Curriculum Structure and Detailed Syllabus

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

(Applicable for the Student Batch of 2021-25)

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: Lifelong learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong 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.

Department of Chemical Engineering
Haldia Institute of Technology
B. Tech. Course curriculum under Autonomy

B. Tech First year (Semester I)

Theory Papers

Sl no.	Categories	Course code	Course title	Hours/week L :T:P	Credit	Marks
1	Basic Science course	BS-M 101	Mathematics - I	3-1-0	4	100
2	Basic Science course	BS-PH 101	Physics - I	3-1-0	4	100
3	Engineering Science courses	ES- EE 101	Basic Elec. & Electro. Engg.	3-1-0	4	100
Total					12	300

Practical/Sessional papers

Sl no.	Categories	Course code	Course title	Hours/week L:T:P	Credit	Marks
1	Basic Science course	BS-PH 191	Physics lab - I	0-0-3	1.5	100
2	Engineering Science courses	ES- EE 191	Basic Elec.& Electro.Engg. lab	0-0-3	1.5	100
3	Engineering Science courses	ES – ME - 192	Workshop Practice	1-0-3	2.5	100
	Extra Curricular activity		NSS		0.0	
Total					5.5	300

B. Tech First year (Semester II)

Theory Papers

Sl no.	Categories	Course code	Course title	Hours/week L:T:P	Credit	Marks
1	Basic Science course	BS- M 201	Mathematics - II	3-1-0	4	100
2	Basic Science course	BS- CH 201	Chemistry - I	3-1-0	4	100
3	Engineering Science courses	ES- CS 201	Programming for problem solving	3-1-0	4	100
4	Humanities and social science courses	HM- HU 201	English Language and Technical Communication	2-0-0	2	100
Total					14	400

Practical/Sessional papers

Sl no.	Categories	Course code	Course title	Hours/week L:T:P	Credit	marks
1	Basic Science course	BS-CH 291	Chemistry lab - I	0-0-3	1.5	100
2	Engineering Science courses	ES-CS 291	Programming Lab	0-0-3	1.5	100
3	Engineering Science courses	ES-ME 292	Engg. Drawing	1-0-3	2.5	100
4	Humanities and social science courses	HM-HU 291	Language Lab	0-0-2	1.0	100
Total				Total	6.5	400

** Students will undergo Institutional Internship after 2nd Semester Examination for a period 3 weeks and that will be evaluated during 3rd Semester examination as the Paper code SI-CHE 391.

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	Basic Science course	BS-CH 301	Chemistry II	3-0-0	3	100	3
2	Basic Science course	BS-CHE 301	Energy and its Utilization	3-0-0	3	100	3
3	Professional core courses	PC-CHE 301	Fluid Mechanics	3-1-0	4	100	4
4	Professional core courses	PC-CHE 302	Particle and fluid – particle Processing	3-0-0	3	100	3
5	Professional core courses	PC- CHE 303	Material and Energy balance Computations	3-0-0	3	100	3
6	Engineering Science courses	ES – BIO - 301	Biology	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	Basic Science course	BS-CHE 391	Energy Engineering laboratory	0-0-2	1	100	2
2	Professional core courses	PC-CHE 391	Fluid Mechanics laboratory	0-0-3	1.5	100	3
3	Professional core courses	PC-CHE 392	Particle and fluid – particle Processing laboratory	0-0-3	1.5	100	3
4	Professional core courses	SI-CHE 391	**Institutional Internship	0-0-20	2	100	20
Total					6	400	28

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	Engineering Science courses	ES-CHE 401	Materials Science	3-0-0	3	100	3
2	Professional core courses	PC-CHE 401	Heat Transfer	3-1-0	4	100	4
3	Professional core courses	PC-CHE 402	Chemical Engineering Thermodynamics	3-1-0	4	100	4
4	Professional core courses	PC-CHE 403	Numerical Methods in Chemical Engineering	3-0-0	3	100	3
5	Humanities and social science courses	HM-HU 401	Values and professional ethics	3-0-0	3	100	3
6	Mandatory non credit course	MC-CHE 401	Environmental Science	2-0-0	0	50	2
Total					17	550	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 491	Heat Transfer laboratory	0-0-3	1.5	100	3
2	Professional core courses	PC-CHE 492	Numerical Methods in Chemical Engineering laboratory	0-0-3	1.5	100	3
Total					3	200	6

Students will undergo Industrial Internship after 4th Semester Examination for a period 6 weeks and that will be evaluated during 5th Semester examination as the Paper code SI-CHE 591.

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	4-0-0	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 I	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	Humanities and social science courses	HM-HU 501	Economics for Engineers	3-0-0	3	100	3
7	Mandatory non- credit course	MC-CHE 501	Constitution of India	2-0-0	0	50	2
Total					21	650	23

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	Instrumental method of analysis laboratory	0-0-3	1.5	100	3
2	Professional core courses	PC-CHE 592	Chemical reaction engineering laboratory	0-0-3	1.5	100	3
3	Professional core courses	PC-CHE 593	Process equipment design and drawing - I	0-0-3	1.5	100	3
4	Professional core courses	SI-CHE 591	## Industrial Internship	0-0-30	4	100	30
Total					8.5	400	39

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	Process Technology and Economics	3-0-0	3	100	3
2	Professional core courses	PC-CHE 602	Mass Transfer II	3-1-0	4	100	4
3	Professional Elective courses	PEC-CHE 601	Core Elective II	3-0-0	3	100	3
5	Open Elective courses	OEC-CHE 601	Open Elective II	3-0-0	3	100	3
6	Humanities and social science courses	HM- HU 601	Principles of management	3-0-0	3	100	3
7	Mandatory non credit course	MC-CHE 601	Essence of Indian Traditional Knowledge	2-0-0	0	50	2
Total					16	550	18

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	Mass Transfer I laboratory	0-0-3	1.5	100	3
2	Professional core courses	PC-CHE 692	Process equipment design and drawing - II	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					4.5	300	9

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

- Students will undergo Industrial Internship after 6th Semester Examination for a period 6 weeks and that will be evaluated during 5th 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 core courses	PC-CHE 701	Instrumentation and process control	3-1-0	4	100	4
2	Professional Elective courses	PEC-CHE 701	Core Elective III	3-0-0	3	100	3
3	Open Elective courses	OEC-CHE 701	Open Elective III	3-0-0	3	100	3
4	Open Elective courses	OEC-CHE 702	Open Elective IV	3-0-0	3	100	3
Total					13	400	13

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 - 791	Instrumentation and process control lab	0-0-3	1.5	100	3
2	Industrial Internship	SI-CHE 791	❖ Industrial Internship	0-0-30	4	100	30
Total					5.5	200	33

Core Elective III	PEC-CHE 701A	PEC-CHE 701B	PEC-CHE 701C
Name of the Subject	Biotechnology and Biochemical Engineering	Advanced Separation Processes	Industrial pollution control

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	Professional Elective courses	PEC- CHE 801	Core Elective IV	3-0-0	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-1	PROJ-CHE 891	Project Work & Report making.	0-0-14	4	200	14
2	Project-2	PROJ-CHE 892	Project Presentation & Viva Voce		1.5	100	
3	Grand Viva	GV-CHE 891	Grand Viva		2.0	100	
Total					7.5	400	14

Core Elective IV	PEC – CHE 801A	PEC – CHE 801B	PEC – CHE – 801C
Name of the Subject	Modern tools and their design aspects	Computational Fluid Dynamics	Safety and Hazards analysis in Industries

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 - 701 C
	Open Elective IV	Statistical quality control	OEC – CHE – 702A
		Operation research	OEC – CHE – 702B

Total credit

Semester	Theory	Practical/sessional	Total
First	12.0	5.5	17.5
Second	14.0	6.5	20.5
Third	19.0	6.0	25.0
Fourth	17.0	3.0	20.0
Fifth	21.0	8.5	29.5
Sixth	16.0	4.5	20.5
Seventh	13.0	5.5	18.5
Eighth	3.0	7.5	10.5
Total credit			162.0

Honours papers for first, second, third and fourth year of Chemical engineering.

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

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

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

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

A student of 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 PollutionControl	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/NPTEL	https://swayam.gov.in
4	Soft Nano Technology	8	2	Swayam/NPTEL	https://swayam.gov.in
5	Plastic Waste Management	8	2	Swayam	https://swayam.gov.in
6	Waste 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 and Assessment	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/NPTEL	https://swayam.gov.in
15	Data Analytics with Python	12	3	Swayam/NPTEL	https://swayam.gov.in
16	IBM DATA 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/nd 1_noc19_ee66/preview
35	Technologies For Clean And Renewable Energy Production	8	4	Swayam	https://swayam.gov.in/nd 1_noc19_ch26/preview
36	Introduction to Deep Earth Science	5	3	Edx	https://www.edx.org/cour se/introduction-to-deep- earth-science
37	Basic Analytical Chemistry	6	3	Edx	https://www.edx.org/cour se/basic-analytical- chemistry
38	Air Pollution – a Global Threat to our Health	3	2	Coursera	https://www.coursera.or g/learn/air-pollution- health-threat
39	Demand and Supply Analytics	12	6	Edx	https://www.edx.org/cour se/demand-and-supply-analytics
40	Introduction to Engineering and Design	3	2	Edx	https://www.edx.org/cour se/introduction-to- engineering-and-design
41	Biorefinery: From Biomass to Building Blocks of Bio-based Products	7	4	Edx	https://www.edx.org/cour se/biorefinery-from- biomass-to-building- blocks-of-biobased-products-2
42	Water quality and the biogeochemical engine	13	6	Edx	https://www.edx.org/cour se/water-quality-and-the- biogeochemical-engine
43	Programming for the Internet of Things Project	4	2	Coursera	https://www.coursera.org/learn/intern et-of-things- project

44	Introduction to 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 fulfilment	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

All of the MOOCs courses are to be taken from any MOOCs platform as per following scheme of credit points. There would not be any concept of 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 / class room mode.

For NPTEL/Swayam platform: Credit points as specified in the platform
For other MOOCs platforms like Coursera, edX, Udemy, Simpilearn etc, 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 III

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/Week
Basic Science Course	**BS – CH - 301**	**Chemistry II**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Understand the concepts related to homogeneous and heterogeneous catalysis,
- Understand the mechanisms of industrially important reactions
- Understand spectroscopic and chromatographic methods for identification of compounds.

Contents:

1. Homogeneous and Heterogeneous catalysis:
Homogeneous Lewis acid-base catalysts, organometallic catalysts and industrial examples. Heterogeneous catalysts, basic concepts and industrial examples. **(6L+1T)**

2. Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes:
- Alkylation and acylation, e.g. alkylation of benzene, phenols, etc.
- Halogenation, e.g. chlorination of toluene
- Nitration and sulfonation, e.g. nitration, sulfonation of benzene, etc. **(6L+2T)**

3. Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes:
- Hydrogenation and reductive alkylations, e.g. hydrogenation of nitrobenzene, reductive alkylation reactions of anilines, etc.
- Oxidation, e.g. oxidation of xylenes, etc. **(6L+2T)**

4. Mechanisms and recent advances (green chemistry, catalysis etc.) of following processes:
Polymerization, e.g. polyethylene, polypropylene, polyester and nylon, etc. **(6L+2T)**

5. Analytical chemistry:
Statistical Aspects, Molecular and atomic spectroscopy method. **(6L+1T)**

6. Analytical chemistry: Thermal & Chromatographic methods. **(6L+1T)**

Total: 45 (L+T)

Text Books:

1. Engineering Chemistry, Satyaprakashb& Manisha Agarwal, Khanna Book Publishing, Delhi
2. A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
3. Essentials of Physical Chemistry, Bahl&Tuli, S.Chand Publishing

4. Applied Chemistry, Sunita Rattan, Kataria
5. Engineering Chemistry, Baskar, Wiley
6. Engineering Chemistry – I, D. Grour Krishana, Vikas Publishing
7. Laboratory Manual Engg. Chemistry, Anupma Rajput, Dhanpat Rai & Co.

