B.Tech.

IN

CHEMICAL ENGINEERING

CURRICULUM AND SYLLABI

OF

FIRST YEAR COURSES

(Applicable from 2023 Admission onwards)

Department of Chemical Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode - 673601, Kerala, India

The Program Educational Objectives (PEOs) of B.Tech. in Chemical Engineering

PEO1	Practice chemical engineering in traditional and emerging fields.
PEO2	Excel in advanced studies with strong foundation laid in the under graduate education.
PEO3	Exhibit leadership, ethical attitude, communication skills, teamwork in their profession and multidisciplinary skills.
PEO4	Engage in lifelong learning and continuous professional development.

Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) of B.Tech. in Chemical engineering

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, 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 modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1	Apply the principles of chemical engineering to design, analyze, optimize and control chemical processes and systems in various industries.
PSO2	Develop solutions for complex engineering problems using conventional, modern tools and techniques
PSO3	Able to think individually, communicate effectively, work in teams and assume position as leaders

CURRICULUM

The total credit for completing B.Tech. in Chemical Engineering is 150.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of B.Tech. programmes shall have the following Course Categories:

Sl. No.	Course Category	Number of Courses	Minimum Credits
1	Institute Core (IC)	8	22
2	Program Core (PC) and Program Electives (PE)	27	82
3	Open Electives (OE)	8	24
4	Institute Electives (IE) (Entrepreneurship Innovation (EI) + Digital / Automation Technologies (DA) + Humanities, Social Science, Management (HM))	6	18
5	Activity Credits (AC)	--	4

COURSE REQUIREMENTS

The effort to be put in by the student is indicated in the tables below as follows:
L: Lecture (One unit is of 50 minute duration)
T: Tutorial (One unit is of 50 minute duration)
P: Practical (One unit is of one hour duration)
O: Outside the class effort / self-study (One unit is of one hour duration)

1. INSTITUTE CORE (IC)

a) Mathematics

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	MA1001E	Mathematics I	3	1*	0	5	3
2.	MA1011E	Mathematics II	3	1*	0	5	3
3.	MA2001E	Mathematics III	3	1*	0	5	3
4.	MA2002E	Mathematics IV	3	1*	0	5	3
		Total	**12**	**4***	**0**	**20**	**12**

*Optional for Students (can be replaced by self-study)

b) Basic Sciences

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	PH1001E	Physics of Materials	3	0	0	6	3
2.	CY1005E	Chemistry-I	3	0	0	6	3
		Total	**6**	**0**	**0**	**12**	**6**

c) Professional Communication and Professional Ethics

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	CH1001E	Professional Ethics	1	0	0	2	1
2.	MS1001E	Professional Communication	3	0	0	6	3
		Total	**4**	**0**	**0**	**8**	**4**

2A. PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Pre-requisites	L	T	P	O	Credits
1	CH1002E	Material and energy balance	NIL	3	0	0	6	3
2	CH1003E	Elements of Biotechnology	NIL	3	0	0	6	3
3	CH1091E	Chemical Analysis Lab	NIL	0	0	3	3	2
4	CY1006E	Chemistry-II	NIL	3	0	0	6	3
5	CH1004E	Introduction to Computing	NIL	2	0	2	5	3
6	CH1005E	Process Fluid Mechanics	NIL	3	0	0	6	3
7	CH1006E	Mechanical Operations	NIL	3	0	0	6	3
8	CH2001E	Process Heat Transfer	NIL	3	0	0	6	3
9	CH2002E	Materials Science	NIL	3	0	0	6	3
10	CH2003E	Chemical Engineering Thermodynamics	NIL	3	0	0	6	3
11	CH2091E	Fluid and Particle Mechanics Lab	NIL	0	0	3	3	2
12	CH2004E	Chemical Reaction Engineering	NIL	3	0	0	6	3
13	CH2005E	Mass Transfer Operations	NIL	3	1	0	8	4
14	CH2092E	Heat and Mass Transfer Lab	NIL	0	0	3	3	2
15	CH3001E	Process Instrumentation and Control	NIL	3	1	0	8	4
16	CH3002E	Chemical Technology	NIL	3	0	0	6	3

17	CH3091E	Reaction Engineering and Process Control Lab	NIL	0	0	3	3	2
18	CH3003E	Chemical Process Equipment Design	NIL	3	0	2	7	4
19	CH3004E	Transport Phenomena	NIL	3	0	0	6	3
20	CH3095E	Project Part I	NIL				9	3
21	CH4091E	Summer Internship	NIL				†	2
			Total	**44**	**2**	**16**	**115**†	**61**

†*Decided by the organisation in which the internship is done*

2B. LIST OF ELECTIVES

The following courses may be credited under the categories mentioned in the table below, in addition to the Programme Electives.

