyd Algorithm; Maximal Flow Problem: Ford-Fulkerson; PERT & CPM (Cost Analysis, Crashing, Resource Allocation excluded). **(10)**

Module-4

Queuing Theory: Introduction; Basic Definitions and Notations; Axiomatic Derivation of the Arrival & Departure (Poisson Queue). Poisson Queue Models: (M/M/1): (∞ / FIFO) and (M/M/1: N / FIFO) and problems.
Inventory Control: Introduction to EOQ Models of Deterministic and Probabilistic; Safety Stock; Buffer Stock.
Sequencing: Johnson's algorithm. **(10)**

Total: 42 L

References

1. H. A. Taha, "Operations Research", Pearson

2. P. M. Karak – "Linear Programming and Theory of Games", ABS Publishing House

3. Ghosh and Chakraborty, "Linear Programming and Theory of Games", Central Book Agency

4. Ravindran, Philips and Solberg - "Operations Research", WILEY INDIA

Course Outcome:

On completion of the course students will be able to

CO1 Recall the fundamental principles and formulas related to linear algebra and linear inequalities.

CO2 Demonstrate a comprehensive understanding of the theoretical principles and applications of linear algebra, convex & concave combination, graph theory and stochastic process necessary for engineering practice by enhancing the power of knowledge.

CO3 Apply advanced techniques in LPP, Transportation problem, Game theory, Network analysis, Inventory theory and Queuing theory to solve complex mathematical problems and analyze linear dependency & independency, types of solutions, loop formation, steady state in optimization and multivariable analysis.

CO4 Evaluate multidisciplinary problems using different mathematical models and create a model and build a path by which a complex multidisciplinary engineering problem can be solved.

Practical / Sessional papers

Categories	Course code	Course title	Hours/week L: T:P	Credit marks	Marks	Total contact hours/week
Project-II	**PROJ-CHE 891**	**Project work & Report Making**	**0-0-32**	**8**	**100**	**32**

Course Objectives:

- To develop the capacity of students in correlating theoretical knowledge in to practical systems either to perform creative works or to perform analysis and hence to suggest solutions to problems, pertaining to environmental engineering domain and bring up collaborative learning skills.
- To develop self-directed inquiry and life-long skills.
- To enhance the communication skills of the students by providing opportunities to discuss in groups and to present their observations, findings and report in formal reviews both in oral and written format.

Content:

Project work for B. Tech students has to be allotted to the student at the beginning of 7th semester and this is expected to be completed in the 8th semester. Each group of students will be required under the supervision of a faculty/ joint supervision of a faculty. The research work has to be carried out by the students themselves occasionally consulting his supervisor(s). Each group of students is expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. The project work is included of identifying particular area of investigation, literature review, preliminary investigation, field excursion, conducting of experiments, numerical modeling to validate experimental data, interpretation of results and report writing. The course content of 'Project I' is Research topic determination and literature review and preliminary and primary investigation and 'Project II' contain literature review and extensive work and analysis of the project work.

The report of the project work has to be submitted in typed and bound form 7 days before commencement of the 7th semester and 8th semester examination. Assessment would be made on the basis of the submitted report and the presentation & viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee.

Course Outcomes:

Students will have the ability in:

CO1: remembering and understanding the idea about the current scope of research in the particular field.

CO2: applying the knowledge and information gathered from literature review to demonstrate the ideas in the project.

CO3: analyzing the generated experimental data to develop the technical knowledge and skill.

CO4: evaluating the parameters for process optimization, justification of methods used and verifying the literature data available.

Categories	Course code	Course title	Hours/week L: T:P	Credit	Marks	Total contact hours/ week
Grand Viva	**GV–CHE 891**	**Grand Viva**		**2**	**100**	

Course Objectives:

- This course provides a revision of all chemical engineering subjects and helps them to relate one subject with the other effortlessly.
- They relate fluid mechanic with thermodynamics also fluid mechanics with mass transfer etc. Students simply draw the interdependence between every subject. This practice facilitates students in the industry.
- Combines concepts of all engineering subjects assist them working on a specific project. Students are expected to develop technical engineering skills while also building valuable leadership and organizational skills.

