

B. Tech. in Chemical Science and Technology (CST)

Program Learning Objectives:	Program Learning Outcomes (PLO):
Program Goal 1: Fundamental Understanding: To impart knowledge and proficiency in an advanced level of theoretical and practical aspects in the major fields of Chemical Science and Technology.	Program Learning Outcome 1: PLO-1: Students will acquire knowledge and demonstrate understanding of the core concepts, principles, and processes across the fields of chemistry and Chemical technology. Program Learning Outcome 2: PLO-2: Students will be able to recognize when information is needed and have the ability to locate, evaluate, and use the needed information for a wide range of purposes pertaining to Organic, Inorganic, Physical, Polymer, Industrial, Analytical and Material Chemistry
Program Goal 2: Basic Training for Research and Industry: To provide quality training for conducting fundamental and advanced research in Chemistry and technology development. Ethics in scientific research and publication.	Program Learning Outcome 3: PLO-3: Students will learn the critical thinking skills necessary to apply the scientific method and develop problem-solving skills. This includes: applying scientific inquiry and hypothesis building strategy, designing and conducting investigative experiments, applying quantitative reasoning skills to answer scientific questions. Ethics in scientific research and publication. Program Learning Outcome 4: PLO-4: Students will learn to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.
Program Goal 3: Skill Enhancement: To focus on skill enhancement in the core chemistry with practical expert hands. This will make students employable in academia and industries.	Program Learning Outcome 5: PLO-5: Students will synthesize knowledge, use quantitative reasoning and data to address issues in global scale to help them developing good skill in core chemistry suitable for getting employed in academia and industries.

Program Goal 4: Communication Skill: To develop various communication skills such as reading, listening, speaking, etc. This will help in expressing ideas and views clearly and effectively.	Program Learning Outcome 6: PLO-6: Students will learn how to read and understand research papers, make presentations and communicate to a large audience, develop the ability to work collaboratively.
Program Goal 5: Social Awareness: To make understand social, economic, health and environmental issues related to chemical science and technology and develop methods and means to abate and create awareness in society.	Program Learning Outcome 7: PLO-7: Students will have awareness on various global problems related to chemistry, such as global warming, climate change, environmental pollution, energy crisis, etc. Program Learning Outcome 8: PLO-8: Students will be able to use their intellectual skills to devise and develop solutions to environmental problems in their communities to apply fact-based chemical science and technology solutions to situations relevant to everyday life in areas such as education, human health, the natural environment, technological advances and policy.

Sl. No.	Subject Code	SEMESTER I	L	T	P	C
1.	MA1101	Calculus and Linear Algebra	3	1	0	4.0
2.	CS1101	Foundations of Programming	3	0	3	4.5
3.	PH1101/PH1201	Physics	3	1	3	5.5
4.	CE1101/CE1201	Engineering Graphics	1	0	3	2.5
5.	EE1101/EE1201	Electrical Sciences	3	0	3	4.5
6.	HS1101	English for Professionals	2	0	1	2.5
TOTAL			15	2	13	23.5

Sl. No.	Subject Code	SEMESTER II	L	T	P	C
1.	MA1201	Probability Theory and Ordinary Differential Equations	3	1	0	4
2.	CS1201	Data Structure	3	0	3	4.5
3.	CH1201/CH1101	Chemistry	3	1	3	5.5
4.	ME1201/ME1101	Mechanical Fabrication	0	0	3	1.5
5.	ME1202/ME1102	Engineering Mechanics	3	1	0	4
6.	IK1201	Indian Knowledge System (IKS)	3	0	0	3
TOTAL			15	3	9	22.5

Sl. No.	Subject Code	SEMESTER III	L	T	P	C
1.	CH2101	Organic Chemistry	3	1	0	4
2.	CH2102	Inorganic Chemistry	3	1	0	4
3.	CH2103	Introduction to Quantum Chemistry	3	1	0	4
4.	CH2104	Fluid Mechanics	3	1	2	5
5.	CH2105	Chemical Process Calculations	3	0	0	3
6.	HS21XX	HSS Elective-I	3	0	0	3
TOTAL			18	4	2	23

Sl. No.	Subject Code	SEMESTER IV	L	T	P	C
1.	CH2201	Structure and function of Biomolecules	3	0	0	3
2.	CH2202	Introduction to Organometallics	3	1	0	4
3.	CH2203	Chemical Thermodynamics and Equilibrium	3	1	0	4
4.	CH2204	Industrial Chemistry	3	0	0	3
5.	CH2205	Chemical Technology Laboratory I	0	0	6	3
6.	XX22PQ	IDE-I	3	0	0	3
TOTAL			15	2	6	20

Sl. No.	Subject Code	SEMESTER V	L	T	P	C
1.	CH3101	Macromolecular Science and Engineering	3	1	0	4
2.	CH3102	Design and Applications of Nanomaterials	2	1	0	3
3.	CH3103	Chemical Kinetics and Electrochemistry	3	0	0	3
4.	CH3104	Techniques for Chemical Analysis	3	1	0	4
5.	CH3105	Chemical Technology Laboratory II	0	0	6	3
6.	XX31PQ	IDE-II	3	0	0	3
TOTAL			14	3	6	20

Sl. No.	Subject Code	SEMESTER VI	L	T	P	C
1.	CH3201	Medicinal Chemistry	3	0	0	3
2.	CH3202	Environmental Science & Technology	3	0	0	3
3.	CH3203	Computational Chemistry	3	0	2	4
4.	CH3204	Chemistry for Propellants and Pyrotechnics	3	0	0	3
5.	CH3205	Chemical Technology Laboratory III	0	0	6	3
6.	CH32XX	Department Elective-I	3	0	0	3
TOTAL			15	0	8	19

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	CH41XX	Departmental Elective – II	3	0	0	3
2.	CH41XX	Departmental Elective – III	3	0	0	3
3.	XX41PQ	IDE-III	3	0	0	3
4.	HS41XX	HSS Elective II	3	0	0	3
5.	CH4198	Summer Internship*	0	0	12	3
6.	CH4199	Project – I	0	0	12	6
TOTAL			12	0	24	21

*** For specific cases of internship after 6th Semester, the performance evaluation would be made on joining the VIIth Semester and graded accordingly in the VIIth Semester:**

Note :

a) (i) Summer internship (*) period of at least 60 days' (8 weeks) duration begins in the intervening vacation between semester VI and VII that may be done in industry / R&D / Academic Institutions including IIT Patna. The evaluation would comprise **combined grading based on host supervisor evaluation, project internship report after plagiarism check and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the three components stated herein.

a) (ii) Further, on return from internship, students will be evaluated for internship work through combined grading based on host supervisor evaluation, project internship report after plagiarism check, and presentation evaluation by the parent department with equal weightage of each component.

b) (i) In the VIIth semester, students can opt for a semester long internship on recommendation of the DAPC and approval of the Competent Authority.

b) (ii) On approval of semester long internship, at the maximum two courses (properly mapped/aligned syllabus) at par with institute electives may be opted from NPTEL and / or SWAYAM and the other two more should be done at the institute through course overloading in any other semester (either before or after the internship) and/or during following summer semester.

b) (iii) The candidates opting two courses from NPTEL and / or SWAYAM would be required to appear in the examination at the Institute as scheduled in the Academic Calendar.

Sl. No.	Subject Code	SEMESTER VIII	L	T	P	C
1.	CH42XX	Departmental Elective – IV	3	0	0	3
2.	CH42XX	Departmental Elective – V	3	0	0	3
3.	CH42XX	Departmental Elective – VI	3	0	0	3
4.	CH4299	Project – II	0	0	16	8
TOTAL			9	0	16	17

Grand Total : (Semester I to VIII) – 166

ELECTIVE GROUPS

Department Electives - I						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH3206	Metal Ions in Chemical Biology	3	0	0	3
2.	CH3207	Petroleum and Petrochemicals	3	0	0	3

Department Electives - II						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4107	Drug Design and Development	3	0	0	3
2.	CH4108	Dyes, Paints and Pigments	3	0	0	3

Department Electives - III						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4109	Group Theory and Spectroscopy	3	0	0	3
2.	CH4110	Application of Statistical Mechanics in Chemistry.	3	0	0	3

Department Electives - IV						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4207	Catalysis	3	0	0	3
2.	CH4208	Colloids and Interface Chemistry	3	0	0	3

Department Electives - V						
3.	CH4209	Food Chemistry	3	0	0	3
4.	CH4210	Green and Sustainable Chemistry	3	0	0	3

Department Electives - VI						
5.	CH4211	Materials Chemistry	3	0	0	3
6.	CH4212	Organic Semiconductors: Fundamentals to Applications	3	0	0	3

IDE (For students of B. Tech. other than Dept. of Chemistry)

Sl. No.	Course Code	Course Name	L	T	P	C
1.	CH2206	IDE-I: Green Science and Technology	3	0	0	3
2.	CH3106	IDE-II: Synthesis of Industrially Important Inorganic Molecules	3	0	0	3
3.	CH4111	IDE-III: Analytical Chemistry	3	0	0	3

Sl. No.	Subject Code	SEMESTER I	L	T	P	C
1.	MA1101	Calculus and Linear Algebra	3	1	0	4.0
2.	CS1101	Foundations of Programming	3	0	3	4.5
3.	PH1101/PH1201	Physics	3	1	3	5.5
4.	CE1101/CE1201	Engineering Graphics	1	0	3	2.5
5.	EE1101/EE1201	Electrical Sciences	3	0	3	4.5
6.	HS1101	English for Professionals	2	0	1	2.5
TOTAL			15	2	13	23.5

Course Number	MA1101
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Calculus and Linear Algebra
Learning Mode	Lectures and Tutorials
Learning Objectives	To provide the essential knowledge of basic tools of Differential Calculus, Integral Calculus, Vector spaces and Matrix Algebra.
Course Description	This course provides a foundation for Calculus and Linear Algebra. Topics related to properties of single and two variable functions along with their applications will be discussed. In addition fundamentals of linear algebra and matrix theory with applications will also be discussed.
Course Content	Differential Calculus (12 Lectures): Limit and continuity of one variable function (including ϵ-δ definition). Limit, continuity and differentiability of functions of two variables, Tangent plane and normal, Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers. Integral Calculus (10 Lectures): Riemann integral for one variable functions, Double and Triple integrals, Change of order of integration. Change of variables, Applications of Multiple integrals such as surface area and volume. Vector Spaces (12 Lectures): Vector spaces (over the field of real numbers), subspaces, spanning set, linear independence, basis and dimension. Linear transformations, range and null space, rank-nullity theorem, matrix of a linear transformation. Matrix Algebra (8 Lectures): Elementary operations and their use in getting the rank, inverse of a matrix and solution of linear simultaneous equations, Orthogonal, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal and unitary matrices and their elementary properties, Eigenvalues and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.
Learning Outcome	Students completing this course will be able to: 1. Understand various properties of functions such as limit, continuity and differentiability. 2. Learn about integrations in various dimension and their applications. 3. learn about the concept of basis and dimension of a vector space. 4. define Linear Transformations and compute the domain, range, kernel, rank, and nullity of a linear transformation. 5. compute the inverse of an invertible matrix. 6. solve the system of linear equations. 7. Apply linear algebra concepts to model, solve, and analyze real-world problems.
Assessment Method	Quiz /Assignment/ MSE / ESE

Textbooks:

1. Thomas, G. B., Hass, J., Heil, C. and Weir M. D., "Thomas' Calculus", 14th Ed., Pearson Education, 2018
2. Kreyszig, E., "Advanced Engineering Mathematics", 10th Ed., Wiley India Pvt. Ltd, 2015

Reference Books:

1. Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", 5th Ed., Narosa Publishing House, 2017
2. Axler, S., "Linear Algebra Done Right", 3rd Ed., Springer Nature, 2015
3. Strang, G., "Linear Algebra and Its Applications" 4th Ed., Cengage India Private Limited, 2005

Course Number	CS1101
Course Credit	3-0-3-4.5
Course Title	Foundations of Programming
Learning Mode	Offline
Learning Objectives	• To understand the fundamental concepts of programming • To develop the basic problem-solving skills by designing algorithms and implementing them. • To learn about various data types, control statements, functions, arrays, pointers, and file handling. • To achieve proficiency in debugging and testing a C program
Course Description	This introductory course provides a solid foundation in programming principles and techniques. Designed for students with little to no prior programming experience, it covers fundamental concepts such as variables, data types, control structures, functions, and basic data structures. Students will learn to write, debug, and execute programs using a high-level programming language. Emphasis is placed on developing problem-solving skills, logical thinking, and the ability to write clear and efficient code. By the end of the course, students will be equipped with the essential skills needed to pursue more advanced studies in computer science and software development.
Course Outline	Introduction and Programming basics, Expressions Control and Iterative statements, Functions, Arrays, Recursion vs. Iteration Pointers, 2D-Array with pointers, Structures, String, Dynamic memory allocation, File handling, Contemporary programming languages, and applications Practical component: Lab to be conducted on a 3-hour slot weekly. It will be conducted with the theory course so the topics for problems given in the lab are already initiated in the theory class.
Learning Outcome	• Understanding of Basic Syntax and Structure in C language • Proficiency in Data Types, Operators, and Control Structures • Function Implementation and learn to use them appropriately • Efficient Use of Arrays and Strings • Pointer Utilization • Ability to perform dynamic memory allocation and deallocation using malloc (), calloc (), realloc (), and free () functions. • Structured data management with structures and unions • Exposure of file Handling • Learning debugging and error Handling
Assessment Method	Internal (Quiz/Assignment/Project), Mid-Term, End-Term

Suggested Reading

- Knuth, Donald E. The art of computer programming, volume 4A: combinatorial algorithms, part 1. Pearson Education India, 2011.
- P.J. Deitel and H.M. Deitel, C How To Program, Pearson Education (7th Edition)
- Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice–Hall
- A. Kelley and I. Pohl, A Book on C, Pearson Education (4th Edition)
- K. N. King, C PROGRAMMING A Modern Approach, W. W. Norton & Company

Course Number	PH1101/PH1201
Course Credit	3-1-0-4
Course Title	Physics
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1 and 2
Course Description	This course deals with fundamentals in Classical mechanics, Waves and Oscillations and Quantum Mechanics. As a prerequisite, the mathematical preliminaries such as coordinate systems, vector calculus etc will be discussed in the beginning.
Course Outline	Orthogonal coordinate systems (Plane polar, Spherical, Cylindrical), concept of generalised coordinates, generalised velocity and phase space for a mechanical system, Introduction to vector operators, Gradient, divergence, curl and Laplacian in different co-ordinate systems. Central force problem and its applications. Rigid body rotation, vector nature of angular velocity, Finding the principal axes, Euler's equations; Gyroscopic motion and its application; Accelerated frame of reference, Fictitious forces. Potential energy and concept of equilibrium, Lennard-Jones and double-well potentials, Small oscillations, Harmonic oscillator, damped and forced oscillations, resonance and its different examples, oscillator states in phase space, coupled oscillations, normal modes, longitudinal and transverse waves, wave equation, plane waves, examples two- and three-dimensional waves. Michelson-Morley experiment, Lorentz transformation, Postulates of special theory of relativity, Time dilation and length contraction, Applications of special theory of relativity.
Learning Outcome	Complies with PLO 1a, 2a, 3a
Assessment Method	Quiz, Assignments and Exams

Suggested Readings:

Textbooks:

1. Engineering Mechanics, M. K. Harbola, 2nd ed., Cengage, 2012
2. D. Kleppner and R. J. Kolenkow, An introduction to Mechanics, Tata McGraw-Hill, New Delhi, 2000.
3. I. G. Main, Oscillations and Waves
4. H. G. Pain, The Physics of Vibrations and Waves, 1968
5. Frank S. Crawford, Berkeley Physics Course Vol 3: Waves and Oscillations, McGraw Hill, 1966.