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

- get into previously learned material by recalling facts, terms, basic concepts about different aspects of catalysis, aromatic reactions and spectroscopy.
- compare and contrast between different types of catalysts, illustrate mechanisms of different types of aromatic reactions, can understand area and importance of spectroscopy in chemical engineering.
- develop the knowledge about Various industrially important catalyzed reactions and discover pathway of synthesizing important aromatic products, also make use of various spectroscopy as an analytical tool.
- analyze the mechanism of important catalytic reactions and assimilate the mechanism of all types of aromatic reactions and also examine clinically a specific product by different analytical techniques

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/Week
Basic Science Course	**BS – CHE - 301**	**Energy and its Utilization**	**3-0-0**	**3**	**100**	**3**

Course Objectives:
This course prepares the student to:

- Introduce the different energy sources and its 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:

1. Introduction: Conventional (fossil energy) and non-conventional (alternative energy) resources &reserves. Global Energy production & consumption pattern. Production & consumption pattern in India. Solid Fuels: Biomass, Wood and Charcoal. Classification &

Rank of Coal, Peat, Lignite, Sub-Bituminous coal, Bituminous coal, Anthracite coal, Cannel & Bog head coal. **(2L + 1T)**

2. Properties and beneficiation: Physical Properties of coal, Proximate & Ultimate Analysis of Coal, Cleaning, washing & Storage of coal. **(2L + 1T)**
3. Utilization of Coal: Physical Properties of coal, Proximate & Ultimate Analysis of Coal, Cleaning, washing & Storage of coal. Carbonization, Combustion, excess air calculation etc. **(2L + 1T)**
4. Liquid Fuels: Constitution of petroleum, theory of formation of crude petroleum oil. Characterization of crude oil & petroleum fuels. Operation and flow-sheet of crude distillation plant. Thermal & catalytic cracking and reforming processes, coking, visbreaking, Process of a typical Indian refinery. **(4L + 2T)**
5. 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. **(2L + 1T)**
6. Liquid fuel from coal: Bergius and Fischer Tropsch process. Other Synthetic Liquid fuels.(Benzol, shale oil, Gashol, power alcohol Colloidal fuel). Hydro processing in refinery **(2L + 2T)**
7. 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, coke-oven gas, blast furnace gas, Natural Gas and LPG. **(3L + 1T)**
8. Coal Bed Methane. Bio Gas: Principles and Operation of Aerobic & Anaerobic digestors, Biogas generation and management & flowsheet with special reference to waste utilization **(4L + 2T)**
9. 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. **(3L + 1T)**
10. Geothermal Energy & Wind Energy: Utilization of Geothermal Energy; Operating principles of different types of Wind Energy Mills, Energy from Ocean, Hydal, Biomass, Fuel Cell, Hydrogen etc. **(4L + 1T)**
11. Nuclear energy: Sources of Nuclear fuels, Indian scenario; Nuclear reactions and power generation by Nuclear reactors-Breeder reactor- reaction &operation. **(3L + 1T)**

Total: 45 (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 Chanra Mohan

Course Outcomes:
Students should be able to:

- Memories the basic concepts of energy and world energy consumption pattern
- Interpret the exploration and processing of solid, liquid and gaseous energy sources
- Demonstrate the engineering aspects in the field of crude oil exploration and processing in a refinery
- Classify the importance of renewable energy sources and their utilization such as solar, wind, hydro, geothermal, ocean thermal, fuel cell etc

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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), relevant to Chemical Engineering operations.
- Introduce students to forces on fluids, hydrostatic forces on submerged bodies, Eulerian and Lagrangian descriptions of flow, flow visualization, integral analysis involving mass and momentum balances, Bernoulli equation, flow through pipes and ducts, flow measurement and instruments, flow transportation - pumps, blowers and compressors, conservation of mass, linear and angular momentum in differential form.
- Introduce students to Navier-Stokes equation, viscous flows, skin and form friction, lubrication approximation, potential flows and boundary layer theory. Turbulence and turbulent flows will be introduced.

Contents:
1. Introduction to fluids, Continuum hypothesis, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization –streamline, pathline, streak line, stress field; viscosity;
Newtonian fluid; Non-Newtonian fluid; Reynold's number—its significance, laminar, transition and turbulent flows: Prandtl boundary layer, compressible and incompressible flows. **(3L + 1T)**

2. Fluid statics - pressure distribution, Manometry, Forces on submerged bodies (planar and curved), Buoyancy, b. 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.

(3L + 1T)

3. Kinematics of fluid , Basic laws for a system; relation of system derivatives to the control volume formulation; conservation of mass; continuity equation, momentum balance equation-Introduction to Navier Stoke's and Euler's Equation. Introduction to roational and irrotational flow,momentum correction factor. flow- Eulerian and Lagrangian descriptions. Kinematic decomposition of flow motion **(3L + 1T)**

4. System and control volume approaches, Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Turbulent flow. Flow of incompressible fluid in 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, 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 **(6L + 2T)**

5. Flow measurement, Transportation of fluids - Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; Weirs, concept of area meters : Rotameter; Local velocity measurement: Pitot tube. mass flow meter. **(4L + 1T)**

6. Differential analysis: mass and momentum balances, Navier-Stokes equation, Unidirectional flow, Viscous flow, Stokes law, Skin drag and pressure drag

Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body; packed bed; concept of Sphericity; Ergun equation, modified friction factor **(5L + 2T)**

7. Potential flow, Potential function, Solution of Laplace equation Introduction; different types of fluidization; minimum fluidization velocity; governing equation; industrial uses.

(4L + 1T)

8. 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; basic characteristics curves for centrifugal pumps **(6L + 2T)**

9. Similitude analysis, Lubrication approximation **(3L + 1T)**

10. Compressible flows, fan, blower and compressor. **(3L + 1T)**

11. Boundary layer theory, Blasius solution, Boundary layer separation. Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition, Spectral nature of turbulence and Kolmogorov hypothesis. **(5L + 2T)**

Total: 60 (L+T)

Text books:

1) S.S. Rattan, Fluid Mechanics, Khanna Publishing House, New Delhi 2018
2) Unit operations of Chemical Engineering: McCabe, Smith and Harriot,TMH, 6th Edn.
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, John wiley
2) Fluid Mechanics, A.K. Mohanty, PHI
3) M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 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, 3rd Edn. PHI
6) Principles of Unit Operations: Foust and Wenzel, Wiley, 1980

Course Outcomes:

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

- define the fundamental properties of fluid and fluid characteristic, laws of fluid Mechanics and their applications. Concepts of Boundary Layer Theory. To explain the fluid kinetics and fluid dynamics.
- establish Euler's Equation and Bernoulli's equation in fluid mechanics. Concept and applicability of Navier Stoke's.
- analyze the flow over immersed bodies, concept of drag and lift. Principle of packed column and its importance in chemical industries and to know the importance of fluidization; minimum fluidization velocity; pneumatic conveying and their industrial applications.
- understand and develop the concept about flow measuring devises and their industrial applications. fluid moving machinery, pumps, their working principles and industrial applications, and numerical solution .

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/ Week
Professional Core Courses	**PC – CHE - 302**	**Particle and fluid – particle Processing**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Introduce students to the numerous industrial operations dealing with the particulate solids, their handling in various unit operations, and those in which particle fluid interactions are important.
- Addresses fundamentals of fluid-particle mechanics, such as the notion of drag, and builds on those fundamentals to develop design concepts for various industrial processes like packed bed operation, fluidized operations, sedimentation, filtration, separation of solids and fluids, etc. Industrial applications are discussed.
- Introduce to colloidal systems, soft materials and nanoparticles.

Contents:

1. Introduction: Relevance of fluid and particle mechanics, and mechanical operations, in chemical engineering processes **(1L)**
2. Solid particle characterization: Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area; Measurement of surface area **(5L)**
3. Flow around immersed bodies: Concept of drag, boundary layer separation, skin and form drag, drag correlations **(4L)**
4. Packed bed: Void fraction, superficial velocity, channeling, Ergun equation and its derivation, Kozeny Carman equation, Darcy's law and permeability, Blaine's apparatus. **(4L)**
5. Fluidization: Fluidized bed, minimum fluidization velocity, pressure drop, Geldart plot etc. Types of fluidization: Particulate fluidization, Bubbling fluidization, Classical models of fluidization, Circulating fluidized beds, Applications of fluidization **(5L)**
6. Separation of solids from fluids: Introduction **(1L)**
7. Sedimentation: Free Settling, hindered settling, Richardson-Zaki equation, design of settling tanks. **(3L)**
8. Filtration: Concepts, design of bag filters, design of electrostatic filters **(3L)**
9. Centrifugal separation, design of cyclones and hydrocyclones **(3L)**
10. Size reduction, milling, laws of communition, classification of particles **(3L)**
11. Size enlargement; Nucleation and growth of particles **(3L)**
12. Transport of fluid-solid systems: pneumatic and hydraulic conveying **(2L)**
13. Colloidal particles: stabilization, flocculation **(3L)**
14. Introduction to nanoparticles: Properties, characterization, synthesis methods, applications **(5L)**

Total: 45 (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.

References Books

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

Course Outcomes:

Students will be able to:

- Define and describe fluid-particle systems in terms of their basic physical properties.

- Illustrate the velocity of particles moving in a fluid as a function of particle characteristics (size, shape, deformability and concentrations) and fluid properties.
- Perform basic design calculations and analyses of typical fluid-particle operations and related industrial equipment.
- Build work proficiently and effectively in small teams.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/ Week
Professional Core Courses	**PC – CHE - 303**	**Material and Energy balance Computations**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Understand and apply the basics of calculations related to material flow in the processes with and without 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:

1. Dimensions and units, physical quantities in chemical engineering, Dimensionless groups, Dimensional homogeneity, Dimensional analysis, Buckingham's pi theorem and its application, **(3L + 2T)**
2. Concept of mole, mole fraction, weight fraction, average molecular weight, Compositions of mixtures of solids, liquids and gases. **(1L+1T)**
3. Material Balance without Chemical Reaction: "Basis" of calculations, material balance problems on mixing, crystallization, absorption, extraction, distillation, drying, etc. **(5L+3T)**
4. Humidity and Saturation, various humidity terms like molar, absolute, relative & percentage saturation, humid heat, humid volume, dry bulb temperature, dew point, humidity chart and its use. **(3L+1T)**
5. 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. **(5L+2T)**
6. Material Balances with recycle, bypass and purge. **(2L+2T)**
7. Fundamental concept of vapour pressure & boiling point, Clausius-Clapeyron equation, Antoine Equation, Cox chart, Duhring's plot, Raoult's law, Henry'slaw and related numerical problems. **(2L+2T)**

8. Energy balance: open and closed system, estimation of heat capacities, calculation of enthalpy changes. **(4L+2T)**
9. Energy balances with chemical reaction: Heat of reaction, heat of combustion, heat of formation, Calorific values, Hess's Law, related problems of various chemical processes. **(3L+2T)**

Total: 45 (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 & Energy Balances", Second Edition, CBS Publishers & Distributors, 2004
3. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
4. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.

Course outcomes:

Students completing the course will be able to

- Define the useful physical quantities in terms different dimensions – units, convert them and use dimensional analysis to demonstrate the basic chemical engineering processes in terms of dimensionless group.
- Explain various liquid-vapour-gas laws and use them in relevant chemical engineering processes.
- Compare and solve various material balance calculations with and without chemical reactions, and involving concepts like recycle, bypass and purge.
- Use the laws related to thermo-physics and thermo-chemistry to solve energy balance problems with and without chemical reaction required for process calculations and design purposes.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/Week
Engineering Science courses	ES – BIO - 301	Biology	3-0-0	3	100	3

Course Objectives:

This course prepares the student to:

- Introduce the basics of biology such as cell structure and functions, inheritance & evolution, basic concepts of genetics, and an introduction to microbiology with an emphasis on evolution of biology as a multidisciplinary field.

- Make students aware of application of engineering principles in biology and engineering robust solution inspired by biological examples.
- Make them aware about recent application of biology in engineering research and industry.

Contents:

1. Basics: Diversity of life, prokaryotes and eukaryotes, basic cell constituents and macromolecules. **(4L + 2T)**
2. Biochemistry: Metabolism (Catabolism and Anabolism) and Bioenergetics **(9 L + 2T)**
3. Genetics: Basic principles of Mendel, molecular genetics, structure and function of genes and chromosomes, Transcription and Translation, gene expression and regulation. **(9L + 2T)**
4. Cell Biology: Macromolecules, membranes, organelles, cytoskeleton, signaling, cell division, differentiation, motility. **(9L + 2T)**
5. Microbiology: host-microbe interactions, physiology, ecology, diversity, and virology. **(4L + 2T)**

Total: 45 (L + T)

Text Book:

1. Biology for Engineers (ISBN: 9781121439931), TMH

Course Outcomes:

After completion of this course, the learners will be able to:

- understand the biological concepts from an engineering perspective.
- discuss different aspects of the structure and function of various biomolecules.
- identify and classify microorganisms.
- integrate biological principles for developing next generation technologies.

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Practical Papers:

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total Contact Hours/ Week
Basic Science course	**BS – CHE - 391**	**Energy Engineering laboratory**	**0-0-2**	**1**	**100**	**2**

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

Text Books:

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

Course Outcomes:

After completion of this course, the learners will be able to:

- Memorize the fundamentals of energy technology and importance of various apparatus used to determine the various parameters of fuels.
- Identify various parameters of fuel such as flash point, fire point, aniline point, kinematic viscosity as well as proximate and ultimate analysis of coal
- Implement the importance of those various parameters in energy technology.

- Differentiate the professional ethics and responsibility in aspects of safety and environmental protection during experimental work.

