K.R. MANGALAM UNIVERSITY
THE COMPLETE WORLD OF EDUCATION

SCHOOL OF BASIC AND APPLIED SCIENCES

(SBAS)

Programme Handbook

(Programme Structure and Evaluation Scheme)

Bachelor of Sciences (Honours/Honours with Research) in Chemistry

Programme Code: 210

FOUR YEAR UNDERGRADUATE PROGRAMME

As per National Education Policy 2020

(Multiple Entry and Exit in Academic Programmes)

(with effect from 2025-26 session)

Approved in the 38th Meeting of Academic Council Held on 28 June 2025

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1. Preface

Introduction

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The K. R. Mangalam University visualizes all its programmes in the best interest of their students and in this endeavour; it offers a new vision to all its Under-Graduate courses.

We are committed to implementing the National Education Policy (NEP) 2020 in its entirety, and to creating a more inclusive, holistic, and relevant education system that will prepare our students for the challenges of the 21st century. With the focus on Outcome-Based Education (OBE), our university is continuously evolving an innovative, flexible, and multidisciplinary curriculum, allowing students to explore a creative combination of credit-based courses in variegated disciplines along with value-addition courses, Indian Knowledge Systems, vocational courses, projects in community engagement and service, value education, environmental education, and acquiring skill sets, thereby designing their own learning trajectory.

All academic programmes offered by the University focus on employability, entrepreneurship and skill development and their course syllabi are adequately revised to incorporate contemporary requirements based on feedback received from students, alumni, faculty, parents, employers, industry and academic experts

The School of Basic and Applied Sciences presents four years undergraduate programme Bachelor of Science (Hons. with Research) chemistry i.e. (B.Sc. (Hons. with Research) Chemistry) according to the New Education Policy-2020. We have designed a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options for the duration of 2025-2029.

We are following Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" incorporating a flexible choice-based credit system (CBCS), Learning Outcome-based Curriculum Framework (LOCF), multidisciplinary approach, and multiple entry and exit options. This will facilitate students to pursue their career path by choosing the subject/field of their interest.

The curricula are aligned with the needs of the industry and the job market and is flexible enough to adapt to changing trends and technologies. It integrates cross-cutting issues relevant to professional ethics, gender, human values, environment and Sustainable Development Goals (SDGs).

All the courses are having defined objectives and Learning Outcomes, which will help prospective students in choosing the elective courses to broaden their skills in the field of chemistry and interdisciplinary areas. The courses will train students with sound theoretical and experimental knowledge that suits the need of academics and industry. The courses also offer ample skills to pursue research as career in the field of chemistry and interdisciplinary areas. The K. R. Mangalam University hopes the NEP-2020 approach of this four-year undergraduate programme B.Sc. (Hons. with Research) chemistry will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

2. NEP-2020: Important features integrated in the curriculum

K.R. Mangalam University has adopted the National Education Policy NEP-2020 to establish a holistic and multidisciplinary undergraduate education environment, aiming to equip our students for the demands of the 21st century. Following the guidelines of NEP-2020 regarding curriculum structure and duration of the undergraduate programme, we now offer a Four-Year Undergraduate Programme with multiple entry and exit points, along with re-entry options, and relevant certifications.

- **UG Certificate** after completing 1 year (2 semesters with the required number of credits) of study, and an additional vocational course/internship of 4 credits during the summer vacation of the first year.
- **UG Diploma** after completing 2 years (4 semesters with the required number of credits) of study, and an additional vocational course/internship of 4 credits during the summer vacation of the second year.
- **Bachelor's Degree** after completing 3-year (6 semesters with the required number of credits) programme of study.
- 4-year **Bachelor's Degree (Honours)**with the required number of credits after eight semesters programme of study.
- Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. Upon completing a research project in their major area(s) of study in the 4th year, a student will be awarded **Bachelor's Degree (Honours with Research)**.

Advantage of pursuing 4-year Bachelor's degree programme with Honours/Honours with Research is that the Master's degree will be of one year duration. Also, a 4-year degree programme will facilitate admission to foreign universities.

Table 1: Minimum Credit Requirement for Four Year UG Program

S. No.	Broad Categories of Courses	Minimum Credit Requirement for Four Year UG Program
1	Major (Core)	80
2	Minor	32
3	Multidisciplinary	09
4	Ability Enhancement Course (AEC)	08
5	Skill Enhancement Course (SEC)	09
6	Value-Added Course (VAC)	06-08
7	Summer Internship	02-04
8	Research Project/Dissertation	12
9	Total	160

2.1 Categories of Courses

Major: The major would provide the opportunity for a student to pursue in-depth study of a particular subject or discipline.

Minor: Students will have the option to choose courses from disciplinary/interdisciplinary minors and skill-based courses. Students who take enough courses in a discipline or an interdisciplinary area of study other than the chosen major will qualify for a minor in that discipline or in the chosen interdisciplinary area of study.

Students have multiple minor streams to choose from. They can select one minor stream from the available options, which will be pursued for the entire duration of the programme.

Multidisciplinary (Open Elective): These courses are intended to broaden the intellectual experience and form part of liberal arts and science education. These introductory-level courses may be related to any of the broad disciplines given below:

- Natural and Physical Sciences
- Mathematics, Statistics, and Computer Applications
- Library, Information, and Media Sciences
- Commerce and Management
- Humanities and Social Sciences

A diverse array of Open Elective Courses, distributed across different semesters and aligned with the aforementioned categories, is offered to the students. These courses

enable students to expand their perspectives and gain a holistic understanding of various disciplines. Students can choose courses based on their areas of interest.

Ability Enhancement Course (AEC): Students are required to achieve competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills. The courses aim at enabling the students to acquire and demonstrate the core linguistic skills, including critical reading and expository and academic writing skills, that help students articulate their arguments and present their thinking clearly and coherently and recognize the importance of language as a mediator of knowledge and identity.

Skills Enhancement Courses (SEC): These courses are aimed at imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students.

Value-Added Course (VAC): The Value-Added Courses (VAC) are aimed at inculcating Humanistic, Ethical, Constitutional and Universal human values of truth, righteous conduct, peace, love, non-violence, scientific and technological advancements, global citizenship values and life-skills falling under below given categories:

- Understanding India
- Environmental Science/Education
- Digital and Technological Solutions
- Health & Wellness, Yoga education, Sports, and Fitness

Research Project / Dissertation: Students choosing a 4-Year Bachelor's degree (Honours with Research) are required to take up research projects under the guidance of a faculty member. The students are expected to complete the Research Project in the eighth semester. The research outcomes of their project work may be published in peer-reviewed journals or may be presented in conferences /seminars or may be patented.

3. University Vision and Mission

3.1 Vision

K.R. Mangalam University aspires to become an internationally recognized institution of higher learning through excellence in inter-disciplinary education, research, and innovation, preparing socially responsible life-long learners contributing to nation building.

3.2 Mission

- Foster employability and entrepreneurship through futuristic curriculum and progressive pedagogy with cutting-edge technology

- Instill the notion of lifelong learning through stimulating research, Outcomes-based education, and innovative thinking
- Integrate global needs and expectations through collaborative programs with premier universities, research centers, industries, and professional bodies.
- Enhance leadership qualities among the youth understanding ethical values and environmental realities

4. About the School of Basic and Applied Sciences

The School of Basic and Applied Science imparts both teaching and research through its four disciplines of Physics, Chemistry, Mathematics and Forensic science.

SBAS imparts students' disciplinary knowledge, enhances their skills and ability, motivating them to think ingeniously, helping them to act independently and take decisions accordingly in all their scientific pursuits and other endeavours. It strives to empower its students and faculty members to contribute for the development of society and Nation.

The faculty is in constant touch with various experts in the relevant fields and is willing to experiment with latest ideas in teaching and research.

5. School Vision and Mission

5.1 Vision

To be a premier school for advance learning and research in the field of basic and applied sciences.

5.2 Mission

1. Collaborations with national, international academic & research organisations and industries for knowledge creation, advancement, and application of innovative practises in sciences.
2. Create conducive environment for lifelong learning.
3. Empower students to be socially responsible and ethically strong individuals through value-based science education.

6. About the Programme: Bachelor of Sciences (Hons. / Hons. With Research) in Chemistry

The B.Sc. (Hons. / Hons. with Research) in Chemistry is a four-year undergraduate program designed to provide students in the captivating realm of chemistry. This program features a comprehensive and dynamic curriculum that delves into essential areas such as organic chemistry, inorganic chemistry, physical chemistry, and analytical chemistry. Students will investigate fundamental chemical principles, engage in complex problem-solving, and refine their analytical and critical thinking skills. The program seamlessly integrates hands-on

laboratory work with theoretical study, offering practical experience alongside a deep understanding of scientific research methods. By the end of the program, students will be well-prepared for a range of career opportunities in scientific research, technology, education, and other fields that demand a deep comprehension of chemistry principles and applications. The B.Sc. (Hons. with Research) in Chemistry equips graduates with the knowledge and skills to excel in diverse professional environments and contribute meaningfully to advancements in the chemical sciences.

6.1. Nature of B.Sc. (Hons. with Research) chemistry Programme

Taking the NEP-2020 as an opportunity to review our existing academic programs and redesign them for a more holistic, multidisciplinary and inclusive education, SBAS, K.R. Mangalam University is transforming its academic structure in a phased manner. School of Basic and Applied Sciences is offering Four Year Undergraduate Degree programme B.Sc. (Hons. with Research) Chemistry with Multiple Entry- Multiple Exit option from the academic session 2023-24. Through multiple entry/exit option, students will be able to enter and exit the program at various stages. This course emphasized hands on practice, innovative thought process and project-based learning

6.2. Aims of B.Sc. (Hons. with Research) chemistry Programme

The aims of the B.Sc. (Hons. with Research) chemistry program, in accordance with the National Education Policy (NEP), are multifaceted and comprehensive. The program aims to cultivate a strong foundation in chemistry principles and foster a deep understanding of the subject. It seeks to promote critical thinking, analytical skills, and problem-solving abilities among students, enabling them to address real-world challenges effectively. The B.Sc. (Hons. with Research) chemistry program also encourages research-oriented thinking and provides opportunities for students to engage in scientific inquiry and exploration. By emphasizing hands-on laboratory work and practical applications, the program aims to equip students with the necessary skills for conducting experiments and analysing data. Moreover, the program seeks to foster an interdisciplinary approach, enabling students to connect chemistry with other scientific disciplines and societal issues. Overall, the B.Sc. (Hons. with Research) chemistry program aspires to produce well-rounded graduates with a passion for learning and a strong foundation in chemistry, ready to make significant contributions to the scientific community and society at large.

6.3. Definitions

- **Programme Educational Objectives (PEOs)**

Programme Educational Objectives of a degree are the statements that describe the expected achievements of graduates in their career, and what the graduates are expected to perform, achieve and how will they conduct professionally during the first few years after graduation.

- **Programme Outcomes (POs)**

  Programme Outcomes are statements that describe what the students are expected to know and would be able to do upon the graduation. These relate to the skills, knowledge, and behaviour that students acquire through the programme.

- **Programme Specific Outcomes (PSOs)**

  Programme Specific Outcomes are statements about the various levels of knowledge specific to the given program which the student would be acquiring during the program.

- **Credit**

  Credit refers to a unit of Lectures/tutorial hours per week or 02 hours of lab/practical work per week.

6.4. Programme Educational Objectives (PEO*)*

These are deferred outcomes measured few years after completion of the programme, where the graduates of this program will:

PEO 1: Graduates will become globally competent chemistry professionals, ready for careers in government, industry, and research sectors, and equipped with skills for entrepreneurial initiatives in multidisciplinary fields.

PEO 2: Graduates will demonstrate strong technical knowledge in chemistry, utilizing critical and innovative thinking to solve complex scientific and technological challenges.

PEO 3: Graduates will act as ethical professionals, capable of leading and collaborating effectively within teams, contributing to their growth and the success of their organizations.

PEO 4: Graduates will engage in lifelong learning, continuously developing their expertise to make meaningful contributions to society and the field of chemistry.

PEO 5: Graduates will be well-prepared to advance to higher education and research opportunities in chemistry and related disciplines.

6.5. Programme Outcomes (PO)

At the end of the programme the students will be able:

PO1: To apply chemistry principles and analytical techniques to solve real-world problems related to chemistry.

PO2: To develop strong critical thinking skills to analyse and evaluate scientific evidence and methods in chemistry research and applications.

PO3: To promote teamwork and collaborative learning for interdisciplinary research projects.

PO4: To build strong interpersonal and leadership abilities to collaborate effectively in diverse professional environments.

PO5: To communicate scientific ideas and research findings clearly to scientific and general audiences.

PO6: To learn the ability to work independently or in team and stay updated with scientific advancements.

PO7: To acquire a strong commitment to high ethical standards, responsible research, and professionalism in academic and industry settings.

PO8: To demonstrate environmental and social consciousness by integrating sustainable practices and responsible decision-making into scientific work.

6.6. Programme Specific Outcomes (PSO)

At the end of the program the students will be:

PSO1: Understanding fundamental concepts, reactions, principles, and theories in organic, inorganic, physical, and analytical chemistry.

PSO2: Analyzing experimental data, chemical reactions, issues, and problems related to chemistry.

PSO3: Evaluating the validity and reliability of experimental results in chemistry.

PSO4: Applying chemistry principles and equations to solve problems, design experiments, and conduct research in various subfields of chemistry.

PSO5: Observing existing experimental methods by integrating new techniques and skills to improve the accuracy and efficiency of chemical research.

PSO6: Exhibiting coordinated manual skills in conducting chemistry experiments, ensuring safe and efficient handling of chemical, tools, and equipment while following detailed procedural steps.

6.7. Career Avenues

- **Research Scientist**
- **Academic Researcher**
- **Pharmaceutical Industry**
- **Chemical Analyst**
- **Materials Scientist**

- **Environmental Scientist**
- **Forensic Scientist**
- **Quality Control Specialist**
- **Science Communication**
- **Consulting**
- **Government Agencies**
- **Industrial Research**
- **Product Development**
- **Health and Safety Officer**
- **Entrepreneurship:**

These career avenues highlight the versatility and breadth of opportunities available to graduates with a B.Sc. in Chemistry and a research focus. Tailoring your skills and interests to these options can lead to a fulfilling and impactful career.

Graduates can pursue above careers, or continue with higher education (MSc, PhD) leading to academic or specialized roles in chemistry. Opportunities also exist in sectors like govt. jobs, defence services, data science, finance, and competitive examinations.

6.8. Duration

The duration of this programme is four years (eight semesters) with multiple entry/exit options.

6.9. Eligibility Criteria for Award of Degree

Name of Degree	Credits requirement	Completion Year
UG Certificate Chemistry	47	First Year
UG Diploma Chemistry	104	Second Year
B.Sc. Chemistry Credit:	148	Third Year
B.Sc. (Hons.) in Chemistry	176	Fourth Year
B.Sc. (Hons. With Research) in Chemistry	176	Fourth Year (Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level)

The student must fulfil the credit requirement as prescribed in Table 2 (Programme Study)

7. Student's Structured Learning Experience from Entry to Exit in the Programme

➢ Education Philosophy and Purpose:

- **Learn to Earn a Living:**
  At KRMU we believe in equipping students with the skills, knowledge, and qualifications necessary to succeed in the job market and achieve financial stability. All the programmes are tailored to meet industry demands, preparing students to enter specific careers and contributing to economic development.
- **Learn to Live:**
  The university believes in the holistic development of learners, fostering sensitivity towards society, and promoting a social and emotional understanding of the world. Our aim is to nurture well-rounded individuals who can contribute meaningfully to society, lead fulfilling lives, and engage with the complexities of the human experience.

➢ University Education Objective: Focus on Employability and Entrepreneurship through Holistic Education using Bloom's Taxonomy

By targeting all levels of Bloom's Taxonomy-remembering, understanding, applying, analyzing, evaluating, and creating-students are equipped with the knowledge, skills, and attitudes necessary for the workforce and entrepreneurial success. At KRMU we emphasize on learners critical thinking, problem-solving, and innovation, ensuring application of theoretical knowledge in practical settings. This approach nurtures adaptability, creativity, and ethical decision-making, enabling graduates to excel in diverse professional environments and to innovate in entrepreneurial endeavours, contributing to economic growth and societal well-being.