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Additional Categories			
								PE	EI	DA	HM
1.	CH2021E	Energy Technology	3	0	0	6	3	Y	N	N	N
2.	CH2022E	Polymer Technology	3	0	0	6	3	Y	N	N	N
3.	CH2023E	Ceramic Technology	3	0	0	6	3	Y	N	N	N
4.	CH2024E	Fertilizer Technology	3	0	0	6	3	Y	N	N	N
5.	CH2025E	Human Resource Management	3	0	0	6	3	Y	N	N	N
6.	CH2026E	Waste to Energy Conversion	3	0	0	6	3	Y	N	N	N
7.	CH2027E	Mathematical Methods in Chemical Engineering	3	0	0	6	3	Y	N	N	N
8.	CH2028E	Computational Fluid Dynamics	2	0	2	5	3	Y	N	Y	N
9.	CH3021E	Operations Research	3	0	0	6	3	Y	N	N	N
10.	CH3022E	Petroleum Refining Operations and Processes	3	0	0	6	3	Y	N	N	N
11.	CH3023E	Corrosion Engineering	3	0	0	6	3	Y	N	N	N
12.	CH3024E	Food Technology	3	0	0	6	3	Y	N	N	N
13.	CH3025E	Colloid and Interface Science	3	0	0	6	3	Y	N	N	N
14.	CH3026E	Drugs and Pharmaceutical Technology	3	0	0	6	3	Y	N	N	N

15.	CH3027E	Natural Gas Engineering	3	0	0	6	3	Y	N	N	N
16.	CH3028E	Rheology of Complex Fluids	3	0	0	6	3	Y	N	N	N
17.	CH3029E	Mineral Processing Technology	3	0	0	6	3	Y	N	N	N
18.	CH3030E	Data Analytics for Process Systems	3	0	0	6	3	Y	N	Y	N
19.	CH3031E	Polymer Alloys	3	0	0	6	3	Y	N	N	N
20.	CH3032E	Fuel Cells	3	0	0	6	3	Y	N	N	N
21.	CH3033E	Hydrogen Production and Storage	3	0	0	6	3	Y	N	N	N
22.	CH3034E	Catalysis	3	0	0	6	3	Y	N	N	N
23.	CH3092E	Simulation Lab	1	0	3	5	3	Y	N	N	N
24.	CH3093E	Energy Lab	1	0	3	5	3	Y	N	N	N
25.	CH3094E	Instrumentation Lab	1	0	3	5	3	Y	N	N	N
26.	CH4021E	Biochemical Engineering	3	0	0	6	3	Y	N	N	N
27.	CH4022E	Electrochemical Engineering	3	0	0	6	3	Y	N	N	N
28.	CH4023E	Environment Impact Assessment and Clean Technology	3	0	0	6	3	Y	N	N	N
29.	CH4024E	Process Automation	3	0	0	6	3	Y	N	Y	N
30.	CH4025E	New Enterprises Creation and Management	3	0	0	6	3	Y	Y	N	N
31.	CH4026E	Speciality Polymers	3	0	0	6	3	Y	N	N	N
32.	CH4027E	Membrane Technology	3	0	0	6	3	Y	N	N	N
33.	CH4028E	Risk Analysis and Hazop	3	0	0	6	3	Y	N	N	N
34.	CH4029E	Project Engineering	3	0	0	6	3	Y	N	N	N
35.	CH4030E	Composite Materials	3	0	0	6	3	Y	N	N	N
36.	CH4031E	Safety in Chemical Industries	3	0	0	6	3	Y	N	N	N
37.	CH4032E	Process Optimization	3	0	0	6	3	Y	N	N	N
38.	CH4033E	Semiconductor Processing	3	0	0	6	3	Y	N	N	N
39.	CH4034E	Battery Technology	3	0	0	6	3	Y	N	N	N

40.	CH4035E	Sustainable Engineering: Theory and Practice	3	0	0	6	3	Y	N	N	N
41.	CH4036E	Process Intensification	3	0	0	6	3	Y	N	N	N
42.	CH4037E	Chemical Process Simulation	3	0	0	6	3	Y	N	N	N
43.	CH4038E	Multivariable Process Control	3	0	0	6	3	Y	N	N	N
44.	CH4094E/ CH4092E/ CHxxxxE	Project Part II / Internship/ Programme Elective				9	3	Y	N	N	N
45.	CH4095E/ CH4093E/ CHxxxxE	Project Part III / Internship/ Programme Electives				18	6	Y	N	N	N

3. OPEN ELECTIVES (OE)

Courses offered by Other Departments/Schools/Centres or Approved Online Platforms, with a limit on the maximum number of courses from such platforms specified as per BTech Ordinances and Regulations. In addition, PE courses offered by the Parent department shall be included in this category for students of the Parent department.

4. INSTITUTE ELECTIVES (IE)

In case of the Institute Electives, courses in the appropriate categories offered by other departments/schools/centres also can be credited instead of the courses offered by the Department of Chemical Engineering, NIT Calicut, subject to the approval from the Course Faculty and Faculty Advisor.

a) Entrepreneurship / Innovation Basket (EI):

Courses proposed by the Departments/Schools/Centres and approved by Institute Innovation Council. The total credits required is 3.

b) **Digital Automation Technologies (DA):**

Courses related to programming/automation tools & techniques / Industry 4.0. The total credits required is 6.

c) Humanities, Social Science, Management (HM):

Courses such as Indian and Foreign languages, Economics, Engineering Management, Financial Management and Design Thinking. The total credits required is 9.

5. ACTIVITY CREDITS (AC)

A minimum of 80 Activity Points are to be acquired for obtaining the 4 Activity Credits required in the curriculum.

Activity points acquired should be a minimum of 20 at the end of S4.
Activity points acquired should be a minimum of 40 at the end of S6.