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

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 ChemicalEngineering (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 be able to

- Explain the relation between Reynolds number and fluid flow patterns and measure Reynolds number to demonstrate different flow regimes for pipe flow.
- Verify Bernoulli's Principle; differentiate between open channel flow and closed channel flow; compare the performances of various flow meters by measuring their coefficient parameter.
- Measure and evaluate the important characteristics parameters of packed bed and fluidized.
- Summarize several piping parts used to transport fluid and illustrate them by assembling various pipe parts.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional core courses	**PC – CHE - 392**	**Particle 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 Particle and fluid – particle Processing laboratory 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. Verification of Rittinger's Law and determination of grind ability index of a drop weight crusher for a given 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'HammerMill'.
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 time and power consumption for fluid mixing for different rotational speed 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 sedimentation duty.
9. Determination of specific cake resistance '$\propto$' and filter medium resistance 'Rm' by filtering a slurry using plate and frame filter press.
10. Estimation of '$\propto$' (specific cake resistance) and 'Rm' by filtering a slurry using a batch centrifugal filter.

Text/ Book of reference:

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

Course Outcomes:

Students will be able to

- Memorize the fundamentals of mechanical operation by doing the experiment in hand through teamwork.
- Identify the working principle and importance of various equipments of mechanical operations used in process industries.
- Implement the principles of mechanical operation for designing various size reduction equipment, size separation, filtration and conveying equipments.
- Distinguish between the professional ethics and responsibility in aspects of safety and environmental protection during experimental work.

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**SI – CHE 391**	**Institutional Internship**	**0-0-20**	**2**	**100**	**20**

Course Objectives :

The main objective of the course is to

- see how the theoretical aspects learned in classes are integrated into the practical world.
- learn new skills and supplement knowledge.
- practice communication, to meet new people and learn networking skills.

Contents:

During the summer vacations, after the 2nd Semester, students are required to be involved in Inter/ Intra Institutional Activities viz; Training with higher Institutions; Soft skill training organized by Training and Placement Cell of the respective institutions; contribution at incubation/ innovation /entrepreneurship cell of the institute; participation in conferences/ workshops/ competitions etc.; Learning at Departmental Lab/Tinkering Lab/ Institutional workshop; Working for consultancy/ research project within the institutes and Participation in all the activities of Institute's Innovation Council for eg: IPR workshop/Leadership Talks/ Idea/Design/ Innovation/ Business Completion/ Technical Expos etc.

Course Outcomes:

Students will be able to

- Define the fundamentals of chemical engineering through professional approach.
- Describe the nature and function ofthe organization in which the internship experience takes place.
- Demonstrate content knowledge appropriate to job assignment.
- Appraise the internship experience in terms of their personal, educational and career needs.

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Detailed Syllabus, B. Tech Second year, Semester IV

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Engineering Science Courses	**ES – CHE - 401**	**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.

Contents:

1. 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. **(3L)**
2. Introduction to Crystal Geometry; crystal co-ordinate system; classification of crystals and lattices; translational and non-translational symmetry; characteristics or defining symmetry of different crystal systems. **(4L)**
3. Miller indices of directions and planes,Weiss Zone law and it's application, Inter-planer spacing, Bragg's law, introduction to experimental techniques of XRD for material characterization highlighting links between molecular structure and macroscopic properties.**(4L)**
4. 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, voids in closed packed structure. **(5L)**
5. 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.**(5L)**
6. Imperfections/defects in solids: vacancies, interstitial, dislocations: types and characteristics of dislocations, free surface, grain boundary, stacking faults equilibrium concentration of vacancy. **(6L)**
7. Strength and properties of Materials: Yield strength, tensile strength and ductility of materials: stress strain behavior of metals, ceramics and polymers, thermal expansion, elastic modulus and melting point of materials, tensile test, plastic deformation, necking, visco-elasticity, hardness, toughness, brittleness. creep behavior and fatigue in engineering materials. **(5L)**
8. 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.(**3L**)
9. Eutectic systems: Pb-Sn phase diagram; eutectic reaction ;eutectic, hypoeutectic and hypereutectic alloys, Gibbs phase rule, Iron-Carbon phase diagram: eutectoid, hypoeutectoid and hypereutectoid steels.Phase transformation: estimation of ΔG for freezing; nucleation, growth and overall transformation, T-T-T diagram, heat treatment -introduction and purposes of heat treatment **(8L)**
10. Corrosion: basic concepts and forms of corrosion, corrosion mechanism and prevention. protective materials and coating. **(2L)**

Total : 45 (L)

Text books:

1. William F. Smith, Javad Hashemi and Ravi Prakash Materials Science and Engg by (latest edition)
2. H. Lawrence, Vanvlack, Elements of Material Science and Engineering, Pearson Education.
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.

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 able to

- Recall the knowledge of general or basic engineering science relevant to this subject as prerequisites what they learned in earlier.
- Classify of hard and soft materials, including polymers and composites, their characterization, properties, and use in engineering applications
- Select methods of characterization of engineering materials and **identify** materials for applications in chemical process industry
- Analyze the interactions between materials of construction of equipment and the chemicals processed.

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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:

- Basic Concepts of Heat Transfer in Conduction, Convection and Radiation.
- Application of heat transfer concepts in heat exchanging equipment like Heat exchangers & Evaporators
- Design and Rating of Heat exchangers with and Without Phase Change.

Contents:

1. Heat Transfer Fundamentals: Modes of heat transfer, thermal diffusivity and heat transfer coefficient; Differential equations of heat transfer; special forms. **(3L+1T)**

2. Conductive heat transfer – Fourier's law, Thermal conductivity, compound resistance in series, one dimensional problem, heat transfer from extended surfaces, two dimensional problems, Thermal diffusivity, concept of heat transfer coefficient in convective-conductive system, General heat conduction equation, Insulation, critical insulation thickness. Lumped system analysis, Slab – use of transient temperature chart **(6L+2T)**

3. 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; Analogies and Correlations, Physical Interpretation of different Dimensionless groups; Reynolds analogy, Colburn Analogy; Wilson Equation, Analysis of free convection in hot vertical plate, and over cylinder, **(6L+2T)**

4. Concept of LMTD, LMTD correction factor, dirt factor, Individual and overall heat transfer coefficient. (**6L +1T**)

5. 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. **(5L+2T)**

6. Basics of Heat transfer with phase change - Introduction to boiling, Introduction to condensation, Drop wise and film wise condensation, Film condensation on vertical surface, Nusselt equation, Condensation outside horizontal and vertical tube bank, Heat transfer to boiling liquid, Analysis of boiling curve, Nucleate boiling mechanism. **(5L+ 2T)**

7. Design aspects of Condensers, Reboilers and 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. **(6L + 2T)**

8. Heat Transfer to Agitated tanks, unsteady state heat transfer. **(3L + 1T)**

9. 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. **(5L + 2T)**

Total: 60 (L+T)

Text Books:

1. W. J. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, Sixth Edition, McGraw Hill (2005).
2. B. K. Dutta, Heat Transfer – Principles and Applications (2004).
3. J. P. Holman, S. Bhattacharya, Heat Transfer, 10th Ed., Tata McGraw-Hill (2011).
4. Er. R. K. Rajput, Heat and Mass Transfers, S. Chand Publications.

Reference Books:

1. Bejan, A., A. D. Kraus, Heat Transfer Handbook, John Wiley (2003).
2. D.Q. Kern, Process Heat Transfer, Tata-McGraw Hill (1997).

3. 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

- Identify and select the different type shell and tube Heat Exchangers based on TEMA classification
- Design of double pipe heat exchanger, Shell and tube heat exchanger, concept of finned tube and other compact heat exchangers .
- Know the concept of different type Evaporators and their design.
- Enrich the overall concept about the conductive, convective and radiative heat transfer for their Engineering applications

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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 to:

- Introduce the principles and application of laws of thermodynamics, and phase equilibria.
- Introduce the concepts of fugacity, activity coefficient, vapour-liquid equilibrium and reaction equilibrium.
- Introduction to molecular thermodynamics.

Contents:

1. Introduction- scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems . Heat effects. **(4L + 2T)**

2.Phases, phase transitions, PVT behavior; description of materials – Ideal gas law, van der Waals, virial and cubic equations of state; Reduced conditions & corresponding states theories; correlations in description of material properties and behavior. **(5L+2T)**

3. Statements of the second law; Heat engines, Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Thermodynamic property of fluids, Maxwell relations, The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. Concept of free energy. **(6L + 2T)**

4. Application of thermodynamics to flow processes-pumps, compressors and turbines. Thermodynamic analysis of steam power plants; Rankine cycle; internal combustion engine, Otto engine; Diesel engine; Jet engine. **(4L + 1T)**

5. Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties Vapor-liquid equilibrium: phase rule, simple models for VLE – Raoults law; Bubble point, dew point, Flash calculations. **(6L+2T)**

6. 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. **(6L+2T)**

7. 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. **(6L+2T)**

8. 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. **(6L+2T)**

9. Introduction to molecular/statistical thermodynamics. **(2L)**

Total: 60 (L + T)

Text Books:

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, "Introduction to Chemical Engineering Thermodynamics", 7thedition, 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 to

- recall the basic concepts and related laws of thermodynamics, its application in closed and open system.
- discuss and apply the basic concepts of heat engine and heat pump / refrigerator, refrigeration and other cycles

- recognize the concept of fugacity, activity, the Raoults law, the bubble point, dew point and flash calculation and Chemical Reaction Equilibria.
- predict the application of solution thermodynamics ,Chemical Reaction Equilibria, and solve different thermodynamic problems involving equilibria of different phases.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional core courses	**PC – CHE - 403**	**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:

1. Introduction, Approximation and Concept of Error & Error Analysis. **(3L)**
2. 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. **(7L)**
3. 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. **(7L)**
4. Interpolation and Approximation:
   Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression. **(7L)**
5. Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, Chemical engineering problems involving numerical differentiation and integration **(7L)**
6. Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive RungeKutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs. **(7L)**

7. Introduction to Partial Differential Equations:
   Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method. **(7L)**

Total: 45 (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 Compute rApplications, McGraw 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. Press et. al., Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Course Outcomes:

Students will be able to

- Identify the consequences of finite precision and the inherent limits of the numerical methods considered.
- Illustrate the various types of problems in engineering and science in consideration of the mathematical operations involved, accuracy requirements and available computational resources.
- Implement the use of numerical methods in modern scientific computing.
- Utilize the numerical solution technique for integration, linear equations, ordinary differential equations, interpolations etc.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Humanities and Social Science Courses	**HM – HU - 401**	**Values and Professional Ethics**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity, which are the core aspirations of all human beings
- To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the

Human reality and the rest of Existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way

- To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature Thus, this course is intended to provide a much needed orientational input in value education to the young enquiring minds.

Contents:

Science, Technology and Engineering as knowledge and as Social and Professional Activities

1. Effects of Technological Growth: **(15L)**
   Rapid Technological growth and depletion of resources, Reports of the Club of Rome. Limits of growth: sustainable development
   Energy Crisis: Renewable Energy Resources
   Environmental degradation and pollution. Eco-friendly Technologies. Environmental Regulations, Environmental Ethics
   Appropriate Technology Movement of Schumacher; later developments
   Technology and developing notions. Problems of Technology transfer, Technology assessment impact analysis.
   Human Operator in Engineering projects and industries. Problems of man, machine, interaction, Impact of assembly line and automation. Human centered Technology.
2. Ethics of Profession: **(15L)**

   Engineering profession: Ethical issues in Engineering practice, Conflicts between business demands and professional ideals. Social and ethical responsibilities of Technologists. Codes of professional ethics. Whistle blowing and beyond, Case studies.

3. Profession and Human Values: **(15L)**

   Values Crisis in contemporary society
   Nature of values: Value Spectrum of a good life
   Psychological values: Integrated personality; mental health
   Societal values: The modern search for a good society, justice, democracy, secularism, rule of law, values in Indian Constitution.
   Aesthetic values: Perception and enjoyment of beauty, simplicity, clarity
   Moral and ethical values: Nature of moral judgments; canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility.

Total: 45 (L)

Reference Books:

1. Stephen H Unger, Controlling Technology: Ethics and the Responsible Engineers, John Wiley & Sons, New York 1994 (2nd Ed)
2. Deborah Johnson, Ethical Issues in Engineering, Prentice Hall, Englewood Cliffs, New Jersey 1991.

3. A N Tripathi, Human values in the Engineering Profession, Monograph published by IIM, Calcutta 1996.

Course Outcomes:

Students will be able to:

- Relate the code of ethics to social experimentation.
- Compare between ethical and non ethical situations.
- Construct moral judgment in conditions of dilemma.
- Analyze concepts based on moral issues and enquiry.

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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**	**50**	**2**

Course Objectives:

As human being, we are not an object isolated from the environment around us rather we are a constituent seamlessly integrated and co-exist with the environment around us. We are not an entity so separate from the environment that we can think of mastering and controlling it rather we must understand that each and every action of ours reflects on the environment and vice versa. Ancient wisdom drawn from Vedas about environment and its sustenance reflects these ethoses. There is a direct application of this wisdom even in modern times. Idea of an activity-based course on environment safety is to sensitize the students on the above issues through following two types of activities.