References:

1. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lecture in Physics, Vol I, Narosa Publishing House, New Delhi, 2009.
2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, NY, 2007.
3. P. C. Deshmukh, Foundations of Classical Mechanics, Cambridge University Press, 2019

Course code	CE1101/CE1201
Course Credit (L-T-P-C)	1-0-3-2.5
Course Title	Engineering Graphics
Learning Mode	Lectures and Practical
Learning Objectives	Complies with PLO-1a 1. The course on engineering drawing is designed to introduce the fundamentals of technical drawing as an important form of conveying information. 2. Apply principles of engineering visualization and projection theory to prepare engineering drawings, using conventional and modern drawing tools. 3. Practice drawing orthographic projections, isometric views, and sectional views, of simple and combined solids in different orientations.
Course Description	This course will introduce drawing as a tool to represent a complex three-dimensional object on two-dimensional paper through methods of projections. The course explains the use of different drafting tools and the importance of conventions for uniformity and standardization of the interpretation of the drawings.
Course Outline	Fundamental of engineering drawing, line types, dimensioning, and scales. Conic sections: ellipse, parabola, hyperbola; cycloidal curves. Principle of projection, method of projection, orthographic projection, plane of projection, first angle of projection, Projection of points, lines, planes and solids. Section of solids: Sectional views of simple solids- prism, pyramid, cylinder, cone, sphere; the true shape of the section. Methods of development, development of surfaces. Isometric projections: construction of isometric view of solids and combination of solids from orthographic projections. Introduction to AutoCad and solving isometric problems.
Learning Outcome	After attending this course, the following outcomes are expected: 1. The student will understand the basic concepts of engineering drawing. 2. The student will be able to use basic drafting tools, drawing instruments, and sheets. 3. The student will be able to represent three-dimensional simple and combined solid objects on two-dimensional paper. 4. The student will be able to visualize and interpret the orientation of simple and combine solid objects.
Assessment Method	Laboratory Assignments (30%), Mid-semester examination (25%) and End-semester examination (45%).

Suggested Readings:

Textbooks:

1. N.D. Bhatt, Engineering Drawing, Charotar Publishing House.
2. Agrawal & Agrawal, Engineering Drawing, McGraw Hill.
3. Jolhe, Engineering Drawing.

References:

1. Engineering Drawing and Design by David Madsen

Course Number	EE1101/EE1201
Course Credit	3-0-3-4.5
Course Title	Electrical Sciences
Learning Mode	Lectures and Experiments
Learning Objectives	Complies with Program goals 1, 2 and 3
Course Description	The course is designed to meet the requirements of all B. Tech programmes. The course aims at giving an overview of the entire electrical engineering domain from the concepts of circuits, devices, digital systems and magnetic circuits.
Course Outline	Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source Transformations, Thevenin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance, Instantaneous power, Real, reactive power and power factor. Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, UJT, Bipolar Junction Transistors, MOSFET, Transistor Biasing, Transistor Small Signal Analysis, Transistor Amplifier and their types, Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, Power Opamp, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Amplifier, Active Filters and Oscillators. Number Systems, Logic Gates, Boolean Theorem, Algebraic Simplification, K-map, Combinatorial Circuits, Encoder, Decoder, Combinatorial Circuit Design, Introduction to Sequential Circuits. Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Power measurement in three phase system, Electromechanical Energy Conversion, Introduction to Rotating Machines (DC and AC Machines). <u>Laboratory:</u> Experiments to verify Circuit Theorems; Experiments using diodes and bipolar junction transistor (BJT): design and analysis of half -wave and full-wave rectifiers, clipping and clamping circuits and Zener diode characteristics and its regulators, BJT characteristics (CE, CB and CC) and BJT amplifiers; Experiment on MOSFET characteristics (CS, CG, and CD), parameter extraction and amplifier; Experiments using operational amplifiers (op-amps): summing amplifier, comparator, precision rectifier, Astable and Monostable Multivibrators and oscillators; Experiments using logic gates: combinational circuits such as staircase switch, majority detector, equality detector, multiplexer and demultiplexer; Experiments using flip-flops: sequential circuits such as non-overlapping pulse generator, ripple counter, synchronous counter, pulse counter and numerical display; Power Measurement by two Wattmeter method; Open and Short Circuit Tests of Transformer.
Learning Outcomes	Complies with PLO 1a, 2a and 3a
Assessment Method	Quiz, Assignments and Exams

Texts/References

1. C. K. Alexander, M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008.
2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993.
3. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001.
4. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008.
5. Floyd, Jain, Digital Fundamentals, 8th Edition, Pearson.
6. David V. Kerns, Jr. J. David Irwin, Essentials of Electrical and Computer Engineering, Pearson, 2004.
7. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.
8. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.
9. A. E. Fitzgerald, C. Kingsley Jr., S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003.
10. D. P. Kothari, I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004.

11. Del Toro, Vincent. "Principles of electrical engineering." (No Title) (1972).

Course Number	HS1101
Course Credit	L-T-P-W: 2-0-1-2.5
Course Title	English for Professionals
Learning Mode	Offline
Learning Objectives	This course aims to help the students (a) attain proficiency in written English through the construction of grammatically correct sentences, utilization of subject-verb agreement principles, mastery of various tenses, and effective deployment of active and passive voice to ensure coherent and impactful written expression; (b) enhance oral communication skills by honing public speaking abilities, acquiring strategies to deliver persuasive presentations, and cultivating a polished telephone etiquette, enabling confident and articulate verbal communication; (c) foster active listening capabilities by recognizing different types of listening, and applying proven methods and strategies to improve active listening skills; (d) strengthen reading skills, including comprehension, interpretation, and critical analysis, to grasp diverse written materials and derive meaning from various types of texts encountered in academic and professional contexts; (e) develop adeptness in written communication for business purposes, encompassing the understanding of essential writing elements, mastery of appropriate writing styles thereby enhancing prospects for successful job interviews and subsequent professional endeavors.
Course Description	This academic course on communication skills aims to equip students with fluency in spoken and written English for effective expression in both academic and professional settings. By focusing on essential communication principles and providing practical experiences, students develop clarity, precision, and confidence in their communication. Through interactive discussions and exercises, students enhance critical thinking and adaptability in diverse contexts. Upon completion, students will excel in formal presentations, group discussions, and persuasive writing, enhancing their overall communication proficiency.
Course Outline	Unit I: Introduction to professional communication – LSRW - Phonetics and phonology Sounds in English Language – production and articulation – rhythm and intonation – connected speech - Basic Grammar and Advanced Vocabulary Sounds in English Language – production and articulation – rhythm and intonation – connected speech – persuading and negotiating – brevity and clarity in language. Unit II: Characteristics of Technical Communication: Types of communication and forms of communication - Formal and informal communication Verbal and non-Verbal Communication – Communication barriers and remedies Intercultural communication – neutral language Unit III: Comprehension and Composition – summarization, precis writing Business Letter Writing CV/ Resume – E-Communication Unit IV: Statement of Purpose, Writing Project Reports, Writing research proposal, writing abstracts, developing presentations, interviews – combating nervousness Tutorial: Listening Exercises, Speaking Practice (GDs, and Presentations), and Writing Practice Learning Outcome • Attain proficiency in written English, enabling the construction of grammatically correct sentences and coherent written expression through the use of appropriate grammar, tenses, and voice. • Enhance oral communication skills, including public speaking, persuasive presentation, and polished telephone etiquette, fostering confident and articulate verbal expression. • Cultivate active listening abilities, recognizing different listening types, overcoming obstacles, and employing strategies for attentive and effective communication. • Develop proficient written communication skills for business purposes, demonstrating understanding of essential writing elements, appropriate styles, and

	the creation of reports, notices, agendas, and minutes that effectively convey information.
Assessment Method	Class test + Quiz = 20%; Mid-semester = 25%; Assignment = 15%; End semester = 40%

Suggested Reading

1. Balzotti, Jon. Technical Communication: A Design-Centric Approach. Routledge, 2022.
2. Kaul, Asha, Business Communication. PHI Learning Pvt. Ltd. 2009
3. Laplante, Phillip A. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals. CRC Press, 2018.
4. Lawson, Celeste, et al. Communication Skills for Business Professionals, Second Edition. CUP, 2019.
5. Sharon Gerson and Steven Gerson. Technical Writing: Process and Product (8th Edition), London: Longman, 2013
6. Rentz, Kathryn, Marie E. Flatley & Paula Lentz. Lesikar's Business Communication Connecting in a Digital world, McGraw-Hill, Irwin.2012
7. Allan & Barbara Pease. The Definitive Book of Body Language, New York, Bantam,2004
8. Jones, Daniel. The Pronunciation of English, New Delhi, Universal Book Stall.2010
9. Savage, Alice. Effective Academic Writing. OUP. 2014
10. Swan and Alter. Oxford English grammar course. OUP. 201

Sl. No.	Subject Code	SEMESTER II	L	T	P	C
1.	MA1201	Probability Theory and Ordinary Differential Equations	3	1	0	4
2.	CS1201	Data Structure	3	0	3	4.5
3.	CH1201/CH1101	Chemistry	3	1	3	5.5
4.	ME1201/ME1101	Mechanical Fabrication	0	0	3	1.5
5.	ME1202/ME1102	Engineering Mechanics	3	1	0	4
6.	IK1201	Indian Knowledge System (IKS)	3	0	0	3
TOTAL			15	3	9	22.5

Course Number	MA1201
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Probability Theory and Ordinary Differential Equations
Learning Mode	Lectures and Tutorials
Learning Objectives	To introduce the basic concepts of probability, statistics, and Differential equations.
Course Description	This course aims to cover basic concepts of probability, statistics and ordinary differential equations. In particular, popular distributions, random sampling, various estimators and hypothesis testing will be discussed. Students will also get exposure to the linear ordinary differential equations and their solution techniques.
Course Content	Probability (12 Lectures): Random variables and their probability distributions, Cumulative distribution functions, Expectation and Variance, probability inequalities, Binomial, Poisson, Geometric, negative binomial distributions, Uniform, Exponential, beta, Gamma, Normal and lognormal distributions. Statistics (10 Lectures): Random sampling, sampling distributions, Parameter estimation, Point estimation, unbiased estimators, maximum likelihood estimation, Confidence intervals for normal mean, Simple and composite hypothesis, Type I and Type II errors, Hypothesis testing for normal mean. Ordinary Differential Equations (20 Lectures): First order ordinary differential equations, exactness and integrating factors, Picard's iteration, Ordinary linear differential equations of n-th order, solutions of homogeneous and non-homogeneous equations (Method of variation of parameters). Systems of ordinary differential equations, Power series methods for solutions of ordinary differential equations. Legendre equation and Legendre polynomials, Bessel equation and Bessel functions.
Learning Outcome	Students will get exposure and understanding of: 1. Random variables and their probability distributions 2. Understand popular distributions and their properties 3. Sampling, estimation and hypothesis testing 4. Solution of ordinary differential equations 5. Solution of system of ordinary differential equations 6. Special functions arising as power series solutions of ordinary differential equations
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Hogg, R. V., Mckean, J. and Craig, A. T., "Introduction to Mathematical Statistics", 8th Ed., Pearson Education India, 2021
2. S.M. Ross "An introduction to Probability Models, Academic Press INC, 11th edition.
3. Miller, I. and Miller, M., "John E. Freund's Mathematical Statistics with Applications", 8th Ed., Pearson Education India, 2013
4. S. L. Ross, Differential equations, 3rd Edition, Wiley, 1984
5. W. E. Boyce and R. C. Di Prima, Elementary Differential equations and Boundary Value Problems, 7th Edition, Wiley, 2001.

Course Number	CS1201
Course Credit	3-0-3-4.5
Course Title	Data Structure
Learning Mode	Offline
Learning Objectives	• Understand the principles and concepts of data structures and their importance in computer science. • Learn to implement various data structures and understand how different algorithms works. • Develop problem-solving skills by applying appropriate data structures to different computational problems. • Achieving proficiency in designing efficient algorithms.
Course Description	This course provides a comprehensive study of data structures and their applications in computer science. It focuses on the implementation, analysis, and use of various data structures such as arrays, linked lists, stacks, queues, trees, and graphs. Through theoretical concepts and practical programming exercises, this course aims to develop problem-solving and algorithmic thinking skills essential for advanced topics in computer science and software development.
Course Outline	• Introduction to Data Structure, • Time and space requirements, Asymptotic notations • Abstraction and Abstract data types • Linear Data Structure: stack, queue, list, and linked structure • Unfolding the recursion • Tree, Binary Tree, traversal • Search and Sorting, • Graph, traversal, MST, Shortest distance • Balanced Tree Practical component: Lab to be conducted on a 3-hour slot weekly. It will be conducted with the theory course so the topics for problems given in the lab are already initiated in the theory class.
Learning Outcome	• Understand Data Structure Fundamentals • Implement Basic Data Structures using a programming language • Analyse and Apply Algorithms • Design and Analyse Tree Structures • Understand the usage of graph and its related algorithms • Design and Implement Sorting and Searching Algorithms • Debug and Optimize Code
Assessment Method	Internal (Quiz/Assignment/Project), Mid-Term, End-Term

Suggested Reading

- Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, Data Structures and Algorithms, Published by Addison-Wesley
- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein., Introduction to Algorithms,
- Mark Allen Weiss, Data Structures and Algorithm Analysis in Java
- Robert Sedgewick and Kevin Wayne, Algorithms
- Narasimha Karumanchi, Data Structures and Algorithms Made Easy

Course Number	CH1101/CH1201
Course Credit	L-T-P-C: 3-1-3-5.5
Course Title	Chemistry
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation for all three branches of chemistry, viz. Organic, Inorganic, and Physical Chemistry. The course aims to nurture knowledge to appreciate the interface of chemistry with other science and Engineering branches by combining theoretical concepts and experimental studies.
Course Description	This course introduces basic organic chemistry, inorganic chemistry and Physical chemistry to understand fundamental laws that governs various reactions, reaction rates, equilibrium, and their applications in daily life through relevant experimentation.
Course Outline	Module 1: Thermodynamics: The fundamental definition and concept, the zeroth and first law. Work, heat, energy and enthalpies. Second law: entropy, free energy and chemical potential. Change of Phase. Third law. Chemical equilibrium. Conductance of solutions, Kohlrausch's law-ionic mobilities, Basic Electrochemistry. Module 2: Coordination chemistry: Crystal field theory and consequences color, magnetism, J.T distortion. Bioinorganic chemistry: Trace elements in biology, heme and non-heme oxygen carriers, haemoglobin and myoglobin; Organometallic chemistry. Module 3: Stereo and regio-chemistry of organic compounds, conformational analysis and conformers, Molecules devoid of point chirality (allenes and biphenyls); Significance of chirality in living systems, organic photochemistry, Modern techniques in structural elucidation of compounds (UV-Vis, IR, NMR). Module 4 (Lab Component): Experiments based on redox and complexometric titrations; synthesis and characterization of inorganic complexes and nanomaterials; synthesis and characterization of organic compounds; experiments based on chromatography; experiments based on pH and conductivity measurement; experiment related to chemical kinetics and spectroscopy.
Learning Outcome	Students will be able to 1. identify organic and inorganic molecules and relate them to daily life applications through experiments. 2. understand important hypothesis, laws and their derivations to intercept physical phenomenon of chemical reactions and apply them in hands-on experiments. 3. understand the importance of organic and inorganic molecules in our body and environment. 4. know important analytical techniques to intercept chemical entity. 5. approach organic and inorganic synthesis as a skillset for drug manufacturing, calculate limiting reagents and yields, use various analytical tools to characterize organic compounds, interpret and ascertain data related to Physical chemistry aspects and know laboratory safety measures, risk factors and scientific report writing skills.
Assessment Method	Theory: 20% Quiz and assignment, 30% Mid sem and 50% End semester exams for theory part (4 credits). Lab: 60% lab report, lab performance and assignment, 20% End semester exam for practical part, 20% viva/quiz (1.5 credits). Overall Weightage: Theory (70%), Lab (30%).

Suggested Reading:

Text books:

1. Vogel's Qualitative Inorganic Analysis, G. Svehla, 7th Edition, Revised, Prentice Hall, 1996.
2. A. J. Elias, S. S. Manoharan and H. Raj, "Experiments in General Chemistry", Universities Press (India) Pvt. Ltd., 1997.
3. A. J. Elias, A Collection of Interesting General Chemistry Experiments, revised edition, Universities Press (India) Pvt. Ltd., 2007.