➢ Importance of Structured Learning Experiences

A structured learning experience (SLE) is crucial for effective education as it provides a clear and organized framework for acquiring knowledge and skills. By following a well-defined curriculum, teaching-learning methods and assessment strategies, learners can build on prior knowledge systematically, ensuring that foundational concepts are understood before moving on to more complex topics. This approach not only enhances comprehension but also fosters

critical thinking by allowing learners to connect ideas and apply them in various contexts. Moreover, a structured learning experience helps in setting clear goals and benchmarks, enabling both educators and students to track progress and make necessary adjustments. Ultimately, it creates a conducive environment for sustained intellectual growth, encouraging learners to achieve their full potential. At K.R. Mangalam University SLE is designed as rigorous activities that are integrated into the curriculum and provide students with opportunities for learning in two parts:

- Inside classroom (mention broad approach – cognitive outcome, student centric learning, methods, approach, tools and techniques)
- Outside classroom (People skills and psychomotor skills comprising of various types of activities in industry, community and labs)
- **Educational Planning and Execution: What, when and how learning will happen**

The School of Basic and Applied Sciences (SBAS) emphasizes a holistic approach to educational planning and execution, ensuring that both academic and personal development are seamlessly integrated into the student experience. The curriculum encompasses core subjects that establish a solid academic foundation, complemented by open electives, discipline-specific electives, Value-Added Courses (VAC), and Ability Enhancement Compulsory Courses (AECC) to expand intellectual perspectives. In addition, students are offered the opportunity to pursue a Minor in fields such as Environmental Science, Data Science, Artificial Intelligence & Machine Learning, and Nanoscience, enhancing their specialization in the four-year bachelor's degree course. The selection of these minors happens in the first semester, continuing throughout the degree program.

The learning is thoughtfully planned across the curriculum. In the early stages, foundational knowledge and skills are built through core courses. As students' progress, learning becomes more specialized, with electives and minors supporting deeper exploration of disciplines. Co-curricular activities, including sports, technical events, and cultural activities, are integrated throughout to ensure all-around growth. Leadership training, teamwork, communication skills, and discipline are emphasized through structured personality development activities. Ethical values such as truthfulness, gender sensitization, and environmental consciousness are instilled from the outset, becoming a continuous part of the student journey.

At SBAS, learning is dynamic and flexible, utilizing a variety of teaching methods including lectures, case-based learning, problem-based learning, and project-based learning, all aimed at fostering critical thinking and problem-solving abilities. Hands-on learning is reinforced through lab sessions, internships, research projects, and practical activities that connect theoretical knowledge to real-world applications. Workshops, seminars, and guest lectures from industry experts further provide practical insights and professional exposure. We have a strong students' support system in terms of differential learning (slow & fast learning), mentor-mentee system and personal counselling thereby ensuring students move up on the learning curve.

In terms of infrastructure, SBAS supports its academic planning with highly qualified faculty, smart classrooms, a well-equipped library, computer labs, and experimental research facilities. The inclusion of Massive Open Online Courses (MOOCs) and experiential learning ensures that students are prepared for both academic success and professional excellence. This carefully executed planning ensures that students are engaged at all levels of Bloom's Taxonomy, progressing from foundational understanding to higher-order thinking, while also fostering emotional, social, and ethical development. Continuous stakeholder feedback, including input from faculty, industry experts, students, and alumni, ensures that the curriculum remains relevant, aligned with academic advancements, and tuned to industry needs.

Course Registration and Scheduling

- **Major and Minor Selection** – Every student must register at the beginning of each semester for the courses offered in the given semester. Major courses are registered centrally for the students. However, for other multidisciplinary courses (Minor, VAC, OE) the students must register by themselves through ERP.

- **Internships/Projects/Dissertations** – Students need to do summer internship after second and fourth semesters, which carries 2 credits each, duration being 4-6 weeks per internship, during the summer breaks. The same will be evaluated in the upcoming odd semester. In the sixth and seventh semesters students will do Specialization Projects. In the eighth semester students of B.Sc. (Hons. / Hons. with Research) chemistry will do Research Project (Dissertation). Projects are also mapped along with the Lab/ Practical Courses and Experiential Learning Activities.
- **Co-curricular / Extracurricular activities/Community Service: Participation in Co/ Extracurricular activities is part of outside classroom learning.**

Students must earn 2 credits from co/ extracurricular activities. One credit from participation in co-curricular activities like **Club/Society** activities and another credit from Community Service (1 credit each) through participation in NSS/ Redcross activities or NGOs that contribute to their personal development, leadership skills, and community engagement.

- Under the category of **Club/Society**, 1 credit can be earned by registration in one of the Club/Societies of university and active participation in the events organized by the club/society **OR**
- 15 hours of active engagement in any of the recreational/sports activities

Under the category of **Community Service**, 1 credit can be earned by

- 15 hours active engagement in community service through NGO/NSS/Redcross or any other society approved/ empanelled by the university

At the end of the semester, students are required to submit a log of hours, a report, and a certificate of participation/ completion summarizing their activities followed by a presentation.

✓ **Academic Support Services:** (Differential learning needs): The School of Basic and Applied Sciences offers a variety of academic support services tailored to meet the diverse learning needs of its students, ensuring success for all. These services include:

- **Personalized Tutoring**: One-on-one sessions with experienced tutors focus on specific areas such as laboratory techniques, experimental design, research projects, data analysis, and theoretical understanding. Tutoring is customized to each student's level, allowing for targeted support in areas like crystal structure analysis, magnetic properties, and dielectric behaviour.
- **Workshops and Seminars**: Regular workshops on topics such as advanced scientific research methods, materials characterization techniques, and the latest advancements in nanotechnology and superconductivity. These workshops, alongside industry connections, help students enhance both practical skills and theoretical knowledge.
- **Peer Mentoring Programs**: Advanced learners' mentor fellow students by leading study groups, assisting with assignments, and guiding practical projects, fostering a collaborative and supportive academic environment.
- **Accessible Learning Resources**: A variety of online platforms provide access to resources such as recorded lectures, research papers, interactive simulations, and experimental procedure guides, catering to different learning styles and enhancing independent study.

- **Outcome-Based Activities**: Students are encouraged to engage in hands-on practical, such as conducting experiments on material properties, to produce meaningful results. These outcomes are then showcased and celebrated, motivating students to further develop their skills.
- **Diversity and Inclusion Initiatives**: Programs promoting diversity and inclusion ensure that all students, regardless of background, feel valued and can contribute to a rich, collaborative learning environment.
- **Feedback and Assessment**: Continuous feedback mechanisms provide students with constructive evaluations of their work, allowing them to refine their techniques, improve their understanding, and achieve academic excellence.

➢ **Student Career & personal Support Services**

- **Mentor-Mentee:** Every student enrolled in the school is considered a mentee and will be assigned a faculty member as their mentor. The mentor's role is to guide and support the mentee, helping them grow both personally and professionally. Mentors act as coaches by giving feedback, sharing advice, and offering insights from their own experiences. They also challenge the mentee's thinking, help them make important decisions, and connect them to valuable resources and networks. Additionally, mentors provide emotional support, celebrating successes and offering encouragement during tough times. On the other hand, the mentee's role is to actively participate in the learning process by planning meetings, setting goals, and communicating openly with their mentor. Mentees should also apply what they learn, continue growing outside the mentor-mentee relationship, and stay proactive in seeking new opportunities. By staying committed and enthusiastic, mentees can make the most of this relationship and achieve their goals.
- **Counselling and Wellness Services:** Counselling and wellness services typically encompass a range of resources to support students' mental health, emotional well-being, and overall quality of life. The school has various counselling programs such as individual Counselling where one-on-one sessions with licensed counsellors or psychologists are held to address personal issues, stress, and mental health concerns**, Group Counselling** which support groups for shared experiences like anxiety, depression, or adjustment challenges, **Crisis Counselling** for Immediate support for students in urgent situations or experiencing severe emotional distress, **Career Counselling** for guidance on career planning, job search strategies, and professional development and for managing academic stress, time management, and study strategies. School also has various Wellness Services like On-campus clinics which provides

medical care, including physical exams, vaccinations, and treatment for minor illnesses. Various mental health workshops on topics like stress management, mindfulness, and coping strategies are organized. All the students have access to gyms, fitness classes to promote physical health. These services aim to support students in maintaining a balanced and healthy lifestyle while managing the demands of university life.

- **Career Services and Training:** Career services and training programs are designed to support students in their professional development and job search. School provides personalized advice on career paths, goal setting, and job search strategies to students. They are given proper guidance on creating and refining job application materials. Mock interviews are also held. They are given opportunities to connect with alumni, professionals, and potential employers. Students are given professional training in areas like communication, leadership, and time management. These services and programs aim to prepare students for successful careers by enhancing their skills, providing practical experience, and connecting them with potential employers.

➢ Assessment and Evaluation

a. Evaluation scheme for theory courses

Evaluation Component	Weightage
Internal Marks (Theory): - I) Continuous Assessment (40 Marks) (All the components to be evenly spaced) Projects/ Quizzes/ Assignments and Essays/ Presentations/ Participation/ Case Studies/ Reflective Journals (minimum of five components to be covered)	40 Marks
Mid Term Exam	20 Marks
External Marks (Theory): – End Term Examination	40 Marks

* (It is compulsory for a student to secure 40% marks in the Internal and End Term Examination to secure minimum passing grade).

Overview of Internal Evaluation (40 Marks) –

Internal evaluation is designed to assess students' ongoing learning and application of course materials through diverse assessment methods. Instructors have full autonomy within the 40 marks to employ assessment strategies that best align with the course's learning objectives.

Recommended Assessment Types: -

Projects: - Individual or group projects focusing on research, analysis, and practical application of concepts.

Quizzes: - Regular, short assessments to evaluate understanding of the material.

Assignments and Essays: - In-depth tasks to assess critical thinking and problem-solving skills.

Presentations: - Assessing knowledge dissemination and communication skills.

Participation: - Evaluation of engagement and contributions to class activities.

Case Studies: - Application of theoretical knowledge to real-world scenarios.

b. Evaluation scheme for practical courses

Particular	Weightage
Internal Marks (Practical): -	
I) Conduct of Experiment	10 Marks
II) Lab Records	10 Marks
III) Lab Participation	10 Marks
IV) Lab Project	20 Marks
External Marks (Practical): -	
End Term Practical and Viva Voce	50 Marks

*** (It is compulsory for a student to secure 40% marks in Internal and End Term Practical's and Viva Voce to secure minimum passing grade).**

c. Evaluation scheme for internship/research project

Particular	Weightage
Internal Marks: - (Punctuality, Performance, Work Ethics, Efforts and Research Output)	50 Marks
External Marks (Practical): - Presentation Report Writing Viva Voce	50 Marks 20 10 20

*(It is compulsory for the student to provide an internship certificate issued by the relevant institution or organization where they completed their internship during the evaluation process.)

- **7.5.2 GRADING SYSTEM**
- Based on the performance in all evaluation components of a Course, each student will be awarded a final grade in the Course registered, at the end of the semester. The total marks obtained by a student in the Course will be converted to a corresponding letter grade as described below.

Marks Range (%)	Letter Grade	Grade Points	Description of the Grade
% marks > 90%	O	10.0	Outstanding
80 < %marks ≤ 90	A+	9.0	Excellent
70 < %marks ≤ 80	A	8.0	Very Good
60 < %marks ≤ 70	B+	7.0	Good
55 < %marks ≤ 60	B	6.0	Above Average
50 < %marks ≤ 55	C	5.5	Average
40 ≤ %marks ≤ 50	P	5.0	Pass

%marks < 40	F	0	Fail
-	AB	0	Absent
%marks ≥ 50	S	-	Satisfactory
%marks < 50	U	-	Unsatisfactory
-	W	0	Withdrawal

Feedback and Continuous Improvement Mechanisms: Teaching-learning is driven by outcomes. Assessment strategies and andragogy are aligned to course outcomes. Every CO is assessed using multiple components. The attainment of COs is calculated for every course to know the gaps between the desired and actual outcomes. These gaps are analysed to understand where does the student lags in terms of learning levels. Thereafter each student's learning levels are ascertained, if found below desirable level, and intervention strategy is affected in the following semester to make necessary corrections. To cater to the diverse learning needs of its student body, K.R. Mangalam University employs a comprehensive assessment framework to identify both slow and advanced learners. Students' learning levels are continually assessed based on their performance at various stages. If a student's performance in internal assessments falls below or equal to 55%, they are categorized as slow learners. Conversely, if a student's performance score in internal assessments is greater than or equal to 80%, they are identified as advanced learners. Such students are encouraged to participate in advanced learning activities. Through periodic evaluations and the utilization of modern management systems, the institution adeptly tracks students' performance across various courses, allowing for targeted interventions and support mechanisms.

- **Academic Integrity and Ethics:** The School of Journalism and Mass Communication places a strong emphasis on academic integrity and ethics, fostering a culture of honesty and responsibility among students. Clear guidelines are established to educate students about the importance of plagiarism prevention, proper citation practices, and ethical sourcing in their work. Regular workshops and seminars are conducted to discuss case studies and real-world scenarios, encouraging critical thinking about ethical dilemmas in journalism and media. Faculty members serve as role models, promoting transparency and accountability in their interactions and evaluations. By instilling these values, the school prepares students to uphold high ethical standards in their professional careers, emphasizing the critical role that integrity plays in journalism and mass communication.

Table 2. Programme Structure

Semester-I								
S. No.	**Category of Course**	**Course Code**	**Course title**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**
1	MAJOR I	BSCHIC101	INORGANIC CHEMISTRY-I	3	1	0	4	
2		BSCHIC151	INORGANIC CHEMISTRY-I PRACTICALS	0	0	2	1	
3	MAJOR II	BSCHOC 102	ORGANIC CHEMISTRY-I	3	1	0	4	
4		BSCHOC 152	ORGANIC CHEMISTRY-I PRACTICALS	0	0	2	1	
5	SEC-I		DATA EXPLORATION AND ANALYSIS USING EXCEL	1	0	4	3	
6	VAC I		ENVIRONMENTAL STUDIES	2	0	0	2	
7	MAJOR III	BSCHPC 103	PHYSICAL CHEMISTRY-I	3	1	0	4	
8		BSCHPC 153	PHYSICAL CHEMISTRY-I PRACTICALS	0	0	2	1	
Total							**20**	

Award: UG Certificate [after completing 1 year of study (2 semesters with credits as prescribed), and an additional vocational course/internship of 4 credits during the summer vacation of the first year]

Semester-II							
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**
1	MINOR I		MINOR I	4	0	0	4
2	MAJOR IV	BSCHOC 201	ORGANIC CHEMISTRY-II	3	1	0	4

3		BSCHOC 251	ORGANIC CHEMISTRY-II PRACTICALS	0	0	2	1
4	SEC-I I		DOCUMENTATION USING LATEX	2	0	0	2
5	MINOR II		MINOR II	4	0	0	4
6	GEC-I		OPEN ELECTIVE-I	3	0	0	3
7	VAC II (In workshop mode/MOOC)		CYBER SECURITY	2	0	0	2
8	CS001	CS001	CLUB/SOCIETY	0	0	0	1
9	PROJECT I	BSCCPR 205	PROJECT-I				2
Total							**23**
*** Internship will be of 4-6 weeks duration at the end of Semester II during summer break and the evaluation will be done during Semester III**							

Semester-III								
S. No.	**Category of Course**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**
1	MAJOR V	BSCHPC 301	PHYSICAL CHEMISTRY-II	3	1	0	4	**Award: UG Diploma** [after completing 2 years of study (4 semesters with credits as prescribed), and an additional vocational course/internship of 4 credits to be covered within 6-8 weeks during the summer
2		BSCHPC 351	PHYSICAL CHEMISTRY-II PRACTICALS	0	0	2	1	
3	MAJOR VI	BSCHOC 302	ORGANIC CHEMISTRY-III	3	1	0	4	
4		BSCHOC 352	ORGANIC CHEMISTRY-III PRACTICALS	0	0	2	1	
5	AEC-I		SELF AWARENESS	2	0	0	2	
6	GEC-II		OPEN ELECTIVE-II	3	0	0	3	

7	MINOR III		MINOR III	4	0	0	4
8	VAC III/MOOC		ARTIFICIAL INTELLIGENCE	2	0	0	2
9	INTERNSHIP	BSCHIN 303	EVALUATION OF SUMMER INTERNSHIP-I	0	0	0	2
10	CS002		COMMUNITY SERVICES	0	0	0	1
11	PROJECT II	BSCCPR 305	PROJECT-II				2
Total							**26**

Semester-IV							
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**
1	MAJOR VII	BSCHPC 401	PHYSICAL CHEMISTRY-III	3	1	0	4
2		BSCHPC 451	PHYSICAL CHEMISTRY-III PRACTICALS	0	0	2	1
3	MAJOR VIII	BSCHIC402	INORGANIC CHEMISTRY-II	3	1	0	4
4		BSCHIC452	INORGANIC CHEMISTRY-II PRACTICALS	0	0	2	1
5	SEC-III		BASIC IT TOOLS	3	0	0	3
6	MINOR IV		MINOR IV	4	0	0	4
7	GEC-III		OPEN ELECTIVE-III	3	0	0	3
8	MAJOR IX	BSCHNC 403	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS	3	1	0	4
		BSCHNC 453	INTRODUCTION OF NANOCHEMISTRY	0	0	2	1

vacation of the second year]

Entry: The student who took exit after completion of the first year (UG Certificate) is allowed to enter the diploma programme within five years from the first entry in the programme, four years in case of degree program and three years in case of Hons. degree to complete the programme within the stipulated time period of seven years.