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

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 **(16 L)**

i) Plantation
ii) Cleanliness drive
iii) Drive for segregation of waste
iv) To live some big environmentalist for a week or so to understand his 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: 30(L)

Reference Books:

1. Textbook of Environmental Studies, Erach Bharucha, University Press
2. Environmental Studies, MP Poonia & SC Sharma, Khanna Publishing House
3. Environmental Studies, Rajagopalan, Oxford University Press

Course Outcomes:

At the completion of course, students will be able to:

- Recall and define the basic reasons of air pollution, water pollution, solid waste management, process plant safety, hazardous chemicals and its adverse effects on environment.
- Explain the outline of potential methodologies to control pollutions as well as its impact on public health, safety and environment.
- Apply the theoretical knowledge in different field of application related to different environmental issues.
- Analyze the applicability of technologies with respect to environment as well as health, safety and industrial hazards.

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Practical/Sessional Papers:

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

Experiments:

1. Determination of thermal conductivity of metal bar using Fourier's Equation.

2. Determination of thermal conductivity of insulating material used inside the lagged pipe during heat loss through the surface wall of pipe.
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 the effect of air velocity on heat transfer coefficient.
5. Determination of emissivity of an unknown test surface.
6. Determination of overall heat transfer coefficient in Parallel flow/ Counter current double pipe heat exchanger.
7. Determination of overall heat transfer coefficient and efficiency of Shell & Tube heat exchanger.
8. Determination of overall heat transfer coefficients in film wise and drop wise condensation and comparative analysis of heat transfer effects between the both types of condensation.
9. Determination of capacity and economy for single effect evaporator.
10. Determination of internal thermal resistance of the test body by calculating Biot Number during unsteady state heat transfer process.
11. Determination of Stefan-Boltzmann constant using ($dT/d\theta$) from temperature vs. time plot.

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 be able to:

- **Recall** and **relate** the previously learned engineering /basic science concepts or knowledge with the major Heat transfer operations
- **Interpret** the experimental data on the basis the fundamentals of experimented Heat transfer operations.
- **Apply** basic design principles for heat transfer devices to **solve** any problem primarily in different way as per requirement in new situation.
- **Examine** and **classify** the causes of technical problem during experimentation on various heat transfer systems.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC – CHE - 492**	**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 discuss about the ordinary differential equations solution technique.
- It introduces computational and mathematical methods for the solution of multi-scale chemical engineering problems.

Contents:

1. Introduction to use of computers for numerical calculations
2. Matrix Multiplication.
3. Solution of linear algebraic equations using Gauss elimination, Gauss-Siedel etc.
4. Solution of a non-linear equations using bracketing and Newton-Raphson method.
5. Newton's Interpolation, Lagrange Interpolation.
6. Numerical integration: Trapezoidal Rule, Simpson's 1/3 rule.
7. Euler method
8. Runge-Kutta methods for ODEs
9. Solution of system of ODEs using simple methods
10. 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 Computer Applications, McGraw 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. Press et. al., Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Course outcomes:

Students will able to

- Define the methodologies to handle engineering problems numerically.
- Identify the pertinent parameters of different engineering problems using suitable methods.
- Implement a preferable method to handle the different engineering problem.
- Differentiate the engineering problem critically.

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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**	**4-0-0**	**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:

1. 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. **(5L+1T)**

2. Vector and Tensor Analysis: Basic concepts. **(4L+2T)**

3. Basics of momentum transport: Euler/Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor. **(3L+1T)**

4. Shell momentum balances, 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. **(9L+3T)**

5. Basics of energy transport, conductive, convective and viscous dissipation energy fluxes. **(3L+1T)**

6. 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. **(9L+3T)**

7. Basics of mass transport, mechanisms, and mass and molar fluxes. **(3L+1T)**

8. 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.

(6L+2T)

9. Unsteady-state momentum, heat and mass transport, formulation of basic equations and similarity transform method. **(3L+1T)**

Total: 60(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 with

- the analogies and the theoretical relations between Momentum, Heat and Mass Transport
- the shell balances to solve transport problems
- the technique to formulate and solve one-dimensional transport problems by using the conservation equations
- the technique to formulate simple multi-dimensional transport problems the application of energy balances and rate equations, Dimensional analysis ,equations of Continuity to develop various heat and mass transfer model and to solve Chemical Engineering real problems concern with Transport phenomena

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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 including heat effects, Interpretation of Rate data and Design and Rating of Reactors involving multiple reactions including heat effects
- 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:

1. Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory **(4L+2T)**
2. Ideal reactors - generalized material balance, design equations, graphical interpretation **(2L+1T)**
3. Sizing and analysis of ideal batch, mixed (CSTR), plug flow semi- batch and recycle reactors - solving design equations for constant and variable density systems, reactors in series and parallel **(6L+2T)**
4. Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis **(4L+2T)**
5. Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions **(4L+2T)**
6. RTD theory and analysis of non-ideal reactors **(5L+2T)**
7. 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 **(3L+1T)**
8. TGA, XRD, FTIR, TPD, XPS, BET-BJH for catalyst characterization (**2L**)
9. Kinetics of solid catalyzed gas phase reaction **(5L+1T)**
10. Laboratory reactors for catalytic gas solid reactions. Design concepts **(3L+1T)**
11. Mass transfer, Diffusion and Chemical reactions in catalysts. Effects of external mass transfer and heat transfer, Effectiveness factor. Design aspects of catalytic reactors. **(7L+1T)**

Total: 60 (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 to

- Define the analysis of kinetic data to get the kinetic rate expressions for different types of reactions.
- Explain different types of reactors and the determination of their performance equation
- Demonstrate the use of catalyst in the design of different reactors
- Compare the effect of non-ideality and non-isothermal condition in reactors and select the design to solve the problems related to kinetics and reactor

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC – CHE - 503**	**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 equipments involved in separation processes like absorption, distillation, humidification and dehumidification.

Contents:

1. **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. **(7L+2T)**
2. Mass-transfer coefficients; Dimensionless groups in mass transfer; Diffusion in solids. Theories of mass transfer (Film theory, Penetration theory, Surface renewal theory); Analogy between momentum, heat and mass Transfer; Inter-phase mass transfer theory; overall and local mass transfer coefficients. **(4L+2T)**
3. **Equipment for Gas-Liquid Operations:** Selection of equipment for mass transfer operation. **(1L+1T)**

4. **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. **(9L+3T)**
5. **Humidification & Dehumidification Operations:** Principles of Humidification & Dehumidification; Characteristics of saturated and unsaturated vapor- gas mixtures (humidity, percentage saturation, relative saturation, humid volume, humid heat, enthalpy, adiabatic saturation curve, wet bulb temperature, Psychrometric chart and its use). **(4L+2T)**
6. Types of cooling towers, Design of water cooling towers, Make up water calculation of cooling tower, Dehumidifier design concept, Adiabatic humidifier. **(7L+2T)**
7. **Distillation:** vapor-liquid equilibrium; relative volatility, azeotropism, steam distillation; Single stage flash distillation; Simple distillation (Rayleigh Equation), multistage fractionating column design using McCabe Thiele & Ponchon-Savarit method; Azeotropic, extractive distillation. **(13L+3T)**

Total: (45 L+15T)

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).

Course Outcomes:

Student will be able to

- Explain the industrial applications of mass transfer operations and various principles of mass transfer.
- Solve problems related to diffusion, convective and interphase mass transfer.
- Classify and compare performances of some mass transfer equipments related to absorption, distillation and humidification.
- Solve problems related to design calculation of absorption, distillation and humidification equipment.

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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 principle of Unit operation
- Acquaint with fundamentals of food engineering and its process
- Understand the basics of designing of food plant and systems

Contents:

1. Principles of Food Processing, Food Chemistry, Food Microbiology, Food Biology. **(10L)**
2. Food Quality- Analysis & Assurance, Processing of Fruits & Vegetables, Processing of Milk & Milk Products. **(13L)**
3. Processing of Cereals, Pulses & Oilseeds, Processing of Meat, Fish & Poultry Products, Engineering Properties of Food Materials, Food Additives, Food Plant Sanitation. **(12L)**
4. Packaging of Food Products, Marketing Management and Food Product Development. **(10L)**

Total: 45 (L)

Text Books:

1. Textbook of Food Science and Technology – A. Sharma.
2. Food Processing and Preservation -B. Sivasankar
3. Food Science & Technology – B.K.Sakhale & N.A.Giri

Reference Books:

1. Introducing Food Science – Robert L. Shewfelt, Alicia Orta-Ramirez &A.D. Clarke
2. Textbook of Human Nutrition–Anjana Agarwal & Shova A. Udipi
3. Research papers

Course Outcomes:

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

- Recall the relationship between food, nutrition and health.
- Explain digestion, absorption, functions and food sources of various nutrients.
- Implement the concept of balanced diets and menu planning.

- Defend different methods of cooking and ways to prevent nutrient losses.

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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:

1. 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 crop. **(5L)**
2. Nutrient contents of fertilizers; Bio-fertilisers, Nutrient - Secondary nutrients and micronutrients; Fluid fertilizers, Granular fertilizers, Controlled release fertilizers, Slow release fertilizers **(5L)**
3. 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, Their methods of production, Characteristics and specification, Storage and handling. **(10L)**
4. Phosphatic Fertilizers: Raw materials – phosphate rock, sulphur, pyrites etc. Processes for the production of sulphuric and phosphoric acids. Phosphatic fertilizers – ground rock phosphate, bone meal – Single superphosphate, Triple superphosphate, thermal phosphates – their methods of production, characteristics and specifications. **(10L)**
5. Potaasic fertilizers: Potassium Chloride, Potassium sulphate, Potassium magnesium sulphate, Potassium hydroxide, Potassium nitrate – Methods of production: their characteristics and specifications. **(5L)**
6. NPK fertilizers: Urea ammonium phosphate, ammonium phosphate sulphate, Nitro-phosphates, and various grades of NPK fertilizers produced in the country. **(5L)**
7. Pollution from fertilizer industry, Solid, liquid and gaseous pollution control and standards. **(5L)**

Total: 45 (L)

Text Books:

1. Handbook 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, 3 rd ed., East West Press, India, 2010.
2. Austin T.G., Shreve's Chemical Process Industries, 5 th ed., Tata McGraw-Hill Education Pvt. Ltd, USA, 2012.

Course Outcomes:

Students will be able to:

- Select reactions and unit operations steps in manufacturing of various fertilizers.
- Demonstrate fertilizers on the basis of different properties.
- Identify engineering problems in fertilizer manufacturing.
- Examine appropriate synthesis and handling the fertilizers.

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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:

1. Brief History and Survey of Petrochemical Industries in India. Petrochemical Industries & their feed stocks: 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. Make a comparative study among LNG, CNG, NGL, LPG. Production and Utilization of Synthesis gas: Process of Synthesis gas production by steam

reforming of Natural Gas and Naphtha and partial oxidation of Fuel Oil. Production of Methanol from Synthesis gas. Chemicals from Synthesis gas by Oxo synthesis. Production of liquid fuels from Synthesis gas by Fischer Tropsch process. Different types of storage vessels, Fixed roof. Floating roof type. **(10L)**

2. 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. **(10L)**
3. 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. **(10L)**
4. Synthetic Detergents: Classification of detergents. Production of Linear Alkyl Benzene (LAB) from Superior Kerosene and Benzene. Sulphonation of LAB for production of Synthetic Detergents. Additives for synthetic detergents. Hard and soft detergents. **(5L)**
5. 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. **(10L)**

Total: 45(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 to

- Memorize different petrochemicals products, their properties and reaction fundamentals.
- Identify the engineering problem during producing petrochemicals product.

- Implement the process for the petrochemicals product production with consideration of public health, safety and different environmental regulations.
- Compare different petrochemical products and their processing.

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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.

Contents:

1. Characterization of engineering materials: Structure of engineering materials (Crystal structure, Microstructure, Molecular structure of organic polymers and glasses); Determination of mechanical properties: The tensile test, Bend testing ,Statistics of brittle fracture , Hardness testing , Fracture toughness testing, Time-dependent mechanical properties. **(7L)**
2. Metals and alloys:-General strengthening mechanisms: the effect of processing. The families of engineering alloys. **(3L)**
3. Corrosion -Corrosion Principles and types of Corrosion, Impact on economy, 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. **(8L)**

4. Glasses and ceramics: -types of ceramic crystral 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.**(7L)**
5. Minerals and extraction of iron, aluminum, magnesium copper & gold, Electrometallurgy, surface finishing, selection of materials of constructions: cantilever, pressure vessels, design and corrosion factor for chemical contact, water pipelines, crude oil pipelines. **(6L)**
6. Organic polymeric materials: Forming processes for polymers, Directionality of properties, Mechanical properties, joining of polymers, Polymer degradation. (**3L**)
7. Polymer composite materials: Various types of engineering composites; factors influencing composite properties; role of reinforcement, matrix phase and reinforcement-matrix interface strength on composite behavior; key design consideration of composites; selection criteria of fillers; various methods of polymer composites preparations; Nano-composite materials: Nanomaterials classifications depending on location and based on the number of dimensions; approaches for the nanomaterial preparations, nano-fillers, recent advancement in technology.**(7L)**
8. Biomaterials: importance of biomaterials; materials for synthesis and application; key role of chemical engineers**.(4L)**

Total: 45(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., 3 rd 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, 2 nd 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, 5 th Edition, 2003.