4. F. Albert Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry - 6th Edition New Delhi: Wiley India, 2008.
5. K. Mukkanti, Practical Engineering Chemistry, B.S. Publications, Hyderabad, 2009.
6. Shriver and Atkins inorganic chemistry / Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong-5th Edition – Oxford: UOP. 2012.
7. Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press, 11th Edition 2017.
8. K. L. Kapoor, A Textbook of Physical Chemistry, Vol: 1, 2 (6th Edition, 2019), Vol: 3 (5th Edition, 2020) McGraw Hill.
9. G. R. Chatwal, S. K. Anand, Instrumental Methods of Chemical Analysis, 5th Edition, Himalaya Publications, 2023.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X	X	X	X	X	X	X
CLO-2	X	X		X	X			
CLO-3	X	X	X	X		X	X	
CLO-4	X	X		X	X	X	X	X
CLO-5			X	X	X			X

Course Number	ME1101/ME1201
Course Credit	L-T-P-C: 0-0-3-1.5
Course Title	Mechanical Fabrication
Learning Mode	Fabrication work – hands on fabrication work in Workshop
Learning Objectives	Complies with PLOs 3-4. • This course aims to develop the concepts and skills of various mechanical fabrication methods. • Fabrication of metallic and non-metallic components, fabrication using bulk and sheet metals, subtractive and additive manufacturing methods, and assemble the parts
Course Description	This course is designed to fulfil the need of hand on experience about various approaches (conventional and CNC, subtractive and additive) of mechanical fabrication approaches. Prerequisite: NIL
Course Outline	The jobs for various shops should be planned such that they are the parts of an assembled item. The student groups will fabricate different parts in various shops which will involve some amount of their creativeness/input particularly in design and/or planning. Various components as required for the assembled part can be made using the following shops: Sheet Metal Working: Development, sheet cutting and fabrication of designated job using sheet metal (ferrous/nonferrous); Joining of required portions by soldering, in case part is desired to be made leak proof. Pattern Making and Foundry: Making of suitable pattern (wood); making of sand mould, melting of non-ferrous metal/alloy (Al or Al alloys), pouring, solidification. Observation/identification of various defects appeared on the component. Joining: Butt/lap/corner joint job fabrication as required of low carbon steel plates; weld quality inspection by dye-penetration test (non-destructive testing approach) of the component made. Demonstration of semi-automatic Gas Metal Arc welding (GMAW). Conventional machining: Operations on lathe and vertical milling to fabricate the required component. The fabrication of the component should cover various lathe operations like straight turning, facing, thread cutting, parting off etc., and operations using indexing mechanism on vertical milling. CNC centre: Fundamentals of CNC programming using G and M code; setting and operations of job using CNC lathe or milling, tool reference, work reference, tool offset, tool radius compensation to fabricate the component with a designed profile on Al/Al-alloy plate. 3D printing (Fused Filament Fabrication): (2 weeks) Create the model, select appropriate slicing and path for fabrication of a 3D job by layer deposition (additive manufacturing approach) using polymeric material. Demonstration on pattern fabrication using 3D printing.
Learning Outcome	• This course would enable the students to develop the concept of design, fabrication (subtractive and additive) for various engineering applications. Fabrication of components and assemble them. • The practical skill and hands on experience for various fabrication methods from bulk, sheet metal using conventional as well as CNC machines.
Assessment Method	Fabrication of components in each of the shops required for assembly of the given part; submission of reports for each shop, and quiz assessment.

Text and Reference books:

1. Hajra Choudhury, HazraChoudhary and Nirjhar Roy, 2007, Elements of Workshop Technology, vol. I, Mediapromoters and Publishers Pvt. Ltd.
2. W A J Chapman, Workshop Technology, 1998, Part -1, 1st South Asian Edition, Viva Book Pvt Ltd.
3. P.N. Rao, 2009, Manufacturing Technology, Vol.1, 3rd Ed., Tata McGraw Hill Publishing Company.
4. M.Adithan, B.S. Pabla, 2012, CNC machines, New Age International Publishers

Course Number	ME1102/ME1202
Course Number	Engineering Mechanics
L-T-P-C	3-1-0-4
Pre-requisites	Nil
Semester	Spring
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1, 4 The objective of this first course in mechanics is to enable engineering students to analyze basic mechanics problems and apply vector-based approach to solve them.
Course Outline	Rigid body statics: Equivalent force system. Equations of equilibrium, Free body diagram, Reaction, Static indeterminacy. Structures: 2D truss, Method of joints, Method of section. Beam, Frame, types of loading and supports, axial force, Bending moment, Shear force and Torque Diagrams for a member. Friction: Dry friction (static and kinetic), wedge friction, disk friction (thrust bearing), belt friction, square threaded screw, journal bearings, Wheel friction, Rolling resistance. Centroid and Moment of Inertia Introduction to stress and strain: Definition of Stress, Normal and shear Stress. Relation between stress and strain, Cauchy formula. Stress in an axially loaded member and stress due to torsion in axisymmetric section
Learning Outcomes:	Following learning outcomes are expected after going through this course. - Learn and apply general mathematical and computer skills to solve basic mechanics problems. - Apply the vector-based approach to solve mechanics problems.
Assessment Method	Mid semester examination, End semester examination, Class test/Quiz, Tutorials

Reference Books

- H. Shames, Engineering Mechanics: Statics and dynamics, 4th Ed, PHI, 2002.
- F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, 3rd Ed, Tata McGraw Hill, 2000.
- J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I - Statics, 5th Ed, John Wiley, 2002.
- E.P. Popov, Engineering Mechanics of Solids, 2nd Ed, PHI, 1998.
- F. P. Beer and E. R. Johnston, J.T. Dewolf, and D.F. Mazurek, Mechanics of Materials, 6th Ed, McGraw Hill Education (India) Pvt. Ltd., 2012.

Sl. No.	Subject Code	SEMESTER III	L	T	P	C
1.	CH2101	Organic Chemistry	3	1	0	4
2.	CH2102	Inorganic Chemistry	3	1	0	4
3.	CH2103	Introduction to Quantum Chemistry	3	1	0	4
4.	CH2104	Fluid Mechanics	3	1	2	5
5.	CH2105	Chemical Process Calculations	3	0	0	3
6.	HS21XX	HSS Elective-I	3	0	0	3
TOTAL			18	4	2	23

Course Number	CH2101
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Organic Chemistry
Learning Mode	Offline
Learning Objectives	The aim of this course is to lay down a strong foundation of modern organic chemistry, encompassing the mechanisms of organic transformations and various applications of organic chemistry with a focus on strategies and control.
Course Description	This course introduces basic organic chemistry with emphasis on reaction mechanism, stereochemical implications, reaction intermediates and their properties, landmark organic transformations, different types of organic reactions and reagents involved therein.
Course Outline	Module 1: Introduction to types of organic reactions; structure and stability of reactive intermediates: carbocations, carbanions, free radicals, carbenes, arynes and nitrene. Module 2: Methods of determining organic reaction mechanism: thermodynamic and kinetic requirements, transition state theory, Hammond postulate, Curtin-Hammett principle, kinetic vs. thermodynamic control reaction, isotope effects, substituent effects, Hammett linear free energy relationship, Taft equation. Module 3: Addition reaction to C=C and C=O; preliminary idea of radical reactions; Application of Oxidation and Reduction reactions and reagents, Name reactions (e.g. Asymmetric hydrogenation/oxidation, Suzuki coupling, Heck coupling etc.). Module 4: Mechanism of aromatic nucleophilic and electrophilic substitutions.
Learning Outcome	Students will be able to 1. identify, classify, organize, and analyze organic molecules. 2. draw structures of organic molecules, interpret molecular structure following organic chemical transformations. 3. acquire knowledge of the mechanistic pathways of the synthesis and reactions. 4. acquire the cognitive skill to functionalize aromatic compounds.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested readings:

Text books:

1. P. Sykes, A guide to mechanism in Organic Chemistry, 6th Edition, Pearson Education, 2004.
2. E. V. Anslyn and D. A. Dougherty, Modern Physical Organic Chemistry, 1st Edition, University Science Books, California, 2005.
3. L. Kürti and B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, 1st Edition, Elsevier Academic Press, 2005.
4. F. A. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th Edition, Springer, New York, 2007.
5. F. A. Carey and R. A. Sundberg, Advanced Organic Chemistry: Part B: Reaction and Synthesis, 5th Edition, Springer, New York, 2007.
6. M. B. Smith and J. March, March's Advanced Organic Chemistry, 7th Edition, John Wiley and Sons, 2007.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3		X	X		X		X	
CLO-4	X				X	X	X	

Course Number	CH2102
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Inorganic Chemistry
Learning Mode	Offline
Learning Objectives	After completion of the course the learners will be thorough with the concepts of inorganic acids and their conjugate bases and various related theories, compounds of B, Si, P, Se, Te, halogens and Xenon, redox reactions, Potential diagrams, and Frost–Ebsworth diagrams. Applications of redox reactions in industrial processes. Students will have a sound foundation of several important aspects of basic inorganic chemistry.
Course Description	To make students understand the concepts of Acid-Base Chemistry of inorganic species, the fundamentals of redox reactions, to predict course of reactions and their applications to industrial processes, the basic chemistry of selected p-block elements of B, Si, P, Se, Te, halogens and Xenon with reference to certain compounds in each case.
Course Outline	Module 1: Acid-Base Chemistry: Definitions and concepts- Brønsted Lowry, Lux-Flood, Solvent system, Lewis, Usanovich, Hard-Soft Acid and Base (classification, strength and relation with electronegativity). Module 2: Redox reactions and oxidation states, Reduction potentials and Gibbs energy, Disproportionation, Potential diagrams, Frost–Ebsworth diagrams. Module 3: The effect of complex formation or precipitation on M^{2+}/M reduction potentials, Applications of redox reactions to industrial processes. Module 4: Chemistry of Boron, Silicon, Phosphorous and Sulphur. Module 5: Interhalogen compounds and polyhalogen ions, oxides and oxofluorides, oxoacids and salts of chlorine, and chemistry of xenon.
Learning Outcome	Students will be able to 1. identify inorganic acids and bases. 2. identify, balance and apply redox reactions for various practical applications. 3. learn the synthesis of selected compounds of p-block elements. 4. know and decipher the important uses and applications of various elements.
Assessment Method	Quiz and assignment (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Reading:

Text Books:

1. P. Atkins, T. Overton, J. Rourke, M. Weller, and F. Armstrong, Shriver & Atkins' Inorganic Chemistry, 5th Edition, Oxford University Press, 2010.
2. Catherine E. Housecroft, and Alan G. Sharpe, Inorganic Chemistry, Pearson; 5th Edition, 2018.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, Imprint: Pearson Education, 5th Edition, 2022.

Reference Book:

1. F. Albert Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, - 6th Edition - New Delhi: Wiley India, 2008.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3	X	X			X			
CLO-4	X				X			

Course Number	CH2103
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Introduction to Quantum Chemistry
Learning Mode	Offline
Learning Objectives	To develop the concept of quantum mechanics, steps to get the energies and wave functions of model systems (particle in a box, harmonic oscillator etc.). To describe angular momentum in quantum mechanics. To demonstrate approximate methods such as perturbation and variation methods.
Course Description	This course demonstrates the concept of quantum mechanics starting from postulates, general principles, Schrödinger equation and its application on some model systems. Further the course describes the applications of variational methods and perturbation theory.
Course Outline	Module 1: The motivation for quantum mechanics, postulates and general principles of quantum mechanics, operators, and their properties. Module 2: Schrödinger equation and its application on some model systems: free-particle and particle in a box (1D and 3D), particle in a finite square well potential, tunneling, the harmonic oscillator, particle on a ring, the rigid rotor. Module 3: Approximate methods: The variation theorem, linear variation principle, time-independent perturbation theory, applications of variational methods and perturbation theory. Module 4: Angular momentum: eigenfunctions and eigenvalues of angular momentum operator, Ladder operator, addition of angular momenta.
Learning Outcome	Students will be able to 1. understand the origin and postulates of quantum mechanics. 2. solve for the energies and wave functions of model systems (particle in a box, harmonic oscillator, particle on a ring etc.). 3. to use approximation methods like variation theorem and variation method. 4. solve for the eigenfunctions and eigenvalues of angular momentum.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

- 1.F. L. Pilar, Elementary Quantum Chemistry, 2nd Edition, Dover Publications, Inc. NY, 2003
- 2.P. W. Atkins and R. S. Friedman, Molecular Quantum Mechanics, 5th Edition, Oxford University Press, 2010.
- 3.I. N. Levine, Quantum Chemistry, 7th Edition, Pearson, 2013.
- 4.D. A. McQuarrie, Quantum Chemistry, Viva student Edition, Viva, 2020.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X						
CLO-3	X	X	X		X			
CLO-4	X	X	X					

Course Number	CH2104
Course Credit	L-T-P-C : 3-1-2 5
Course Title	Fluid Mechanics
Learning Mode	Classroom lectures and practical
Learning Objectives	To build an understanding on the importance and scope of fluid in rest (statics) and fluid in motion (dynamics) in process systems. Learning basics of pressure development, fluid properties and their role in driving various types of flows and fluid response under different external/internal forces. To study governing equations and dimensionless groups which drive the flow and their applications in the designing of pipe networks, pumps, etc.
Course Description	The course helps to develop a basic understanding of fluid mechanics and its application in chemical engineering. Equations and concepts in fluid statics, kinematics, and dynamics are covered in the course.
Course Content	Introduction; Types of fluids; Non-Newtonian viscosity; Dimensional analysis (Buckingham PI theorem); Fluid statics; Hydrostatic force on submerged bodies; Rigid body motion; Kinematics of flow- Eulerian and Lagrangian descriptions; Integral analysis- mass and momentum balances; Bernoulli equation; Differential analysis of flow; Conservation of mass, linear, and angular momentum; Navier-Stokes equation; Unidirectional flow; Viscous flow; Turbulent flow; Skin friction and form friction; Friction factor; Flow through pipes and ducts; Potential flow; Boundary layer theory; Boundary layer separation; Flow around immersed bodies; Drag and lift; Flow through packed and fluidized beds, Compressible flow; Flow measurement; Fluid transportation- pumps, blowers and compressors.
Learning Outcome	Development and application of governing equations and laws of fluid systems. Study on flow and pressure measuring equipment, frictional losses in pipes/conduits, laminar/turbulent flows, compressible/incompressible flows, boundary layer development and flows through porous beds. Illustrating the physical significance of pertinent non-dimensional groups through dimensional analysis.
Assessment Method	Assignments, Quiz, Mid-semester examination and End-semester examination

Text Books:

1. N. de Nevers, Fluid Mechanics for Chemical Engineers, McGraw-Hill Education (India) Private Ltd., 2017.
2. R.W. Fox, A.T. McDonald, P.J. Pritchard, Introduction to Fluid Mechanics, Wiley, 7th Ed., 2009.
3. F.M. White, Fluid Mechanics, Mc-Graw Hill, 6th Ed., 2008.

Reference Books:

1. M. Denn, Process Fluid Mechanics, Prentice Hall, 1979.
2. V.L. Streeter, Fluid Mechanics, 5th Ed., Mc-Graw Hill, 1971.
3. R.B. Bird, W.E. Stewart, E. N. Lightfoot, Transport Phenomena, 2nd Ed., Wiley, 2006.
4. J. M. Coulson, J. F. Richardson, J. R. Backhurst and J. H. Harker, Chemical Engineering, Vol. 1, 5th Ed., Elsevier, 2015.
5. W. L. McCabe, J. C. Smith, P. Harriott, Unit Operations of Chemical Engineering, 7th Ed., Mc-Graw Hill, 2005.