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA1001E	Mathematics-I	3	1*	0	5	3	IC
2.	CY1005E	Chemistry-I	3	0	0	6	3	IC
3.	PH1001E	Physics of Materials	3	0	0	6	3	IC
4.	CH1001E	Professional Ethics	1	0	0	2	1	IC
5.	CH1002E	Material and Energy balance	3	0	0	6	3	PC
6.	CH1003E	Elements of Biotechnology	3	0	0	6	3	PC
7.	CH1091E	Chemical Analysis Lab	0	0	3	3	2	PC
		Total	**16**	**1***	**3**	**34**	**18**	**--**

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA1011E	Mathematics-II	3	1*	0	5	3	IC
2.	MS1001E	Professional Communication	3	1*	0	5	3	IC
3.	CY1006E	Chemistry-II	3	0	0	6	3	PC
4.	CH1004E	Introduction to Computing	2	0	2	5	3	PC
5.	CH1005E	Process Fluid Mechanics	3	0	0	6	3	PC
6.	CH1006E	Mechanical Operations	3	0	0	6	3	PC
		Total	**17**	**2***	**2**	**33**	**18**	**--**

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA2001E	Mathematics-III	3	1*	0	5	3	IC
2.	CH2001E	Process Heat Transfer	3	0	0	6	3	PC
3.	CH2002E	Materials Science	3	0	0	6	3	PC
4.	CH2003E	Chemical Engineering Thermodynamics	3	0	0	6	3	PC
5.	MSxxxxE	HM Elective[&] - 1	3	0	0	6	3	HM
6.	XXxxxxE	Open Elective[#] - 1	3	0	0	6	3	OE
7.	CH2091E	Fluid and Particle Mechanics Lab	0	0	3	3	2	PC
		Total	**18**	1*	**3**	**38**	**20**	**--**

*Optional for Students (can be replaced by self-study)

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA2002E	Mathematics-IV	3	1*	0	5	3	IC
2.	CH2004E	Chemical Reaction Engineering	3	0	0	6	3	PC
3.	CH2005E	Mass Transfer Operations	3	1	0	8	4	PC
4.	CH20xxE	Programme Elective - 1	3	0	0	6	3	PE
5.	XXxxxxE	Digital Automation Elective[$] - 1	3	0	0	6	3	DA
6.	XXxxxxE	Entrepreneurship / Innovation Elective[€]	3	0	0	6	3	EI
7.	CH2092E	Heat and Mass Transfer Lab	0	0	3	3	2	PC
8.	XXxxxxE	Minor Course – 1	3	0	0	6	3[#]	MC
Total (Excluding the Minor Courses)			**18**	**1+1***	**3**	**40**	**21(+3[#])**	**--**

Semester V

Sl. No	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CH3001E	Process Instrumentation and Control	3	1	0	8	4	PC
2.	CH3002E	Chemical Technology	3	0	0	6	3	PC
3.	XXxxxxE	Open Elective - 2	3	0	0	6	3	OE
4.	CHxxxxE	Programme Elective - 2	3	0	0	6	3	PE
5.	MSxxxxE	HM Elective – 2	3	0	0	6	3	HM
6.	CH3091E	Reaction Engineering and Process Control Lab	0	0	3	3	2	PC
7.	CH3092E/ CH3093E/ CH3094E	Lab Elective (Simulation, Energy, Instrumentation)	1	0	3	5	3	PE
8.	XXxxxxE	Minor Course - 2	3	0	0	6	3[#]	MC
Total (Excluding the Minor Courses)			**16**	**1**	**6**	**40**	**21 (+3[#])**	**--**

*Optional for Students (can be replaced by self-study)

[#]Minor course elective

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CH3003E	Chemical Process Equipment Design	3	0	2	7	4	PC
2.	CH3004E	Transport Phenomena	3	0	0	6	3	PC
3.	CHxxxxE	Programme Elective - 3	3	0	0	6	3	PE
4.	XXxxxxE	Open Elective - 3	3	0	0	6	3	OE
5.	XXxxxxE	Digital Automation Elective- 2	3	0	0	6	3	DA
6.	MSxxxxE	HM Elective - 3	3	0	0	6	3	HM
7.	CH3095E	Project Part I				9	3	PC
8.	XXxxxxE	Minor Course - 3	3	0	0	6	3[#]	MC
Total (Excluding the Minor Courses)			**18**	**0**	**2**	**46**	**22 (+3[#])**	**--**

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	XXxxxxE	Open Elective - 4	3	0	0	6	3	OE
2.	XXxxxxE	Open Elective - 5	3	0	0	6	3	OE
3.	XXxxxxE	Open Elective - 6	3	0	0	6	3	OE
4.	XXxxxxE	Open Elective - 7	3	0	0	6	3	OE
5.	XXxxxxE	Open Elective - 8	3	0	0	6	3	OE
6.	CH4091E	Summer Internship				†	2	PC
7.	CH4094E/ CH4092E/ CHxxxxE	Project Part II / Internship/ Programme Elective				9	3	PE
8.	XXxxxxE	Minor Course - 4	3	0	0	6	3[#]	MC
Total (Excluding the Minor Courses)			**15**	**0**	**0**	**39[†]**	**20 (+3[#])**	**--**

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CH4095E/ CH4093E/ CHxxxxE	Project Part III / Internship/ Programme Electives				18	6[$]	PE
2.		Activity Credits (minimum of 80 points)					4	AC
Total			**0**	**0**	**0**	**18**	**10**	**--**

[#]Minor course elective

†Decided by the organisation in which the internship is done

$ Project Part III is preferably done as Internship / Product development / Entrepreneurship / Research project

MA1001E MATHEMATICS - I

Pre-requisites: NIL

L	T	P	O	C
3	1	0	5	3

Total Lecture sessions: 39

Course Outcomes:

CO1: Formulate some engineering problems as ODEs and hence solve such problems

CO2: Solve linear ODEs with constant coefficients.

CO3: Find the limits, check for continuity and differentiability of real valued functions of two variables.

CO4: Test for the convergence of sequences and series.