Contents:

This is a Viva – Voce examination to ascertain the student's overall grasp of the principles of Chemical Engineering and allied subjects. Assessment would be made on the basis of the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of three faculty members with Head of the Department as Chairman during 8th Semester examination.

Course Outcomes:

Students will able in:

CO1: Memorizing technical knowledge, gathered throughout the course.
CO2: Understanding the overall technical aptitude for industry readiness.
CO3: Applying technical knowledge in virtual environment of professional interview.
CO4: Analyzing different technical puzzles and industrial troubleshooting

Value added courses:

VAC – CHE 01

1. Auto CAD for Chemical Engineering

Course Objectives:

- Learn sketching and taking field dimensions.
- Take data and transform it into graphic drawings.
- Learn basic engineering drawing formats.
- Learn basic Auto Cad skills.

Duration of the Each Course: 28 hrs.

Syllabus:

Module-I

Use different types of scales and their utilization in reading and reproducing drawings of objects and maps. Basic introduction and operational instructions of various commands in AutoCAD

(7L)

Module-II

Draw 2 - dimensional view of different objects viewed from different angles (orthographic views); Draw and interpret complete inner hidden details of an object which are otherwise not visible in normal view.

(7L)

Module-III

To make projections of Solid; Generate isometric (3D) drawing from different 2D (orthographic) views/sketches; Identify conventions for different engineering materials, symbols, sections of regular objects and general fittings used in Chemical Engineering.

(7L)

Module-IV

Computer aided design of Reactors, Evaporators, and Adsorption columns, Distillation columns (Specific attention to multi components systems) Heat Exchangers.

(7L)

Recommended Books

Practical Autodesk AutoCAD 2021 and AutoCAD LT 2021: A no-nonsense, beginner's guide to drafting and 3D modelling with Autodesk AutoCAD Kindle Edition, by Yasser Shoukry, Jaiprakash Pandey, Packt Publishing

Course Outcome:

CO1: Understanding the description of key terms and concepts associated with drafting and the drafting profession by Identifying software drafting tools.

CO2: Applying the concept elements of the AutoCAD software interface by Creating, formatting, editing and saving an Auto CAD drawing.

CO3: The student will demonstrate an understanding of the skills necessary to create basic 2D AutoCAD drawings.

CO4: The student will demonstrate an understanding of working with text and conveying non-pictorial information in AutoCAD

VAC – CHE 02

2. Green Technology

Course Objective:

- Green Technologies is a highly interdisciplinary degree program that emphasizes green systems and the environment, energy technology and efficiency, and sustainability and society. The objective of this course is to:
- Seek opportunities for alternative sourcing, conservation, efficiency and repurposing through an understanding of product life cycles from origins to recycling or inevitable disposal.
- To design products, processes and complex infrastructure systems to promote sustainable attributes of importance to the environment and the global community.
- To combine technical and scientific skills with an understanding of the environment, renewable energy management, waste utilization, resource management and land based industries who can contribute to the national and global development.

Module-I

What Is Green Technology? Basic Principles Behind Green Technology. What Are the Applications of Green Technology in Daily life? (7L)

Module-II

Energy-Saving Lighting. Solar-Powered Systems. Renewable Energy Sources. (7L)

Module III

Electric Cars, Server Technology. Smart Power Strips. (7L)

Module-IV

Smart Thermostats. Energy-Efficient Appliances. Telecommuting Software. Device Recycling. (7L)

Reference:

1.Green Technologies and Environmental Sustainability by Ritu Singh · Sanjeev Kumar., Springer
2.Emerging Green Technologies Book by Matthew N.O. Sadiku

Course Outcome:

CO1: Understanding the principles of green chemistry and engineering.
CO2: Applying the design processes those are benign and environmentally viable.
CO3: Analyzing the design processes and products those are safe and hazard free.
CO4: Evaluating the updated concept to modify chemical processes making hazardous products and make them green safe and economically acceptable by using biotechnology.

VAC – CHE 03

3. Industrial Corrosion and its Prevention

Course Objective:

- To understand the needs for Corrosion Education, The Functions and Roles of an Engineer to prevent Corrosion.
- Understanding of basic concepts of Corrosion, Corrosion in different materials, Corrosion Electrochemistry, Corrosion Thermodynamics, Kinetics and Applications.
- To impart the interdisciplinary subject in which Chemical Engineering, Materials Engineering, Electrical Engineering, Civil Engineering and Metallurgy Engineering are involved.