	CLO1	CLO2	CLO3
PLO1	X	X	
PLO2	X	X	
PLO3		X	X

Course Number	CH2105
Course Credit	L-T-P-C : 3-0-0-3
Course Title	Chemical Process Calculations
Learning Mode	Classroom lectures and tutorials
Learning Objectives	To learn the fundamental concepts of material balance and their applications. To learn the fundamental concepts of energy balance and their applications. To learn the overall concepts of combined material and energy balance and their diverse applications.
Course Description	This course is mainly about learning the concepts of material balance and energy balance and their applications (individual or combined) with reference to different chemical engineering systems/processes.
Course Content	Steady-state and dynamic processes; Lumped and distributed processes; Single and multi-phase systems; Correlations for physical and transport properties; Equilibrium relations; Ideal gases and gaseous mixtures; Vapor pressure; Vapor liquid equilibrium; Various Thermodynamics cycle such as Rankine Cycle, Carnot Cycle; Otto Cycle; Brayton Cycle; Material balances: Non-reacting single-phase systems; Systems with recycle, bypass and purge; Processes involving vaporization and condensation; Intensive and extensive variables; Rate laws; Calculation of enthalpy change; Heat of reaction; Fuel calculations; Saturation humidity, humidity charts and their use; Energy balance calculations; Flow-sheeting; Degrees of freedom and its importance in flow-sheeting.
Learning Outcomes	Familiarize with different units. Analyse and comprehend steady-state and dynamic processes. Understand and calculate problems related to material balances. Understand and calculate problems related to energy balances. Understand and calculate problems related to combined material and energy balances.
Assessment Method	Assignments, Quiz, Mid-semester examination and End-semester examination

Text Books:

1. B. I. Bhatt; S. B. Thakore, Stoichiometry, McGraw Hill, 6th Ed., 2021.
2. O. A. Hougen, K. M. Watson and R. A. Ragatz, Chemical Process Principles, CBS Publishers, Part-1, 2nd Ed., 2004.
3. D. M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall of India, 8th Ed., 2014.

Reference Books:

1. N. Chopey, Handbook of Chemical Engineering Calculations, Mc-Graw Hill, 3rd Ed., 2004.
2. R. M. Felder and R. W. Rousseau, Elementary Principles of Chemical Processes, Wiley, 3rd Ed., 2014.

	CLO1	CLO2	CLO3
PLO1	X	X	
PLO2			X
PLO3			X

Sl. No.	Subject Code	SEMESTER IV	L	T	P	C
1.	CH2201	Structure and function of Biomolecules	3	0	0	3
2.	CH2202	Introduction to Organometallics	3	1	0	4
3.	CH2203	Chemical Thermodynamics and Equilibrium	3	1	0	4
4.	CH2204	Industrial Chemistry	3	0	0	3
5.	CH2205	Chemical Technology Laboratory I	0	0	6	3
6.	XX22PQ	IDE-I	3	0	0	3
TOTAL			15	2	6	20

Course Number	CH2201
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Structure and Function of Biomolecules
Learning Mode	Offline
Learning Objectives	The aim is to impress upon the concept of Biomolecules and related metabolic processes in organisms; to lay down a strong foundation of biomolecules structure and their function.
Course Description	This course introduces molecular structure and interactions of biomolecules that help in functioning and organization of organisms including vital metabolic processes.
Course Outline	Module 1: Amino acids, Peptides and Proteins: structure, classification and function of amino acids, acid-base properties and Isoelectric point. Proteins: structure, classification and different protein functions, determination of primary structure of proteins, Ramachandran plot, enzyme as a special class of proteins, nomenclature and function, enzyme kinetics and enzyme inhibition. Module 2: Carbohydrates: Structure, properties, and reactions of mono- and disaccharides, carbohydrate conformers, function of different carbohydrates in our body, storage polysaccharides-linkage, variety, and uses. Module 3: Lipids: nomenclature, structure, properties and function of various biologically relevant lipids, membrane structure. Module 4: Nucleic acids: Building blocks, Structure, characteristics and functions of DNA/RNA.
Learning Outcome	Students will be able to 1. interpret molecular structure and interactions of essential biomolecules like proteins, nucleic acids, carbohydrates and lipids. 2. elucidate important metabolic pathways related to biomolecules. 3. explain landmark discoveries related to biochemistry important to modern day healthcare. 4. relate and interpret bioprocesses related to modern pharmaceuticals and medicinal chemistry.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. C. Ratledge and B. Kristiansen, Basic Biotechnology, Cambridge University Press, 3rd Edition, 2007.
2. Donald Voet and Judith Voet, Biochemistry by Wiley, 4th Edition, 2010
3. D. L. Nelson; M. M. Cox, Lehninger Principle of Biochemistry, W. H. Freeman Co. Ltd, 8th Edition, 2021.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3			X		X		X	
CLO-4					X	X	X	

Course Number	CH2202
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Introduction to Organometallics
Learning Mode	Offline
Learning Objectives	To highlight the importance of organometallic chemistry that bridges organic and inorganic sub-disciplines in chemistry. To enthuse interest among students by discussing rich chemistry and important applications of transition-metal based organometallic molecules in catalysis and their relevance in industry.
Course Description	The course describes ligands, molecular models and reaction types relevant to describe organometallic chemistry of transition metals. Early and recent examples of transition-metal based catalysis of industrial importance in present context.
Course Outline	Module 1: s and p-block organometallic compounds Module 2: 18-Electron rule, organometallic complexes with ligands such as hydrides, alkyl, carbonyl, nitrosyl, olefin and phosphines. Module 3: Metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Module 4: Homogeneous catalysis including C-C coupling, metathesis and olefin oxidation, alkene isomerization, alkene hydrogenation, alkene hydroformylation, hydrocyanation of butadiene, alkene hydrosilylation and hydroboration Module 5: Heterogeneous catalysis including Fischer-Tropsch reaction and Ziegler-Natta polymerization.
Learning Outcome	Students will be able to 1. understand scientific reports describing use of transition metal based organometallics. 2. propose mechanism and identify intermediates for reactions catalyzed by transition metal based organometallics. 3. propose design and syntheses of new catalysts based on transition metals. 4. explain the application of transition metal based molecules as catalysts in organic transformation.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%)

Text books:

1. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 7th Edition, Wiley, 2019.
2. BD Gupta, Anil J. Elias, Basic Organometallic Chemistry: Concepts, Syntheses and Applications Paperback, Universities Press; 2nd Edition, Reprint 2020.

Reference Book:

1. C. Housecroft, Alan G. Sharpe, Inorganic Chemistry, Pearson; 4th Edition (September 4, 2012).

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X	X					
CLO-3	X	X	X		X			
CLO-4	X	X	X		X		X	

Course Number	CH2203
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Chemical Thermodynamics and Equilibrium
Learning Mode	Offline
Learning Objectives	To develop the concept of classical thermodynamics, phase equilibria, solid solutions, and apply it to an existing, and emerging problem in basic science.
Course Description	This course demonstrates the concept of classical thermodynamics starting from basic laws, different thermodynamic parameters, phase equilibria, solid solutions etc. relevant for undergraduate students.
Course Outline	Module 1: Ideal gasses, real gasses, critical state; thermodynamic laws; reversible and irreversible processes. Module 2: Thermochemistry: Hess's law, Kirchoff's equation; Joule-Thompson experiment and co-efficient, Entropy; application of law of thermodynamics; Carnot cycle; Clausius inequality; equations of state; Gibbs and Helmholtz free energies; Maxwell equations and thermodynamic properties of pure substances; The thermodynamic description of mixtures, Colligative properties; chemical potential. Module 3: Chemical equilibria; equilibrium constant; Le Chatelier principle and its applications; Clapeyron equation and its applications; phase equilibria: Gibbs phase rule, one component systems and two component systems – simple eutectic, solid solutions; congruent melting and incongruent melting; Phase behaviour of liquids and their application in chemical industry.
Learning Outcome	Students will be able to 1. understand the fundamentals of classical thermodynamics. 2. develop problem-solving ability in classical thermodynamics. 3. develop the concept of phase equilibria in one component and two component systems. 4. develop the concept of solid solutions. 5. apply the fundamental knowledge of classical thermodynamics to an existing and emerging problem in basic science.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested readings:

Text books:

1. G. W. Castellan, Physical Chemistry, 3rd Edition, Addison Wesley Publishing Company, 1983.
2. A Textbook of Physical Chemistry, K. L. Kapoor, Vol: 1, 2, 6th Edition, 2019, Vol: 3, 5th Edition, 2020, McGraw Hill.
3. Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press, 12th Edition, 2022.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X			
CLO-2	X	X	X		X	X		
CLO-3	X	X			X			
CLO-4	X	X		X	X		X	
CLO-5	X	X	X		X		X	X

Course Number	CH2204
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Industrial Chemistry
Learning Mode	Offline
Learning Objectives	To highlight the importance of selected inorganic reagents, inorganic materials and chemicals those are commercially important. Students will learn their classifications, composition, syntheses and environmental aspects of these materials.
Course Description	The course describes various classes of inorganic materials, their industrial syntheses, commercial applications and their impact on the environment.
Course Outline	Module 1: Inorganic reagents Hydrazine: Manufacturing of hydrazine, Raschig process, Urea process, Bayer process, H₂O₂ process; use of hydrazine as rocket fuel, in fuel cell. Module 2: Insecticides and Herbicides Definition and classification of Insecticides; Manufacturing of insecticides; environmental effects; definition and classification of herbicides, health effect. Module 3: Mineral Fertilizers Economic importance, manufacturing of N and P-containing fertilizers. Module 4: Construction Materials Lime, Quicklime, Slaked Lime; Cement, miscellaneous cement types, composition and manufacturing of cements. Module 5: Enamel Classification, Enameling, Coating processes, Storing of enamels. Module 6: Ceramics General information and classification, Physical and Chemical Processes related to manufacturing of clay ceramics, Metal and metalloid ceramic materials; Metallic hard materials and fibres.
Learning Outcome	Students will be able to 1. have a basic knowledge of propellants and rocket fuel. 2. have a basic knowledge of agrochemicals of commercial importance including inorganic based fertilizers. 3. identify construction materials in general and cement types in particular. 4. appreciate the types and importance of enamels and ceramics and their various applications.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. A. Heaton, An introduction to Industrial Chemistry, 3rd Edition, Blackie Academic, 1996.
2. T. W. Swaddle, Inorganic Chemistry: An Industrial and Environmental Perspective, 1st Edition, Academic Press, 1997.
3. K. H. Davis and F. S. Berner, Handbook of Industrial Chemistry, Vols. 1 & 2, CBS, New Delhi, 2005.

Reference Book:

1. C.A. Heaton, Introduction to Industrial Chemistry (AN), 1st Edition, Springer, 2019.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X			
CLO-2	X	X			X		X	X
CLO-3			X		X		X	
CLO-4			X		X			X

Course Number	CH2205
Course Credit	L-T-P-C: 0-0-6-3
Course Title	Chemical Technology Laboratory I
Learning Mode	Offline
Learning Objectives	The main objective of this course is to train students on experimental skills pertaining to organic synthesis and characterization, enable scientific data presentation and reporting, learn laboratory safety measures and precaution, advanced laboratory practices with hands-on experience in synthesizing drug molecules for future employability.
Course Description	This course introduces experiments on detection of elements in organic compounds, separation of compounds, isolation of natural products, preparation of drug molecules, and characterization of synthesized products by spectroscopic techniques.
Course Outline	Experiments: Identification of unknown organic compounds: element detection, confirmation of the functional groups, derivatization; Separation technique: normal and reduced pressure distillation, solubility method, column chromatography method, sublimation; Isolation of medicinal compounds from plants/other sources: soxhlet extraction; Preparation: aspirin, paracetamol, imidazole, dye preparation; multistep synthesis; Estimation of organic compounds: paracetamol, glucose; Characterization of unknown organic compounds by UV-Vis, IR and ¹ H-NMR techniques. Experiments based on petrochemicals.
Learning Outcome	Students will be able to 1. perform organic synthetic transformation, calculate limiting reagents and yields. 2. use various analytical tools to characterize organic compounds. 3. interpret data related to organic compound characterization. 4. acquire knowledge of retro synthesis and disconnection approaches. 5. know the laboratory safety measures, risk factors and scientific report writing skills.
Assessment Method	Lab report, lab performance and assignment (80%), End sem examination (20%)

Suggested readings:

Text Books:

1. J. R. Mohrig, T. C. Morrill, C. N. Hammond and D.C. Neckers, Experimental Organic Chemistry, W.H. Freeman and Co. 1998.
2. Vogel's Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith and A. R. Tatchell, 5th Edition, Pearson India; 2003.
3. Vogel's textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, 6th Edition, Pearson Education, New Delhi, 2005.
4. N. K. Vishnoi, Advanced practical Organic Chemistry, 3rd Edition, S. Chand Pvt. Ltd., 2010

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X		X				
CLO-2	X	X		X	X		X	X
CLO-3			X	X	X		X	X
CLO-4				X	X	X	X	
CLO-5				X	X	X	X	X

Sl. No.	Subject Code	SEMESTER V	L	T	P	C
1.	CH3101	Macromolecular Science and Engineering	3	1	0	4
2.	CH3102	Design and Applications of Nanomaterials	2	1	0	3
3.	CH3103	Chemical Kinetics and Electrochemistry	3	0	0	3
4.	CH3104	Techniques for Chemical Analysis	3	1	0	4
5.	CH3105	Chemical Technology Laboratory II	0	0	6	3
6.	XX31PQ	IDE-II	3	0	0	3
TOTAL			14	3	6	20

Course Number	CH3101
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Macromolecular Science and Engineering
Learning Mode	Offline
Learning Objectives	• Basic understanding of polymers and their structure-property relation. • Design and synthesis of functional polymers via different methods. • Basis of properties of polymers and their characterizations. • Few examples of commercially available real life polymer applications and understanding of their synthesis and properties.
Course Description	The course provides an introduction to polymer science based on synthesis mechanisms, including outlined mechanisms of living polymerization, and properties of polymers and their origin. Characterization of polymeric properties and understanding of degradable polymers are included. Synthesis and properties of a number of commercially available polymers in our day-to-day life will be discussed.
Course Outline	Module 1: Basic Principles: Introduction and historical development, classification of polymers, nomenclature, number and weight average molecular weights, stereochemistry of polymers. Module 2: Different Polymerization techniques: Step growth and chain growth polymerizations. Examples and outlined mechanisms of controlled radical polymerization, anionic polymerization, ring opening polymerization, examples should include the preparation of block copolymers, star polymers and graft copolymers, emulsion polymerization and its uses in practical applications. Module 3: Polymer Conformation and Polymer solution: Three different models, Flory-Huggins theory (outlines and physical significances), polymer morphology: amorphous state and crystallinity. Module 4: Polymer properties and characterization: Thermal property: stability, glass-transition temperature, mechanical properties and rheology, polymer degradation. Polymer characterization by NMR (only polymer aspects), SEC, DSC and TGA. Module 5: Different class of commercially available polymers from day to day applications: specific discussion about synthesis and properties (as learned from module 1 to 4) of different class of commercially available polymers and their applications in different fields, for example vinylic polymers (such as polystyrenes and low and high density polyethylene), polyesters (such as PET, Ekonol), polyamides (such as Nylon, Kevlar), polycarbonates and polyethylene glycols.
Learning Outcome	At the end of the course the students should be able to 1. develop specific skills, competencies, and thought processes sufficient to support further study or work in this field of Polymer Chemistry. 2. learn various polymerization techniques, many of them are regularly used in industries. 3. various properties in polymers, including thermal and mechanical properties and polymer degradation and weathering. 4. characterization and analysis of different basic polymer properties.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. Fred W. Billmeyer, Jr., Textbook of Polymer Science, 3rd Edition, Wiley, 2008
2. Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and Their Applications, CRC Press, 2019.