Course outcomes:

Students will be able to

- Select methods of characterization of engineering materials
- Classify of materials, including polymers and composites on the basis of their properties characterization, and applicability in engineering applications
- Identify materials for applications in chemical process industry
- Analyze the interactions between materials of construction of equipment and the chemicals processed

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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:

1. 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. **(10L)**
2. Area of application of light energy, solar photovoltaic, solar thermal applications and technologies, solar appliances, weather dependency, economics and hazard. **(15L)**
3. Area of application of wind energy, trend and future, solar turbine technologies, technological solutions of technology in weather crisis, economics and hazard. **(10L)**
4. 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 .
5. Hydrogen energy roadmap, hydrogen production processes, hydrogen storage and hydrogen transport. **(8L)**
6. Fuel cell, fuel cell types, fuel cell components, fuel cell design, fuel cell operation and performance. **(10L)**

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:

- memorize the environmental aspects of conventional and non-conventional energy resources.
- Summarize the need of different types of renewable energy resources, historical and latest developments.
- 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.
- Appraise the performance of various futuristic approaches of exploration of environmentally benign energy sources and appliances.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Humanities and Social Science Courses	**HM – HU - 501**	**Economics for Engineers**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the student to:

- Make fundamentally strong base for decision making skills by applying the concepts of economics.
- Educate the students on how to systematically evaluate the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.
- Prepare engineering students to analyze profit/revenue data and carry out make economic analysis in the decision making process to justify or reject alternatives/projects.

Contents:

1. Economic Decisions Making – Overview, Problems, Role, Decision making process. **(4 L)**
2. Engineering Costs & Estimation – Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental Costs, Cash Costs vs. Book Costs, Life-Cycle Costs; Types Of Estimate, Estimating Models - Per-Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve, Benefits. **(5 L)**
3. Cash Flow, Interest and Equivalence: Cash Flow – Diagrams, Categories & Computation, Time Value of Money, Debt repayment, Nominal & Effective Interest. **(4 L)**
4. Present Worth Analysis: End-Of-Year Convention, Viewpoint Of Economic Analysis Studies, Borrowed Money Viewpoint, Effect Of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives. **(4 L)**

5. Cash Flow & Rate Of Return Analysis – Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate Of Return, Calculating Rate Of Return, Incremental Analysis; Best Alternative Choosing An Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity And Breakeven Analysis. Economic Analysis In The Public Sector - Quantifying And Valuing Benefits & drawbacks. **(5 L)**
6. Uncertainty In Future Events - Estimates And Their Use In Economic Analysis, Range Of Estimates, Probability, Joint Probability Distributions, Expected Value, Economic Decision Trees, Risk, Risk vs. Return, Simulation, Real Options. **(5 L)**
7. Depreciation - Basic Aspects, Deterioration & Obsolescence, Depreciation And Expenses, Types Of Property, Depreciation Calculation Fundamentals, Depreciation And Capital Allowance Methods, Straight-Line Depreciation Declining Balance Depreciation, Common Elements Of Tax Regulations For Depreciation And Capital Allowances. **(5 L)**
8. Replacement Analysis - Replacement Analysis Decision Map, Minimum Cost Life Of A New Asset, Marginal Cost, Minimum Cost Life Problems. **(4 L)**
9. 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. **(5 L)**
10. Accounting – Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation. **(4 L)**

Total: 45(L)

Reference Books:

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

Course Outcomes:

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

- State different problem issues in engineering related to system design, system deployment, project management, etc. and approach towards optimal solution.
- Discuss estimation for short term targets in an industry and compare the actual costs incurred for the same to determine the efficiency of the system and estimation of supply, installation and commissioning in live projects and take necessary measures of cost control.
- Test long term investment decision; select the most profitable project, take decision related to replacement of assets.
- Formulate the financial statements of the company, and determine its financial health.

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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**	**50**	**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, on the basis of human relationships and resolved individuals.
- Strengthening of self reflection and development of commitment and courage to act.

Contents:

1. Introduction: Constitution' meaning of the term,, Indian Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy **(3L)**
2. 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 **(6L)**
3. State Government and its Administration Governor: Role and Position, CM and Council of ministers, State Secretariat: Organisation, Structure and Functions **(6L)**
4. Local Administration District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO Zila Pachayat: Position and role, Block level: Organizational Hierarchy (Different 4.departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy **(8L)**

5. 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 **(7L)**

Total: 30 (L)

Text book and Reference books:

1. 'Indian Polity' 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 should be able to:

- Define the awareness of their surroundings, society, social problems and their sustainable solutions, while keeping human relationships and human nature in mind.
- Explain about making of Indian Constitution - contribution of Constituent assembly on it.
- Implement the Salient (Outstanding) features of Indian Constitution.
- Relate what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

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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**	**Instrumental Method of Analysis Laboratory**	**0-0-3**	**1.5**	**100**	**3**

Course Objectives:

- This laboratory course will help the students to get knowledge about different sophisticated instruments such as electrical conductivity meter, pH meter, turbidity meter, UV spectrophotomer, gas chromatography, etc.
- Students will get idea about the sample collection or preparation for the analysis of unknown solution using these instruments.
- The student should be able to address the problems of analyzing complex samples. This would include defining the problem, determining any constraints, choosing the best methodology, and determining how to test the methodology to prove its merits. Where there are alternatives the student should be able to define the advantages and disadvantages of each.

At least six experiments are to be performed

Experiments:

1. Determination of electrical conductivity of sample water using conductivity meter.
2. Determination of pH of sample water using pH meter
3. Determination of Turbidity of Water using NepheloTurbidity Meter.
4. Kinetic study of biochemical reaction by UV Spectrophotometer.

5. Determination of Fe^{3+} by Colorimeter Method.
6. Demonstration of working of HPLC/FTIR.
7. Separation of Mixture of Lipids by Thin Layer Chromatography.
8. Construction of standard curve (Absorbance vs. concentration) of a pure protein by Folin's Method using Spectrophotometer.
9. Estimation of an organic mixture (benzene &toluene) by Abbe refractometer.
10. Determination of any optically active substance in the presence of non-active species by a polarimeter.
11. Demonstration of analysis of gases by gas chromatography.
12. Study of migration of proteins by electrophoresis.

Course Outcomes:

From this laboratory course students would be familiar with

- Different analytical techniques for analyzing different parameters of unknown samples.
- Handling of different sophisticated instruments and its characterization techniques.
- To develop the knowledge of design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- To expand skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**PC – CHE - 592**	**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 non catalytic 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 non catalytic 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 to

- define the unsteady state reactors and study its performance during experiment.
- explain all stages of experiment for the steady state tank type or straight tube type reactors. While conducting the experiment, the student will be able to exercise and illustrate tidiness, safety in the laboratory and cleanliness of the lab area.
- use and analyze the raw data generated, including units in the title of data table for the steady state reactors and formulate the data in ways (charts, tables, graphs) that best facilitate interpretation.
- differentiate the operation of various reactors and kinetics in various reactors.

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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**	**1.5**	**100**	**3**

Course Objectives:

The objective of this course is to

- acquire basic understanding of design parameter, Familiarize standard symbols of process flow diagrams and Learn basic symbols used instrumentation diagrams
- complete knowledge of design procedures for commonly used process equipment and their attachments, and to know the selection of material of construction.
- Know detailed dimensional drawings including sectional front view, Full Top/side view depending on equipment.

Content:

1. Introduction to basic knowledge of flow meter and process design of Orifice meter, Venturimeter, Rotameter. **(3 L)**
2. Mechanical design, materials of construction, and drawing of Orifice meter / Venturimeter / Rotameter. **(6 L)**
3. Introduction to basic knowledge of Heat exchanger, types of heat exchanger etc. **(3 L)**
4. Complete process design and mechanical design of Shell & tube heat exchanger. **(9 L)**
   - 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
5. Introduction to basic knowledge of Evaporator, types evaporator etc. **(3 L)**
6. Process design and mechanical design of Multi effect evaporator. **(6 L)**
   - Introduction to standards, codes and regulations.
   - Selection of material and design of various parts of Evaporator.
   - Detailed Design of Multi effect evaporator

7. Drawing of Shell & tube heat exchanger and Multi effect evaporator. **(6 L)**

Each student have to prepare design report and engineering drawing of the equipment and submit the design report in tight and bound form 7 days before commencement of 5th semester examination. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by departmental examiners.

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 by James R. Couper.

Course Outcomes:
Student will be able to

- define the concept of design of process equipment.
- explain the useful guideline in designing process equipment.
- demonstrate the various principles of design relevant to the various unit operation equipment.
- develop the skill to represent the process and mechanical design of specific equipment as well as the requisite accessories using engineering drawing tools.

Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Core Courses	**SI – CHE 591**	**Industrial Internship-I**	**0-0-30**	**4**	**100**	**30**

Course Objectives:
The objective of this course is to

- Provide exposure to students to specific engineering practices in the respective fields and types of industries selected.
- Provide exposure to students to responsibility of becoming an engineer and the profession of engineering.
- Instill communication skills in engineering which include daily interaction with the working environment and technical writing.

Contents:

Students should work in the industry/laboratories as trainees so that they are able to acquire different learning out comes to demonstrate the course outcomes. Industrial training is a training scheme by which a student can undergo practical training within an industrial undertaking having specified amount of fixed assets or turnover or paid-up share capital.

Course Outcomes:
Student will be able to

- Memorize the basic concepts of Project & Production Management.
- Implement Project Planning in their Industrial In-plant Training Project work.
- Recognize the concept of Facility, Location & Layout & implement in their Industrial In-plant training Project work.
- Differentiate the impact of engineering solutions and industrial safety in a global and social context.

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**	**Process Technology and Economics**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

The objective of this course is to:

- Introduce about Basic concepts chemical process technology
- Study the different process principals and technologies
- Teach the strategies to analyze major engineering problems
- Study the basics of engineering economics

Contents:

1. 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: inorganic acids, chlor-alkali, ammonia, fertilizers, etc. **(10L)**
2. Growth, Measurement of microbial growth (direct), Measurement of microbial growth (indirect), Kinetics of cell growth in batch culture, Continuous culture. **(5L)**
3. Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Petrochemicals: C1, C2, C3, C4, etc., benzene, toluene, xylene and other petrochemicals from these basic building blocks **(10L)**
4. Industrially relevant fuels, coal, coal based chemicals and fuels Common utilities such as electricity, cooling water, steam, hot oil, refrigeration and chilled water. **(5L)**
5. Introduction to project cost and cost of production, Various components of cost of production and their estimation, Various components of project cost and their estimation. Estimation of working capital. **(7L)**
6. Analysis of working results project: Balance sheets, Project financing, concept of interest, time value of money, depreciation. Profitability Analysis of Projects. **(8L)**

Total: 45(L)

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., MacMillan 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 able to:

- List various manufacturing processes used in chemical process industries
- solve major engineering problems encountered in chemical process industries
- Determine process aspects like yield, byproducts formed, generation of waste
- Judge balance sheets, profitability and economic aspects of different process, etc.

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Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/ week
Professional core courses	**PC – CHE - 602**	**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 equipments/devises.
- To apply the design principles for mass transfer devices/equipments.

Contents:

1. **Liquid-liquid Extraction:** Introduction; Equilibrium data representation; selectivity and choice of solvent; Stage-wise contact; Method of calculation for single stage, Multistage Crosscurrent and Counter-current operation by graphical methods; Extraction efficiency; Types of extraction equipments. **(9L+3T)**
2. **Leaching:** Introduction to leaching; Factors affecting the rate of leaching; Equilibrium data representation; Method of stage calculation; Leaching Equipments. **(6L+2T)**
3. **Drying:** Introduction; Theory and mechanism of drying, classification and selection of dryers; Calculation of rate of drying and time of drying for batch and continuous dryers. **(6L+2T)**
4. **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; Equipments. Biosorption and biochar basics with applications. **(9L+3T)**
5. **Crystallization:** Introduction to crystallization; Theory of crystallization; Formation and growth of crystals; Batch and continuous Crystallizers; Design calculations for crystallizers. **(6L+2T)**
6. **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. **(9L+3T)**

Total: 60 (L+T)

Text books

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

Reference books:

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

Course Outcomes:

Student will be able to:

- Describe various types of mass transfer operations.

- Demonstrate and analyze mass transfer phenomenon in various systems.
- Solve problems pertaining to mass transfer operations like extraction, leaching, adsorption, drying, and crystallization.
- Identify and implement the suitable membrane separation technique for intended problem.