CO5: Find the Fourier series representing periodic functions.

Existence and uniqueness of solution of first order ODE, methods of solutions of first order ODE, linear ODE, orthogonal trajectories, linear homogeneous second order ODEs with constant coefficients, fundamental system of solutions, existence and uniqueness of solutions, Wronskian, method of undetermined coefficients, solution by variation of parameters, Euler-Cauchy equations, applications of firstand second order ODEs, system of linear ODEs with constant coefficients.

Function of several variables: Limit, continuity, partial derivatives, partial differentiation of composite functions, directional derivatives, gradient, local maxima and local minima of functions of two variables, critical point, saddle point, Taylor's formula for two variables, hessian, second derivative test, method of Lagrange multipliers. Parameterised curves in space, arc length, tangent and normal vectors, curvature and torsion.

Sequences, Cauchy sequence, convergence of sequences, series, convergence of series, tests for convergence, absolute convergence, sequence of functions, power series, radius of convergence, Taylor series, periodic functions and Fourier series expansions, half-range expansions, Fourier integral, Fourier transforms and their properties.

References:

1. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edn., New York: John Wiley & Sons, 2015.
2. G. B. Thomas, M.D. Weirand J. Hass, Thomas' Calculus, 12th Edn., New Delhi, India: PearsonEducation, 2015.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th Edn., New York: John Wiley & Sons, 2015.
4. Apostol, Calculus Vol 1, 1st Edn. New Delhi: Wiley, 2014.

CY1005E CHEMISTRY - I

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the fundamentals of thermodynamics and photochemistry to real-life engineering problems

CO2: Utilize the principles of inorganic chemistry to implement innovative applications.

CO3: Apply the basics of electrochemistry to advanced technologies.

Fundamental of Thermodynamics - Helmholtz and Gibbs free energy, Concept of Entropy, Equilibrium and Spontaneity Conditions, Maxwell Relations, Van't Hoff Equation, Virial Coefficient, Chemical Potential. Phase Diagram of Mixtures - Volatile Liquids, Liquid-Liquid Phase Diagrams, Liquid-Solid Phase Diagrams, Phase Equilibria, Reaction Equilibria, Electrochemical Equilibrium. Application of Thermodynamics to Real World Problems. Photochemistry – Introduction, Quantum Yield and Determination, Factors Affecting Quantum Yield, Actinometry, Photosensitization, Photodegradation, Photocatalysts.

Molecular Orbital Theory - Bonding in homo (Li_2 to F_2) and heteronuclear (CO) diatomic molecules. Boron Nitride. Coordination chemistry - Introduction, Crystal field theory and its applications, Spectral and magnetic properties. Metal ions in living systems - Hemoglobin, Myoglobin. New age coordination compounds - Metal oxides, spinels, superconductors. Organometallics and Catalysis - Metal carbonyls, Oxidative addition and reductive elimination, insertion and elimination reactions, Hydrogenation (Wilkinson's catalyst) and Carbonylation (Monsanto process). Redox Chemistry - Diagrammatic representation and use of Latimer and Frost diagrams.

Electrochemistry of Solutions - Ion-Solvent Interactions, Ion-Ion Interactions, Ionic Migration and Diffusion, Electrolytic Conductivity. Thermodynamics of Galvanic cells - Equilibrium Electrode Potentials. Electrochemical Cells and Applications - Electrical Double Layer, Theories of Double-Layers, Helmholtz–Perrin Model, Diffuse Double Layers, Gouy-Chapman Model, Stern Model Electroanalytical Techniques - Potentiometry, Polarography, Voltammetry (CV), Coulometry, Amperometry, Impedance Spectroscopy.

References:

1. D. West, D. Skoog, F. Holler, S. Crouch, Fundamentals of Analytical Chemistry, 9th Edn, Brooks/Cole Publication,2014.
2. P. Atkins and J. Paula, Physical Chemistry, 8th Edn, W. H. Freeman and Company, New York 2006.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry – Principles of Structure and Reactivity, Pearson India Ltd., 2009.
4. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life – An Introduction and Guide, John Wiley & Sons, 1994.

5. S. J. Lippard, and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Books, 1994.
6. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edn, John Wiley & Sons, 2001.

PH1001E PHYSICS OF MATERIALS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Explain the fundamentals of quantum mechanics.

CO2: Apply quantum mechanics to electron in crystals and study the formation of bands in solid.

CO3: Apply quantum mechanics and study the electrical properties of solids.

CO4: Explain conductivity in semiconducting materials and influence of dopants on conductivity.

Quantum Mechanics

Wave-particle duality – de Broglie waves – group and phase velocity – Davison-Germer experiment – uncertainty principle – properties and significance of wave function – Schrodinger's wave equation – steady state equation, applications to a free particle and particle in a box.

Band theory of solids

Electrons in periodic potential – origin of band in solid – Bloch theorem – Kronig-Penny model (qualitative) – E-k diagram for free electron and electrons in periodic potential – one dimensional zone scheme – band gap.

Electrical conductivity

Classical electron theory – conductivity – factors affecting resistivity – Quantum mechanical consideration, Fermi energy and Fermi Surface – Fermi distribution function, density of states – Effective mass of electron.

Semiconductors

Intrinsic and extrinsic semiconductors – carrier concentration in *n* and *p* types semiconductors – Fermi level – Temperature dependence of electrical conductivity – variation of Fermi level with temperature.