			AND APPLICATIONS PRACTICALS				
9	AEC-II		COMMUNICATION & PERSONALITY DEVELOPMENT	2	0	0	2
10	PROJECT III	BSCCPR 405	PROJECT-III				2
TOTAL							**29**
* Internship will be of 4-6 weeks duration at the end of Semester IV during summer break and the evaluation will be done during Semester V							

Semester-V								
S. No.	**Category of Course**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**
1	MAJOR X	BSCHIC501	INORGANIC CHEMISTRY-III	3	1	0	4	**Award: Bachelor's Degree** [after completing 3-yearof study (6 semesters with credits as prescribed)] Entry: The student who took exit after completion of two years of study (UG Diploma) are allowed to re-enter the degree programme within three years and complete the degree programme
2		BSCHIC552	INORGANIC CHEMISTRY-III PRACTICALS	0	0	2	1	
3	MAJOR XI	BSCHQC 510	INTRODUCTION TO QUANTUM CHEMISTRY	3	1	0	4	
4	MINOR V		MINOR V	4	0	0	4	
5	AEC-III	AEC010	ARITHMATIC REASONING AND SKILL-III	2	0	0	2	
6	SEC-IV		COMPUTER AIDED DRUG DESIGN	3	0	0	3	
7	INTERNSHIP	BSCHIN 503	EVALUATION OF SUMMER INTERNSHIP-II	2	0	0	2	
Total							**20**	

Semester-VI							

S. No.	Category of Course	Course Code	Course	L	T	P	C
1	MAJOR XII	BSCHAC601	ANALYTICAL TECHNIQUES OF CHEMISTRY	3	1	0	4
2		BSCHAC651	ANALYTICAL TECHNIQUES OF CHEMISTRY PRACTICALS	0	0	2	1
3	MAJOR XIII	BSCHOC602	ORGANIC SPECTROSCOPY	3	1	0	4
4	MINOR VI		MINOR VI	4	0	0	4
5	AEC-IV		MANAGING PEOPLE AND ORGANIZATION	2	0	0	2
6	PROJECT -IV	BSCCPR605	PROJECT-IV	0	0	0	2
7	MAJOR XIV	BSCCRM606	RESEARCH METHODLOGY	3	0	0	3
Total							20

within the stipulated maximum period of seven years.

Bachelor's Degree (Honours)Semester-VII								
S. No.	Category of Course	Course Code	Course	L	T	P	C	Multiple Entry
1	MAJOR XV	BSCHHC701/BSCHMC702	HETREOCYCLIC CHEMISTRY/MEDICINAL CHEMISTRY	4	0	0	4	**Entry** The student who took exit after completion of three years of study (UG degree) is allowed to re-enter the degree programme maximum within three years and complete the degree programme within the stipulated maximum period of seven years.
2		BSCHHC751/BSCHMC752	HETREOCYCLIC CHEMISTRY PRACTICALS/MEDICINAL CHEMISTRY PRACTICALS	0	0	2	1	

3	MAJOR XVI	BSCHAM703/BSCHEC704	ADVANCE MATERIAL CHEMISTRY/ENVIRONMENTAL CHEMISTRY	4	0	0	4
4		BSCHAM753/BSCHEC754	ADVANCE MATERIAL CHEMISTRY PRACTICALS/ENVIRONMENTAL CHEMISTRY PRACTICALS	0	0	2	1
5			MINOR VII	4	0	0	4
6	SEC-V		INTELLECTUAL PROPERTY RIGHT (IPR) AND BUSINESS SKILLS FOR CHEMISTS	2	0	0	2
7	MAJOR XVII	BSCCRW706	Scientific Report Writing and Presentation skills	3	0	0	3
Total							**19**
Bachelor's Degree (Honours)Semester-VIII							
1	**Major-XVIII**	BSCHDF803/BSCHSC805/BSCHTD807	CHEMISTRY OF D AND F-BLOCK ELEMENTS AND BIOINORGANIC CHEMISTRY/ STEREOCHEMISTRY, REACTION MECHANISMS AND INTERMEDIATES/THERMODYNAMICS AND ELECTROCHEMISTRY	4	0	0	4

2	**Major-XVIII Practical**	BSCHIC853/BSCHOC855/BSCHPC857	INORGANIC CHEMISTRY-I LAB /ORGANIC CHEMISTRY-I LAB/ PHYSICAL CHEMISTRY-I LAB	0	0	2	1
3	**Major-XVIX**	BSCHOM804/BSCHSO806/BSCHQK808	BORANES, SILICATES AND ORGANOMETALLIC COMPOUNDS/ SPECTROSCOPY OF ORGANIC COMPOUNDS/QUANTUM CHEMISTRY AND CHEMICAL KINETICS	4	0	0	4
4	**Major-XVIX Practical**	BSCHIC854/BSCHOC856/BSCHPC858	INORGANIC CHEMISTRY-I LAB /ORGANIC CHEMISTRY-I LAB/ PHYSICAL CHEMISTRY-I LAB	0	0	2	1
5	**Minor VIII**		Minor EVS/DS/AI&ML	4	0	0	4
6	MAJOR XX	BCCHPC801/BSCHBI802	POLYMER CHEMISTRY/ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY	3	1	0	4
7		BSCHPC851/BSCHBI852	POLYMER CHEMISTRY PRACTICALS/ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY PRACTICALS	0	0	2	1
Total							**14**

*Bachelor's Degree (Honours with Research) Semester-VII

S. No.	Category of Course	Course Code	Course	L	T	P	C
1	MAJOR XV	BSCHHC701/BSCHMC702	HETREOCYCLIC CHEMISTRY/MEDICINAL CHEMISTRY	4	0	0	4

Entry The student who took exit after completion of three years of study (UG degree) is allowed to re-enter the degree programme maximum

2		BSCHHC751/BSCHMC752	HETREOCYCLIC CHEMISTRY PRACTICALS/MEDICINAL CHEMISTRY PRACTICALS	0	0	2	1	within three years and complete the degree programme within the stipulated maximum period of seven years.
3	MAJOR XVI	BSCHAM703/BSCHEC704	ADVANCE MATERIAL CHEMISTRY/ENVIRONMENTAL CHEMISTRY	4	0	0	4	
4		BSCHAM753/BSCHEC754	ADVANCE MATERIAL CHEMISTRY PRACTICALS/ENVIRONMENTAL CHEMISTRY PRACTICALS	0	0	2	1	
5			MINOR VII	4	0	0	4	
6	SEC-V		INTELLECTUAL PROPERTY RIGHT (IPR) AND BUSINESS SKILLS FOR CHEMISTS	2	0	0	2	
7	MAJOR XVII	BSCCRW706	Scientific Report Writing and Presentation	3	0	0	3	
Total							**19**	
***Bachelor's Degree (Honours with Research) Semester-VIII**								
1		BSBSDR805	DISSERTATION	0	0	0	10	

2			MINOR VIII	4	0	0	4
3	MAJOR XVII	BCCHPC801/BSCHBI802	POLYMER CHEMISTRY/ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY	3	1	0	4
4		BSCHPC851/BSCHBI852	POLYMER CHEMISTRY PRACTICALS/ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY	0	0	2	1
Total							19

Total Credits: 176

DISCIPLINE SPECIFIC ELECTIVE- I					
BSCHHC701	HETREOCYCLIC CHEMISTRY	3	1	0	**4**
BSCHHC751	HETREOCYCLIC CHEMISTRY PRACTICALS	0	0	2	**1**
BSCHNC403	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS	3	1	0	**4**
BSCHNC453	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS PRACTICALS	0	0	2	**1**
BSCHAM703	ADVANCE MATERIAL CHEMISTRY	3	1	0	**4**
BSCHAM753	ADVANCE MATERIAL CHEMISTRY PRACTICALS	0	0	2	**1**

DISCIPLINE SPECIFIC ELECTIVE -II					
BSCHMC702	MEDICINAL CHEMISTRY	3	1	0	**4**
BSCHMC752	MEDICINAL CHEMISTRY PRACTICALS	0	0	2	**1**
BSCHNC403	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS	3	1	0	**4**
BSCHNC453	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS PRACTICALS	0	0	2	**1**
BSCHEC704	ENVIRONMENTAL CHEMISTRY	3	1	0	**4**
BSCHEC754	ENVIRONMENTAL CHEMISTRY PRACTICALS	0	0	2	**1**

BCCHPC801	POLYMER CHEMISTRY	3	1	0	**4**
BCCHPC851	POLYMER CHEMISTRY PRACTICALS	0	0	2	**1**

BSCHBI802	ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY	3	1	0	**4**
BSCHBI852	ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY PRACTICALS	0	0	2	**1**

POOL OF ENVIRONMENTAL SCIENCE AS MINOR

S.No.	COURSE CODE	COURSE TITLE	L	T	P	C
Minor I	UNMIES201	Earth And Earth Surface Processes	4	0	0	4
Minor II	UNMIES202	Hydrology And Hydrogeology	4	0	0	4
Minor III	UNMIES301	Natural Resources Management And Sustainability	4	0	0	4
Minor IV	UNMIES401	Natural And Anthropogenic Hazards	4	0	0	4
Minor V	UNMIES501	Environment Legislation Policies And Esg's	4	0	0	4
Minor VI	UNMIES601	Waste Management	4	0	0	4
Minor VII	UNMIES701	Environmental Impact Assessment And Risk Assessment	4	0	0	4
Minor VIII	UNMIES801	Sdg's And Climate Change	4	0	0	4

Pool of Nano Science as Minor

S.No.	Code	Name	L	T	P	C
Minor1	UNMINS201	Study Of Materials	4	0	0	4
Minor2	UNMINS202	Elements Of Nanosciences and Nanomaterials	4	0	0	4
Minor 3	UNMINS301	Nanostructured Materials	4	0	0	4
Minor 4	UNMINS401	Crystallography	4	0	0	4

Minor 4 (Lab)	UNMINS451	Crystallography Lab	0	0	2	1
Minor5	UNMINS501	Synthesis Of Nanomaterials-I	4	0	0	4
Minor 5 Lab	UNMINS551	Synthesis Of Nanomaterials-I Lab	0	0	2	1
Minor6	UNMINS601	Synthesis Of Nanomaterials-II	4	0	0	4
Minor 6 (Lab)	UNMI651	Synthesis Of Nanomaterials-Lab	0	0	2	1
Minor7	UNMINS701	Characterisation Techniques of Nanomaterials	4	0	0	4

Pool of Data Science as Minor						
S.No.	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
MINOR I	UNMIDS201	Data analytics using SQL	2	0	4	4
MINOR II	UNMIDS202	Data analytics using R	2	0	4	4
MINOR III	UNMIDS301	Python for Data Science	2	0	4	4
MINOR IV	UNMIDS401	Data Preprocessing and visualization using Python	2	0	4	4
MINOR V	UNMIDS501	Time Series Analysis & Forecasting using Python	3	0	2	4
MINOR VI	UNMIDS601	Fundamental of Machine Learning	2	0	4	4
MINOR VII	UNMIDS701	Data Driven Applications	2	0	4	4
MINOR VIII	UNMIDS801	Project and Case study	2	0	4	4

Pool of AI/ML as Minor						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	UNMIDS201	Data Analytics using SQL	2	0	4	4
2	UNMIDS202	Data Analytics using R software	2	0	4	4
3	UNMIDS301	Python for Data Science	2	0	4	4

4	UNMIDS402	Data Structures and Algorithms	4	0	0	4
5	UNMIDS502	Fundamentals of Artificial Intelligence	2	0	4	4
6	UNMIDS601	Funudamentals of Machine Learning	2	0	4	4
7	UNMIDS702	Neural Network and Deep Learning	2	0	4	4
8	UNMIDS802	Natural Language Processing and Generative AI	2	0	4	4

SYLLABI

SEMESTER I

SEMESTER I					
BSCHIC101	**Inorganic Chemistry-I**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-I**				
Total Lectures	**60**				
Pre-Requisites/ Co-Requisites	**Basics of atoms and bonding in molecules**				

Course Perspective: This course provides essential knowledge of atomic structure, chemical bonding, and periodicity, forming the foundation for advanced studies and practical applications in fields like pharmaceuticals, material science, and environmental science. It equips students with the skills to predict chemical behavior, solve complex problems, and prepare for careers in research, chemical engineering, and industry, making it crucial for both academic and professional growth.

Course Outcomes:

On completion of the course the learner will be:

CO1: Understanding key concepts in atomic structure, periodic trends, chemical bonding, and intermolecular forces.

CO2: Applying these concepts to predict electron configurations, molecular shapes, and material properties.

CO3: Analyzing the limitations of atomic theories and the influence of bonding on molecular behavior.

CO4: Evaluating the impact of quantum rules and weak chemical interactions on chemical properties and reactivity.

Course Content

- **Unit A: Atomic Structure** **15 lecture**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de'Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of $\psi 1$and $\psi 2$. Quantum numbers and their significance. Shapes of *s*, *p*, *d* and *f* orbitals, Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

- **Unit B: Periodicity of Elements** **15 lecture**

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van'derWaals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron density ratio.

- **Unit C: Chemical Bonding** **15 lecture**

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(i) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra- atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability, Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Ionic character from dipole moment and electronegativities.

- **Unit D: Metallic bonding and Weak chemical forces** **15 lecture**

(ii) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors, Insulators.

(iii) *Weak Chemical Forces:* Vander Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding

on melting and boiling points, solubility, dissolution.

Learning Experience

This course will be a mix of lectures, interactive sessions, and hands-on learning to deepen understanding of atomic structure, periodicity, chemical bonding, and metallic bonding.

Instruction Methods:

- **Lectures:** Core concepts will be taught using multimedia presentations and problem-solving sessions.
- **Interactive Sessions:** Q&A segments, live quizzes, and discussions will engage students and reinforce learning.

Technology Use:

- **Online Platforms:** An LMS will provide resources, recorded lectures, and discussion forums for extended learning.

Assessments:

- **Formative:** Quizzes and online discussions will provide continuous feedback.
- **Summative:** Exams, peer reviews, and presentations will evaluate overall understanding.

Support: The course instructor will be available for additional guidance, and peer collaboration will be encouraged. Regular feedback will help students improve and achieve course outcomes.

Textbook

1. Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edn.

Reference Books

1. Douglas, B.E., McDaniel, D.H., Alexander J.J., Concepts & Models of Inorganic Chemistry, (Third Edition) John Wiley & Sons, 1999.
2. Atkins, P. W. and DePaula, J. Physical Chemistry, Tenth Edition, Oxford University Press, 2014.
3. Rodger, G. E. Inorganic and Solid-State Chemistry, Cengage Learning, 2002.