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Core Elective II	PEC – CHE – 601A	PEC – CHE – 601B	PEC – CHE – 601C
Name of the Subject	Project Engineering	Nano science 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:

1. Role of a project engineer, 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 L)**
2. Time value of money, simple interest, Nominal & effective interest rates, continuous interest, present worth & discount, Annuities, perpetuities and capitalized cost. **(5L)**
3. Depreciation**:** Types of depreciation, Depletion, Concepts of service life, Salvage value and Book value; Depreciation calculation by straight line method, Text book and double declining balance method, sum-of-the-years digit method and sinking fund method. **(7L)**
4. Profitability analysis method: Return on investment (ROI), payout period, Net present worth (NPW), Discounted cash flow rate of return, (DCFR), effect of inflation on profitability,

Alternative investment, Choices among various alternatives, Replacements, Methods of profitability evaluation for replacements. **(8L)**

5. 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. **(7L)**
6. 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. **(8 L)**

Total: 45 (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. PERT CPM, L. S. Srinath, East West Press

Course Outcome:

Students will able to:

- Define the basic principles of project engineering and its objectives.
- Explain the relevant methodologies of project management and parameters.
- Execute the different case studies of projects as well as different calculations.
- Examine the optimum design parameters.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC – CHE – 601B**	**Nano science 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:

1. 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. **(8L)**
2. Synthesis of nanomaterials: General approaches (Top-down and Bottom-UP), Physical Methods, Chemical Methods, Biological Methods, hybrid methods. **(8L)**
3. Characterization techniques of nanomaterials: Microscopy, Spectroscopy and Diffraction techniques. **(7L)**
4. Some special nanomaterials: Fullerene, Carbon nanotubes, Nanowires, Quantum dots, Core-shell nanoparticles, Doped nanoparticles. **(7L)**
5. Properties of nanomaterials: Mechanical, Structural, Thermal, Electrical & Optical properties. **(7L)**
6. Applications of nanomaterials: Nanolithography, Nanoparticles as catalyst, Drug delivery, Bio-imaging, Nanomedicines, Sensor applications. **(8L)**

Total: 45 (L)

Text Books:

1. NANOTECHNOLOGY: Principles & Practices; Sulabh K. Kulkarni, Capital Publishing Company, Kolkata.
2. Nanoscience and Nanotechnology: Fundamentals of Frontiers, M. S. Ramchandra Rao, S. Singh, Wiley, 2013.
3. Introduction to Nanotechnology, C. P. Poole Jr., F. J. Owens, Wiley, 2007.

Reference Books:

1. Principles of nanotechnology: N. Phani kumar; Scitech, Kolkata.
2. Introduction to nanotechnology: Charles P. Poole & Frank Li Owens, Wiley India (p) Ltd, New Delhi.

Course outcomes:

On completion of the course, students would be familiar with:

- Fundamentals of nanomaterials and structure and bonding of materials
- Different synthesis approaches of nanomaterials
- Characterization techniques of nanomaterials
- Specific properties of the nanomaterials and its applications

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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:

1. **Basic Concepts:** Concepts and classification of polymers, Functionality, Structure and property relationship. **(5L)**
2. **Polymerization Mechanism &Synthesis:** Step-growth and chain-growth polymerization; Polydispersity, concept & significance of molecular weight averaging; Bulk, solution, emulsion and suspension polymerization; Comparison of polymerization processes. **(7L)**
3. **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, Inhibition and retardation, kinetics of copolymerization. **(8L)**
4. **Polymer Rheology:** Viscoelastic behavior, Flow curve concept, Melt & solution viscosity; Melting temperature & Glass transition temperature; Melt instability & Melt flow index. **(5L)**
5. **Polymer Characterization:** Chemical properties, Thermal properties & its measurement, Mechanical properties & morphology. Outlines of polymer blends & composites **(7L)**
6. **Polymer Degradation:** Factors affecting polymer stability; Thermal degradation, mechanical degradation, Chemical degradation, Hydrolysis, oxidative degradation & Ozonolysis; Stabilization. **(7L)**
7. **Polymer Processing:** Polymer compounding ingredients; compression, transfer, injection, jet & blow molding; casting; extrusion, calendaring, lamination, spinning & finishing. **(6L)**

Total: 45(L)

Text Books:

1. Text Book of Polymer Science, F. W. Billmeyer, John Wiley, New York 2. Polymer Science & Technology, P.Ghosh, TMC

2. 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:

Students will be able to:

- Match the relationship between polymer properties (thermal, rheological, mechanical), and polymer microstructure and molecular weight.
- Explain methods for determining the microstructure and molecular weight of polymers and describe the significance of polymer solubility, melting point and glass transition temperature.
- Describe different types of polymerization process, and the significance in each of: initiation, propagation, termination, branching; and, for copolymerization, reactivity ratios and monomer ratio.
- Analyze polymer properties to their processing and uses.

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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 sysytem

Contents:

1. **Introduction**: Introduction to Cryogenic Engineering and its applications. Properties of Cryogenic Fluids, Superfluid and Supercritical fluids and also behavioural changes of Solids at low temperatures. **(5L)**
2. **Refrigeration, Liquefaction Refrigeration and Liquefaction Principles**: Joule-Thomson Expansion, Isentropic Expansion, Cascade Processes, Ortho-Parahydrogen Conversion, Ultra-Low-Temperature Refrigerators, Thermodynamic Analyses of Systems. **(10L)**
3. **Equipment Associated with Low-Temperature Systems**: Heat Exchangers, Compressors, Expanders, Effects of Component Inefficiencies, System Optimization. **(6L)**
4. **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). **(12L)**
5. **Cryogenic Special**: Hydrogen Separation Systems, Helium Separation Systems, Liquefaction of Natural Gas (LNG), Storage and Transfer Systems, Insulation Concepts. **(12L)**

Total: 45 (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, McGraw Hill, 1985.
4. R.B.Scott, Cryogenic Engineering, Van Nostrand and Co., 1962.

Course Outcomes:

Students will be able to:

- Understand the various cryogenic process principles and behaviours of materials at cryogenic temperatures.
- Apply to solve problems of separation and purification of cryogenic fluids.
- Evaluate eventuality of choosing equipment/ materials at cryogenic conditions.
- Create / formulate devices which can smoothly work at cryogenic conditions.

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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

Contents:

1. Types of Bioreactor, Heat transfer, Scale – up, Airlift Bioreactors, Introduction, Design and construction of the airlift – loop reactor, Hydrodynamics, Three – phase flow, Mixing, Oxygen transfer. **(10L)**
2. Growth, Measurement of microbial growth (direct), Measurement of microbial growth (indirect), Kinetics of cell growth in batch culture, Continuous culture. Microbial Fermentation, Design of Chemostat. Design of Batch Fermentor, Mixed flow reactor and Plug flow reactor. **(8L)**
3. Introduction, Mass transfer, Theory of mixing, Rheological properties, Bioreactor sensor characterizes, Temperature measurement control, principles of dissolved oxygen measurement and control, principles of PH / redox measurement and control, deduction and prevention of foam, determination of biomass and application of biosensors **(10L)**
4. Study of structured models for analysis of various bioprocesses – compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model. **(7L)**
5. Modeling, digital simulation, formulation and solution of problems by simulations, digital simulation programming languages, ISIM (interactive simulation language) Plant cells, Animal cells. **(10L)**

Total: 45(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, McGraw–Hill, 1988.

Course Outcomes:

Students will be able to:

- define microbial growth, fermentation, culture medium based on nutritional requirements of microbial cells.
- explain design criteria for medium sterilization and solve problems involving both batch and continuous sterilization.
- Apply the principles of microbial growth kinetics in bioreactors.
- Analyze bioreactor performance applying strategies for fermentation control, mass and heat transfer correlations to bioreactor design and modern bioengineering equipments.

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Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/ week
Humanities and social science courses	**HM – HU - 601**	**Principles of management**	**3-0-0**	**3**	**100**	**3**

Course objectives:

- To develop the knowledge of different fictional levels of management
- To enable the students to learn about the different personal management attributes
- To enable students to learn about management in technology, operations and in market.

Contents:

1. Basic concepts of management: Definition – Essence, Functions, Roles, Level.**,** Functions of Management : Planning – Concept, Nature, Types, Analysis, Management by objectives; Organisation Structure –Concept, Structure, Principles, Centralization, Decentralization, Span of Management; Organisational Effectiveness. **(7 L)**
2. Management and Society – Concept, External Environment, CSR, Corporate Governance, Ethical Standards.
   People Management – Overview, Job design, Recruitment & Selection, Training & Development, Stress Management, job satisfaction **(7 L)**
3. Personality and attitudes: Meaning of personality, Personality determinants and traits, Development of personality, types of attitudes. **(5 L)**
4. Managerial Competencies – Communication, Motivation, Team Effectiveness, Conflict Management, Creativity, Entrepreneurship,
   Leadership: Concept, Nature, Styles,
   Decision making: Concept, Nature, Process, Tools & techniques.
   Group behavior: Characteristics of group, Types of groups, Stage of group development, group decision making.
   Communication: Communication process, Direction of communication, Barriers of effective communication. **(12 L)**
5. Economic, Financial & Quantitative Analysis – Production, Markets, National Income Accounting, Financial Function & Goals, Financial Statement & Ratio Analysis, Quantitative Methods – Statistical Interference, Forecasting, Regression Analysis, Statistical Quality Control.
   Customer Management – Market Planning & Research, Marketing Mix, Advertising & Brand Management.
   Operations & Technology Management – Production & Operations Management, Logistics & Supply Chain Management, TQM, Kaizen & Six Sigma, MIS. **(7 L)**

6. Conflict management: Traditional vis-à-vis, modern view of conflict, functional and Dysfunctional conflict, conflict process, Negotiation- Bargaining strategies, Negotiation Process. **(7 L)**

Total: 45 (L)

Text and reference books:

1. Principle of Management-Premvir Kapoor, Khanna Publishing House, 2019
2. Management: Principles, Processes & Practices – Bhat, A & Kumar, A (OUP).
3. Essentials for Management – Koontz , Revised edition, Tata McGraw Hill(TMH)
4. Management – Stoner, James A. F. (Pearson)
5. Management - Ghuman, Tata McGraw Hill(TMH)

Course Outcomes:

Students will be able to:

- Define managerial functions like planning, and have same basic knowledge on international aspect of management.
- Demonstrate the planning process in the organization.
- Apply the concept of organization.
- Assume the ability to directing ,leadership and communicate effectively

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Mandatory Non Credit Course	**MC – CHE - 601**	**Essence of Indian Traditional Knowledge**	**2-0-0**	**0**	**50**	**2**

Course Objectives:

This course prepares the student to:

- Impart the basic principles of thought process, reasoning and inferencing. Sustainability is at the core of Indian Traditional Knowledge Systems connecting society and nature.
- Holistic life style of Yogic-science and wisdom capsules in Sanskrit literature is also important in modern society with rapid technological advancements and societal disruptions.
- Introduce to Indian Knowledge System, Indian perspective of modern scientific world-view and basic principles of Yoga and holistic health care system.

Contents:

1. Basic structure of Indian Knowledge System (i) Veda, (ii) Upaveda(Ayurveda, Dhanurveda,Gandharveda, Sthapatyaveda) (iii)vedanga (Shiksha, Kalpa, Nirukta, Vyakaran, Jyotisha, Chhanda), (iv) Upanga (Dharma Sartra, Mimamsa, Puran, Tarkasastra) **(8L)**
2. Modern Science and Indian Knowledge System **(7L)**
3. Yoga and Holistic Health care **(7L)**
4. Case studies **(8L)**

Total: (30L)

Text/Reference Books:

1.V. Sivaramakrishna (Ed.), Cultural Heritage of India-Course Material, Bharatiya Vidya Bhavan, Mumbai, 5th Edition, 2014

2. Swami Jitatmanand, Modern Physics and Vedant, Bharatiya Vidya Bhavan

3.Fritz of Capra, Tao of Physics

4. Fritz of Capra, The wave of Life

5. V N Jha (Eng. Trans,), Tarkasangraha of Annam Bhatta, Inernational Chinmay Foundation, Velliarnad, Amaku,am

6. Yoga Sutra of Patanjali, Ramakrishna Mission, Kolkatta

7. GN Jha (Eng. Trans.) Ed. R N Jha, Yoga-darshanam with Vyasa Bhashya, Vidyanidhi Prakasham, Delhi, 2016

8. RN Jha, Science of Consciousness Psychotherapy and Yoga Practices, VidyanidhiPrakasham, Delhi, 2016

9. P R Sharma (English translation), ShodashangHridayam

Course Outcomes:

Student will be able to

- Memorize the basics of Indian traditional knowledge in modern scientific perspective and describe the philosophy of Indian culture.
- Explain the philosophy of ancient, medieval and modern India.
- Implement the Indian languages and literature and distinguish the information about the fine arts in India and
- Defend the contribution of scientists of different eras

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<u>Practical/Sessional papers</u>

Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/ week
Professional core courses	**PC – CHE - 691**	**Mass Transfer I 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 laboratory experiments: (at least eight experiments are to be conducted)

The list 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 different periods of drying.
5. Experimentation on Forced Draft Tray Dryer to study the drying characteristics curve at different periods of drying.
6. Experimentation on Othmer Still for boiling point diagram and equilibrium diagram of a binary liquid 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, Multicomponent Mass Transfer, John Wiley, New York , 1993

Course Outcomes:

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

- **Recall** and **relate** the previously learned engineering /basic science concepts or knowledge with the major mass transfer operations.
- **Interpret** the experimental data on the basis the fundamentals of experimented mass transfer operations.
- **Apply** basic design principles for mass transfer equipments to s**olve** primarily any complex mass transfer problem facing in day to day life by industry.
- **Examine** and **classify** the causes of technical problem during experimentation in various mass transfer areas.