References:

1. Beiser, Concepts of Modern Physics 6th Edn, McGraw-Hill, 2009.
2. K. Krane, Modern Physics 4th Indian Edn, Wiley, 2021.
3. R. E. Hummel, Electronic Properties of Materials 4th Edn, Springer, 2014.
4. M. A. Wahab, Solid State Physics – Structure and Properties of Materials 3rd Edn, Narosa, 2015.

CH1001E PROFESSIONAL ETHICS

Pre-requisites: NIL

L	T	P	O	C
1	0	0	2	1

Total Lecture Sessions: 13

Course Outcomes:

CO1: Develop a clear understanding of human values and use it as the basis for all the activities.

CO2: Understand and follow the ethical aspects of the engineering profession.

CO3: Align with the Code of Ethics prescribed by the American Institute of Chemical Engineers (AIChE) in all professional activities.

CO4: Assimilate the elements of academic integrity and Honour Codes, and adopt them in all relevant activities.

Human Values

Morals, values and ethics – integrity – work ethic – service learning – civic virtue – sharing – honesty – courage – valuing time – cooperation – commitment – empathy – self-confidence – character.

Ethics in Professional Practice

Ethics in professional context – ethical basis of engineering activities – ethical responsibilities to consumers and customers – safety and risk – ethics in management of intellectual property – environmental matters and sustainability.

Code of Ethics and Academic Integrity

Code of Ethics of the American Institute of Chemical Engineers (AIChE), elements of Academic Integrity: honesty, trust, fairness, respect, responsibility – plagiarism as a violation of academic integrity – Honour Codes: specifying the expected ethical standards from the stakeholders of an organization.

References:

1. R.S. Naagarazan, A Textbook on Professional Ethics and Human Values, 3rd Edn., New Age International Pvt.Ltd. 2022
2. A.F. Bainbridge, Ethics for Engineers: A Brief Introduction, CRC Press, 2021
3. E.G. Seebauer R.L. Barry, Fundamentals of Ethics for Scientists and Engineers, Oxford University Press, 2021
4. Caroline Whitbeck, Ethics in Engineering Practice and Research, Cambridge University Press, 2011.
5. C. E. Harris Jr., Michael S. Pritchard, M.J. Rabins, R W. James, and E. E. Englehardt, Engineering Ethics: Concepts and Cases, Cengage Learning, 6th Edn 2019
6. AIChE Code of Ethics, American Institute of Chemical Engineers, New York
7. Promotion of academic Integrity and prevention of plagiarism in higher educational institutions, UGC 2018

CH1002E MATERIAL AND ENERGY BALANCE

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the areas where Chemical Engineering plays a major role.

CO2: Understand the units of measurements in different systems of units and their conversion from one system to another.

CO3: Quantify the mass in mole and vice versa.

CO4: Apply the equation of state to characterize the properties of gas mixtures and quantify the humidity of vapors in non- condensable gases and accompanying calculations.

CO5: Formulate and solve the material balance equations to analyze steady-state processes without and with reaction.

CO6: Formulate the energy balance in closed and open systems and calculate the heat accompanying the chemical reactions.

Introduction and fundamentals of chemical engineering

Chemical Engineering in day to life with examples, origin and growth of chemical engineering, chemical engineering job titles/options, unit operations and unit processes concepts, scaling up or down, recent developments in chemical process industries, units and dimensions, conversion of units, mole concept and mole fraction, weight fraction and volume fraction, concentration of liquid solutions, molarity, molality, normality, ppm, density and specific gravity, composition relationships, ideal gases and gas mixtures, real gases, vapour pressure, vapour liquid equilibrium, humidity and saturation.

Material balance

General material balance equation - simplifications for steady-state processes without chemical reaction, element balance, material balance problems involving multiple subsystems, recycle, bypass and purge calculations, Material balance problems with chemical reactions, concept of limiting, excess reactants, fractional conversion and percentage of conversion, percentage yield.

Energy balance

Orsat analysis, ultimate and proximate analysis of coal, material balance problems involving simultaneous equations, Energy balance, heat capacity, estimation of heat capacities, calculation of enthalpy changes (without phase change), enthalpy change for phase transitions, thermochemistry, heat of formation, reaction, combustion, Hess's law of summation, theoretical flame temperature.

References:

1. K. V. Narayanan, B. Lakshmikuttyamma, Stoichiometry & Process Calculations, 2nd Edn., Prentice Hall Publishing, 2016.
2. D.H. Himmelblau, Basic Principles and Calculations in Chemical Engineering, 8th Edn., Prentice Hall, New York, 2014.
3. B.I. Bhatt, S. B. Thakore, S. R. Shah, Stoichiometry, 6th Edn., Tata McGraw-Hill Publishing Company Ltd., 2021.
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5. R.M. Felder, R.W. Rousseau, Elementary Principle and Chemical Processes, 3rd Edn., John Wiley & Sons Inc., 2008.
6. K. A. Solen, J. N. Harb, Introduction to Chemical Engineering- Tools for Today and Tomorrow, 5th Edn., John Wiley & Sons, Inc., 2011.

CH1003E ELEMENTS OF BIOTECHNOLOGY

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Illustrate the scope, significance and types of Biotechnology.
CO2: Describe organizations of living cells and their function.
CO3: Review the essentials of biomolecules, molecular biology and genetic engineering.
CO4: Demonstrate applications of biotechnology for energy, environment and value-added products.

Introduction to Biotechnology

Biotechnology: History, scope, significance and Ethics, Types of Biotechnology: Microbial, agricultural, animal, plant, aquatic, food, medical; Industrial Organisms: Prokaryotes, Eukaryotes; Metabolic processes: Anabolism and Catabolism, Energy production in aerobic microorganisms, anaerobic metabolism.