Open Educational Resources (OER)

- https://www.t.soka.ac.jp/chem/iwanami/intorduct/ch02structure.pdf
- https://www2.chemistry.msu.edu/courses/cem151/chap7lect_2009.pdf
- https://authors.library.caltech.edu/105209/6/TR000574_01_chapter-1.pdf
- https://ncert.nic.in/textbook/pdf/kech104.pdf
- https://www.youtube.com/watch?v=f5bLO2nx1dE&list=PLeO0gXBrQL63QPgzoT9PGwVJqpd7jDgCd
- https://kanchiuniv.ac.in/coursematerials/Mrs.%20KI%20-%20Chemical%20Bond.pdf
- https://www.youtube.com/watch?v=f5bLO2nx1dE&list=PLeO0gXBrQL63QPgzoT9PGwVJqpd7jDgCd

Evaluation Scheme

Evaluation components	Weightage

Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/Test/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
BSCHIC151	**Inorganic Chemistry-I Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**
Category of Course	**Major (Practical)**				
Total Lectures	**15**				
Pre-Requisites/ Co-Requisites	**12th level practices and experiments**				

Course Perspective

This course provides a hands-on introduction to titrimetric analysis, a fundamental technique in quantitative chemistry. Students will learn to calibrate and use laboratory apparatus, prepare solutions of varying concentrations, and work with primary and secondary standards. The course covers key areas such as oxidation-reduction titrimetric and acid-base titrations, enabling students to accurately estimate the composition of various substances. By the end of the course, students will have the skills to perform precise titrations, essential for further studies in chemistry or professional laboratory work.

Course Outcomes

Upon completion of the course the learner will be able to:

CO1: Observing how to use titration equipment and prepare solutions with accurate concentrations.

CO2: Imitating steps to perform oxidation-reduction and neutralization titrations, like estimating iron and oxalic acid in samples.

CO3: Practicing titration techniques to measure substances like carbonates, bicarbonates, and alkalis in mixtures.

Course Content **30 lecture**

List of Experiments

- Calibration and use of apparatus.
- Preparation of solutions of different Molarity/Normality of titrant.

- Use of primary and secondary standard solutions
- Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
- Estimation of oxalic acid and sodium oxalate in each mixture.
- Estimation of Fe(II) with $K2Cr_2O_7$using internal (diphenylamine, anthranilic acid) and external indicator.
- Estimate of carbonate and hydroxide present together in mixture.
- Estimation of carbonate and bicarbonate present together in a mixture.
- Estimation of free alkali present in different soaps/detergents

Learning Experience

This lab course will be conducted through hands-on experiments, interactive sessions, and collaborative group work, focusing on the practical application of Titrimetric Analysis, Oxidation-Reduction Titrimetric, and Acid-Base Titrations.

Methods of Instruction:

- **Lab Experiments:** Students will engage in extensive hands-on lab work, directly performing titrations such as the estimation of Fe(II), oxalic acid, and various mixtures. Each session will involve detailed demonstrations followed by supervised practice to ensure accuracy and precision in technique.
- **Interactive Lab Sessions:** During lab work, students will have opportunities to ask questions and engage in discussions with the instructor and peers.

Use of Technology:

- **Lab Equipment:** Students will use calibrated lab apparatus. This includes the preparation of solutions with precise molarity/normality and the use of primary and secondary standard solutions.
- **Online Resources:** An LMS will be used to share lab manuals, instructional videos, and troubleshooting guides. Discussion boards will be available for students to discuss challenges and share insights outside lab hours.

Textbooks

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.

Reference Books

1. O. P. Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

(Note: A candidate must perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm206.pdf
- https://www.youtube.com/watch?v=dLNsPqDGzms&pp=ygUTQWNpZC1CYXNlVGl0cmF0aW9ucw%3D%3D
- https://www.ramauniversity.ac.in/online-

studymaterial/pharmacy/bpharma/isemester/pharmaceuticalanalysis-i/lecture-8.pdf

- https://www.youtube.com/watch?v=hZxP-Qdm55s&pp=ygUdT3hpZGF0aW9uLVJlZHVjdGlvblRpdHJpbWV0cnk%3D
- https://www.youtube.com/watch?v=5rtJdjas-mY&pp=ygUdT3hpZGF0aW9uLVJlZHVjdGlvblRpdHJpbWV0cnk%3D
- https://faculty.ksu.edu.sa/sites/default/files/unit_11_-_redox_titrations_-_subjects_1_0.pdf
- https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXII/chemistry/lelm106.pdf
- **Evaluation Scheme:**

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
BSCHOC102	**Organic Chemistry-I**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-II**				
Total Lectures	**60**				
Pre-Requisites/ Co-Requisites	**Basics introduction of organic chemistry**				

Course Perspective: This course in Organic Chemistry is fundamental for students aiming to excel in chemistry and related fields, offering essential knowledge of organic compounds, stereochemistry, and hydrocarbons. It provides a strong foundation for advanced studies and research in areas such as biochemistry, pharmaceuticals, and materials science. The course equips students with skills crucial for careers in chemical research, drug development, and petrochemicals, where understanding molecular structure, reaction mechanisms, and stereochemistry is key. The content is highly applicable in real-world situations, from designing

safer and more effective drugs to developing new materials and chemicals used in everyday life.

Course Outcomes

Upon completion of the course the learner will be able to:

CO1: Understanding key concepts in organic chemistry, including classification, nomenclature, hybridization, and electronic displacements.

CO2: Applying knowledge of stereochemistry to analyze molecular shapes, geometrical isomerism, and optical activity.

CO3: Analyzing the mechanisms of various organic reactions, including addition, elimination, and substitution, along with the behaviour of reaction intermediates.

CO4: Evaluating the principles of aromaticity and electrophilic aromatic substitution, focusing on the directing effects of substituents and the significance of Huckel's rule.

Course Content

- **Unit A: Basics of Organic Chemistry 15 Lectures**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes). Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

- **Unit B: Stereochemistry 15 Lectures**

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis-trans and syn-anti isomerism E/Z notations with C. I. P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

- **Unit C: Chemistry of Aliphatic Hydrocarbons 15 Lectures**

Carbon-Carbon sigma bonds: Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

Carbon-Carbonpi-bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration- demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2-

and 1, 4- addition reactions in conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene,1-butene,toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilicadditions.

Cycloalkanes and Conformational Analysis: Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

Unit D: Aromatic Hydrocarbons 15 Lectures

Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.

Learning Experience Description

This Organic Chemistry course combines lectures, interactive sessions, and hands-on activities for an engaging learning experience.

Instruction Methods:

Lectures: Multimedia presentations will cover key topics such as organic compound classification, stereochemistry, and hydrocarbon reactions, with integrated problem-solving sessions.

Interactive Sessions: Q&A segments, live quizzes, and group discussions will enhance engagement and solidify understanding.

Online Platforms: An LMS will provide resources and support for extended learning.

Assessments:

Formative: Regular quizzes and online discussions for ongoing feedback.

Summative: Exams, peer reviews, and presentations to evaluate overall understanding.

Support: The instructor will offer additional guidance, and peer collaboration will be encouraged. Regular feedback will aid in achieving course outcomes.

Textbooks

1. Bahl and Bahl, Advanced Organic Chemistry, S. Chand Publication House.

Reference Books

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, 6thEdn., Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
2. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill,(2007)
3. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
4. J.Clayden, N.Greeves, S.Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press.
5. F. A. Carey, R. J. Sundberg,Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher,(2000).

Open Educational Resources (OER)

- Organic Chemistry - Basic Introduction - Bing video
- Complete Hydrocarbons | Day 2 | Organic Chemistry in 7 Days | MahaYuddh | NEET | NiteshDevnani - Bing video
- Introduction to chirality | Stereochemistry | Organic chemistry | Khan Academy - Bing video
- Aromatic Hydrocarbons | L 25 | Master Organic Chemistry | NEET 2023/2024 | NiteshDevnani - Bing video

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
BSCHOC152	**Organic Chemistry-I Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**
Category of Course	**Major (Practical)**				
Total Lectures	**15**				
Pre-Requisites/ Co-Requisites	**Basics of reaction mechanism**				

Course Perspective

This course in Organic Chemistry Laboratory Techniques is crucial for developing practical skills essential in both academic and professional settings. Students will learn to calibrate thermometers, purify organic compounds using methods like crystallization, distillation, and sublimation, and determine melting and boiling points with precision. The course also introduces chromatographic techniques for separating and identifying mixtures. These hands-on experiences are directly applicable in research, pharmaceuticals, and quality control, where accuracy in compound purification and analysis is critical. Mastery of these techniques prepares students for advanced studies and careers in various chemistry-related fields, making this course a fundamental component of their education.

Course Outcomes

Upon completion of the coursethe learner will be able to:

CO1: Identifying: Learn to check thermometer calibration and understand basic purification methods like crystallization and distillation.

CO2: Imitating: Follow procedures for purifying compounds, measuring melting and boiling points, and separating mixtures using chromatography.

CO3: Practicing: Use techniques to purify compounds, test the impact of impurities on melting points, and separate mixtures with chromatography.

Course Content` **30 lecture**

List of experiments

1. Checking the calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:
   a. Water b. Alcohol c. Alcohol-Water
3. Purification by Distillation, Decolouration (Charcoal treatment) and Sublimation.
4. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
5. Effect of impurities on the melting point -mixed melting point of two unknown organic compounds.
6. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100ºC by distillation and capillary method)
7. Chromatography

- Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
- Separation of a mixture of two sugars by ascending paper chromatography
- Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Learning Experience

This lab course will involve hands-on experiments, interactive sessions, and group work focused on practical techniques for calibration, purification, and chromatography.

Methods of Instruction:

- **Lab Experiments:** Students will conduct experiments on calibration, purification, and determining melting and boiling points, with demonstrations and supervised practice.

Use of Technology:

- **Lab Equipment:** Students will use calibrated instruments and advanced lab apparatus.
- **Online Resources:** An LMS will provide lab manuals, instructional videos, and discussion forums for support.

Activities:

- **Experiments:** Practical work includes crystallization, distillation, chromatography, and measuring physical properties.
- **Group Work:** Collaborative projects and discussions to enhance learning.

Assessments:

- **Formative:** Ongoing feedback during labs and online.
- **Summative:** Evaluations through lab performance and reports.

Support: The instructor will offer additional guidance, and peer collaboration will be encouraged, with regular feedback to support student progress.

Textbooks

1. Mann, F. G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

Reference Books

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
2. O.P. Pandey, Practicals of Chemistry, Laxmi Publication.

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
	Data Exploration and Analysis Using Excel	**L**	**T**	**P**	**C**
Version 3.0		**1**	**0**	**4**	**3**
Category of Course	**Skill Enhancement Course SEC-I**				
Total Lectures	**45**				
Pre-Requisites/ Co-Requisites	**Basics of Computers**				

Course Objectives:

The course will enable the student-teacher to:

- Enhance Excel-based data modeling skills.
- Understand data conversion, categorization, data collection, and appropriate formatting.
- Compute logical and mathematical averages, dispersion measures, using Excel's built-in and advanced tools.
- Represent data graphically (e.g., histogram, cumulative frequency, bar charts for subgroups).
- Analyze problem frequencies and use financial/statistical functions.

Course Outcomes:

CO1: Understand and recall basic Excel features such as cells, formulas, and formatting.

CO2: Use Excel to enter, organize, and summarize data with basic functions and charts.

CO3: Analyze data using descriptive statistics like averages, dispersion, and trends.

CO4: Interpret results using charts and statistical tools to draw data-based conclusions.

Course Content

UNIT 1: Getting Started with Excel **11 Lecture**

- Understanding Excel Interface: Cells, Rows, Columns, Worksheets
- Data Entry: Text, Numbers, Dates
- Basic Formatting: Fonts, Colors, Borders, Merging Cells
- Basic Formulas: SUM, AVERAGE, MIN, MAX
- Copying Formulas using Fill Handle
- Saving and Printing Excel Files

UNIT 2: Working with Data and Functions **11 Lecture**

- Sorting and Filtering Data
- Introduction to Logical Functions: IF
- Date and Text Functions: TODAY(), CONCATENATE(), LEFT(), RIGHT()
- Introduction to Tables and Named Ranges
- Data Validation (Dropdown Lists)
- Using Freeze Panes and Conditional Formatting

UNIT 3: Charts and Visual Representation **11 Lecture**

- Creating Charts: Column, Bar, Pie, Line
- Customizing Charts: Titles, Labels, Legends, Colors
- Insert Sparklines and Data Bars
- Understanding and Creating Pivot Tables (Basic Level)

- Using Slicers for Interactivity in Pivot Tables
- Creating Simple Dashboards with Charts

UNIT 4: Descriptive Statistics and Basic Analysis **12 Lecture**

- Measures of Central Tendency: Mean, Median, Mode
- Measures of Dispersion: Range, Variance, Standard Deviation
- Introduction to Correlation (Conceptual Only)
- Data Summary using Descriptive Statistics Tool (Add-ins)
- Using Excel Templates for Data Analysis
- Project: Analyze and Present a Small Dataset

Textbook

1. Mohamed Miled. Introduction to Data Analysis: Excel/VBA, SQL, Python, R
2. Wayne Winston – Microsoft Excel Data Analysis and Business Modeling, Microsoft Press

Reference Book

1. Robert de Levie (2004), *Advanced Excel for Scientific Data Analysis*, Oxford University Press *(Use with guidance for visuals and examples)*

Open Educational Resources (OER):

1. **Microsoft Excel Training Center** (Official Microsoft tutorials) https://support.microsoft.com/en-us/excel
2. **Excel Easy** – Free Excel tutorials and examples https://www.excel-easy.com/
3. **GCFLearnFree – Excel Training** https://edu.gcfglobal.org/en/excel/
4. **Coursera: Excel Skills for Business** – University of Macquarie (Free to audit) https://www.coursera.org/learn/excel-essentials

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Theory & Practical) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment/Practical/class-participation	**50 Marks**
III. External Marks (Practical): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
	Environmental Studies	**L**	**T**	**P**	**C**
Version 2.0		**2**	**0**	**0**	**2**
Category of Course	**Value Added Course VAC-I**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites	**Basics of Environment**				

Course Perspective: This course on Environmental Sciences and Disaster Management provides a comprehensive understanding of environmental issues and disaster preparedness, crucial for students pursuing careers in environmental science, public policy, and emergency management. The curriculum covers critical topics such as land and water resources, pollution control, environmental policies, and disaster management strategies. Students will gain practical skills in assessing environmental impacts, managing resources sustainably, and preparing for and responding to various types of disasters. This knowledge is directly applicable in real-world scenarios, such as developing effective pollution control measures, implementing sustainable practices, and enhancing disaster response strategies. By integrating case studies and practical applications, the course equips students with the tools needed to address pressing environmental challenges and contribute to resilience and sustainability efforts globally.

Course Outcomes

Upon completion of the coursethe learner will be able :

CO1: Understanding the types, causes, and effects of environmental pollution, and outline key environmental laws in India.

CO2: Applying knowledge of environmental science and legal frameworks to real-world scenarios, particularly in disaster preparedness and management.

CO3: Analyzing the impact of human activities on the environment and the effectiveness of existing environmental laws and disaster management practices in India.

CO4: Evaluating the effectiveness of governance frameworks and disaster management practices, proposing improvements for sustainable development.

Course Content

- **Unit A: Environment and Natural Resources 8 Lectures**

Multidisciplinary nature of environmental sciences; Scope and importance; Need for public awareness. Land resources; land use change; Land degradation, soil erosion and desertification.

Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.

Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).

Energy resources: Renewable and non- renewable energy sources, use of alternate energy sources, growing energy needs, case studies. Carbon Footprints.

- **Unit B: Environmental Pollution and Environmental Policies 7 Lectures**

Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution Nuclear hazards and human health risks; Solid waste management: Control measures of urban and industrial waste; Pollution case studies.

Sustainability and sustainable development; Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture; Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; wildlife Protection Act; Forest Conservation Act; Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context. Fundamentals and Application of ESG (Environment Social Governance).

- **Unit C: Introduction to Disasters 8 Lectures**

Concept and definitions- Disaster, Hazard, vulnerability, resilience, risks. Different Types of Disaster: Causes, effects and practical examples for all disasters. Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc. Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures (Building and Bridge), War & Terrorism etc.