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Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/ week
Professional core courses	**PC – CHE - 692**	**Process equipment design and drawing - II**	**0-0-3**	**1.5**	**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.
- 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.

Introduction to the basic principle of 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/Absorption tower/ Dryer.(Any one)
   Introduction to the basic principles distillation process and its applications, Design of distillation column with its process design and mechanical design and various parts of column and drawing of internals of distillation column. Design of supports for vertical and horizontal towers.
   Mechanical drawing of Distillation column

Each student shall be allotted design problems on sl. no 1& 2 at the beginning of the 6th semester and the student shall carryout complete process and mechanical design under supervision of a faculty member. The student shall also prepare engineering drawing of the equipment and submit two copies of the design report in tied and bound form 7 days before commencement of 6th semester examination. 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 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.

Course outcomes:

Student will be able to:

- Define the concept of design of process equipment and explain the useful guideline in designing process equipment.
- Interpret the various principles of design relevant to the various unit operation equipment
- Compare the process and develop mechanical design output as well as the requisite accessories using engineering drawing tools.
- Select the design and fabrication aspects of equipment.

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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 be able to:

- Know how to give a seminar presentation more professionally and to develop their leadership quality through this process.
- Explain any topic in a shorter time to their audience more clearly.
- Improve their overall presentation style and to prepare themselves for participating effectively in class discussion.
- Improve their overall capabilities to make them eligible for the corporate world.

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Detailed Syllabus, B. Tech Fourth year, Semester VII

Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/week
Professional	**PC – CHE -**	**Instrumentation**	**3-1-0**	**4**	**100**	**4**

core courses	**701**	**and process control**				

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 behaviour 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:

1. Introduction: Principles of measurement. Error Analysis, Static and dynamic characteristics of instruments. **(2L)**
2. Temperature measurement: Filled system Thermometer, Thermocouples, Resistance Thermometers, radiation and optical pyrometers **(2L)**
3. 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 (inductive/capacitive). Vacuum gauges: mechanical, electrical and ionization types **(3L+1T)**
4. Flow: Head flow meters, area flow meters, positive displacement flow meters, mass and magnetic flow meters **(2L+1T)**
5. Level: Direct and inferential type; composition. **(2L+1T)**
6. Different forcing functions: Step, Impulse, Ramp, Sinusoidal and frequency inputs & their graphical representation, Laplace transform. **(3L+1T)**
7. First order system; transfer function; response of different forcing functions; two first order systems in series- non- interacting & interacting **(3L+2T)**
8. Second order system: under-damped, critically damped & over damped, Transportation lag. **(3L+2T)**
9. Classical feedback controllers- P, PI, PD, PID & their transfer function, different types of control valves; characteristic curve & transfer function **(3L+1T)**
10. Development of block diagrams, block diagram reduction techniques **(3L+1T)**
11. Closed loop response- servo & regulatory control. **(2L+1T)**

12. 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. **(2L+1T)**
13. Definition of stability, concept of unbound function, Routh stability criterion, Routh Array Root locus diagrams (rule based) **(4L+2T)**
14. Introduction to frequency response, Bode stability analysis, Nyquist stability criteria **(3L+1T)**
15. Controller tuning: Zeigler-Nichols controller settings **(3L)**
16. Introduction to advanced controllers: cascade control, feed forward control, ratio control, Adaptive & digital control. **(3L)**
17. Concept of PLC & DCS. **(2L)**

Total: 60 (L+T)

Referrence 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 be able to:

- define the working principles of the measuring instruments.
- discuss different types of forcing functions and the systems encountered in operations.
- illustrate different types of controllers, control valves and mode of control operations.
- differentiate different controllers, control strategies in different unit processes and also analyze the stability of the control system and controller tuning.

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Core Elective III	**PEC – CHE – 701A**	**PEC – CHE – 701B**	**PEC – CHE – 701C**

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 – 701A	Biotechnology and Biochemical Engineering Technology	3-0-0	3	100	3

Course Objectives:

- Knowledge of this paper helps them competent to analyse problems in fermentation plant and to rectify defects.
- It also help 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 these knowledge in any fermentation industry.

Contents:

1. Introduction to industrial microbiology; Production of organic acids(vinegar, lactic acid), Recombinant DNA technology, Enzyme Immobilization **(7 L)**
2. Propagation of baker's yeasts: single cell protein; Microbial production of vitamins (B_2 and B_{12}), antibiotics (penicillin,streptomycin) **(10 L)**
3. 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 bio process. **(10 L)**
4. Bio-product recovery: Downstream processing-separation process for cell mass and product, filtration, centrifuging, membrane process (reverse osmosis, ultra filtration, chromatographic separation) **(10 L)**
5. Bioprocess economics, Cost analysis of alcohol production plant, fermentation plant design project, Bio-product regulation. **(8 L)**

Total: 45 (L)

Text and reference books:

1. Biochemical Engineering Fundamentals: J.E Bailey, D F Olli, MGH
2. Biochemical Engineering: Aiba S; Academia press, NY
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:

- define and review basic principles of industrial microbiology and biochemical engineering for ethanol, antibiotics, organic acids and allied biochemicals through fermentation considering techno-economic feasibility.
- design and develop processes to address problems and find solutions for various bioengineering plants to optimize production of high value biochemicals.
- 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.
- 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.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC – CHE – 701B**	**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: 10 L

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.

Module II: 10 L

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, membrane age, advantages, disadvantages and application of RO process, Numerical problems.

Module III: 10 L

Pervaporation: Theory of Pervaporation, separation factor, factors affecting pervaporation , Osmotic Distillation, advantages of pervaporation, temperature drop at membrane interface, application of pervaporation. Chromatographic Separation: Theory of Chromatographic separation, selectivity or separation factor, Efficiency of chromatographic system, types of Chromatography, Liquid Chromatography, Liquid-Solid Chromatography, High performance liquid chromatography; Advantages & Disadvantages of Chromatographic Separation.

Electrophoresis: Basic principles, Proteins and amino-acids separation; Operation of vertical and horizontal electrophoresis- casting gel, plating, SDS- PAGE Electrophoresis

Module IV: 15 L

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.

Total : 45 (L)

Text books:

1. J.D. Seader and Ernet J. Henlay; Separation Process Principles.

2. Anil K.Pabby, Syed S.H. Rizvi, Ana Maria Sastre: Hand Book of Membrane separations.

Reference books:

1. Membrane Separation Processes by Kaushik Nath

2. Membrane Handbook by Ho and Sircar.

3.Ultrafiltration Handbook by Munir Cheriyan, CRCPress.

4. Practical Biochemistry: Principles & Techniques, Wilson & Walker, 5ed. Cambridge Univ. press

Course Outcomes:

Students will be able to

- Understand and identify different membrane separation processes and assess the life time of membranes under different process environments
- Characterize different types of membranes with the material of construction, advantages and disadvantages of different types of process and its engineering applications.
- Design or modify structure of membrane as per requirements of process and the chemicals involved.
- Gain knowledge about overall concept of membrane separation processes and mathematical modeling of different types of membranes.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	PEC – CHE – 701C	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 characteristic, 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 and also acquainted with the various control methods and equipment required. They can design the appropriate process and equipment for a given industrial pollutant.
- 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.

Contents:

1. Types of emissions from Chemical industries and Effects of environment, Environment legislation **(5L)**

2. 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. **(7L)**
3. Methods of Primary treatments: Screening, Sedimentation, Flotation, Neutralization, and methods of tertiary treatment. **(5L)**
4. Brief studies of Carbon absorption, Ion exchange, Reverse osmosis, Ultra filtration, Chlorination, Ozonation, treatment and disposal. **(5L)**
5. 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. **(8L)**
6. 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. **(7L)**
7. Air pollution control methods and equipments: 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. **(8L)**

Total: 45(L)

Text Book:

1. Environmental Pollution and Control Engineering, Rao C. S., Wiley Eastern Limited, India, 1993.
2. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. Environmental Engineering, McGraw HillInternational (1985).
3. Metcalf & Eddy, Wastewater Engineering, Tata McGraw-Hill Education Private Limited (2009).

Reference books:

1. Pollution Control in Process Industries, S.P. Mahajan, TMH., 1985.
2. Waste Water Treatment, M.NarayanaRao and A.K.Datta, 3rd Edition, Oxford and IHB, 2008.
3. Industrial Pollution Control and Engineering, Swamy AVN, Galgotia publications, 2005.
4. Masters, G.M., Introduction to Environmental Engineering and Science, Prentice Hall off India, (2008).
5. Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern (2010).
6. De Nevers, N., Air Pollution Control Engineering, McGraw-Hill (2000).

Course Outcomes:

Students will be able to

- relate consciousness about the methods for a clean environment.
- classify the different pollutions
- plan for the efficient treatment of effluent streams, (liquids, solids and gaseous streams) and design water / sewage treatment systems at an affordable cost.
- list the effective environmental management policies

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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.

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Contents:

1. 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. **(6 L)**
2. Basic concepts of thermal destruction of microorganisms – lethality, D, Z and F values; assessment of adequacy of thermal processing of food processing operations **(6L)**
3. 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 **(7L)**

4. 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. **(6L)**
5. 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 **(7 L)**
6. Preservationbymicrobialfermentation(principle,types,applications);Chemical preservatives; Bio-preservation; lactic acid bacteria, antibiotics; lantibiotics; Hurdle technology, Principles of preservation by use of sugar and salt, curing, pickling; smoking, Overview of minimal processing **(7L)**
7. NovelNon thermal methods: HPP, ultrasonication, ohmic heating, microwave, pulse delectricfield, pulse dlight, coldplasma, 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. **(6 L)**

Total: 45 (L)

Text and Reference Books:

1. Technology of Food Preservation by Desrosier
2. Handbook of. Food Preservation. Second Edition edited by. M. Shafiur Rahman. CRC 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.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Open	**OEC – CHE – 701B**	**Industrial**	**3-0-0**	**3**	**100**	**3**

Elective Courses		**total quality management**				

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:

1. Basic concepts– Three paradigms of management and evolution of concept of quality management, Organization: its basic objectives and goal, Mission and Vision, customer and secondary customer, Deming's wheel, bottom line: profit vs quality, historical defilements: Juran, Deming, Ischikawa and Taguchi, Kaizen, JIT. Basic statistical concepts associated with quality management, measurement of central tendency and dispersion, range versus variance, quality and process capability, probability distributions, concept of statistical quality control. **(10L)**
2. Use of control charts and process engineering techniques for implementing the quality plan: X—R chart, moving average chart, p-chart, c-chart and control chart for continuous production Acceptance sampling: single–double and multiple sampling, AOQ, AQL, LTPD, Chain sampling plan, Dodge-Romig plan. **(10L)**
3. Tools and techniques for improvement in TQM: type A techniques with a special reference to FPC & FD, QFD, SWOT analysis; type B techniques with a special reference to brainstorming, stratification, Ischikawa diagram, check sheet, Pareto diagram Philosophy and concept of quality circle: formation, steering committee, power and functions of leader, dy. Leader, coordinator, facilitator, case studies. **(15L)**
4. Different 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. **(10L)**

Total: 45 (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 -SK Ghosh, Oxford

Course Outcomes:
Students will be able to:

- Omit the dimensional barrier regarding Quality to match the total quality principles.
- Demonstrate the tools utilization for quality improvement.
- Apply the new decision of principle in real time projects.
- Analyze the various types of techniques are used to measure quality..

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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:

1. Rapid Prototyping- Overview of Rapid Prototyping.
2. Product development process.
3. Design for Modularity (Manufacturing).
4. Subtractive versus Rapid Manufacturing.
5. Reverse Engineering: Use of CMM and 3-D Camera for making virtual model.
6. Powder based processes.
7. Extrusion based processes.
8. Sheet Stacking processes.
9. Beam Deposition processes.
10. 3D printing processes: Basic Process- CAD Model Creation, Conversion to STL format, Slicing the STL File, Layer by layer construction, Clean and finish.
11. Materials in Rapid Manufacturing.
12. Post-processing concerns.
13. Product costing for Rapid Manufacturing.
14. Rapid Product Development, CAE and CIM.