Biochemistry and Genetic Engineering

Biomolecules: Types, structure and Function of Carbohydrates, Proteins, Lipids, Nucleic acids; Gene and Genome, Central dogma of molecular biology, Genetic Engineering, Recombinant DNA Technology: Recombinant Proteins, genetically modified crops and organism, cloning.\

Bioproducts and Biosystems Engineering

Biomass: Baker's Yeast, Algae; Bioproducts: Aminoacids, Organic acids, Antibiotics, Microbial Polysaccharides and Lipids, Bioplastics, Biofertilizers, Enzymes, Biosensors, Vaccines, Monoclonal antibodies; Biofuels: Bioethanol, biogas; Bioremediation for petroleum spill, wastewater treatment.

References:

1. C. Ratledge, B. Kristiansen, Basic Biotechnology, 3rd Edn., Cambridge University Press, 2006.
2. W.J. Thieman, M. A. Palladino, Introduction to Biotechnology, 4th Edn., Pearson Education Ltd., 2021.
3. S.C. Bhatia, Textbook of Biotechnology, Atlantic Publishers, 2005.
4. T. Palmer, P.L. Bonner, Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, 2nd Edn. 2007.

CH1091E CHEMICAL ANALYSIS LAB

Pre-requisites: NIL

L	T	P	O	C
0	0	3	3	2

Total Practical Sessions: 39

Course Outcomes:

CO1: Analyse the oil properties.

CO2: Estimate the quality of sugar, soap and soil.

CO3: Evaluate the water pollutants quantitatively and qualitatively.

List of Experiments:

1. Sugar analysis.
2. Determination of saponification value.
3. Determination of the flash, fire and smoke points.
4. Soap analysis.
5. Determination of Iodine value.
6. Determination of acidity and alkalinity.
7. Determination of the total organic carbon content.
8. Separation of mixtures using paper chromatography and thin layer chromatography.
9. Determination of boiling point range of oils using distillation range Apparatus.
10. Moisture analysis of oils using Karl Fischer Titrator.

References:

1. R. Gopalan, D. Venkappayya, S. Nagarajan, Textbook of Engineering Chemistry, 4th Edn., Vikas Publishing House. 2013
2. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn., Longman Scientific and Technical, 1989,
3. R.B. Baird, Standard Methods for the Examination of Water and Wastewater, 23rd Edn., American Public Health Association, New York, 2017.

MA1011E MATHEMATICS - II

Pre-requisites: NIL

L	T	P	O	C
3	1	0	5	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Find the parametric representation of curves and surfaces in space and evaluate integrals over curves and surfaces

CO2: Use Laplace transform and its properties to solve differential equations and integral equations.

CO3: Test the consistency of the system of linear equations and solve it.

CO4: Diagonalise symmetric matrices and use it to find the nature of quadratic forms.

Vector field, divergence, curl, identities involving divergence and curl, scalar potential, line integral, independence of path, conservative field, evaluation of double integral, change of variables, Jacobian, polar coordinates, Green's theorem for plane, finding areas using Green's theorem, triple integral, cylindrical and spherical coordinates, mass of a lamina, centre of gravity, moments of inertia, parameterized surface, surfacearea and surface integral, flux, Gauss' divergence theorem, Stokes' theorem.

Laplace transform, sufficient condition for existence, linearity, inverse Laplace transform, Dirac delta function, transforms of derivatives and integrals, shifting theorems, convolution, differentiation and integration of transform, solution of differential equations and integral equations using Laplace transform.

System of linear equations, augmented matrix, existence and uniqueness of solution, Gauss elimination method, elementary row operations, LU decomposition, row-equivalent systems, row echelon form, rank of a matrix, linear dependence, consistency of linear system, linear combination of solutions, general solution. typesof matrices and their properties, eigenvalues, eigenvectors, eigenvalue problems, Cayley- Hamilton theorem, similarity of matrices, diagonalisation, quadratic form, reduction to canonical form.

References:

1. E. Kreyszig, Advanced Engineering Mathematics,10th Edn., New Delhi, India: Wiley, 2015.
2. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edn., New York: John Wiley & Sons, 2015.
3. V. I. Arnold, Ordinary Differential Equations, New York: Springer, 2006.
4. P. Dyke, An Introduction to Laplace Transforms and Fourier Series, New York: Springer

MS1001E PROFESSIONAL COMMUNICATION

L	T	P	O	C
3	1	0	5	3

Pre-requisites: NIL

Total Lecture Sessions : 39

Course Outcomes:

CO1: Distinguish the role and purpose of communication at the workplace and for academic purposes.

CO2: Decide strategies and modes for effective communication in a dynamic workplace.

CO3: Combine multiple approaches for successful and ethical information exchange.

CO4: Estimate best communication practices to assist productivity and congeniality at the workplace.