- Understand the Methodology, Methods and Materials to prevent the Corrosion.

Module – I

What is corrosion? Definitions of Corrosion Terminology. Basic Concepts in Corrosion. Factors Influencing Corrosion. Atmospheric Corrosion. Underground or Soil Corrosion. High Temperature (Hot) Corrosion.

(7L)

Module -II

Corrosion of Iron and Steel, Nickel, Aluminum, Titanium and Superalloys. Polymer and Ceramic Materials. Galvanic Corrosion. Pitting, Crevice Corrosion. Stress Corrosion Cracking (SCC) and Corrosion Fatigue (CF).

(7L)

Module – III

Prevention of Corrosion: Protective Coating and Inhibitors. Cathodic and Anodic Protection. Techniques for Diagnosing Corrosion Failures. Analysis of Corrosion Failures. Laboratory Tests.

(7L)

Module – IV

Case Studies of Corrosion Failures. Corrosion Issues in Specific Industries like Power Generation, Chemical Processing Industries, Oil and Gas Industries.

(7L)

Reference:

1. Corrosion Engineering by Fontana, M.G., McGraw-Hill,
2. Corrosion & Corrosion Control by H.H. Uhlig, John Wiley & Sons.
3. Introduction to Metallic Corrosion by Evans.

Course Outcome:

Upon completion of the course, the student should be able to

CO1: Understanding the Chemistry behind the corrosion, process of corrosion, different factors affecting the rate of corrosion.

CO2: Applying the Kinetics and different forms of corrosion and will able to recognize the corrosion occurring in the different materials.

CO3: Analyzing the corrosion avoidance, corrosion failure and the various factors.

CO4: Evaluating the process to prevent the corrosion, selection of materials for corrosion prevention, how to alter the environment for minimal rate of corrosion, different protection techniques and coating to prevent corrosion.

VAC – CHE 04

4. Industrial Waste Water Treatment

Course Objective:

The objective of the teacher is to impart knowledge and abilities to the students to:

- Distinguish between the quality of domestic and industrial water requirements and Wastewater quantity generation
- Understand the industrial process, water utilization and waste water generation

- Impart knowledge on selection of treatment methods for industrial wastewater
- Acquire the knowledge on operational problems of common effluent treatment plants.

Module– I

Difference between industrial & municipal waste waters - Effects of industrial effluents on sewers and Natural water Bodies. Pre & Primary Treatment - Equalization, Proportioning, Neutralization, Oil separation by Floating-Waste Reduction-Volume Reduction-Strength Reduction. (7L)

Module-II

Waste Treatment Methods - Nitrification and De-nitrification-Phosphorous, Fluoride, Chloride etc removal -Heavy metal removal - Membrane Separation Process. (7L)

Module-III

Characteristics and Composition of waste water and Manufacturing Processes of Industries like Petrochemicals and Petroleum Refinery industries.

(7L)

Module-IV

Treatment of Waste water and Domestic Sewage: Common Effluent Treatment Plants (CETP) – Location, Design, Operation and Maintenance Problems – Economical aspects.

(7L)

Reference:

1. Peavy, H.S., Rowe and Tchobonoglous, G., (1985), "Environmental Engineering", McGraw Hill
2. Metcalf and Eddy Inc., (2003), "Wastewater Engineering - Treatment and Reuse", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
3. Benefield R.D., and Randal C.W., (1980), "Biological Process Design for Wastewater Treatment", Prentice Hall, Englewood Chiffs, New Jersey.
4. Karia G.L., and Christian R.A., (2001), "Wastewater Treatment Concepts and Design Approach", Prentice Hall of India Pvt. Ltd., New Delhi.

Course Outcome:

After completing this course, the student must demonstrate the knowledge and ability in:

CO1: Understanding the fundamental concepts of wastewater treatment.

CO2: Applying the fundamental scientific processes underlying the design and operation of wastewater treatment plant.

CO3: Analyzing the management of residuals from water and wastewater treatment.

CO4: Evaluating the design of a water and wastewater treatment plant.

New Suggestions for Value-Added Courses:

- MAT LAB Simulation Software
- IOT application in process industries
- Design and concepts of Zero-Liquid–Discharge system (ZLD system)