- **Unit D: Disaster Management 7 Lectures**

Disaster Preparedness Plan, Prediction, Early Warnings and Safety Measures of Disaster, Role of Government, International and NGO Bodies in Disaster Preparedness. Reconstruction and Rehabilitation, Post Disaster effects and Remedial Measures Disaster Management Act, 2005: Disaster management framework in India before and after Disaster Management Act, 2005, Applications of AI and ML in Disaster Management and risk predictions.

Learning Experience

This comprehensive course integrates lectures, interactive discussions, hands-on activities, and field experiences to provide a deep understanding of environmental science, pollution, disaster types, and management strategies.

Instruction Methods:

- **Lectures:** Core concepts will be presented through multimedia and problem-solving sessions.
- **Interactive Sessions:** Includes Q&A segments, live quizzes, and discussions to enhance engagement and understanding.
- **Technology Use:** The Learning Management System (LMS) will provide resources, recorded lectures, and discussion forums.

Activities:

- **Case Studies & Group Work:** Students will analyze real-world problems related to environmental and disaster issues, working collaboratively on projects.
- **Field Visits:** Real-world observation of environmental and disaster management practices.
- **Assessments:**
- **Formative:** Ongoing feedback through quizzes and online discussions.

- **Summative:** Exams, presentations, and case study reports to evaluate overall understanding and application of course content.

Support:

Instructors will offer additional guidance and feedback, and peer collaboration will be encouraged to support student learning and achievement of course outcomes.

Textbooks

1. Content building programme (CBP) book on Disaster Management, Forum AS.
2. Kaushik and Kaushik, Environmental Studies, New Age International Publishers (P) Ltd. New Delhi.

Reference Books

1. A.K. De, Environmental Chemistry, New Age International Publishers (P) Ltd. New Delhi.
2. S.E. Manahan, Environmental Chemistry, CRC Press.
3. S.S Dara and D.D. Mishra, Environmental Chemistry and Pollution Control, S.Chand& Company Ltd, New Delhi.

Open Educational Resources (OER)

- OpenStax
- Khan Academy
- MIT OpenCourseWare
- Coursera and edX
- YouTube
- Wikibooks
- OER Commons
- NOAA Education
- UNEP Education
- TED Talks

Evaluation Scheme :

Evaluation components	**Weightage**
End Term Examination	**100 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
BSCHPC103	**Physical Chemistry-I**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-III**				
Total Lectures	**60**				

Pre-Requisites/ Co-Requisites	**Basics of Chemistry**

Course Perspective

This course in States of Matter and Ionic Equilibria is essential for understanding the fundamental principles of chemistry related to gases, liquids, solids, and their interactions. It covers topics such as real gas behaviour, liquid properties, ionic equilibria, and the solid state, equipping students with the theoretical knowledge and practical skills necessary for various scientific and industrial applications. Students will gain expertise in analysing gas deviations from ideal behaviour, calculating viscosity and molecular velocities, understanding liquid properties and surface tension, and exploring the principles of ionic equilibria and buffer solutions. Additionally, the course delves into the structural and symmetry aspects of solids, including X-ray diffraction techniques. This knowledge is crucial for careers in chemical research, materials science, and environmental science, where accurate analysis of materials and reactions is essential for developing new technologies and solving complex problems.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Understanding key concepts in the gaseous state, including real gas behavior, van der Waals equation, and deviations from ideal gas laws.

CO2: Applying the kinetic molecular model to analyze properties of gases and liquids, such as viscosity, vapor pressure, and temperature dependence.

CO3: Analyzing ionic equilibria, including the behavior of strong and weak electrolytes, buffer solutions, and the Brönsted-Lowry concept of acid-base reactions.

CO4: Evaluating the solid state, including the nature of solids, crystal systems, and the analysis of X-ray diffraction patterns, as well as understanding defects in solids.

Course Content

- **Unit A: Gaseous state 15 Lectures**

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior, relation between mean free path and coefficient of viscosity.Deviations from ideal gas behavior, compressibility factor *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior, van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

- **Unit B: Gaseous and Liquid state 15 Lectures**

Gaseous state Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their

temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. **Liquid state**Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

- **Unit C: Ionic equilibria 15 Lectures**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-proticacids.Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts.Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product. Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations.Multistageequilibria in polyelectrolytes.

- **Unit D: Solid State 15 Lectures**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Millerindices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitativeidea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-raydiffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method.Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals,Glasses and liquid crystals.

Learning Experience:

This course will feature lectures, interactive sessions, and hands-on activities to explore key concepts in gaseous and liquid states, ionic equilibria, and solid-state chemistry.

Instruction Methods:

- **Lectures:** Core concepts through multimedia and problem-solving.
- **Interactive Sessions:** Q&A, quizzes, and group discussions.
- **Hands-On Activities:** Laboratory experiments and case studies.

Technology Use:

- **Online Platforms:** LMS for resources, recorded lectures, and forums.

Assessments:

- **Formative:** Quizzes, lab reports, and discussions.
- **Summative:** Exams, peer reviews, and presentations.

Support:

- **Instructor Guidance:** Available for additional help.

- **Peer Collaboration:** Encouraged for improved learning.
- **Feedback:** Regular feedback to support achievement of course outcomes.

Textbooks

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).

Reference Books

1. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)

Open Educational Resources (OER)

- https://www.oercommons.org/
- https://www.merlot.org/merlot/index.htm
- https://ocw.mit.edu/index.htm
- https://www.khanacademy.org/
- https://openstax.org/
- https://www.coursera.org/courses?query=free
- https://epathshala.nic.in/
- http://chemcollective.org/
- http://nsdl.niscair.res.in/
- https://www.youtube.com/watch?v=3m-TNF0qTrE

Evaluation Scheme :

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER I					
BSCHPC153	**Physical Chemistry-I Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**

Category of Course	**Major (Practical)**
Total Lectures	**15**
Pre-Requisites/ Co-Requisites	**Basics of Chemistry**

Course Perspective

This course on Physical Chemistry Laboratory Techniques provides critical hands-on experience in measuring and analyzing physical properties such as surface tension, viscosity, and pH, which are essential for understanding chemical behavior and reactions. Students will learn to determine surface tension using drop number and drop weight methods, explore the effects of solutes on viscosity, and conduct pH metric titrations to analyze buffer solutions and acid dissociation constants. These practical skills are fundamental for careers in chemical research, quality control, and environmental monitoring, where accurate measurement and analysis are crucial. By applying these techniques, students will be well-prepared for real-world challenges, such as developing new materials, improving industrial processes, and conducting precise chemical analyses.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Identifying how to measure surface tension, viscosity, and pH, and learn the basics of each method.

CO2: Imitating steps to measure surface tension, viscosity, and pH using the appropriate equipment and techniques.

CO3: Practicing techniques to explore how different concentrations affect surface tension, viscosity, and pH, and prepare buffer solutions.

Course Content

List of Experiments **30 lecture**

1. Surface tension measurements.

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration. .

2. Viscosity measurements using Ostwald's viscometer.

(a) Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature.

(b) Study the effect of variation of viscosity of an aqueous solution with the concentration of solute.

3. pH metry

a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid

j. Ammonium chloride-ammonium hydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

d. Determination of dissociation constant of a weak acid.

Learning Experience

This lab course involves hands-on experiments and interactive sessions on surface tension, viscosity, and pH metry.

Methods of Instruction:

- **Lab Experiments:** Students will perform measurements on surface tension, viscosity, and pH, with demonstrations and supervised practice.
- **Interactive Sessions:** Real-time feedback and discussions will support learning.

Use of Technology:

- **Lab Equipment:** Calibrated apparatus for accurate measurements and solution preparation.
- **Online Resources:** LMS for lab manuals, instructional videos, and discussion forums.

Activities:

- **Experiments:** Measuring surface tension, viscosity, and pH; preparing buffers; performing titrations.
- **Group Work:** Collaborative analysis and discussions.

Assessments:

- **Formative:** Continuous feedback during labs and online.
- **Summative:** Evaluations based on lab performance and reports.

Support: The instructor will provide guidance, and peer collaboration will be encouraged with regular feedback to aid student progress.

Textbooks

1. Khosla, B. D.; Garg, V. C. &Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi(2011).

Reference Books

1. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
2. Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).
3. Athawale V. D. amdMathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

Open Educational Resources

- **https://www.khanacademy.org/**
- **https://www.coursera.org/**
- **https://www.open.edu/openlearn/**
- **https://ocw.mit.edu/index.htm**
- **https://openstax.org/**
- **http://chemcollective.org/**

- https://libretexts.org/
- https://nptel.ac.in/
- http://www.chemguide.co.uk/
- https://www.saylor.org/

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER II

SEMESTER II					
BSCHPC201	**Organic Chemistry-II**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-IV**				
Total Lectures	**60**				
Pre-Requisites/ Co-Requisites	**Basics of reaction mechanism**				

Course Perspective

This course in Organic Chemistry focuses on the chemistry of halogenated hydrocarbons, alcohols, phenols, ethers, epoxides, carbonyl compounds, and carboxylic acids, providing a deep understanding of their preparation, reactivity, and mechanisms. Students will explore the nuanced behaviours of alkyl and aryl halides, the reactivity of various alcohols and phenols, and the reactions of carbonyl compounds, including complex mechanisms and rearrangements. Additionally, the course covers the properties and reactions of carboxylic acids and their derivatives. These topics are vital for careers in organic synthesis, pharmaceuticals, and material science, where precise knowledge of functional groups and reaction mechanisms is essential. By mastering these concepts, students will be well-equipped to

design and execute complex chemical syntheses, understand and apply advanced reaction mechanisms, and contribute to innovative solutions in various scientific and industrial contexts.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: **Understanding** the properties and preparation methods of alkyl and aryl halides, alcohols, phenols, ethers, and epoxides.

CO2: **Explaining** the differences between nucleophilic substitution and elimination reactions and describe the preparation and reactions of ethers and epoxides.

CO3: **Applying** your knowledge to predict the outcomes of organic reactions and design synthetic pathways using organometallic compounds.

CO4: **Analyzing** how reaction mechanisms and conditions affect the transformation of organic compounds.

Course Content

- **Unit A: Chemistry of Halogenated Hydrocarbons 15Lectures**

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN^1, SN^2 and S_N^I mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. *Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li and their use in synthesis.

- **UnitB: Alcohols, Phenols, Ethers and Epoxides 15Lectures**

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

- **Unit C: Carbonyl Compounds 15 Lectures**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff- Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

- **Unit D: Carboxylic Acids and their Derivatives 15 Lectures**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric,maleicandfumaricacids;Preparationandreactionsofacidchlorides,anhydrides,estersand amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement.

Sulphur containing compounds

Preparation and reactions of thiols, thioethers and sulphonic acids.

Learning Experience

This course will blend lectures, interactive sessions, and hands-on activities to enhance understanding of halogenated hydrocarbons, alcohols, phenols, ethers, epoxides, carbonyl compounds, carboxylic acids, and sulfur-containing compounds.

Instruction Methods:

- **Lectures:** Core concepts will be introduced using multimedia presentations and problem-solving exercises.
- **Interactive Sessions:** Engage students through Q&A segments, live quizzes, and discussions to reinforce learning.

Technology Use:

- **Online Platforms:** An LMS will provide resources, recorded lectures, and discussion forums for additional support.

Assessments:

- **Formative:** Continuous feedback through quizzes and online discussions.
- **Summative:** Evaluation via exams, peer reviews, and presentations.

Support:

- **Instructor Guidance:** Available for additional support.
- **Peer Collaboration:** Encouraged to enhance learning and improvement.
- **Feedback:** Regular feedback will assist students in achieving course outcomes.

Textbooks

1 Bahl and Bahl, Advanced Organic Chemistry, S. Chand Publication House.

Reference Books

1 Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry,* John Wiley & Sons, Inc (2009).

2 McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.

3 P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.

4 Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India,2003.

Open Educational Resources (OER)

- Alkyl Halides and Aryl Halides Class 12 | Lecture 1 | JEE Main | JEE Advanced |Harsh Sir| Vedantu - Bing video
- Alcohol Phenol and Ethers in 3 Hours for Class 12 Boards | Complete NCERT + Notes - Bing video
- Carbonyl Compounds । Class12 | JEE | NEET (L1) | MOP of Carbonyl Compounds - Bing video
- Carboxylic Acids Class 12 Chemistry | NCERT Chapter 12 CBSE One Shot CBSE JEE NEET - Bing video

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER II					
BSCHOC251	**Organic Chemistry-II Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**
Category of Course	**Major IV (Practical)**				
Total Lectures	**15**				
Pre-Requisites/ Co-Requisites	**Basics knowledge of organic compounds**				

Course Perspective

This Organic Chemistry Laboratory course equips students with essential skills in identifying functional groups, conducting organic preparations, and performing qualitative analysis of various organic compounds. The course covers practical techniques such as acetylation, benzoylation, oxidation, bromination, nitration, and selective reduction, including both conventional and green chemistry approaches. Students will also engage in hydrolysis, aldol condensation, and rearrangement reactions, gaining hands-on experience with a range of methods from traditional to sustainable practices. By

learning to identify elements and functional groups, and analyzing unknown organic compounds, students will develop critical analytical skills and practical expertise vital for careers in research, pharmaceuticals, and chemical industries. These skills will enable them to tackle complex chemical synthesis, improve reaction processes, and ensure accurate identification and characterization of organic substances in real-world applications.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Observing: Identify key elements and functional groups using standard tests, and understand organic synthesis and qualitative analysis techniques.

CO2: Imitating: Follow procedures to perform organic reactions and tests for identifying compounds.

CO3: Practicing: Use techniques to analyze organic compounds and carry out organic preparations.

Course Content **30 Lectures**

Unit No: Unit Name

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

1. **Identification** of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.

2. Organic preparations:

i. Acetylation of one of the following compounds: amines (aniline,*o*-,*m*-,*p*-toluidines and *o*-,*m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistry approach)

ii. Benzolyation of one of the amines (aniline,*o*-,*m*-,*p*-toluidinesand*o*-,*m*-,*p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination (anyone)

a. Acetanilide by conventional methods

b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration: (anyone)

a. Acetanilide/nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of *meta* dinitro benzene to *m*-nitroaniline.

vii. Reduction of *p*-nitro benzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semi carbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid,

phenyl acetic acid and phthalic acid).

xi. Aldol condensation with either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

3. Qualitative analysis of the following types of unknown organic compounds

(a) Carboxylic acids

(b) Phenols

(c) Alcohols

(d) Aldehydes

(e) Ketones

(f) Esters

(g) Carbohydrates

(h) Primary, secondary and tertiary amines

(i) Nitro compounds

(j) Amides

(k) Aryl halides

(l) Hydrocarbons

(m)Collected solid samples may be used for recrystallization, melting point and TLC.

Learning Experience

This lab course involves hands-on experiments, interactive sessions, and group work on organic chemistry techniques.

Methods of Instruction:

- **Lab Experiments:** Perform tests for functional groups, organic preparations, and qualitative analysis, with demonstrations and supervised practice.
- **Interactive Sessions:** Engage in discussions and receive real-time feedback.

Use of Technology:

- **Lab Equipment:** Calibrated apparatus for precise measurements.
- **Online Resources:** LMS for manuals, videos, and discussion boards.

Activities:

- **Experiments:** Conduct various organic tests and syntheses.
- **Group Work:** Collaborative analysis and discussions.

Assessments:

- **Formative:** Ongoing feedback during labs and online.
- **Summative:** Evaluations based on lab performance and reports.

Support: The instructor will provide guidance, and peer collaboration will be encouraged, with regular feedback to aid progress.

Textbooks

1 O.P. Pandey, Practical Chemistry.

Reference Books

1 Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)

2 Furniss, B.S., Hannaford, A.J., Smith, P.W.G. &Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson(2012)

3 Ahluwalia,V.K.&Aggarwal,R.*ComprehensivePracticalOrganicChemistry:Preparationand Quantitative Analysis,* University Press(2000)

4 Ahluwalia, V.K. &Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press(2000).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER II					
	DOCUMENTATION USING LATEX	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Skill Enhancement Course**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites					

Course Perspective

This course introduces students to LaTeX, a high-quality typesetting system commonly used for technical and scientific documents. Students will explore the advantages of LaTeX over traditional word processors, focusing on its precision in formatting and mathematical typesetting. The course covers essential topics such as formatting text, creating lists, typing complex math formulas, and utilizing various environments (e.g., equations, matrices). Students will learn to insert tables, figures, and graphics, as well as create professional presentations using Beamer. Additionally, the course will guide students through the

installation of LaTeX and necessary packages, while leveraging online resources for enhanced productivity.