Listening and Reading Comprehension

Conversation starters: introductions and small talk - Seek and provide information, clarification, polite enquiries, requests, congratulate people, apologies, give and respond to feedback - Describe graphs, tables, and charts - Words often confused: Lexicon and Meaning - Sense Groups - Listening for specific purposes: Listening to lectures, Summarise academic lectures for note-taking - Appropriate Language to Request and Respond - Public Speaking

Vocabulary and Speaking

Developing professional vocabulary - Basic Sentence Structures from Reading Texts - Concord - Functions of Auxiliary Verbs and Modals - Strategies for Effective Reading - Skimming and Scanning, Determine themes and main ideas, Predicting content using photos, images and titles - Critical Reading: Discussing and Summarising text points - Understanding Text Structures: sequencing, comparing and contrasting, relating cause and effect, problems and problem-solving - Discussing Rhetorical and Cultural Aspects in Texts - Text Appreciation: Drawing inferences, Framing Opinions and Judgments on Reading Text

Effective Writing

Note Making and Summarising: Prepare notes from reading texts, Paraphrasing - Use of Multimedia for Assistive Purposes - Paragraph Writing: cohesive devices to connect sentences in a paragraph - transitional devices - Use Text Structures in Paragraphs: sequencing, comparing and contrasting, relating cause and effect, problems and problem-solving - Avoiding Ambiguity and Cleft Sentences - Applications- Writing Iinstructions, Descriptions and Explanations - Official Letters of Request and Denial - Official E-mails - Abstract Writing - Digital Resources for Effective Communication

Communication at Workplace

Communication Theory - Process of Communication - Modes of Communication - Verbal and Non-Verbal Communication - Tone in Communication - Formal and Informal Communication at Workplace - Passive, Assertive and Aggressive Styles of Communication - Positive Body Language - Group Discussions - Presentation - Workplace Communication - Active Listening - Giving Feedback - Communication Etiquette - Persuasion - Negotiation - Tone and Voice – Telephone etiquette - Establishing Credibility in Conversations - Digital Communication and Netiquette: Conducting Oneself in Virtual Interactions, Constructive use of Social media - Ethical and Culturally Sensitive

Communication: Ethical considerations in professional communication, Addressing diversity, Inclusive Communication Practices

References:

1. Bhatnagar, N., & Bhatnagar, M. (2010). Communicative English for engineers and professionals. Dorling Kindersley.
2. Foley, M., & Hall, D. (2018). Longman advanced learners 'grammar: A self-study reference & practice book with answers. Pearson Education.
3. Garner, B. A. (2012). HBR Guide to better business writing: Engage readers, tighten and Brighten, make your case. Harvard Business Review Press.
4. Hewings, M. (2013). Advanced grammar in use: A reference and practice book for Advanced learners of English. Cambridge University Press.
5. Ibbotson, M. (2015). Cambridge English for Engineering. Cambridge University Press.
6. Kumar, S., & Lata, P. (2015). Communication Skills. Oxford University Press.
7. Sudarshana, N., & Savitha, C. (2016). English for Technical Communication. Cambridge English

CY1006E CHEMISTRY - II

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Choose suitable separation strategies for the identification of molecules

CO2: Identify appropriate characterization techniques for the identification of molecules and materials

CO3: Examine the fundamental concepts of reaction mechanisms in synthetic chemistry

Separation techniques. Chromatography - Retention and separation factors, Theoretical plates. Basic principles of mass spectrometry - ionization methods, introduction to soft ionization techniques, ESI-MS, isotope abundance, high-resolution MS, molecular ions, fragmentation processes of organic and inorganic molecules and its applications in structural elucidations.

Spectroscopic techniques - General principles in electronic and infrared spectroscopy, Group frequencies, Electronic spectroscopy of conjugated molecules, Woodward-Fieser Rule. Introduction to NMR spectroscopy - Fundamentals of ^{1}H and ^{13}C NMR, chemical shifts. Structure elucidation of organic molecules using spectroscopic techniques. X-ray diffraction

Thermodynamic and kinetics data, Substituent effects, Linear free energy relationships, Basic mechanistic concepts like kinetic vs thermodynamic control, Curtin-Hammett principle. Synthesis of fine chemicals - Hydroboration, Dihydroxylation, Epoxidation, and Oxidative cleavage. Oxidation - Oxidation of hydrocarbons, alcohols, and ketones. Reduction - Catalytic hydrogenation, reduction by dissolving metals and reduction by hydride transfer reagents. Methods of polymerization - Cationic, anionic and radical chain polymerization. Cross-linking - sulfur and peroxides. Stereochemistry of polymers. Synthesis of organic materials.

References:

1. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 5th Edn., McGraw Hill Education, 2013.
2. R. M. Silverstein, F. X. Webster and D. J. Kiemle, Spectrometric Identification of Organic Compounds, 7th Edn., John-Wiley and sons, New York, 2005.
3. Harald Gunther, NMR Spectroscopy: Basic Principles Concepts And Application In Chemistry, 3rd Edn., Wiley Publication.
4. D. West, D. Skoog, F. Holler, S. Crouch, Fundamentals of Analytical Chemistry, 9th Edn., Brooks/Cole Publication, 2013.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry: Part A: Structure and Mechanisms, 5th Edn, Springer Publication, 2008.

6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry: Part A: Reactions and Synthesis, 5th Edn, Springer Publication, 2008.
7. T. W. G Solomon, C. B. Fryhle, Organic Chemistry, Global edition, Wiley Publication, 2017.
8. R. T. Morrison, R. N. Boyd, Organic Chemistry, 6th Edn., Pearson Publication, 2018.
9. O. George, Principles of Polymerization, 4th Edn, Wiley Publication, 2004.

CH1004E INTRODUCTION TO COMPUTING

Pre-requisites: NIL

L	T	P	O	C
2	0	2	5	3

Total Sessions: 26L + 26P

Course Outcomes:

CO1: Understand the basic programming principles needed for engineers.

CO2: Create algorithms and flowcharts for a computer program.

CO3: Compile and run programs in computers with accuracy.

CO4: Apply the programming skills to solve for common numerical schemes used in Chemical Engineering.