3. Timothy P. Lodge, Paul C. Hiemenz, Polymer Chemistry, 3rd Edition, CRC Press, 2020

Reference Books:

1. Malcolm P. Stevens, Polymer Chemistry: An Introduction, Oxford University Press, USA, 3rd Edition, 1998.
2. Krzysztof Matyjaszewski, Yves Gnanou, Ludwik Leibler, Macromolecular Engineering: Precise Synthesis, Materials Properties, Applications, Wiley-VCH Verlag GmbH & Co. KGaA, 2007.
3. R. J. Young, and P. A. Lovell, Introduction to Polymers, CRC Press, 3rd Edition, 2011.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3			X		X		X	
CLO-4					X	X	X	

Course Number	CH3102
Course Credit	L-T-P-C: 2-1-0-3
Course Title	Design and Applications of Nanomaterials
Learning Mode	Offline
Learning Objectives	To impart foundational knowledge of Nanoscience and related fields, to make the students acquire an understanding of Nanoscience. To help them understand the broad outline of Nanoscience and Nanotechnology with experimental understanding of synthesis and characterization techniques.
Course Description	This course introduces the fundamentals of nano-scale science, engineering and technology, applications of nanostructured materials, synthetic routes, the main physical forces controlling size, shape and properties of nanomaterials. Laboratory experiments will cover well-established synthesis/fabrication methods with hands-on experience on standard characterization methods.
Course Outline	Module 1: Nanomaterials in daily life: Examples, and types of Nanomaterials: metal and metal oxides, semiconductor nanomaterial, carbon, polymeric, organic nanomaterials. Module 2: Nanomaterial properties: Optical and electronic properties. Module 3: Chemical Routes for Synthesis of Nanomaterials: Top down and bottom up approaches, Chemical precipitation; Sol-gel synthesis. Module 4: Applications of Nanomaterials.
Learning Outcome	Upon successful completion, students will have the knowledge and skills to 1. explain the fundamental principles of nanotechnology and their applications. 2. apply concepts to the nano-scale and non-continuum domain. 3. identify and compare state-of-the-art nanofabrication methods and perform a critical analysis of the research literature. 4. design processing conditions to engineer functional nanomaterials. 5. discuss, evaluate and perform state-of-the-art characterization methods for nanomaterials, and determine nanomaterial safety and handling methods required during characterization.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text books:

1. T Pradeep, A Textbook of Nanoscience and Nanotechnology, 1st Edition, McGraw Hill Education, 2017.
2. Poole and Owen, Introduction to Nanoscience and Nanotechnology, Wiley Indian Edition, 2020.

Reference books:

1. Masuro Kuno, Introductory Nanoscience, Garland Science, 2011.
2. L. E. Foster, Nanotechnology, Pearson, 2011.
3. Nanomaterials - An Introduction to Synthesis, Properties and Applications, D Vollath, 2nd Edition, Wiley-VCH, 2013

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X		X				
CLO-2	X	X		X	X			
CLO-3			X	X	X		X	
CLO-4			X	X	X	X	X	X
CLO-5	X	X			X		X	X

Course Number	CH3103
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Chemical Kinetics and Electrochemistry
Learning Mode	Offline
Learning Objectives	To develop the concept of chemical kinetics, electrochemistry. Understand the different theories of chemical kinetics, and apply them to predict the rate law, and whether a proposed mechanism is viable or not. Effect of different factors such as concentration, temperature, medium and the presence of a catalyst on the speed of a chemical reaction. Concept on different theories of electrochemistry. Get knowledge about different types of batteries, fuel cells, over potential.
Course Description	This course demonstrates the concept of chemical kinetics, electrochemistry starting from basic theories, and the effect of different factors on the speed of a chemical change. Application of electrochemistry for the determination of activity coefficient; pH, pKa, solubility product; thermodynamic functions of an electrochemical reaction, etc. relevant for undergraduate students.
Course Outline	Module 1: Rates of Chemical reactions: Elementary rate laws, temperature dependence of rate, opposing reactions, consecutive reactions, parallel reactions. Module 2: Reaction mechanism, unimolecular reactions, reversible reactions; Relaxation method; principle of microscopic reversibility; complex reactions: chain reactions, branched chain reactions, polymerization reactions, catalysis, autocatalysis, enzyme catalysis. Module 3: Theories of chemical kinetics: Collision theory, activated complex theory; Ionic reactions, kinetic salt effect; adsorption and surface catalysis. Photochemistry: rates of photochemical processes, complex photochemical processes; photosynthesis. Module 4: Equilibrium Electrochemistry: Electrochemical cells, cell representation, types of electrodes, half reactions, standard potentials, types of electrochemical cells, cell reactions, cell EMF; activity and activity coefficients; Debye Hückel theory; applications of standard potentials: electrochemical series, determination of activity coefficient; pH, pKa, solubility product; thermodynamic functions; batteries and Fuel cells; Over potential; mechanism of electrode reactions; corrosion.
Learning Outcome	Students will be able to 1. understand the concept of rate of change associated with chemical change, and how it can be measured. 2. determine the rate law of chemical change based on experimental data. 3. understand the theories of Chemical kinetics and when they apply. 4. understand the concept of mechanism, and using rate law data predict whether a proposed mechanism is viable or not. 5. recall and explain why certain factors such as concentration, temperature, medium, and the presence of a catalyst will affect the speed of a chemical change. 6. understand the fundamentals of electrochemistry, cell reactions. 7. get knowledge about different types of batteries, fuel cells.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. G. M. Barrow, Physical Chemistry, 5th Edition, Tata Mcgraw-Hill, 1992.
2. K. Laidler, Chemical Kinetics, 3rd Edition, Pearson Education, 2004.
3. Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press, 12th Edition, 2022.

Reference Books:

1. G. W. Castellan, Physical Chemistry, 3rd Edition, Narosa Publishing House, 1985.
2. R. J. Silbey and R. A. Alberty, Physical Chemistry, 3rd Edition, John Wiley & Sons, 2002.
3. T. Engel and P. Reid, Physical Chemistry, 1st Edition, Pearson Education, 2006.
4. Samuel Glasstone, An Introduction To Electrochemistry, East-West Press (Pvt.) Ltd., 2006.
5. Robert C. Fay Jill Kirsten Robinson, John E. McMurry, Chemistry, 8e Pearson Education, 2022.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X						
CLO-3	X	X				X		
CLO-4	X	X					X	X
CLO-5	X	X				X		
CLO-6	X	X			X		X	
CLO-7	X	X			X		X	

Course Number	CH3104
Course Credit	L-T-P-C: 3-1-0-4
Course Title	Techniques for Chemical Analysis
Learning Mode	Offline
Learning Objectives	Impart concept on various purification and separation techniques and their applications in compound analysis, understanding different electrochemical methods and their application for various chemical analysis
Course Description	This course gives an introduction to analytical chemistry and an overview of important analytical methods and their range of application within detection of inorganic and organic compounds. Important analytical quantitative techniques from classical methods, electrochemical methods, spectrochemical/spectrophotometric methods, mass spectrometry and separation techniques are reviewed. The course also includes steps and procedures in analytical chemistry, and evaluation/ interpretation of results. The course gives an overview of important use of selected classical and instrumental chemical quantitative analytical methods and a short introduction to their basic theory.
Course Outline	Module 1: UV-Visible Spectroscopy: General principles and instrumentation, analytical applications: qualitative and quantitative analysis of inorganic and organic compounds. Module 2: Infrared Spectroscopy: Instrumentation and application in chemistry. Vibrations of polyatomic molecules, group frequency and its application. Module 3: Nuclear Magnetic Resonance Spectroscopy: General principles, sensitivity of the method, instrumentation. Application in chemical analysis (with special reference to ^1H – NMR): basic definitions, shift reagents, off- resonance decoupling, multinuclear NMR. Module 4: Mass Spectrometry: Theory and principles, Instrumentation, Methods of ionization. Structure elucidation of inorganic and organic compounds. Module 4: Thermal Analysis: TGA, DTA and DSC and their applications in chemistry.
Learning Outcome	Student would be able to 1. explain quantitative methods of working, the theoretical principles and important applications of analytical techniques. 2. perform various techniques, selected instrumental methods within electroanalytical, spectrometric/spectrophotometric and mass spectrometry methods, and main components in such analytical instruments. 3. explain the data analysis to understand the unknown structure. 4. familiar with calculations in analytical chemistry and method evaluation, and perform statistical evaluation of results from classical and instrumental chemical experiments and analyses.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to Spectroscopy, 5th Edition, CENGAGE Learning, 2015.
2. Silverstein, Bassler, Kiemle, Bryce, Spectrometric Identification of Organic Compounds, 8th Edition, Wiley, 2015.
3. Vogel's textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, 6th Edition, Pearson Education, New Delhi, 2005.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X	X		
CLO-3			X		X	X		
CLO-4					X	X		

Course Number	CH3105
Course Credit	L-T-P-C: 0-0-6-3
Course Title	Chemical Technology Laboratory II
Learning Mode	Offline
Learning Objectives	To develop the practical skills required to obtain industrial important chemicals. To train students with techniques used by synthetic inorganic chemists to synthesize catalysts, fertilizers, nano materials, and soaps/detergents.
Course Description	The course includes various experiments that students perform to learn syntheses and characterization of various inorganic chemicals and compounds with practical applications and use in daily life.
Course Outline	Module 1: Modern synthetic and analytical techniques to synthesize and characterize industrially important inorganic compounds. Module 2: Synthesis and characterization of alum, phosphate fertilizers, soaps and detergents. Module 3: Synthesis of gold/silver/iron oxide/zinc oxide nanoparticles, cadmium-zinc sulphide nanoparticles, pressure and temperature sensitive LCD display. Module 4: Environmental inorganic chemistry: preparation of clathrate compounds and applications in catalysis. Module 5: Redox and complexometric titrations.
Learning Outcome	Students will be able to 1. learn skills and techniques required to synthesize inorganic compounds and complexes as well as inorganic nanomaterials. 2. learn practical application of spectroscopic techniques while characterizing the synthesized molecules/compounds/materials. 3. learn good laboratory practices such as following safety rules applicable to a chemistry synthesis lab. 4. learn how to document experimental procedures, observation and chemical conclusions. 5. learn to handle hazardous chemicals and proper disposal of toxic chemicals.
Assessment Method	Lab report, lab performance and assignment (80%), End sem examination (20%)

Suggested readings:

Text Books:

1. Vogel's textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, 6th Edition, Pearson Education, New Delhi, 2005.
2. G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edition, Pearson Education, New Delhi, 2006.
3. A. J. Elias, A Collection of Interesting General Chemistry Experiments, Revised Edition, Universities Press (India) Pvt. Ltd, 2007.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X		X				
CLO-2	X	X		X				
CLO-3			X		X		X	
CLO-4				X	X	X	X	X
CLO-5				X		X	X	X

Sl. No.	Subject Code	SEMESTER VI	L	T	P	C
1.	CH3201	Medicinal Chemistry	3	0	0	3
2.	CH3202	Environmental Science & Technology	3	0	0	3
3.	CH3203	Computational Chemistry	3	0	2	4
4.	CH3204	Chemistry for Propellants and Pyrotechnics	3	0	0	3
5.	CH3205	Chemical Technology Laboratory III	0	0	6	3
6.	CH32XX	Department Elective-I	3	0	0	3

Course Number	CH3201
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Medicinal Chemistry
Learning Mode	Offline
Learning Objectives	The main objective of this course is to familiarize students with the medicinal chemistry, to train students on various aspects of new drugs. Students will learn the classification of drugs, synthesis and mode of action of different class of drugs.
Course Description	This course provides a comprehensive exploration of medicinal chemistry, focusing on the classification, synthesis, and pharmacological properties of various classes of drugs. Through a combination of theoretical knowledge and practical applications. Students will be introduced to the fundamental principles of medicinal and pharmaceutical chemistry. They will learn about methods of classifying drugs based on their chemical structure and biological activity. By the end of the course, students will be equipped with the knowledge and skills necessary to critically evaluate drugs based on their chemical properties, biological activity, and therapeutic potential.
Course Outline	Module 1: Introduction to medicinal and pharmaceutical chemistry: Methods of classification of drugs based on structure and biological activity. Module 2: Study of the chemistry and synthesis of the following classes of drugs: Anti-infective agents such as antiseptic and disinfectant, antibiotics (including stability and degradation products), antiparasitic, antiamoebic, anti-helminthic, anti-mycobacterial, antifungal, anticancer, antiviral. Module 3: Non-steroidal anti-inflammatory agents (NSAIDs); Drugs used in hypertensive, vasodilator, immunopharmacology.
Learning Outcome	Students will be able to 1. correlate pharmacology of a disease and its mitigation or cure through medicinal chemistry. 2. understand the drug metabolic pathways, adverse effect and therapeutic value of drugs. 3. know the structural activity relationship of different class of drugs. 4. well acquainted with the synthesis of some important class of drugs. 5. have knowledge about the mechanism pathways of different class of medicinal compounds.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Text books:

1. Principles of Medicinal Chemistry, W. O. Foye, 3rd Edition, Lea & Febiger/Varghese Publishing House, Bombay, 1989.
2. Medicinal Chemistry, A. Burger, Vol. I-III, Wiley Interscience Publications, New York, 1995.
3. D. Lednicer, Strategies for Organic Drug Synthesis and Design, John Wiley & Sons Inc., New York, 2nd Edition, 2008.
4. Strategies for organic drug synthesis and design, D. Lednicer, John Wiley & Sons, New York, 2009.
5. D. A. Williams and T. L. Lemke, V. F. Roche, S.W. Zito, Foye's Principles of Medicinal Chemistry, Lippincott Williams & Wilkins, Philadelphia, 2012
6. A. Kar, Medicinal Chemistry, New Age International Publishers, 2018.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						X
CLO-2	X	X			X			
CLO-3			X		X		X	
CLO-4					X	X	X	
CLO - 5	X	X						

Course Number	CH3202
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Environmental Science & Technology
Learning Mode	Offline
Learning Objectives	The objective of the course is to understand our atmosphere in terms of its composition and the chemicals, chemical reactions that pollute air, water, and soil. The course objective is also to provide a basic understanding of removal pathways of contaminants from the environment and analytical techniques to determine the contamination level.
Course Description	The course is understanding of atmosphere, and pollutants that contaminate our environment, removal of contaminants and their chemical analysis
Course Outline	Module 1: Introduction: Atmospheric composition and behavior, principles of contaminant behavior in the environment. Module 2: Chemistry in Aqueous Media: Chemical and physical reactions in the water environment. Module 3: Major Contaminant Groups and Their Natural Pathways for Removal from Water, Soil: Groundwater and subsurface contamination, Soil profiles, Acid-base and ion exchange reactions in soils, Fertilizers, wastes and pollutants in soil. Module 4: Atmosphere and Atmospheric Chemistry: Inorganic and organic air pollutants, Sulfur dioxide sources and the sulfur cycle, Nitrogen oxides in the atmosphere, Smog forming reactions of organic compounds in the atmosphere, mechanisms of smog formation. Module 5: Nature and Importance of Chemical Analysis: Major categories of chemical analysis, Application of analytical chemistry to environmental chemical analysis.
Learning Outcome	After successful completion of the course, students will be able 1. to learn about the composition and behavior of atmosphere 2. to learn about the contaminants behavior in our environment 3. to learn about the chemical and physical reactions in aqueous media 4. to learn natural pathways for removal of contaminants 5. to learn inorganic and organic air pollutants and smog formation 6. to learn chemical analysis and its application in environmental chemical analysis
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Text Books:

1. S. E. Harnung, M. S. Johnson, Chemistry and the Environment, 1st Edition, Cambridge University Press, 2012.
2. J. S. Gaffney, N. A. Marley, Chemistry of Environmental Systems: Fundamental Principles and Analytical Methods, 1st Edition, Wiley, 2019.