Course Outcomes (CO)

CO1: Remembering the basic commands and syntax of LaTeX, including formatting lines, paragraphs, and simple documents.

CO2: Applying LaTeX commands to format text, insert tables, figures, and create professional presentations using Beamer.

CO3: Analyzing the structure of LaTeX documents by breaking down environments (e.g., equations, matrices) and correctly integrating mathematical formulas and symbols.

CO4: Critically assessing and troubleshooting LaTeX documents by identifying and correcting errors in formatting, layout, or typesetting.

Course Content

Unit-1 **8 Lectures**

Introduction to LaTeX, Benefits and comparison with word processor, Installing LaTeX, Formatting lines and paragraph, typesetting a simple document, Text alignment, Installing packages

Unit 2 **8 Lectures**

Creating Lists, Typing Math Formulas, Environments – equations, arrays, matrices, Footnotes, Fonts, Title and headers

Unit-3 **6 Lectures**

Sectioning, Listing references, Math styles – cases, braces, math symbols

Unit-4 **8 Lectures**

Graphics in LaTeX, Inserting Tables and Figures, Beamer presentation, Sample presentation, Using online resources

Learning Experience:

The learning experience in this LaTeX course is designed to be highly practical and hands-on, allowing students to build confidence in document preparation through incremental mastery of LaTeX. Starting with foundational concepts, students will engage in guided exercises that introduce essential commands and structures. As they progress, students will tackle increasingly complex tasks, such as typesetting mathematical formulas, creating professional-grade presentations, and integrating graphics.

Interactive sessions, coupled with real-time feedback, will enable students to experiment and refine their skills in a supportive environment. By the end of the course, students will have not only a thorough understanding of LaTeX but also a portfolio of completed projects that showcase their ability to produce polished, publication-ready documents. This experiential learning approach ensures that students are well-equipped to apply LaTeX in their academic and professional endeavors.

Instruction Methods:

- **Lectures with Visual Aids:** Core concepts and LaTeX fundamentals will be introduced through live or recorded lectures, supplemented with visual demonstrations of coding and document preparation. These sessions will focus on explaining the syntax, commands, and structural elements of LaTeX.
- **Assignments and projects:** Students will be given regular assignments and a final project that requires them to apply the skills learned in class. These tasks will range from simple document creation to more complex projects involving advanced formatting, mathematical typesetting, and presentations.

Technology Use:

- **Online Platforms:** An LMS will host resources, recorded lectures, assignments, and discussion forums to facilitate extended learning.

Assessments:

- **Formative:** Regular quizzes, assignments, and online discussions will provide continuous feedback.
- **Summative:** Exams, project presentations, and peer reviews will assess students' mastery of the material.

Support: The course instructor will offer additional guidance, with peer collaboration encouraged through group work and review sessions. Continuous feedback will ensure students' progress and improvement in achieving course outcomes.

Textbooks

1. David F. Griffiths, Desmond J. Higham, Learning LaTeX, Society for Industrial and Applied Mathematics(SIAM), 2016.
2. Stefan Kottwitz, LaTeX Beginner's Guide. Packet Publishing, Birmingham, UK, 2011.

Reference Books

1. Lamport, Leslie, LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Addison-Wesley, 1994.
2. **The LaTeX Companion** by Frank Mittelbach, Michel Goossens, Johannes Braams,

David Carlisle, and Chris Rowley

This book offers a deeper dive into advanced LaTeX techniques, including formatting, typesetting, and customizing documents, making it perfect for students looking to go beyond the basics.

3. **Guide to LaTeX** by Helmut Kopka and Patrick W. Daly

   A practical guide that walks readers through LaTeX commands and document structuring, with examples ranging from simple to complex document preparation.

4. **More Math into LaTeX** by George Grätzer

   Ideal for students focusing on mathematical typesetting, this book provides detailed guidance on producing equations, formulas, and mathematical symbols in LaTeX.

5. **LaTeX in 24 Hours: A Practical Guide for Scientific Writing** by Dilip Datta

   This book provides a step-by-step approach to learning LaTeX, making it an excellent resource for beginners looking for practical, hands-on learning.

6. **Online Resource: LaTeX Wikibook**

   Available online for free, this resource is an excellent place for students to explore tutorials, examples, and community-driven content on LaTeX.

Open Educational Resources (OER)

1. **https://www.overleaf.com**
2. **https://www.w3schools.com/html/**

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Group Project/quizzes/Lab Participation /presentation/ case studies/Practical Record	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately to secure minimum passing grade

SEMESTER II					
	CYBER SECURITY	**L**	**T**	**P**	**C**
Version ___		**2**	**0**	**0**	**2**
Category of Course	**VAC-II (MOOC)**				
Total Lectures	30				
Pre-Requisites/ Co-Requisites	**Basic computer literacy**				

Course Perspective

In the digital age, cyber security is a critical component of everyday life—from personal communication and online transactions to national security. This course introduces students to the fundamentals of cyber space, common cyber threats, security tools, and best practices for safe digital behavior. The course emphasizes hands-on learning through case studies, simulations, and practical tools used in cyber security. It also covers legal and ethical considerations, social engineering, and national cyber initiatives, preparing learners to navigate the digital world responsibly and safely.

Course Outcome:

By the end of this course, learners will be able to:

CO1: Understanding foundational concepts of cyber space, cyber-crimes, and basic information security principles.
CO2: Identifying common digital threats and apply appropriate security measures for browsers, devices, networks, and social platforms.
CO3: Demonstrating safe online behavior, including secure password practices, mobile and online banking precautions, and protection against social engineering.
CO4: Interpreting legal frameworks such as the IT Act and assess India's cyber security initiatives and response strategies.
CO5: Using tools for data cleaning, protection, recovery, and secure digital communication.

Course Content:

Unit 1: Introduction to Cyber Space and Basic Security Practices
Topics:

- Overview and History of Internet
- Introduction to Cyber Crime
- Information Security and Computer Ethics
- Security Policies and Safe Internet Usage
- Choosing and Securing Web Browsers
- Basics of Antivirus and Email Security
- Secure Password Guidelines and Two-Factor Authentication
- Introduction to Password Managers and Wi-Fi Security

Unit 2: Device and Social Media Security

- Social Media Safety Guidelines and Best Practices
- Basic Windows Security and User Account Protection
- Smartphone Security (Android & iOS)

- Security of Micro ATMs, e-wallets, and POS Systems
- Online and Mobile Banking Security
- UPI and Credit/Debit Card Security

Unit 3: Cyber Threats, Social Engineering, and Legal Framework

- Social Engineering: Types and Prevention
- Cyber Criminal Techniques and Real-Life Scenarios
- Cyber Threat Landscape and Emerging Threats
- Introduction to Cyber Security Techniques
- Use of Firewalls and Defensive Programming
- Overview of the IT Act and Legal Countermeasures
- Web Application & Digital Infrastructure Security

Unit 4: Cyber Security Infrastructure and Data Management

- National Cyber Security Initiatives
- Incident Handling and Assurance Practices
- Cyber Security Exercises
- Data Destruction and Recovery Tools
- Use of Tools like CCleaner for Secure Information Management

Text Books and references

1. Introduction to Cyber Security available at http://uou.ac.in/foundation-course
2. Fundamentals of Information Security https://www.uou.ac.in/progdetail?pid=MSCCS-18
3. Cyber Security Techniques https://www.uou.ac.in/progdetail?pid=MSCCS-18
4. Cyber Attacks and Counter Measures: User Perspective https://www.uou.ac.in/progdetail?pid=MSCCS-18
5. Information System https://www.uou.ac.in/progdetail?pid=MSCCS-18

Evaluation Scheme:

Students will complete this course through a MOOC platform, and upon receiving a certificate of completion from the respective online portal, they will be awarded the designated course credits.

SEMESTER II					
BSCCPR205	**Project-I**	**L**	**T**	**P**	**C**
Version ___		**0**	**0**	**0**	**2**
Category of Course	**Project I**				
Total Lectures	15				
Pre-Requisites/ Co-Requisites	**Basic Scientific Knowledge**				

Course Perspective:

This project-based course is designed to foster creativity, innovation, and independent learning by allowing students to explore real-world problems through hands-on experimentation, research, or interdisciplinary approaches. By choosing a category that aligns with their interests—such as working models, research, skill development, innovation, or entrepreneurship—students gain practical experience, apply theoretical knowledge, and enhance their problem-solving, technical, and presentation skills. The course emphasizes inquiry, design thinking, and collaborative learning to prepare students for academic, industrial, or entrepreneurial pursuits.

Course Outcomes:

CO1: Understanding key concepts, scientific principles, or societal needs relevant to the selected project category.

CO2: Applying scientific methods, laboratory techniques, or computational tools to execute project tasks effectively.

CO3: Analyzing data, processes, or systems to derive insights, troubleshoot problems, and refine approaches.

CO4: Evaluating the feasibility, functionality, or impact of the project and justify decisions based on evidence.

CO5: Creating an original project output—such as a model, report, prototype, codebase, or strategy—that integrates knowledge across disciplines and addresses real-world applications.

Course Content:

Students may choose one of the following categories:

A. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.
B. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.
C. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.
D. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.
E. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.
F. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).
G. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

- Clarity of Objective – 10 marks

- Innovation / Creativity – 20 marks
- Scientific/Technical Accuracy – 20 marks
- Practical Application / Relevance – 15 marks
- Execution / Model Functionality – 20 marks
- Presentation / Report Quality – 5 marks
- Teamwork / Effort – 10 marks

For detailed guidelines, please refer to **Annexure-I** attached.

SEMESTER III

SEMESTER III					
BSCHPC301	**PHYSICAL CHEMISTRY-II**	**L**	**T**	**P**	**C**
Version ___		**3**	**1**	**0**	**4**
Category of Course	**Major V**				
Total Lectures	60				
Pre-Requisites/ Co-Requisites	Basics of Physical Chemistry (Upto class XII)				

Course Perspective

This course provides students a basic understanding of thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics. This course will strengthen the fundamentals of thermodynamics and their correlation with other branches of physical chemistry.

Course Outcomes

Upon completion of the course the learner will be able:

CO1:Understanding basic concepts of chemical thermodynamics.

CO2:Applying chemical thermodynamics principles to everyday life scenarios.

CO3:Analyzing partial molar properties and the Gibbs-Duhem equation, and their impact on thermodynamic parameters based on composition.

CO4:Evaluating the application of thermodynamics in engineering, chemistry, and real-world situations to make informed decisions and solve practical problems.

Course Content

Unit A: Introduction to thermodynamics **15 Lectures**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions**.**

Unit B: Thermochemistry **15 Lectures**

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions. Second Law, Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Unit C: Third law of thermodynamics **15 Lectures**

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules. Free Energy Functions, Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit D: Partial molar quantities **15 Lectures** Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Learning Experience:

This course combines lectures, interactive sessions, and practical exercises to explore thermodynamics, including intensive/extensive variables, heat, work, and energy changes in various systems.

- **Instruction Methods:** Multimedia presentations and problem-solving sessions, with Q&A, live quizzes, and discussions to engage and reinforce learning.
- **Technology Use:** LMS for resources, recorded lectures, and forums for extended learning.
- **Assessments:** Quizzes and online discussions for continuous feedback; exams, peer reviews, and presentations for comprehensive evaluation.
- **Support:** Instructor guidance and peer collaboration with regular feedback to enhance understanding and achieve course outcomes.

Textbooks

1 Atkins P. and De Paula, J. Physical Chemistry Tenth Ed., OUP, 2014. 2

2 Castellan, G. W. Physical Chemistry 4th Ed., Narosa, 2004.

Reference Books

1 Engel, T. and Reid, P. Physical Chemistry 3rd Ed., Prentice Hall, 2012.

2 McQuarrie, D. A. and Simon, J. D. Molecular Thermodynamics Viva Books, 2004.

3 Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

4 Commonly Asked Questions in Thermodynamics. CRC Press, 2011.

5 Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill, 2010.

6 Metz, C.R. 2000 solved problems in chemistry, Schaum Series, 2006.

Open Educational Resources (OER)

- https://www.khanacademy.org/science/physics/thermodynamics
- https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/
- https://www.coursera.org/learn/thermodynamics-1
- https://phet.colorado.edu/en/simulations/category/physics/thermodynamics
- http://hyperphysics.phy-astr.gsu.edu/hbase/thermo.html
- https://chem.libretexts.org/Courses/Mount_Royal_University/Chem_1201/Unit_2%3A_Thermochemistry/Chapter_17%3A_Thermodynamics%3A_Four_Laws_that_Move_the_Universe
- https://www.youtube.com/playlist?list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr
- https://pressbooks.bccampus.ca/thermodynamics/
- http://chemcollective.org/vlabs
- https://demonstrations.wolfram.com/topic.html?topic=Thermodynamics

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER III					
BSCHPC351	**Physical Chemistry-II Practicals**	**L**	**T**	**P**	**C**
Version ___		**0**	**0**	**2**	**1**
Category of Course	**Major IV Practicals**				
Total Lectures	15				
Pre-Requisites/ Co-Requisites	Basics of Physical Chemistry				

Course Perspective

This course provides the basic understanding of laboratory techniques. Various experiments in the course will strengthen the fundamental and basic concepts of physical chemistry practical techniques.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Observing: Learn how to measure critical solution temperature, study reaction equilibria, and understand adsorption and thermochemistry basics.

CO2: Imitating: Follow procedures to measure critical solution temperature, study reaction rates, and verify adsorption methods.

CO3: Practicing: Use techniques to measure reaction rates, calculate heat capacities, and study adsorption effects.

Course Content

List of Experiments

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

2. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) I_2 (aq) + I^- → I_3^- (aq)

(ii) Cu^{2+} (aq) + nNH_3 → $Cu(NH_3)_n$

3. Study the kinetics of the following reactions.

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

4. Adsorption: Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.

(Use of calorimeter for calculation of heat of reactions may be demonstrated)

5. (I) Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of copper sulphate.

(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Learning Experience

This lab course focuses on thermochemistry, reaction kinetics, and adsorption.

Methods of Instruction:

- **Lab Experiments:** Conduct experiments on solution temperature, reaction equilibria, kinetics, adsorption, and thermochemistry with demonstrations and supervised practice.
- **Use of Technology:**
- **Lab Equipment:** Calibrated instruments for accurate measurements.
- **Online Resources:** LMS for manuals.

Activities:

- **Experiments:** Analyze critical solution temperature, reaction kinetics, adsorption, and thermochemical properties.
- **Group Work:** Collaborative analysis and discussions.

Assessments:

- **Formative:** Ongoing feedback during labs and online.
- **Summative:** Evaluations based on lab performance and reports.

Support: Instructor guidance and peer collaboration, with regular feedback for progress.

Textbooks

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand, New Delhi, 2011.

Reference Books

1. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, Eighth Edition, McGraw-Hill (2003).

2. Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry, Third Edition, W, H. Freeman (2003).

Open Educational Resources (OER)

- http://chemcollective.org/
- https://www.khanacademy.org/science/chemistry
- https://chem.libretexts.org/
- https://ocw.mit.edu/courses/chemistry/
- https://www.youtube.com/user/TheOrganicChemistry
- https://pubchem.ncbi.nlm.nih.gov/
- http://www.chemcollective.org/vlabs

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Practicals)	
I. Conduct of experiment	**10 Marks**
II . Lab Record	**10 Marks**
III. Lab Participation	**10 Marks**
IV. Lab Project	**20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER III					
BSCHOC302	ORGANIC CHEMISTRY-III	**L**	**T**	**P**	**C**
Version ___		**3**	**1**	**0**	**4**
Category of Course	**Major VI**				
Total Lectures	60				
Pre-Requisites/ Co-Requisites	Basics of organic Chemistry and reaction mechanism				

Course Perspective

This course infused with details of nitrogen containing functional groups, preparation of polynuclear hydrocarbons, introduction of heterocyclic compounds, and general features of alkaloids. A comprehensive understanding of these topics will be developed by taking examples of representative members of each class. This course will also discuss some of the key applications of each class of compounds in diverse fields.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Understanding: the key methods and structures for different organic compounds.