Introduction to C++ Programming

Basic Computer Fundamentals: Introduction to computer systems- CPU organization, ALU, registers, memory and input-output devices; Number system: binary and hexadecimal; Fixed and Floating point numbers; Errors and Approximations. Basic Programming in C++: Concepts of algorithm & flow charts; Input/output, constants, variables, expressions and operators; Naming conventions and styles; Conditions and selection statements; Looping and control structures; File input/output, header files, string processing; Pre-processor directives such as #include, #define, #ifdef, #ifndef; Compiling and linking.

Arrays and Function Definitions

Modular Programming: Functions (void and value returning), parameters, scope and lifetime of variables, passing by value, passing by reference, passing arguments by constant reference; Recursive Functions; Design of functions and their interfaces, recursive functions; Function overloading and default arguments; Library functions; Matters of style, naming conventions, comments. Aggregate Data-types: Arrays and pointers; Dynamic data and pointers, dynamic arrays, File Handling and Object-Oriented Programming: Class and Object.

Numerical Computations

Solution of Linear and Non-Linear Equation: Direct methods such as Gaussian elimination and Thomas algorithm for tri-diagonal systems; Iterative methods such as Jacobi method and Gauss-Seidel method; Single variable using Bisection method and Newton- Raphson method; Application of Newton-Raphson to two variables; Numerical Interpolation, Differentiation and Integration: Difference tables, forward, central and backward difference interpolation; Interpolating polynomials; Differentiation formulas; Trapezoidal rule, Simpson's rule.

References:

1. E. Balaguruswamy, Object Oriented Programming with C++, 8th Edn., Tata McGraw Hill Education, 2020.
2. H.M. Dietel, P.J. Dietel, C++ How to Program, 10th Edn., Prentice Hall, 2016.
3. S.S. Sastry, Introductory Methods of Numerical Analysis, 5th Edn., Prentice Hall India, 2012.

4. S. Lipschutz, Data Structure, 1st Edn., McGraw Hill Education, 2014.
5. R. Lafore, Object Oriented Programming with C++, 4th Edn., Pearson, 2008.

CH1005E PROCESS FLUID MECHANICS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand the basic laws and the equations governing fluid flows.
CO2: Calculate the head losses in pipe flows and chemical engineering systems.
CO3: Choose the right fluid measurement devices and pumps for the required applications.

Fluid Flow Description and Conservation Principles

Introduction, basic fluid concepts, Newtonian and non-Newtonian fluids, fluid kinematics – flow patterns and flow visualization, vorticity and rotation, Reynolds transport theorem, continuity equation, Navier- Stokes equations, momentum balance, energy balance equation.

Fundamentals of Internal and External Flow

Boundary layer theory, Bernoulli's equation, flow of incompressible fluids in pipes, head loss due to friction in pipes, fittings etc. Flow past immersed bodies-friction in flow through beds of solids, motion of particles through fluids, fluidization.

Fluid Machineries and Operation Principles

Dimensional analysis and similitude, flow rate and velocity measuring devices, transportation of fluids- positive displacement pumps, rotary and reciprocating pumps, centrifugal pumps and characteristics, calculation of NPSH.

References:

1. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, 7th Edn. McGraw-Hill, 2017
2. Y.A. Cengel, J.M. Cimbala, Fluid Mechanics – Fundamentals and Applications, 4th Edn., McGraw- Hill 2019.
3. N. H. De Nevers, Fluid Mechanics for Chemical Engineers, 3rd Edn., McGraw-Hill, 2004.
4. R.W. Fox, A.T. McDonald, P.J. Pritchard, J.W. Mitchell, Fluid Mechanics, 10th Edn., Wiley 2021.

CH1006E MECHANICAL OPERATIONS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the basic principles of particle characterization in different processes involving solids.
CO2: Evaluate the crushing efficiency of different size reduction equipment by applying crushing laws.
CO3: Analyze various mixing processes and calculate the power requirement.
CO4: Select the appropriate equipment for particle separation.

Particle Characterization and Size Reduction

Properties and handling of particulate solids, characterization of solid particles, standard screen series, particle size and screen analysis, Properties of particulate masses, pressure in masses of particles. Size reduction, principles of comminution- Rittinger's law, Kick's law, Bond's crushing law and work index, energy and power requirements in comminution, size reduction equipment- crushers, grinders, ultrafine grinders. Screening, comparison of ideal and actual screens, capacity and effectiveness of screens.

Filtration and Sedimentation

Particle separation methods: filtration, principles of cake filtration, pressure drop through filter cake, filter medium resistance, constant pressure filtration, constant rate filtration, centrifugal filtration, equipment of liquid-solid separation - separations based on the motion of particles through fluids, gravity settling processes, batch sedimentation, differential settling methods, centrifugal settling processes, centrifugal decanters, cyclone separation.

Particle Separation, Storage and Transportation

Magnetic separation, electrostatic separation, jigging, heavy media separation, froth floatation process. Agitation and mixing of liquids, agitation equipment, power consumption in agitated vessels, mixing of solids and paste, types of mixers. Conveying methods, Storage methods and design of silo, bins and hoppers.

References:

1. W. L. McCabe, J. C. Smith, P. Harriott, Unit Operations of Chemical Engineering, 7th Edn. McGraw-Hill, 2022.
2. J. M. Coulson, J. F. Richardson, Chemical Engineering, Vol. II, 5th Edn., Butterworth - Heinemann, 2002.
3. L. Svarovsky, Solid-Liquid Separation, 4th Edn., Butterworth-Heinemann, 2000.