Reference Books:

1. S.E. Manahan, Fundamentals of Environmental and Toxicological Chemistry: Sustainable Science, 4th Edition, CRC Press, 2013.
2. M. K. Hill, Understanding Environmental Pollution, 4th Edition, Cambridge University Press, 2020.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X		X			X	X	X
CLO-2	X		X			X	X	X
CLO-3	X		X			X	X	X
CLO-4	X		X					
CLO-5	X		X			X	X	
CLO-6			X					

Course Number	CH3203
Course Credit	L-T-P-C: 3-0-2-4
Course Title	Computational Chemistry
Learning Mode	Offline
Learning Objectives	The course addresses computer-based calculations within chemistry. The course intends to integrate theory with practical computation elements applied within the fields of environmental chemistry, protein chemistry and medicinal chemistry. The students are expected to acquire knowledge within quantum chemistry, molecular mechanics, bioinformatics, and the theoretical characterization of molecules, and applied methods for computation of the geometric and electronic structure of molecules.
Course Description	Central concepts for the computer-based application of organic molecules within quantum chemistry will be described and discussed. The focus within molecular mechanics is on describing and discussing the practical application of organic molecules, including proteins.
Course Outline	Module 1: Wave function of a particle in a box, harmonic oscillator, anharmonic oscillator. Module 2: Radial wave function of a hydrogen atom, atomic & hybridized orbitals, Wien's Law, ionization energy of hydrogen. Module 3: Time dependent perturbation theory: Integration of Schrodinger equation: 1D box, spherical box, simple harmonic oscillator, eigenvalues and eigenvectors. Module 4: SCF energies and dipole moment, calculation of auto-correlation function Fourier Transform and spectral applications.
Learning Outcome	After completing the course, students shall be able to 1. explain the most important principles for quantum chemical and molecular mechanical methods of computing the geometry and energy of molecules. 2. plan and apply computer-based calculations to determine the geometry, energies and electronic properties of molecules. 3. describe the theory behind methods of protein sequence comparisons and protein structure comparisons. 4. describe theoretical methods and plan to conduct computer-based calculations of chemical properties.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

- 1.W. Gehrke, Fortran 95 language guide, Springer Verlag, London, 1996.
2. S. A. Rice and M. Zhao, Optical control of molecular dynamics, John Wiley & Sons, New York, 2000.
- 3.R. D. Levine, Molecular reaction dynamics, C.U.P., Cambridge, 2005.
4. W. H. Press, Numerical recipes: the art of scientific computing, 3rd Edition, C.U.P., Cambridge, 2007.
- 5.H. D. Meyer, F. Gati and G. A Worth, Multidimensional, quantum dynamics: MCTDH theory and applications, John Wiley, 2009.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3	X	X	X		X			
CLO-4	X	X			X	X		

Course Number	CH3204
Course Credit	L T P C: 3 0 0 3
Course Title	Chemistry of Propellants and Pyrotechnics
Learning Mode	Offline
Learning Objectives	The objective of the course is to understand the chemistry related to propellants and pyrotechnics, which includes various synthesis processes, physical and energetic properties, stability, safety and performance of propellants and pyrotechnics. The course is also aimed at providing an understanding of various rocket propulsion systems, and parameters that govern the performance of rocket motors.
Course Description	This course is a basic understanding of propellant and pyrotechnic chemistry and its applications in space industry
Course Outline	Module 1: Introduction and classification of chemical propellants: General characteristic of propellants, liquid propellants, solid propellants, homogeneous propellants, single-base propellants, double-base propellants, triple-base propellants, heterogeneous propellants, composite propellants, composite modified double-base propellants, fuel-rich propellants, hybrid propellants, gel propellants Module 2: Performance of propellants: Force constant, oxygen balance, burn rate, burning rate coefficients, thrust, total impulse and specific impulse, chamber pressure, characteristic velocity Module 3: Ingredients of solid rocket propellants: Oxidizers, ammonium perchlorate, ammonium nitrate, ammonium dinitramide, hydrazinium nitroformate, binders, characteristic of binders, polyurethanes as binders, novel binders, inert or non-energetic binders, energetic binders, metal fuels, plasticizers, bonding agents, stabilizers, burn-rate modifiers. Module 4: Inhibition of rocket propellants: Characteristics of inhibitors, testing of inhibitors, ballistic evaluation of inhibited propellants, materials for inhibition, techniques of inhibition, inhibition of double-base propellants, tailoring of properties of unsaturated polyesters, inhibition of composite propellants, chemistry of epoxy resins, synthesis, curing agents for epoxy resins, plasticizer migration in composite propellants, inhibition of CMDB propellants Module 5: Insulation of rocket motors: Characteristics of insulators or insulating materials, materials for insulation, process for insulation of motors, future materials for insulation Module 6: Introduction and properties of pyrotechnics: Ingredients of pyrotechnic formulations, important characteristics of ingredients for pyrotechnic formulations, types of pyrotechnic formulations, performance assessment of pyrotechnic formulations.
Learning Outcome	After successful completion of the course, students will be able 1. To learn various commercial synthesis processes of chemical propellants 2. To understand the parameters pertaining to performance of propellants 3. To learn about the synthesis and properties of ingredients that constitutes solid propellants 4. To learn about the techniques of inhibition of rocket propellants and properties of various inhibitors

	5. To learn about the insulation process of rocket motors and properties of insulating materials 6. To learn synthesis of various pyrotechnics and to assess performance of pyrotechnic formulations.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Reference Books:

1. J. P. Agrawal, High Energy Materials: Propellants, Explosives and Pyrotechnics, 1st edition, Wiley-VCH Verlag GmbH; 2010
 2. D. P. Mishra, Fundamentals of Rocket Propulsion, CRC Press; 2017
- E. C. Koch, High Explosives, Propellants, Pyrotechnics, De Gruyter; 2021

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5
CLO-1		X	X		X
CLO-2			X		X
CLO-3		X	X		X
CLO-4			X		X
CLO-5			X		X
CLO-6		X	X		X

Course Number	CH3205
Course Credit	L-T-P-C: 0-0-6-3
Course Title	Chemical Technology Lab-III
Learning Mode	Offline
Learning Objectives	The students will be able to learn how to apply the concepts of physical chemistry by doing experiments. Students will learn different instrumental techniques used to explain the fundamentals of physical chemistry. This will give them experience to solve the existing problem in basic science. They will be able to demonstrate some instrumental techniques at the end of the course.
Course Description	This course contains experiments based on the concept of Physical Chemistry. Students will do experiments based on instrumentation methods, volumetric methods, surface chemistry, electrochemistry etc.
Course Outline	Module 1: Experiments based on various physical properties such as viscosity, surface tension, optical rotation and refractive index, light absorption and emission (spectroscopy). Module 2: Experiments based on chemical kinetics and thermodynamics: determination of order of simple reactions, energy of activation, equilibrium constants, determination of thermodynamic functions. Module 3: Experiments based on sound velocity in liquids systems. Module 4: Experiments based on EMF and conductance measurements: determination of electrode potentials, solubility product, pH equivalent conductance; Determination of the CMC of surfactants from conductivity and surface tension measurements. Module 5: Experiments based on adsorption of an organic acid by activated carbon in aqueous media using the Langmuir adsorption isotherm and determination of surface area. Module 6: Experiments based on phase equilibria: Study of binary and ternary liquid systems.
Learning Outcome	Students will be able to 1. Develop skill to solve problems related to physical chemistry. 2. Demonstrate procedures and methods applied in physical chemistry by doing experiments. 3. To learn different instrumental techniques to explain the fundamentals of physical chemistry. 4. Design, interpretation and documentation of laboratory experiments related to physical chemistry, which will be suitable to get an entry level position in the chemical industry.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text books:

1. V. D. Athawale and Parul Mathur, Experimental Physical Chemistry, New Age International Publishers, 2001.
2. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, Viva Books Private Ltd., 2005.
3. R. A. Day (Jr.) and A. L. Underwood, Quantitative Analysis, 6th Edition, Prentice-Hall of India Pvt. Ltd., 2006.
4. D. P. Shoemaker, C. W. Garland and J. W. Nibler, Experiments in Physical Chemistry, 8th Edition, McGraw- Hill International Ed., 2008.
5. J. M. Postma, J. L. Roberts (Jr.), Chemistry in the Laboratory, 8th Edition, W.H. Freeman and Company, 2016.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1		X		X				
CLO-2				X	X			
CLO-3		X	X	X	X			
CLO-4				X	X			

List of Department Electives (DE-I) for 6th semester						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH3206	Metal Ions in Chemical Biology	3	0	0	3
2.	CH3207	Petroleum and Petrochemicals	3	0	0	3

Course Number	CH3206
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Metal Ions in Chemical Biology
Learning Mode	Offline
Learning Objectives	To introduce this highly interdisciplinary subject and show how selected metal ions are important in the biological environment, highlight the role of the metal ions in catalysis of biochemical reactions and their importance in sustaining life-processes.
Course Description	The course describes the biological significance of various essential and trace metal including their storage, transport, and bio-mineralization. Students will learn about diseases associated with deficiency or toxicity of essential and trace metal ions. It also introduces the mechanistic course of action of various metalloproteins and enzymes under physiological conditions and their important roles in sustaining life.
Course Outline	Module 1: Historical development of Bioinorganic Chemistry and contributions of notable scientists and Nobel laureates, Role of metal ions in biological systems, alkali and alkaline earth cations in biological systems and ionophores. Module 2: Non-redox metalloenzymes such as Carboxypeptidases, Carbonic Anhydrase, and Alcohol Dehydrogenase. Module 3: Redox-proteins: Siderophores, Iron–Sulfur Proteins, Haem, non-haem and electron transfer proteins of iron. Copper proteins including Plastocyanin, Azurin, Superoxide Dismutase, and Hemocyanin. Module 4: Storage and transport of Zn, Mo, Co, Cr, V, and Ni; biomineralization of Iron, Active site structure and function/activity of xanthine oxidase, nitrogenase, vitamin B12 coenzyme, photosystem I and II.
Learning Outcome	Students will be able to 1. understand scientific reports describing inorganic aspects of proteins and enzymes. 2. understand structure-property relationship of metal-based proteins/enzymes and appreciate the importance of metal ions. 3. propose design and syntheses of new synthetic models that would mimic enzymes. 4. understand and explain the reaction pathways of various metal based enzymes in physiological systems 5. understand the causes of various diseases that are caused due to deficiency or biomagnification of metal ions.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%)

Suggested Readings:

Text Books:

1. Ochiai Ei-Ichiro, Bioinorganic Chemistry: A Survey, Elsevier India, 2012,
2. W. Kaim, B. Schwederski, A. Klein, Bioinorganic Chemistry - Inorganic Elements in the Chemistry of Life: An Introduction and Guide, 2nd Edition, Wiley, 2013.

Reference Book:

1. H. B. Gray, E. I. Stiefel, J. S. Valentine, I. Bertini, Biological Inorganic Chemistry: Structure and Reactivity, 1st Edition, University Science Book, 2006.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						X
CLO-2	X	X			X			
CLO-3	X		X		X		X	
CLO-4	X	X			X	X	X	
CLO-5	X	X						X

Course Number	CH3207
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Petroleum and Petrochemicals
Learning Mode	Offline
Learning Objectives	The objective of the course is to understand the basic chemistry pertaining to processing of petroleum products, thermal and catalytic cracking for formation of various useful chemicals, and synthesis process of petrochemical products. In addition, the aim of the course is to provide an understanding of various industrial problems and solutions related to petroleum and petrochemical industry
Course Description	The course is a understanding of various chemical processes related petroleum and petrochemical industry
Course Outline	Module 1: Origin: Formation and composition of petroleum Module 2: Petroleum processing: Fractionation, blending of gasoline, gasoline treatment, kerosene treatment, treatment of lubes, petroleum wax and purification Module 3: Thermal and catalytic processes: Thermal cracking, catalytic cracking, catalytic reforming, naphtha cracking, coking, hydrogen processes, alkylation, isomerization processes; polymer gasoline, asphalt, upgradation of heavy crudes; Module 4: Specialty products: Industrial gases, liquid paraffin, petroleum jelly. Module 5: Sources of Petrochemicals and Synthesis: Synthesis of methanol, formaldehyde, acetylene, synthetic gas, ethanol, ethylene, ethylene glycol, vinyl acetate, acrylic acid and acrylates, acrylonitrile, acetone, acetic acid, chloroprene, vinyl chloride, vinyl acetate, acrylonitrile, propylene, butadiene, butanes, isobutene, adipic acid, adiponitrile, benzene, toluene, xylene, phenol, styrene, phthalic acid, phthalic anhydride and their applications in chemical industry.
Learning Outcome	After successful completion of the course, students will be able 1. to learn about formation and composition of petroleum 2. to learn various techniques of petroleum products processing including the purification process. 3. to learn thermal and catalytic processes for preparation of various industrially useful chemicals. 4. to learn about synthesis of various petrochemicals 5. to learn about applications of petrochemical products in chemical industry
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. P. Wiseman, Petrochemicals, John Wiley & Sons, 1986.
2. I. D. Mall, Petrochemical Process Technology, 2nd Edition, Laxmi Publications Private Limited, 2017.
3. B. K. B. Rao, Modern Petroleum Refining Processes, 6th Ed., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2018.

Reference Books:

1. R. A. Meyers, Handbook of Petroleum Refining Processes, 4th Edition, McGraw-Hill, 2016.
2. S. Raseev, Thermal and Catalytic Processes in Petroleum Refining, 1st Edition, CRC Press, 2020.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X							
CLO-2	X		X		X			
CLO-3	X	X	X		X			
CLO-4	X	X			X			
CLO-5			X		X			

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	CH41XX	Departmental Elective – II	3	0	0	3
2.	CH41XX	Departmental Elective – III	3	0	0	3
3.	XX41PQ	IDE-III	3	0	0	3
4.	HS41XX	HSS Elective II	3	0	0	3
5.	CH4198	Summer Internship*	0	0	12	3
6.	CH4199	Project – I	0	0	12	6
TOTAL			12	0	24	21

Department Electives - II						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4107	Drug Design and Development	3	0	0	3
2.	CH4108	Dyes, Paints and Pigments	3	0	0	3

Course Number	CH4107
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Drug Design and Development
Learning Mode	Offline
Learning Objectives	Understand the fundamental principles of drug targets and their role in pharmacotherapy. Explain the concepts of absorption, distribution, metabolism, and excretion (ADME) in pharmacokinetics and their implications in drug development. Analyze different routes of administration and dosing strategies for various drugs. Differentiate between in vivo and in vitro drug testing methods and their applications in preclinical research. Identify natural and synthetic lead compounds in drug discovery and explain the process of combinatorial synthesis. Apply pharmacokinetics-based drug design principles to optimize drug efficacy and safety. Describe the principles of computer-aided drug design (CADD) including quantitative structure-activity relationship (QSAR) models. Assess the importance of toxicology, pharmacology, and drug metabolism studies in drug development. Understand the phases and design of clinical trials and the regulatory affairs involved in commercializing a pharmaceutical product. Comprehensive understanding of the drug development process from discovery to commercialization.
Course Description	This course provides a comprehensive overview of the multidisciplinary field of drug development, covering key concepts and methodologies from discovery to commercialization. Students will delve into the intricate processes involved in identifying drug targets, optimizing pharmacokinetics, conducting preclinical and clinical testing, and navigating regulatory affairs and commercialization strategies.
Course Outline	Module 1: Drug targets; Pharmacokinetics: ADME, administration and dosing; Drug testing: in vivo and in vitro. Module 2: Drug discovery with case studies: natural lead, synthetic lead, combinatorial synthesis. Module 3: Pharmacokinetics based drug design; Computer aided drug design: Principles of QSAR, 2D QSAR, 3D QSAR; Module 4: Chemical development, Patenting, Process development; Toxicology. Module 5: Pharmacology, Drug metabolism, Clinical trials, Commercialization: regulatory affairs, pipeline development, pharmaceutical market places, business opportunities.
Learning Outcome	Students will be able to 1. gain a thorough understanding of the multidisciplinary aspects of drug development, including drug targets, pharmacokinetics, drug testing, discovery methods, and commercialization strategies. 2. develop the ability to analyze and evaluate different drug development processes, including absorption, distribution, metabolism, and excretion (ADME), as well as in vivo and in vitro testing methods. 3. apply concepts such as pharmacokinetics-based drug design, computer-aided drug design (CADD), and quantitative structure-activity relationship (QSAR) modeling to optimize drug efficacy and safety. 4. integrate knowledge from various disciplines including chemistry, biology, pharmacology, toxicology, and business to understand the complex interplay involved in bringing a drug from discovery to commercialization.

Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).
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Suggested Readings:

Text Books:

1. G. Patrick, Instant Notes: Medicinal Chemistry, Viva Books Pvt. Ltd., 2002.
2. G. Thomas, Fundamentals of Medicinal Chemistry, John Wiley & Sons Ltd., 2006.