CO2: Explaning how different compounds react and their uses.

CO3: Applying: Use techniques to make and study organic compounds.

CO4: Analysing: Examine how reactions work and how structures affect properties.

CO5: Evaluating: Judge how effective methods are and the importance of different compounds.

Course Content

UNIT A : Nitrogen Containing Functional Groups 15 Lectures

Preparation and importantreactionsofnitroandcompounds, nitrilesandisonitriles. Amines:Effect of

substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann- elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and syntheticapplications.

UNIT B: Polynuclear Hydrocarbons 15 Lectures

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

UNIT C Heterocyclic Compounds 15 Lectures

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containingoneheteroatom;Synthesis,reactionsandmechanismofsubstitutionreactionsofFuran, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler- Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoicacid.

UNIT D Alkaloids 15 Lectures

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.Terpenes: Occurrence,classification,isoprenerule;Elucidationof structure andsynthesisofCitral,Neraland α-terpineol.

Learning Experience:

This course features lectures, interactive sessions, and hands-on activities on nitrogen-containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, and alkaloids.

- **Instruction Methods:** Multimedia lectures, Q&A, and discussions.
- **Technology Use:** LMS for resources and forums.
- **Assessments:** Quizzes, exams, and presentations.
- **Support:** Instructor guidance and peer collaboration with regular feedback.

Textbooks

1. Solomons, T.W., Fryhle Craig, *Organic Chemistry,* John Wiley & Sons, Inc(2009).

Reference Books

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7thEdn., Pearson.

2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Welly & Sons (1976).

3. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

4. Kalsi, P. S. *Organic reactions and their mechanisms*, New Age Science(2010).

5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford UniversityPress

Inc., New York(2001).

6. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, PrajatiParakashan(2010).

7. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).

Open Educational Resources (OER)

- **https://www.khanacademy.org/science/organic-chemistry/amines/amines-tutorial**
- **http://www.chemguide.co.uk/mechanisms/nitro/mechanisms.html**
- **http://chemcollective.org/**
- **http://chemcollective.org/**
- **http://www.chemguide.co.uk/basicorg/conventions/heterocyclic.html**
- **http://www.chemguide.co.uk/basicorg/conventions/alkaloids.html**
- **https://www.rsc.org/Education/teachers/learnnet/terpenes/index.htm**

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER III					
BSCHOC352	ORGANIC CHEMISTRY-III PRACTICAL	**L**	**T**	**P**	**C**
Version ___		**0**	**0**	**2**	**1**
Category of Course	**Major IV Practical**				
Total Lectures	15				
Pre-Requisites/ Co-	Basics of organic chemistry and reaction mechanism				

Course Perspective

The course provides the basic knowledge of functional group analysis and identification of organic compounds by using IR and NMR spectroscopy. The understanding of the concept of functional group analysis helps to do the qualitative analysis of organic compound.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Observing Learn to identify and understand organic compounds and their functional groups using basic tests and spectroscopy.

CO2: Imitating Follow standard procedures to analyze and prepare organic compounds, including using spectroscopy for identification.

CO3: Practicing Carry out tasks like extracting caffeine, analyzing sugars, and performing organic reactions.

Course Content

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.

2. Identification of functional groups of simple organic compounds by IR spectroscopy andNMR spectroscopy (IR and NMR of simple organic compounds may be done wherever facilities are available, otherwise sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc., for identification of functional groups. References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill).

3. Preparation of methyl orange.

4. Extraction of caffeine from tealeaves.

5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars usingsimplelabprocedures.

Organic preparations

6. Acetylation of amines and phenols
7. Benzolyation of amines and phenols by Schotten-Baumann reaction
8. Hydrolysis of amides and esters to obtain benzoic acid.
9. 2,4-DNP, semicarbazone and oxime derivative of carbonyl compound
10. Nitration of nitrobenzene, chlorobenzene & bromobenzene
11. Oxidation of the benzaldehyde, benzyl alcohol, acetophenone to benzoic

Learning Experience

This lab course involves qualitative analysis, spectroscopy, organic preparations, and extractions.

Methods of Instruction:Lab Experiments: Analyze organic compounds, use IR and NMR spectroscopy, and perform preparations and extractions with demonstrations and supervised practice.

Use of Technology: Lab Equipment: Spectroscopy tools and sample spectra.

Online Resources: LMS for manuals.

Activities:Experiments: Qualitative analysis, spectroscopy, and various organic syntheses.

Assessments:

- **Formative:** Ongoing feedback during labs.

- **Summative:** Evaluation based on lab work and reports.

Support: Instructor guidance and peer collaboration, with regular feedback.

Textbooks

1. Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson(2012).

Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)
2. Furniss,B.S.;Hannaford,A.J.;Smith,P.W.G.;Tatchell,A.R.*PracticalOrganicChemistry,5th Ed.,* Pearson(2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press(2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press(2000).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- **https://www.organic-chemistry.org/**
- **http://www.chemguide.co.uk/mechanisms/menu.html**
- **https://www.rsc.org/Education/teachers/learnnet/pdf/organic/carbohydrate_analysis.pdf**
- **http://chemcollective.org/**
- **http://www.chemguide.co.uk/analysis/group7.html**
- **https://learn.saylor.org/course/view.php?id=11**

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER III					
	Self Awareness	**L**	**T**	**P**	**C**
Version 3.0		**2**	**0**	**0**	**2**

Category of Course	**AEC-I**
Total Lectures	**30**
Pre-Requisites/ Co-Requisites	**Basics of Chemistry**

Course Perspective

The course aims to improve language proficiency in three key areas: grammar, vocabulary and identification of grammatical errors in writing. Language proficiency enables students to comprehend lectures, understand course materials and enhances students' ability to express themselves clearly and effectively. In many professions, strong language skills are a prerequisite. Whether in business, medicine, law, or science, being able to communicate fluently and accurately is essential for collaboration, negotiation, and advancement. A strong command of verbal abilities can significantly impact job interviews. It allows candidates to answer questions confidently, demonstrate their qualifications effectively and leave a positive impression on potential employers

Course Outcomes

Upon completion of the course the learner will be able:

CO 1. **Understanding** the grammar rules and word meaning (Vocabulary).
CO 2. **Applying** grammar rules and vocabulary in different context & purpose
CO 3.**Analyzing** situations/ context of communication and selecting appropriate grammar and words.
CO 4. **Developing** sentences and paragraphs to describe and narrate a situation

Course Content

Unit A Vocabulary Development and Application 10 Lecture

Content Summary: Understanding the concept of root words, Prefix and suffix, Ways to enhance Vocabulary, Crosswords and word quizzes, Confusing words, One word substitution, Odd one out, Synonyms and Antonyms, Commonly misspelt words, Idioms and Phrases

Unit B Fundamentals of Grammar and Sentence Structure 8 Lecture

Content Summary: Introduction to Parts of Speech, Tenses and its ‘rules, Sentences (Simple, Compound and Complex), Subject Verb Agreement, Pronoun Antecedent agreement, Phrases and Clauses

Unit C Mastering Sentence Accuracy and Completion Skills 12 Lecture

Content Summary: Spot the error (grammatical errors in a sentence), Sentence Correction (Improvement of sentences based on Grammar rules), Sentence Completion, Cloze Tests

Unit D Enhancing Sentence Structure and Reading Comprehension Skills 6Lecture

Logical Arrangement of Sentences, Comprehending passages, Contextual questions, Anagrams, Analogies

Learning Experience : This course will integrate lectures, interactive sessions, and hands-on activities to enhance skills in communication, personality development, mindset, and spoken skills.

Instruction Methods:

- **Lectures:** Core topics such as effective communication, personality development, mindset, and spoken skills will be delivered through multimedia presentations and problem-solving sessions.
- **Interactive Sessions:** Q&A segments, live quizzes, and group discussions will actively engage students and reinforce their learning.
- **Technology Use:**

- **Online Platforms:** An LMS will provide resources, recorded lectures, and discussion forums to support extended learning.
- **Assessments:**
- **Formative:** Continuous feedback through quizzes and online discussions.
- **Summative:** Evaluation through exams, peer reviews, and presentations to assess overall understanding.

Support: The instructor will offer additional guidance, and peer collaboration will be encouraged. Regular feedback will assist students in improving and achieving course outcomes.

Textbooks

1. Norman Lewis – Word Power Made Easy
2. Wren & Martin – High School English Grammar & Composition

Reference Books

1. R.S. Agarwal & Vikas Agarwal – Quick Learning Objective General English
2. S.P. Bakshi - Objective General English
3. Praxis Groups -Campus Recruitment Complete Reference

Additional Readings:

https://www.indiabix.com/online-test/aptitude-test/

https://www.geeksforgeeks.org/aptitude-questions-and-answers/

https://www.hitbullseye.com/

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER III					
BSCHIN303	**Evaluation of Summer Internship/Project**	**L**	**T**	**P**	**C**

Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Internship**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites	**Practical Exposure**				

Course Perspective:

In the end of Semester II, students will be asked to join research/academic organizations or industries to get hands on knowledge on the selected topics. The student will work on the assigned topic for 3-4 weeks in regular consultation with his/her assigned expert/guide. The student will write a report based on the work carried out during internship and prepare two copies to be submitted to the office of the Head of the Department duly signed by the student and the expert. The student will make a power point presentation based on the work carried out and mentioned in the report to the board of examiners appointed by the University in the third semester. The student will be evaluated based on a report and presentation.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Carrying out the extensive literature survey on the topic assigned by academicians and industry experts.

CO 2: Applying various methods and techniques applicable to their research topic to study and contribute to domain knowledge.

CO 3: Analyzing the result of the experiment carried out and present the results using data visualization methods.

CO 4: Evaluating the effectiveness of methods used and the significance of research findings.

CO 5: Writing and presenting technical reports/articles.

Learning Experience:

The internship course will be experiential through hands-on lab work, real-world research projects, and active participation in ongoing studies. Students will collaborate with faculty and researchers, applying theoretical knowledge to experimental tasks and data analysis. Regular group discussions, progress presentations, and peer feedback will enhance collaborative learning. The course will also include reflective journaling to encourage self-assessment and growth throughout the internship.

Evaluation Scheme:

Particular	**Weightage**

Internal Marks: - Internship completion certificate obtained from supervisor from host institute.	40 marks
External Marks (Practical): - Presentation Report Writing Viva Voce	70 Marks 25 25 20

SEMESTER III					
	ARTIFICIAL INTELLIGENCE	**L**	**T**	**P**	**C**
Version ___		**2**	**0**	**0**	**2**
Category of Course	**VAC III**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites	Basics of Physical Chemistry				
SEMESTER III					
BSCCPR305	**PROJECT-II**	**L**	**T**	**P**	**C**
Version ___		**0**	**0**	**0**	**2**
Category of Course	**PROJECT-II**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites	**Basic Scientific Knowledge**				

Course Perspective:

This project-based course is designed to foster creativity, innovation, and independent learning by allowing students to explore real-world problems through hands-on experimentation, research, or interdisciplinary approaches. By choosing a category that aligns with their interests—such as working models, research, skill development, innovation, or entrepreneurship—students gain practical experience, apply theoretical knowledge, and enhance their problem-solving, technical, and presentation skills. The course emphasizes inquiry, design thinking, and collaborative learning to prepare students for academic, industrial, or entrepreneurial pursuits.

Course Outcomes:

CO1: Understanding key concepts, scientific principles, or societal needs relevant to the selected project category.

CO2: Applying scientific methods, laboratory techniques, or computational tools to execute project tasks effectively.

CO3: Analyzing data, processes, or systems to derive insights, troubleshoot problems, and refine approaches.

CO4: Evaluating the feasibility, functionality, or impact of the project and justify decisions based on evidence.

CO5: Creating an original project output—such as a model, report, prototype, codebase, or strategy—that integrates knowledge across disciplines and addresses real-world applications.

Course Content:

Students may choose one of the following categories:

H. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.
I. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.
J. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.
K. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.
L. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.
M. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).
N. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

- Clarity of Objective – 10 marks
- Innovation / Creativity – 20 marks
- Scientific/Technical Accuracy – 20 marks
- Practical Application / Relevance – 15 marks
- Execution / Model Functionality – 20 marks
- Presentation / Report Quality – 5 marks
- Teamwork / Effort – 10 marks

SEMESTER IV

SEMESTER IV					
BSCHPC401	**Physical Chemistry-III**	**L**	**T**	**P**	**C**
Version ___		**3**	**1**	**0**	**4**
Category of Course	**Major VII**				
Total Lectures	**60**				
Pre-Requisites/ Co-Requisites	Basics of Physical Chemistry				

Course Perspective

This course makes students able to understand the concept of phase, component, and degree of freedom and have understanding of kinetics of chemical reactions, catalysis and surface chemistry.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Understanding basics of phases, phase diagrams, Clausius-Clapeyron equation, phase equilibria, reaction rates and catalysts working.

CO2: Applyingphase diagrams and reaction rate formulas to solve problems. Apply catalysis concepts to different reactions.

CO3: Analyzingdifferent types of phase diagrams, reaction rates, and catalyst mechanisms. Analyze adsorption data.

CO4: Evaluatingthe effectiveness of catalysts and reaction methods. Assess adsorption techniques.

Course Content

Unit A: Phase Equilibria **15 Lectures**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactiveandreactivesystems;Clausius-Clapeyronequationanditsapplicationstosolid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.Phasediagramsforsystemsofsolid-liquidequilibriainvolvingeutectic,congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform- acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivationandapplicationstofractionaldistillationofbinarymiscibleliquids(idealandnonideal), azeotropes,leverrule,partialmiscibilityofliquids,CST,misciblepairs,steamdistillation.Nernst distribution law: its derivation andapplications.

Unit B: Chemical Kinetics **15 Lectures**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited tofirstorder):(i)Opposingreactions(ii)parallelreactionsand(iii)consecutivereactionsandtheir differential

rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reactionrates.

Unit C: Catalysis **15 Lectures**

Types of catalyst,specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis- Menten mechanism, acid-base catalysis.

Unit D: Surface chemistry **15 Lectures**

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuiradsorptionisotherms,surfaceareadetermination),BETtheoryofmultilayeradsorption (no derivation), Adsorption insolution.

Learning Experience:

This course integrates lectures, interactive sessions, and practical exercises to explore phase equilibria, chemical kinetics, catalysis, and surface chemistry.

- **Instruction Methods:** Multimedia lectures, Q&A, and discussions.
- **Technology Use:** LMS for resources and forums.
- **Assessments:** Quizzes, exams, and presentations.
- **Support:** Instructor guidance and peer collaboration with regular feedback.

Textbooks

1. Atkins. AndDePaulaJ., *PhysicalChemistry,(*tenthedition)OxfordUniversityPress,2014.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa,2004.

Reference Books

1. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.
2. Engel, T. & Reid, P. *Physical Chemistry* Third Edition, Prentice-Hall, 2012.
3. Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011 6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.
4. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.
5. Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.
6. Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill,2009.

Open Educational Resources (OER)

- Khan Academy Chemistry: https://www.khanacademy.org/science/chemistry
- MIT OpenCourseWare - Chemistry: https://ocw.mit.edu/courses/chemistry/
- Coursera - Introduction to Physical Chemistry: https://www.coursera.org/courses?query=physical%20chemistry
- ChemCollective: http://chemcollective.org/
- Chemguide: http://www.chemguide.co.uk/
- YouTube :https://www.youtube.com/playlist?list=PLB7fHrN_yPjDdR-gAPzK0lKy5Mwu5lF01
- Virtual Chemistry Experiments: http://chemcollective.org/vlab

- NOVA Labs - Chemistry: http://www.pbs.org/wgbh/nova/labs/lab/chemistry/)
- ChemSpider: http://www.chemspider.com/
- OpenStax - Chemistry: https://openstax.org/details/books/chemistry

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV					
BSCHPC451	**Physical Chemistry-III Practicals**	**L**	**T**	**P**	**C**
Version ___		**0**	**0**	**2**	**1**
Category of Course	**Major –VII (Practical)**				
Total Lectures	15				
Pre-Requisites/ Co-Requisites	Basics of Chemistry				

Course Perspective

Potentiometry and conductometry are analytical techniques used in titration to determine the concentration of analytes in solution. Application of potentiometry to determine the endpoint of acid-base titrations using pH electrodes. Using conductometry the endpoint of acid-base titrations can be determined based on changes in conductivity.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Observinghow to determine cell constants and measure conductance and potential in various titrations.