15. Stereo lithography (SLG): Principles, systems, relative advantages and applications.
16. Selective laser sintering (SLS): Principles, systems, relative advantages and applications.
17. Fused deposition modelling (FDM): Principles, systems, relative advantages and applications.
18. Laminated objects manufacturing (LOM): Principles, systems, relative advantages and applications.
19. 3-D Inkjet Printing: Principles, systems, relative advantages and applications.

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),.
3. Patri K. Venuvinod, Weiyin Ma "Rapid Prototyping: Laser-Based and Other Technologies" Springer , 2004
4. Peter D. Hilton, Hilton/Jacobs, Paul F. Jacobs, "Rapid Tooling: Technologies and Industrial Applications", CRC Press, 2000.
5. Burns. M, "Automated fabrication", Prentice-Hall, 1993.

Course Outcomes:

Students will be able to:

- Find geometric transformation techniques in CAD.
- Illustrate mathematical models to represent curves, surfaces and solids.
- Identify STL file problems and apply repair algorithms.
- Categorize part orientation, apply suitable slicing algorithm and generate tool path for minimum build time, support material and part errors.

Open Elective IV	**OEC – CHE – 702A**	**OEC – CHE – 702B**
Name of the Subject	**Statistical quality control**	**Operation research**

Categories	**Course Code**	**Course Title**	**Hours/Week**	**Credit**	**Marks**	**Total**

			L:T:P			contact hours/week
Open Elective Courses	**OEC – CHE – 702A**	**Statistical quality control**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To help students understand the 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.
- 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.

Contents:

1. **Introduction:** Basic concept of quality control, Conformance, Cost of Quality, Value of Quality, Quality Policy, Benefits of SQC, Quality Perspective, modern quality control philosophy. **(7 L)**
2. **Total Quality Management (TQM) :** Concept, Philosophy & Benefits of TQM. Product quality Management, Loss function, Analysis of variance, TQM Models, Benchmarking, Kaizen & Kairyo system. **(7 L)**
3. **Quality Assurance:** Quality Survey, Quality Inspection Planning, Statistical Process Control (SPC), Quality policy deployment, Error proofing. **(7 L)**
4. **Basic Statistical Concept:** Variations, Variables & Attributed data, frequency distribution, Normal curve, Probability & Probability distribution. Binomial distribution. Control charts for variables & attributes, Design-Measure-Analyze-Improve-Control paradigm, methods for describing variation including histograms, stem-and-leaf plots, box plots, discrete and continuous random variables, probability plots **(10L)**
5. **Sampling:** Methods, Sampling planes, Continuous sampling plan, Standard sampling plan, Selection of sampling plan for normal inspection, Acceptance sampling by variables, gauge R&R studies. **(7 L)**
6. **Reliability:** Quality & Reliability, Elements, Total Productive Maintenance (TPM), Quality Circle, ISO: 9000 series standards, Approach to six-sigma. **(7 L)**

Total: 45 (L)

Text Books:

1. Montgomery D.C. (2013). Introduction to Statistical Quality Control (7th ed.). John Wiley & Sons, Inc.
2. R. C. Gupta, Statistical Quality Control & Quality Management 9 Edition, Khanna Publishers.

Reference Books:

1. John T. Burr, Elementary Statistical Quality Control 2nd Edition 2004 by, Taylor & Francis Ltd.
2. Grant E.L. and Leavenworth, Statistical Quality Control, TMH, 2000. IS 2500 Standard sampling plan

Course Outcomes:

Students will be able to:

- Find deep knowledge about statistical methods for quality technology and management to solve advanced quality related problems within industry.
- Illustrate the occurrence and consequences of variation in industrial processes.
- Identify situations where statistical methods can contribute to improvement of products and processes.
- Analyze and identify improvement needs for measurement systems in industrial organizations.

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Open Elective Courses	**OEC – CHE – 702B**	**Operation research**	**3-0-0**	**3**	**100**	**3**

Course Objective:

- The central objective of operations research is optimization, i.e., **"To do things best under the given circumstances." and** Solving operational questions, we find out the solutions or policies which decrease our dissatisfaction
- Solving questions related to resources' operations such as: human, machine, materials, energy, information, and funds. Selecting projects, determining the manner of investment, selecting strategy, selecting proper solution are also the objective of the Operation Research

- Solving decision-making questions, we find the best way to get optimum value in different circumferences.

Contents:

1. **L.P.P and Duality:** Definition of O.R., Characteristics of O.R. , Necessity of O.R. in industry, O.R. and Decision making , Scope of O.R. in management, Objectives of O.R. , Types of mathematical models, Role of computer in O.R., Requirements for linear programming problem (L.P.P.), Examples on the application of L.P.P., Graphical solution of Two Variables L.P.P., Canonical and standard Forms of L.P.P., Development of Simplex Method with examples, The Big-B Method with examples. Duality in L.P.P. with problems **(10L**)
2. **Transportation and Assignment Model:** Transportation Model and Optimality test with examples, Assignment Model with examples, Travelling Salesman Problem with example **(10L**)
3. **Decision and Game Theory:** Decision Theory with problems, Game Theory with problems. Dynamic Programming, its need and problems **(7L**)
4. **Network Analysis:** Network Theory, Shortest Path, Maximum Flow Problem, PERT &CPM with problems. **(10L**)
5. **Inventory and Queuing Model**:Inventory Control with Problems, Queuing Models With Problems. **(8L**)

Total: 45 (L)

Text Books:

1. Optimization Theory & Applications- S.S.Rao, Wiley Eastern Ltd.
2. Operations Research- An Introduction-7th edition, -H.A.Taha (EEE) PHI.
3. Operations Research with C Programs- S. Kalavatty- Vikas Publishing House Pvt. Ltd.
4. Operations Research- K.Swarup, P.K.Gupta, &Man Mohan –Sultan Chand & Sons.

Course outcomes:

Students will be able to:

- Students should be proficient in the application of the laws of logic to mathematical statements by selecting appropriate OR methods like Simplex, TP, TS, TSP, Network Analysis to apply to various types of problems in engineering and science inconsideration of the mathematical operations involved, accuracy requirements, and available computational resources

- Realization of journal papers outcomes, and expose them to the world of research. The current research works and publications of the subjects in different fields adopted by the students as per course curriculum in various journals and literature.

- They can explore and enhance research potential explain how the ideas those are adopted can be implemented through projects and demonstrate various models, recent project proposals executing the knowledge adopted from the course.

- An ability to function on multi-disciplinary teams. Lighten on the latest and modern developments in the fields. An understanding of professional, ethical, legal, security and social issues and responsibilities. An ability to analyze the local and global impact of computing on individuals, organizations, and society.

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Practical/Sessional papers

Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/ week
Professional core courses	**PC – CHE - 791**	**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 a two tank non-interacting liquid-level system
9. Dynamics of a 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:

- Temperature measurement using thermocouple and RTD.
- Pressure gauge calibration by dead weight tester.
- Liquid-level measurement using air-purge method

- Dynamic study of single and two tank liquid level systems.

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Categories	Course code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/ week
Professional Core Course	**SI – CHE - 791**	**Industrial Internship-II**	**0-0-30**	**4**	**100**	**30**

Course Objective:

This course aims to:

- Expose students to Chemical Engineering experience and knowledge which is required in industry, where these are not taught in the lecture rooms.
- Apply the engineering knowledge taught in the lecture rooms in real industrial situations and get a feel of the work environment along with responsibilities and ethics.
- Expose the students to future employers and enable students to choose appropriate work upon graduation.

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 equipments 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:

Students are able to:

- Repeat the theoretical knowledge with plant operation and application of various unit operations in a logical approach.
- Identify the specific differences between the theory and its application in industry.
- Execute the strategies of supervision and control of different units in industry and the hazards associated with the operation of chemical process industries and related safety measures.

- Distinguish the industrial work culture through interaction with industry personal.

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Detailed Syllabus, B. Tech Fourth year, Semester VIII

Core Elective IV	PEC – CHE – 801A	PEC – CHE – 801B	PEC – CHE – 801C
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 – 801A	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 steps towards modernization of the chemical engineering process through experiences.

Contents:

1. 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. **(10L)**
2. 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 **(13L)**
3. Industrial accidents and their causes. Human error behind industrial accidents, mechanical failure behind accidents. Industrial disasters essay. **(12L)**
4. Workshop and Interaction with industry **(10L)**

Total: 45 (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, RafiqulGani

Course Outcomes:

Student will be able to :

- Understand modern software and hardware, non- traditional machining processes and the effect of process parameters
- Differentiate the various traditional and non-traditional machining processes
- Understand industrial operation of different equipment and their maintenance, Plant safety and hazardous
- Demonstrate workshop technology

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC – CHE – 801B**	**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 modelling.
- To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.

Contents:

1. 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. **(5L)**
2. 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 Equation, Error Minimization Principles, Boundary conditions: Primary and secondary variables, Least square method, Rayleigh-Ritz method. **(10L)**

3. 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. **(10L)**
4. Discretization of the Momentum Equation: Stream Function-Vorticity approach and 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. **(10L)**
5. 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. **(10L)**

Total: 45 (L)

Text Books:

1. Ghosh Dastidar, P.S., “Computer Simulation of flow and heat transfer”, Tata McGraw 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
4. John David Anderson, "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill , NewYork

References:

1. Anil W. Date “Introduction to Computational Fluid Dynamics” Cambridge University Press, 2005.
2. Chung, T.J. “Computational Fluid Dynamics”, Cambridge University, Press, 2002.
3. Ghosh Dastidar P.S., “Heat Transfer”, Oxford University Press, 2005
4. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2014.

5. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004

Course Outcomes:

Upon the completion of this course the students will be able to:

- Understand the basic principles of mathematics and numerical concepts of fluid dynamics.
- Develop governing equations for a given fluid flow system.
- Analyze Finite difference and Finite volume method for Diffusion
- Analyze Flow field problems, Turbulence models and Mesh generation techniques

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Categories	Course Code	Course Title	Hours/Week L:T:P	Credit	Marks	Total contact hours/week
Professional Elective Courses	**PEC – CHE – 801C**	**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:

1. **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. **(10L)**
2. **Tools for hazards identification:** HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index, Safety Audits. **(10L)**
3. **Risk analysis concept and methodology:** Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number. **(10L)**
4. **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). **(15L)**

Total: 45 (L)

Text Books:

1. Chemical Process Safety: Fundamentals with Applications: D. A.Crowl and J.F.Louvar, Prentice Hall, 1990
2. Elements of Hazardous Waste Management, O.P. Gupta, Khanna Publishing House, 2018.
3. Industrial Safety, S.C. Sharma, Khanna Publishing House, 2018.

References:

1. Safety in Chemical Process Industries: O. P. Kharbanda, E. A. Stallworthy, Heinmann Professional Publishing LTD.,1988.
2. Hazardous Waste management: C. A. Wentz, MGH.
3. Environmental Risks & Hazards, S.L. Cutter, Prentice Hall,1994
4. Chemical Process Technology, O.P. Gupta, Khanna Publishing House, 2019. (AICTE Recommended)

Course Outcomes:

Students will be able to:

- **find** the effect of release of toxic substances
- **classify** the type of risk involved in a chemical plant operation
- **identify** the industrial laws, regulations and source models.
- **discover** the methods of prevention of toxic release, fire and explosions.

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Practical/Sessional papers

Sr no.	Categories	Course code	Course title	Hours/week L:T:P	Credit marks	Marks	Total contact hours/week
1	**Project-1**	**PROJ-CHE 891**	**Project work & Report Writing**	**0-0-14**	**4**	**200**	**14**

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 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 student 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 modelling to validate experimental data, interpretation of results and report writing. The course content of 'Project-I is Research topic determination and literature review and 'Project II' contain literature review and preliminary and primary investigation 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:

Student will be able to

- memorize the idea about the current scope of research in the particular field.
- explain the methodology, resources required, critical issues involved in the project by summarizing the literature available.
- demonstrate the ideas and develop the skill of documentation of a significant piece of work.
- compose the phase wise work distribution, and analyze the generated experimental data use to present the findings

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Categories	Course code	Course title	Hours/ week L:T:P	Credit	marks	Total contact hours/ week
Project-II	**PROJ – CHE - 892**	**Project Presentation and viva voce**		**1.5**	**100**	

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 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 student 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 modelling to validate experimental data, interpretation of results and report writing. The course content of 'Project I' is Research topic determination and literature review and 'Project II' contain literature review and preliminary and primary investigation 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:

At the end of this course, students will be able to:

- recall the information of document report comprising of summary of literature survey, detailed objectives, project specifications etc
- summarize and demonstrate the concept/functionality and part results
- predict the record of continuous progress.
- combine the project report and presentation

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

						week
Grand Viva	**GV – CHE 891**	**Grand Viva**		**2.0**	**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 mechanics 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 to:

- Memorize technical knowledge gather during the course.
- Describe the overall technical aptitude for industry readiness.
- Execute virtual environment of technical interview.
- Examine different technical puzzles and industrial trouble shootings

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