Reference Books:

1. G. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, 2001.
2. T. Nogrady, Medicinal Chemistry: A Biochemical Approach, Oxford University Press, 2004.
3. S. Pidgeon, Wiley handbook of Current and Emerging Drug Therapies, Vol. 4, Wiley Interscience, 2007.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3		X	X		X			
CLO-4	X				X			

Course Number	CH4108
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Dyes, Paints and Pigments
Learning Mode	Offline
Learning Objectives	To impart knowledge regarding various types of paints, pigments and dyes in general. Specifically, the students will learn the composition of paints, pigments and dyes, their industrial syntheses and applications.
Course Description	The course describes various kinds of inorganic materials and organic molecules that are used as colouring agents. Basic requirements that are needed in materials/molecules for such application will be discussed. The syntheses and characterization of various paints, dyes and pigments will be discussed.
Course Outline	Module 1: Paints Compositions binders, extender, thinner and surface active agents; functions of the ingredients; paint formulations; importance of PVC, alkyds, epoxy and polyurethane resins. Module 2: Pigments Introduction – requirements of a pigment, typical inorganic pigments, general information and economic importance, white pigments, Titanium Dioxide pigments, manufacturing processes for TiO₂ pigments, applications for TiO₂ pigments, lithopone and zinc sulphide pigments, iron oxide pigments, Chromium(III) oxide pigments, magnetic pigments, manufacture of magnetic pigments. Module 3: Dyes Colour and chemical constitutions; classification; brightening agents; cyanine dyes; chemistry of colour developer – instant colour processes; synthesis and applications of Methyl orange, Congo red, Crystal violet, Malachite green, Phenolphthalein, Fluorescein, Alizarin and Indigo and Rhodamine B etc.
Learning Outcome	Students will be able to 1. have sound knowledge of polymers present in various commercial paints. 2. classify organic molecules in various categories of dyes based on the functional groups present. 3. identify inorganic compounds with applications as pigments. 4. be aware of the syntheses/manufacture of various paints, pigments and dyes that are of commercial importance.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Text Books:

1. Dyes and Pigments, Samuel Delvin, Ivy Publishing House, 1st Edition, 2006.
2. Industrial Organic Pigments, Martin U. Schmidt, Klaus Hunger and Thomas Heber, Wiley- VCH, 4th Edition, 2018.

	PLO 1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						X
CLO-2	X	X			X			
CLO-3	X		X		X		X	
CLO-4	X	X			X	X	X	X

Department Electives - III						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4109	Group Theory and Spectroscopy	3	0	0	3
2.	CH4110	Application of Statistical Mechanics in Chemistry.	3	0	0	3

Course Number	CH4109
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Group Theory and Spectroscopy
Learning Mode	Offline
Learning Objectives	The student should be able to: Recognize symmetry elements in a molecule; State the point group a molecule belongs to. They will learn how to construct character tables and its applications. Students will be able to explain the different phenomena that take place due to the interaction of light with matter. Students will be able to get basic knowledge on molecular spectroscopy techniques such as rotational spectroscopy, vibrational spectroscopy, Raman spectroscopy, electronic spectroscopy. Fundamental theories behind these techniques, selection rules, and factors affecting the spectra will be covered in this course.
Course Description	This course introduces the concept of group, and different symmetry elements in a molecule, construction of character table and its applications. This course introduces different phenomena that take place due interaction of light with matter, fundamental theories, selection rules, factors that control spectral line width and line shape. This course describes the fundamental theories for different spectroscopic techniques such as rotational spectroscopy, vibrational spectroscopy, Raman spectroscopy, electronic spectroscopy.
Course Outline	Module 1: Group Theory: Definition of group, symmetry, point groups, representation of group, orthogonality theorem, irreducible representation, character table. Module 2: Spectroscopy: Electromagnetic radiation and its interaction with matter; Uncertainty principle: Natural line width and broadening. Module 3: Microwave: classification of molecules, selection rules, intensity of spectral lines, effect of isotopic substitution. Module 4: Infrared: Harmonic oscillator, selection rules, vibrational energy of diatomic molecules, zero-point energy, force constant and bond strength; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P, Q, R, branches; Breakdown of Born-Oppenheimer approximation, vibration of polyatomic molecules; normal mode of vibration, overtone, hot bands. Module 5: Raman: Classical and quantum theories of Raman effect, pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle; Resonance Raman. Module 6: Electronic Spectroscopy: Energy levels, Franck-Condon principle, electronic spectra of polyatomic molecules.
Learning Outcome	Students will be able to 1. categorize molecules on the basis of their symmetry properties, which allow them to predict many molecular properties. 2. describe factors involved in spectroscopic transition, such as transition probability, selection rules, spectral line width and line shape etc. 3. describe spectroscopy in microwave region, rotational spectra of rigid diatomic molecules, selection rules, non-rigid rotor. 4. study vibrating diatomic molecule, energy levels of a diatomic molecule, simple harmonic and anharmonic oscillator, selection rule. 5. understand the concepts of Raman spectroscopy, concept of polarizability, rotational and vibrational Raman Spectra. 6. understand the concepts of electronic spectroscopy.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%)

Suggested Readings:

Texts Books:

1. F.A. Cotton, Chemical Applications of Group Theory, 3rd Edition, Wiley Interscience, 1990.
2. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, 1994.

Reference books:

1. H. E. White, Introduction to Atomic Spectra, McGraw Hill, 1934.
2. G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw Hill, 1962.
3. M. Tinkham, Group Theory and Quantum Mechanics, McGraw Hill, 1964.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X			X			
CLO-3	X	X			X			
CLO-4	X	X			X			
CLO-5	X	X			X			
CLO-6	X	X			X			

Course Number	CH4110
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Application of Statistical Mechanics in Chemistry
Learning Mode	Offline
Learning Objectives	An in-depth study of the Statistical mechanics and apply it to challenging problems in science.
Course Description	This course explores the fundamental principles of statistical mechanics with a focus on their application to chemistry, covering both physical and statistical aspects.
Course Outline	Module 1: Review of basics: Introduction and reviews of classical mechanics, quantum mechanics and thermodynamics; Module 2: Introduction of statistical mechanics: Concept of Microstates and macrostates; Liouville's equation; Concept of ensemble: microcanonical, canonical, and grand canonical ensemble; Boltzmann distribution for distinguishable particles; The emergence of temperature from conditions for equilibrium; postulate for entropy; Module 3: Partition function for ideal gas: Canonical partition function: molecular partition function of non-interacting particles, translational, rotational, and vibrational partition functions for noninteracting particles; Absolute values of different thermodynamic quantities; Statistical mechanics approach of chemical equilibrium Module 3: Partition function for real gas: Derivation of canonical partition function for weakly interacting gas particles; derivation of the Virial equation of state and the second virial coefficient; Application for hard sphere and square well potential. Temperature dependence of the second virial coefficient. Module 4: Quantum statistics: Quantum statistics (Bose-Einstein and Fermi-Dirac) for indistinguishable particles; Photon gas; Density of states for photons; Black body radiation; Debye frequency and specific heat of phonons, heat capacity of a Fermi gas, the classical limit from the quantum mechanical expression for partition function
Learning Outcome	Students will be able to 1. understand the fundamentals of statistical mechanics and its application in Chemistry. 2. develop problem-solving ability in statistical mechanics. 3. develop research aptitude in statistical mechanics related area such as Molecular Dynamics and Monte Carlo. 4. apply the fundamental knowledge in statistical thermodynamics to an existing and emerging problem, such as drug discovery, biophysical chemistry, material science and energy related research, where the knowledge is required.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Text Books:

1. D. A. McQuarrie, Statistical Mechanics, University Science Books, 2000.
2. K. L. Kapoor, A Textbook of Physical Chemistry - Volume 5, 4th Edition, McGraw Hill, 2020.

Reference Books:

1. K. Huang, Statistical Mechanics, Wiley, 2nd Edition, 2008.
2. M. Tuckerman, Statistical Mechanics: Theory and Molecular Simulation, OUP Oxford, 2nd Edition, 2010.
3. B. Bagchi, Statistical Mechanics for Chemistry and Materials Science, CRC Press, 1st edition, 2018.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X	X					
CLO-3					X	X		
CLO-4							X	X

PROJECT – I and II

Course Number	CH4199 & CH4299
Course Credit	CH4199: L-T-P-C: 0-0-12-6 CH4299: L-T-P-C: 0-0-16-8
Course Title	Project-I & Project-II
Learning Mode	Offline
Learning Objectives	Apply the concepts of chemical science and technology by doing experiments/theoretical and computational studies for a particular research project under the supervision of a faculty member; Development of skill to solve problems through hands-on experience on a research problem. To learn different instrumental techniques, and computational methods to interpret and present data
Course Description	This course is aimed at exposing students to research through hands-on learning skills in laboratory set up. Students will do experiments based on research goals as pre decided and floated by faculty members, learn data curation, interpretation, writing reports and present data.
Course Outline	Research in laboratory set up
Learning Outcome	Students will be able to 1. demonstrate planning, time and enhance experimental skills. 2. demonstrate leadership skills. Undertake research independently. 3.demonstrate a capacity to communicate research results clearly, comprehensively and persuasively.
Assessment Method	Research report and presentation

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X		X	X	X	X		X
CLO-2	X		X	X	X	X		X
CLO-3	X		X	X	X	X		X

Sl. No.	Subject Code	SEMESTER VIII	L	T	P	C
1.	CH42XX	Departmental Elective – IV	3	0	0	3
2.	CH42XX	Departmental Elective – V	3	0	0	3
3.	CH42XX	Departmental Elective – VI	3	0	0	3
4.	CH4299	Project – II	0	0	16	8
TOTAL			9	0	16	17
GRAND TOTAL (Semester I to VIII) – 166						

Department Electives - IV						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4207	Catalysis	3	0	0	3
2.	CH4208	Colloids and Interface Chemistry	3	0	0	3

Course Number	CH4207
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Catalysis
Learning Mode	Offline
Learning Objectives	To showcase the usefulness of catalysts to improve efficiency and yields of chemical reactions performed on a small scale as well as industrial scale. To teach the basics of catalysis, associated theories, synthesis and characterizations of commonly used catalysts.
Course Description	The course describes various types of catalysts that are known. This includes discrete inorganic complexes as well as organic molecules, enzymes and insoluble inorganic clusters and materials. Practical examples of catalysts used in small scale (laboratory) and large scale (industry) will be discussed.
Course Outline	Module 1: The basics of catalysis: Different types of catalysts. Module 2: Homogeneous catalysis: Preparation and characterization of transition metal based catalysts, selected reactions of commercial importance that use homogeneous catalysts. Module 3: Heterogeneous catalysis: Freundlich adsorption isotherm, Langmuir adsorption isotherm, determination of surface area of adsorbent, BET adsorption isotherm, thermodynamic treatment of adsorption, adsorption at the surface of a liquid. Industrial applications Module 4: Biocatalysis and Organocatalysis Design and synthesis of catalysts and their applications, practical examples of enzymatic catalysis.
Learning Outcome	Students will be able to 1. identify molecules or chemicals that can be used as catalysts. 2. understand requirements for a chemical to act as catalyst. 3. propose design and syntheses of new catalysts. 4. understand various theories related to enzyme catalysts 5. select an appropriate catalyst among several options for a given chemical transformation.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. J. Weitkamp, and L. Puppe, Catalysis and Zeolites: Fundamentals and Applications, Springer Verlag, 1999.
2. J. J. Carberry, Chemical and Catalytic Reaction Engineering, Dover, 2001.
3. Gadi Rothenberg, Catalysis: Concepts and Green Applications, 2nd Edition, Wiley-VCH, 2017.
4. K. L. Kapoor, Text Book of Physical Chemistry, Vol 5, 4th Edition, McGraw Hill, 2020.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						
CLO-2	X	X						
CLO-3	X		X		X		X	
CLO-4	X	X	X		X		X	
CLO-5	X	X	X		X			

Course Number	CH4208
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Colloids and Interface Chemistry
Learning Mode	Offline
Learning Objectives	The course aims to teach about properties of colloidal solutions, thermodynamics of colloidal solutions and few of their applications in practice.
Course Description	This course will cover a brief introduction and properties of colloidal solution, thermodynamics and stability of colloidal solution, light scattering principles and applications towards molecular weight determination. Also few examples of colloids from real life applications will be discussed and introduced.
Course Outline	Module 1: Colloidal state of matter. Properties of lyophilic and lyophobic colloidal solutions. Module 2: Thermodynamics of electrified interface, stability of colloidal solutions: Theory of Verwey and Overbeek, colloidal electrolytes, polyelectrolytes. Donnan membrane equilibria. Module 3: Determination of molecular weight of macromolecules. Micelles, reverse micelles. Surface energetics and adsorption from liquids. Emulsion, detergent, gels and foams. Module 4: Applications in detergents, personal-care products, pharmaceuticals, nanotechnology, and food, textile, paint and petroleum industries.
Learning Outcome	After completion of the course, students will be able to: 1. Learn about basic properties of colloids. 2. Demonstrate knowledge about thermodynamics and stability of colloids. 3. Apply a concept to determine molecular weight of polymeric colloids via light scattering technique. 4. Apply the concept of colloids in real life applications and find relevance in industries.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Textbooks:

1. P. C. Hiemenz and R. Rajagopalan, Principles of Colloid and Surface Chemistry, Marcel Dekker, New York, 1997.
2. P. Ghosh, Colloid and Interface Science, PHI Learning, New Delhi, 2009.

References:

1. J. Israelachvili, Intermolecular and Surface Forces, Academic Press, New York, 1992.
2. A. W. Adamson and A. P. Gast, Physical Chemistry of Surfaces, John Wiley & Sons, New York, 1997.
3. R. J. Hunter, Foundations of Colloid Science Oxford University Press, New York, 2005.
4. J. C. Berg, An Introduction to Interfaces and Colloids: The Bridge to Nanoscience, World Scientific, Singapore, 2010.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						X
CLO-2	X	X			X			
CLO-3	X		X		X		X	
CLO-4	X	X			X	X	X	

Department Electives - V						
Sl. No.	Subject Code	Course Name	L	T	P	C
1.	CH4209	Food Chemistry	3	0	0	3
2.	CH4210	Green and Sustainable Chemistry	3	0	0	3

Course Number	CH4209
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Food Chemistry
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation for Material Chemistry. The course aims to nurture knowledge to understand fundamental concepts of Material science with their synthesis, characterization and applications.
Course Description	The course applies basic chemical principles to food systems and practical applications. Chemical/biochemical reactions of carbohydrates, lipids, proteins, and other constituents in fresh and processed foods are discussed with respect to food quality. Chemical processes that affect color, flavor, texture, nutrition, and safety of food. Important aspects of food and beverage industry including packaging are discussed.
Course Outline	Module 1: Introduction to food Chemistry: properties, reactions, qualitative and quantitative analysis of carbohydrates, lipids (oils, fats and emulsions) and proteins (meat and dairy) based food products; storage and processing of these food products and how these influence the quality and properties of the food, importance of water for stability and quality of foods. Module 2: Color, flavor, fragrance and preservatives: Chemistry of edible dyes, standards, and regulatory aspects, chemical components of different flavors and preservatives commonly used in the food industry, natural and artificial sweeteners, artificial flavor mimetic compounds including acids, alcohols, esters, ketones, aldehydes, and other flavor compounds; chemical compounds for fragrance and aroma in food and beverage industry, chemicals for preservation and ripening of fruits. Module 3: Microorganisms and toxins in food and beverage industry: role of microbes in dairy products and alcohol production; the use of microbes in flavor, aroma, texture, and digestibility; food spoilage and food poisoning, common chemical food toxins. Module 4: Chemistry of Food packaging: food packaging materials (plastics, biopolymers, glass, and metal) and their properties and applications; ethylene and Oxygen scavengers, toxicity issues, food packaging and circular economy Module 5: Vitamins and Nutraceuticals: Basic chemistry of vitamins and their function; emergence, importance and basic chemistry of nutraceuticals and their health benefits, natural sources and production of nutraceuticals
Learning Outcome	Upon successful completion, students will have the knowledge and skills to: 1. Demonstrate and apply knowledge of the core competencies in Food Chemistry and analysis. 2. Understand the chemistry involved in the properties and reactions of various foods and their components. 3. Understand and effectively apply the principles behind analytical techniques associated with food, components of commonly used chemicals used in food industry. 4. Understand and effectively apply food chemistry and analysis methods to intercept food quality, nutritional requirement and health benefits.
Assessment Method	20% Quiz and assignment, 30% Midsem and 50% End semester exam

Suggested reading

1. Fennema's Food Chemistry, fourth edition, 2007, CRC Press
2. Food Science, B. Srilakshmi, 3rd Edition, New age International Publications
3. Food processing and preservation, S. Sivasankar, 2002, prentice Hall of India.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X	X	X	X
CLO-2	X	X			X		X	
CLO-3			X			X		X
CLO-4	X			X	X	X	X	

Course Number	CH4210
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Green and Sustainable Chemistry
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation of green and sustainable chemistry and its application in solving modern day-to-day problems. The course aims to nurture knowledge to understand fundamental concepts to applications of sustainable chemistry.
Course Description	New ideas and innovations are essential to meeting industry and society's growing needs for green chemistry and clean technology. This course aim is to provide key principles of green chemistry and the importance of clean and sustainable technology. The course will help to develop and enhance your transferable skills as well as those skills required for careers in a range of industries, such as chemical research techniques and how to apply them. Importance of protecting intellectual property and commercializing new inventions.
Course Outline	Module 1: Concepts of sustainable and green chemistry: Concept of sustainable and green chemistry: 12 principles of green chemistry: how to apply them in chemical synthesis: difference between sustainable and green chemistry. Module 2: Principles and systems thinking in green and sustainable Chemistry: Holistic-thinking: control of environmental impact of chemicals: alternative reaction media for green and sustainable chemistry: catalysis for green and sustainable chemistry. Module 3: Applications of green and sustainable chemistry: Clean synthesis: sustainable industrial technologies and processes: renewable resources. Module 4: Resources, recycling and circular economy: insights into the availability and specifics of mineral, biological and fossil resources: challenges of current and future use of these resources, their recycling and the establishment of a circular economy with respect to sustainability. Module 5: Case study for green and sustainable Chemistry: Intellectual Property Rights and Finance: Greener Products and Legislation including circular economy law and science.
Learning Outcome	After completion of the course, students will be able to: 1.learn about basic concept of Green and sustainable chemistry. 2.demonstrate knowledge about Green and sustainable chemistry. 3.apply the concept to differentiate and critically evaluate the importance of heterogeneous catalysis to green chemistry. 4.apply the concept of green and sustainable chemistry in real life applications and find relevance in modern industries.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. Green Chemistry Metrics: Measuring and Monitoring Sustainable Processes A. Lapkin and D. Constable, 2008.
2. Handbook of Green Chemistry, Green Processes, Designing Safer Chemicals P. Anastas and P. Trevorrow, 2013.
3. Green Chemistry: An Introductory Text M. Lancaster, Royal Society of Chemistry, 3rd Edition, 2016, e-pub Print.

Reference Books:

1. Sustainable Catalysis (Green Chemistry Series) M. North, J.H. Clark, 2015.
2. Alternative Energy Sources for Green Chemistry (Green Chemistry Series) G. Stefanifis, A. Stankiewicz, J.H. Clark, A. de la Hoz, J. Fan, R. Mato Chain, J. Santamaria, 2016.
- 3.Sustainable Solvents: Perspectives from Research, Business and International Policy (Green Chemistry Series) J. H. Clark, A. Hunt, C. Topi, G. Paggiola and J. Sherwood, 2017.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X	X		
CLO-2	X	X	X		X	X		
CLO-3	X		X			X		
CLO-4						X	X	X

Department Electives - VI						
Sl. No.	Course Code	Course Name	L	T	P	C
1.	CH4211	Materials Chemistry	3	0	0	3
2.	CH4212	Organic Semiconductors: Fundamentals to Applications	3	0	0	3

Course Number	CH4211
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Material Chemistry
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation for Material Chemistry. The course aims to nurture knowledge to understand fundamental concepts of Material science with their synthesis, characterization and applications.
Course Description	This course introduces basic material chemistry in the macro and nanoscale, their types, properties and their applications in daily life.
Course Outline	Module 1: Introduction to Materials Chemistry: Materials for solid state devices: Rectifiers, transistors, capacitors - IV-V compounds - low - dimensional quantum structures, optical properties, Module 2: Nonlinear Optical Materials: Nonlinear optical effects, second and third order - molecular hyperpolarisability and second order electric susceptibility - materials for second and third harmonic generation. Module 3: Polymeric Materials: Molecular shape, structure and configuration - crystallinity – stress-strain behavior - thermal behavior - polymer types and their applications - conducting and ferroelectric polymers. Module 4: Liquids Crystals: Mesomorphic behavior - thermotropic and lyotropic phases - description of ordering in liquid crystals, the director field and order parameters - nematic and smectic mesophases, smectic - nematic transition and optical properties of liquid crystals. Module 5: Materials in micro and nanoscale: Top down and bottom up approach for construction, types: metallic, semiconductor, carbonaceous etc, analytical techniques to intercept those materials.
Learning Outcome	Upon successful completion, students will have the knowledge and skills to 1. explain the fundamental principles of Material science and technology and their applications 2. apply concepts to the nano-scale and non-continuum domain. 3. identify and compare material and methods to perform a critical analysis of the research literature. 4. design processing conditions to engineer functional materials. 5. distinguish and characterize material diversity, synthesis approaches and material safety issues.
Assessment Method	20% Quiz and assignment, 30% Mid sem and 50% End semester examination.

Suggested reading

Text Books:

1. Malcolm P. Stevens, Polymer Chemistry: An Introduction, Oxford University Press, USA, 3rd Edition, 1999.
2. Robert J. Young, and Peter A. Lovell, Introduction to Polymers, CRC Press, 3rd Edition, 2011.
3. W.D. Callister, D. G. Rethwisch Material Science and Engineering. An Introduction, Wiley, New York 10th Edition (2018).

Reference Books:

1. N.W. Ashcroft, N.W. Mermin, Solid State Physics, Saunders College, Philadelphia (1976).
2. Paul C. Hiemenz, and Timothy P. Lodge, Polymer Chemistry, CRC Press, 2nd Edition, 2007.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						X
CLO-2	X	X			X			
CLO-3	X		X		X		X	
CLO-4	X	X			X	X	X	

Course Number	CH4212
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Organic Semiconductors: Fundamentals to Applications
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation for understanding Organic Semiconductors. It seeks to nurture a comprehensive knowledge of the fundamental concepts of Organic Semiconducting Materials, including their synthesis, characterization, and applications.
Course Description	This course offers an in-depth exploration of conjugated organic oligomers, dendrimers, and polymers, focusing on their structural types, synthesis methods, properties, and applications. The curriculum is designed to provide a comprehensive understanding of these materials, which play a crucial role in modern organic electronics and biomedical.
Course Outline	Module 1: Introduction: Description of conjugated organic oligomers, dendrimers, and polymers. Types of structural polymers; polyacetylenes, polyphenylenevinyls, polyphenyleneethynyls, polyfluorenes, polythiophenes, polyphenylenes, polyanilines, water soluble polymers. Linear and cross-conjugation materials. Module 2: Synthesis: Synthetic methods for constructing of conjugated organic oligomers and polymers. C-C, C=C, C≡C and C-heteroatom coupling reactions – historical context and latest developments. Representative examples. Mechanistic description. Benzenoid polycyclic aromatic hydrocarbons (PAHs)– synthesis, functionalization approaches and applications in organic electronics devices. Module 3: Properties: Electronic structure of organic semiconductors –molecular picture of conjugated organics. Thermal stability. Electrochemistry and energy level measurements. Absorption and Luminescence-Jablonski diagram. Excited state dynamics in organic semiconductors. Fluorescence quenching. Non-linear optical properties. Module 4: Applications: Organic Light-emitting diodes (OLEDs), solar cells–device architectures, Field-effect transistors, optical chemosensors for toxic anions and metals. Photocatalysis. Types of materials, characterization and theory of operation, bioimaging and photodynamic therapy.
Learning Outcome	Upon successful completion, students will have the knowledge and skills to: 1. Attain a comprehensive understanding of the structural diversity of conjugated organic materials. 2. Gain knowledge of various synthetic methods for constructing organic semiconducting materials. 3. Understand the detailed characterization techniques for organic semiconducting materials. 4. Comprehend the molecular design and practical applications of organic materials in organic electronics and biomedical fields.
Assessment Method	20% Quiz and assignment, 30% Midsem and 50% End semester exam

Suggested reading

1. Principles of fluorescence spectroscopy by J. R. Lakowich, Thierd edition.
2. Organic electronics materials and devices, S. Ogawa, Springer, 2015
3. Smart Electronic Materials: Fundamentals and Applications”, Singh J, 2005, Cambridge University Press
4. “Carbon-Rich Compounds: From Molecules to Materials” by Haley, M.M. and Tykwinski, R.R. (Ed.), Wiley.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X	X	X	X
CLO-2	X	X			X		X	
CLO-3			X			X		X
CLO-4	X			X	X	X	X	

IDE (For students of B. Tech. other than Dept. of Chemistry)

Sl. No.	Course Code	Course Name	L	T	P	C
1.	CH2206	IDE-I: Green Science and Technology	3	0	0	3
2.	CH3106	IDE-II: Synthesis of Industrially Important Inorganic Molecules	3	0	0	3
3.	CH4111	IDE-III: Analytical Chemistry	3	0	0	3

Course Number	CH2206
Course Credit	L-T-P-C: 3-0-0-3
Course Title	IDE – 1: Green Science and Technology
Learning Mode	Offline
Learning Objectives	The course aims to nurture knowledge to understand fundamental concepts of sustainable or green chemistry in lab and industry.
Course Description	The course applies basic chemical principles to food systems and practical applications. Chemical/biochemical reactions of carbohydrates, lipids, proteins, and other constituents in fresh and processed foods are discussed with respect to food quality. Chemical processes that affect color, flavor, texture, nutrition, and safety of food. Important aspects of food and beverage industry including packaging are discussed.
Course Outline	Module 1: Principles and Concepts of Green Chemistry: Definition and twelve fundamental principles. Module 2: Waste: production, problems and prevention, sources of waste, cost of waste, waste minimization technique, waste treatment and recycling. Module 3: Greener reactions- catalysis and solvents: Classification of catalysts, heterogeneous catalysts heterogeneous catalysis, biocatalysis. Safer solvents, green solvents, water as solvents, solvent free conditions, ionic liquids, super critical solvents, fluorinated biphasic solvents Module 4: Alternative Energy Source: Energy efficient design, photochemical reactions, microwave assisted reactions, sonochemistry and electrochemistry. Module 5: Industrial Case Studies: Greening of acetic acid manufacture, Leather manufacture (tanning, fatliquoring), green dyeing, polymer, ecofriendly pesticides, paper and pulp industry, pharmaceutical industry. An integrated approach to green chemical industry.
Learning Outcome	Upon successful completion, students will have the knowledge and skills to: 5. Understand different parameters of green chemistry and sustainability. 6. Understand the basis how to design greener reactions and processes. 7. Understand the basis of greener products/chemicals and materials. 8. Understand the application of green chemistry principles to build safer industries.
Assessment Method	20% Quiz and assignment, 30% Midsem and 50% End semester exam

Textbooks:

1. V. K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions, Ane Books India, New Delhi, 2006.
2. M. M. Srivastava, R. Sanghi, Chemistry for Green Environment, Narosa, New Delhi, 2005.

Reference:

1. P. T. Anastas and J.C. Warner, Green Chemistry, Theory and Practice Oxford, 2000. M. Doble and A. K. Kruthiventi, Green Chemistry and Engineering, Academic Press, Amsterdam, 2007.
2. Mike Lancaster, Green Chemistry: An Introductory Text, Royal Society of Chemistry, 2002.
3. R.E. Sanders, Chemical Process Safety: Learning from Case Histories, Butterworth Heinemann, Boston, 1999.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X	X	X	X
CLO-2	X	X			X		X	
CLO-3			X			X		X
CLO-4	X			X	X	X	X	X

Course Number	CH3106
Course Credit	L-T-P-C: 3-0-0-3
Course Title	IDE – II : Synthesis of Industrially Important Inorganic Molecules
Learning Mode	Offline
Learning Objectives	Impart concept on various synthesis of inorganic molecules which are industrially significant and understanding of different selected synthetic methods and their applications.
Course Description	This course gives an overview to synthetic inorganic methods and their application for the inorganic compounds. Important synthetic techniques are reviewed. The course gives an overview of important use of selected synthetic methods and a short introduction to their basic theory.
Course Outline	Module 1: Modern methods applied in the synthesis of inorganic, organometallic and polymer materials. Module 2: Handling of air and moisture sensitive compounds, dry box, glove bag, Schlenk line and vacuum line techniques. Module 3: Methods of purification of and handling of reactive industrial gases. Methods of purification of inorganic compounds and crystallization of solids for X-ray analysis. Module 4: General strategies, brief outline of theory and methodology used for the synthesis of inorganic/organometallic molecules to materials including macromolecules. Emphasis will be placed how to adopt appropriate synthetic routes to control shape and size of the final product, ranging from amorphous materials, porous solids, thin films, large single crystals, and special forms of nanomaterials. Module 5: A few examples of detailed synthesis will be highlighted in each category of materials.
Learning Outcome	Student would be able to 1. Get knowledge on synthetic methods, including sensitive methods. 2. Explain the theoretical principles and important applications of classical methods and the theoretical principles of selected methods. 3. Explain the theoretical theory and methodology of inorganic molecules/materials. 4. Suggest a suitable methodology for a specific purpose, and evaluate the synthesis using industrial important molecules and materials.
Assessment Method	Class test, assignment & quiz (20%), Mid Sem examination (30%), End Sem examination (50%).

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X						X
CLO-2	X	X			X			
CLO-3			X		X		X	
CLO-4					X	X	X	
CLO-5	X	X						

Course Number	CH4111
Course Credit	L-T-P-C: 3-0-0-3
Course Title	IDE – III : Analytical Chemistry
Learning Mode	Offline
Learning Objectives	Impart concept on various analytical methods and their applications in compound analysis, understanding of different selected analytical methods and their applications.
Course Description	This course gives an overview to analytical chemistry, analytical methods and their application for the detection of inorganic and organic compounds. Important analytical techniques are reviewed. The course gives an overview of important use of selected analytical methods and a short introduction to their basic theory.
Course Outline	Module 1: Introductory Topics: Development of Analytical Chemistry, Analytical Terms, Precision and Accuracy, Figures of Merit. Measurement Fundamentals: Signal-to-Noise Ratio, Origin of Instrument Noise, Quantifying Measurements and Extracting Information. Module 2: Atomic Spectroscopy: Principles, Flame Emission Spectroscopy, Atomic Absorption Spectroscopy, X-Ray Fluorescence. Module 3: Introduction to Chromatographic Separations: Classification, Chromatographic Parameters, Resolution, Band Broadening. Liquid Chromatography: HPLC Instrumentation, Adsorption Chromatography, Partition Chromatography. Gas Chromatography: Basic Description, Classification of GC Methods, Stationary Phase, Carrier Gas, Detectors. Module 4: Thermal & surface techniques: TGA, DSC, XPS, SEM, TEM.
Learning Outcome	Student would be able to 1. get knowledge on analytical chemistry, including basic analytical methods. 2. explain the theoretical principles and important applications of classical analytical methods Explain the theoretical principles of selected instrumental methods. 3. explain the theoretical principles of separation techniques in chromatography, and typical applications of chromatographic techniques. 4. suggest a suitable analytical method for a specific purpose, and evaluate the important sources of interferences and errors, and also suggest alternative analytical methods for quality assurance.
Assessment Method	Class test, assignment & quiz (20%), Mid sem examination (30%), End sem examination (50%).

Suggested Readings:

Text Books:

1. Skoog and Leary, "Principles of Instrumental Analysis"; 7th Edition, 2020.
2. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, "Analytical Chemistry an Introduction"; 9th edition, 2014

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X			X			
CLO-2	X	X						
CLO-3	X	X			X			
CLO-4	X	X			X			