CO2: Imitatingprocedures to perform conductometric and potentiometric titrations, and study reaction rates.

CO3: Practicingexperiments to measure conductance, potential, surface tension, and viscosity.

Course Content

List of Experiments

Conductometry

1.Determination of cell constant

2.Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

3.Conductometry titrations of: Strong acid Vs. strong base (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and (iv)weak acid vs. strong base, Strong acid vs. weak base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base (ii) Weak acid vs. strong base

(iii) Dibasic acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt.

3. To study kinetically the reaction rate of decomposition of iodide by H_2O_2.

4. Determination of surface tension/percentage composition of given organic mixture using surface tension method.

5. Determination of viscosity/percentage composition of given organic mixture using viscosity method.

Learning Experience

This lab course includes conductometry, potentiometry, kinetics, and physical property measurements.

Methods of Instruction:

- **Lab Experiments:** Conduct experiments on cell constant, conductance, and titrations (strong/weak acids and bases), potentiometric titrations, reaction kinetics, and physical properties using demonstrations and supervised practice.
- **Interactive Sessions:** Engage in discussions and receive real-time feedback.

Use of Technology:

- **Lab Equipment:** Conductometers, potentiometers, and tools for measuring surface tension and viscosity.
- **Online Resources:** LMS for manuals.

Assessments:

- **Formative:** Ongoing feedback during labs.
- **Summative:** Evaluation based on lab performance and reports.

Support: Instructor guidance and peer collaboration with regular feedback.

Textbooks

1.Khosla,B.D.;Garg,V.C. AndGulati,A.*SeniorPracticalPhysicalChemistry,*R.ChandNew Delhi,2011.

Reference Books

1. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* Eighth Edition*;* McGraw-Hill: New York,2003.

2.Halpern,A.M. AndMcBane,G.C.*ExperimentalPhysicalChemistry3rd Ed.;*W.H.Freeman& Co.: New York,2003.

Open Educational Resources (OER)

- MIT Open Courseware - Principles of Chemical Science: https://ocw.mit.edu/courses/chemistry/5-111-principles-of-chemical-science-fall-2014/

- Khan Academy - Acid-Base Equilibrium: https://www.khanacademy.org/science/chemistry/acids-and-bases-topic
- Coursera - Analytical Chemistry by Rice University: https://www.coursera.org/learn/analytical-chemistry
- ChemCollective - Virtual Chemistry Experiments: http://chemcollective.org/vlab
- PhET Interactive Simulations - Acid-Base Solutions: https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html
- National Repository of Open Educational Resources (NROER) - Chemistry: https://nroer.gov.in/#!/explore/subject/chemistry
- Chemguide - Acid-Base Equilibria: http://www.chemguide.co.uk/physical/equilibria/acidsbaseeqia.html
- ChemCollective - Acid-Base Titration Simulations: http://chemcollective.org/acid-base-titration
- OpenStax Chemistry Textbook: https://openstax.org/details/books/chemistry
- Wikibooks - Analytical Chemistry: https://en.wikibooks.org/wiki/Analytical_Chemistry

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV					
BSCHIC402	**Inorganic Chemistry - II**	**L**	**T**	**P**	**C**
Version ___		**3**	**1**	**0**	**4**
Category of Course	**Major-VIII**				
Total Lectures	60				
Pre-Requisites/ Co-Requisites	Basics of Chemistry				

Course Perspective This course explores the chemistry of the main group elements, which include the s-block and p-block elements of the periodic table. Students will investigate the physical and chemical properties, reactivity, bonding, and applications of these elements and their compounds. The course

integrates theoretical concepts with practical applications, including industrial and environmental relevance.

Course Outcomes

Upon completion of the course the learner will be able:

CO1 Understanding basic principles such as the inert pair effect, how Ellingham diagrams work, and the properties of noble gases and inorganic polymers.key terms and concepts related to redox reactions, electrode potentials, metal purification, and the chemistry of s and p block elements, noble gases, and inorganic polymers.

CO2Applying: Ellingham diagrams to assess metal reduction, classify hydrides, and apply knowledge of elements and compounds in practical examples.

CO3Analyzing: different metal purification methods and examine the properties of s and p block compounds and noble gases.

CO4Evaluating: the effectiveness of metallurgical processes and the significance of complex formation and allotropy in elements and compounds.

Course Content

Unit A: 15 Lecture

Oxidation-Reduction and general principle of metallurgy

Redox equations, Standard Electrode Potential and its application to inorganic reactions.Occurrenceofmetalsbasedonstandardelectrodepotentials. .Ellinghamdiagramsforreductionof metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond's process, Zone refining.

Unit B: Chemistry of *s* and *p* Block Elements 15 Lecture

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

Unit C: Noble Gases 15 Lecture

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

Unit D: Inorganic Polymer 15 Lecture

Types of inorganic polymers, Comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes.Borazines, silicates and phosphazenes, and polysulphates.

Learning Experience

This course features lectures, interactive sessions, and hands-on activities on oxidation-reduction, metallurgy, s and p block elements, noble gases, and inorganic polymers.

- **Instruction Methods:** Lectures: Core concepts will be taught using multimedia presentations and problem-solving sessions, Q&A, and discussions.
- **Technology Use:** LMS for resources and forums.
- **Assessments:** Quizzes, exams, and presentations.
- **Support:** Instructor guidance and peer collaboration with regular feedback.

Textbooks

Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edn

Reference Books

1. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
2. Greenwood, N.N., Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
3. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
4. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry Fourth Ed., Pearson, 2010
6. Atkins, P. W and Shriver D. N. Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

Open Educational Resources (OER)

- (12) Oxidation and Reduction Reactions (Part 1) - Chemical Reactions and Equations | Class 10 Chemistry - YouTube
- (12) Ch.1st General principles of metallurgy of #B.Sc 4th semester of Inorganic Chemistry proper notes - YouTube
- (12) Metallurgy | bsc 2nd yr Chemistry | Aarti mam Chemistry | Physics guru |inorganic Chemistry - YouTube
- (12) I L 1 I S Block Elements I Electronic configuration I Atomic Radii - YouTube
- (12) BSc first year inorganic chemistry : Main points And General properties of p-block elements #RVCc - YouTube
- beta.chem.uw.edu.pl/people/WGrochala/NG_chemistry.pdf
- UNIT-II-Polymers.pdf (aits-tpt.edu.in)
- https://faratarjome.ir/u/media/shopping_files/store-EN-1429082956-7175.pdf

Evaluation Scheme

Evaluation components	Weightage

Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV					
BSCHIC452	**Inorganic Chemistry – II Practicals**	**L**	**T**	**P**	**C**
Version ___		**0**	**0**	**2**	**1**
Category of Course	**Major -VIII (Practical)**				
Total Lectures	**15**				
Pre-Requisites/ Co-Requisites	Inorganic preparation and iodometric analysis				

Course Perspective

This course focuses on iodometric titration, a widely used analytical technique for determining the concentration of oxidizing agents in a solution. Students will gain a comprehensive understanding of the principles, methods, and applications of iodometric titration. This course engages the students for simple inorganic salt preparation by using appropriate analytical method and handling of instruments.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Observinghow to use iodometric and iodimetric methods to measure substances like Cu(II), arsenite, antimony, and chlorine**.**

CO2: Imitating steps to measure substances and prepare solutions using iodometric and iodimetrictitrations, and make cuprous chloride and potash alum.

CO3: Practicing iodometric and iodimetric titrations to find the amounts of Cu(II), arsenite, antimony, and chlorine, and prepare cuprous chloride and potash alum.

Course Content

1. **Iodo / Iodimetric Titrations**

I. Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

II. Estimation of (i) arsenite and (ii) antimony iodimetrically

III. Estimation of available chlorine in bleaching powder iodometrically.

2. Inorganic preparations

I. Cuprous Chloride, Cu_2Cl_2

II. Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.

III. (Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Learning Experience

This lab course focuses on iodometric titrations and inorganic preparations.

Methods of Instruction:

- **Lab Experiments:** Perform iodometric titrations (e.g., Cu(II), arsenite) and inorganic preparations (e.g., cuprous chloride, alum) with demonstrations and supervised practice.
- **Interactive Sessions:** Discuss and receive real-time feedback.

Use of Technology:

- **Lab Equipment:** Calibrated apparatus and standard solutions.
- **Online Resources:** LMS for manuals, videos, and troubleshooting guides.

Activities:

- **Experiments:** Iodometric titrations and preparation of inorganic compounds.

Assessments:

- **Formative:** Feedback during labs.
- **Summative:** Evaluation based on performance and reports.

Support: Instructor guidance and peer collaboration with regular feedback.

Textbooks

Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.

Reference Books

1. O. P. Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Open Educational Resources (OER)

- (12) Iodometric Estimation of Copper using Sodium thiosulphate - YouTube
- THE DETERMINATION OF ARSENIC WITH IODINE (noctrl.edu)
- UNIT IV Redox titrations Priciple and Applications (wordpress.com)
- (12) iodimetry titration || Titration of iodine with sodium thiosulphate - YouTube
- (12) Preparation of cuprous chloride (CuCl) from cupric sulphate - YouTube
- (12) Formation of Potash Alum Experiment 2 inorganic chemistry - YouTube
- (12) practical-chrome alum - YouTube

Evaluation Scheme

Evaluation components	Weightage

Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV					
	Basic IT Tools	**L**	**T**	**P**	**C**
Version 1.0		**3**	**0**	**0**	**3**
Category of Course	**SEC-III**				
Total Lectures	45				
Pre-Requisites/ Co Requisites	-				

Course Perspective

The "Basic IT Tools" course equips students with essential skills in information technology, focusing on fundamental concepts and practical applications. It covers the basics of computer hardware, software, operating systems, and internet usage, emphasizing the importance of digital literacy in today's world. Students learn to navigate common productivity software like word processors, spreadsheets, and presentation tools, enabling them to efficiently manage and present information. Additionally, the course introduces basic networking concepts and cybersecurity awareness, preparing students to safely and effectively use IT resources in both academic and professional settings.

Course Outcomes

Upon completion course, the learner will be able:

CO1. **Applying** word-processing skills to generate documents with appropriate formatting, layout, review, and referencing.

CO2. **Utilizing** spreadsheet functions and formulas to manage and analyse data in worksheets and workbooks.

CO3. **Evaluating** data using spreadsheets to make informed decisions.

CO4. **Creating**meaningful representations of data through charts and pivot tables.

CO5. **Demonstrating** proficiency in managing data in database tables and utilizing it to generate queries, forms, and reports.

Course Content

Unit 1: Introduction to SpreadsheetsLecture: 15 hours

Spreadsheets: Concept of worksheets and workbooks, creating, opening, closing and saving workbooks, moving, copying, inserting, deleting and renaming worksheets, working with multiple worksheets and multiple workbooks, controlling worksheet views, naming cells using name box, name create and name define; Exchanging data using clipboard, object linking and embedding; Printing and Protecting worksheets: Adjusting margins, creating headers and footers, setting page breaks, changing orientation, creating portable documents and printing data and formulae; Implementing file level security and protecting data within the worksheet; Understanding absolute, relative and mixed referencing in formulas, referencing cells in other worksheets and workbooks, correcting common formula errors, working with inbuilt function categories like mathematical, statistical, text, lookup, information, logical, database, date and time and basic financial functions.

Unit 2: Data Analysis in Spreadsheets 15 Lectures

Consolidating worksheets and workbooks using formulae and data consolidate command; Choosing a chart type, understanding data points and data series, editing and formatting chart elements, and creating sparkline graphics, Analysing data using pivot tables: Creating, formatting and modifying a pivot table, sorting, filtering and grouping items, creating calculated field and calculated item, creating pivot table charts, producing a report with pivot tables. Introduction to recording and execution of macros.

Unit 3: Word Processing 15 Lectures

Introduction: Creating and saving your document, displaying different views, working with styles and character formatting, working with paragraph formatting techniques using indents, tabs, alignment, spacing, bullets and numbering and creating borders; Page setup and sections: Setting page margins, orientation, headers and footers, end notes and foot notes, creating section breaks and page borders; Working with tables: Creating tables, modifying table layout and design, sorting, inserting graphics in a table, table math, converting text to table and vice versa; Create newspaper columns, indexes and table of contents, Spell check your document using inbuilt and custom dictionaries, checking grammar and style , using thesaurus and finding and replacing text; Create bookmarks, captions and cross referencing, adding hyperlinks, adding sources and compiling and bibliography; Mail merge: Creating and editing your main document and data source, sorting and filtering merged documents and using merge instructions like ask, fill-in and if-then-else; Linking and embedding to keep things together.

This course will integrate lectures, interactive sessions, and hands-on projects to build a foundational understanding of essential IT tools and their applications.

Instruction Methods:

- **Lectures:** Core concepts of IT, including computer basics, software applications, and internet usage, will be taught using multimedia presentations and real-life scenarios.
- **Interactive Sessions:** Q&A sessions, live demonstrations, and group discussions will encourage active learning and reinforce practical skills.

Technology Use:

- **Online Platforms:** A Learning Management System (LMS) will host course materials, recorded lectures, assignments, and discussion forums, promoting extended learning and collaboration.

Assessments:

- **Formative:** Regular quizzes, practical assignments, and online discussions will provide ongoing feedback and help students monitor their progress.
- **Summative:** Exams, project submissions, and peer reviews will evaluate students' understanding and practical application of IT tools.

Support: The instructor will provide additional help through office hours, and peer collaboration will be fostered through group projects and review sessions, ensuring continuous feedback and improvement in achieving course objectives.

Textbooks

1. Swinford, E., Dodge, M., Couch, A., Melton, B. A. (2013). Microsoft Office Professional 2013. United States: O'Reilly Media.
2. Wang, W. (2018). Office 2019 For Dummies. United States: Wiley. Microsoft Lambert, J. (2019). Microsoft Word 2019 Step by Step. United States: Pearson Education.

Reference Books

1. Jelen, B. (2013). Excel 2013 Charts and Graphs. United Kingdom: Que.
2. Alexander, M., Jelen, B. (2013). Excel 2013 Pivot Table Data Crunching. United Kingdom: Pearson Education.
3. Alexander, M., Kusleika, R. (2018). Access 2019 Bible. United Kingdom: Wiley

Open Educational Resources (OER)

http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00sc-introduction-to-computer-science-and-programming-spring-2011

http://learn.saylor.org/course/cs101

http://openstax.org/books/introduction-to-computer-applications-for-business

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessments (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

SEMESTER IV					
BSCHNC403	**Introduction of Nanochemistry and Applications**	L	T	P	C
Version 1.0		3	1	0	4
Category of Course	**Major IX (DSE-I)**				
Total Lectures	**60**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Perspective

This course introduces nanoscience and nanotechnology, covering nanostructures, their properties, and synthesis methods. Students will learn about different types of nanomaterials, their size-dependent properties (like quantum confinement and surface plasmon resonance), and synthesis techniques including top-down, bottom-up, and self-assembly methods. It also includes material characterization techniques and practical applications in environmental remediation and biology.

Course Outcomes

On completion of this course, the students will be able

CO1: Understanding different types of nanostructures and nanomaterials, how the size of nanomaterials affects their properties, like electrical and optical characteristics.

CO3: Applying synthesis techniques to create nanomaterials, such as gold and silver nanoparticles.

CO4: Analyzingvarious methods for characterizing nanomaterials, such as electron microscopy and spectroscopy.

CO5: Evaluating: how nanomaterials are used in environmental and biological applications.

Course Content

Unit A: Introduction to nanoscience, nanostructure and nanotechnology 15 Lectures

Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures - Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Unit B: Size dependent properties of nanomaterials 15 Lectures

Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

Unit C: Synthesis of Nanomaterials 15 Lectures

Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures- control of nanoarchitecture- one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit D: Material characterization techniques 15 Lectures

Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).

Learning Experience Summary

Course Structure:

- Lectures: Cover foundational topics in nanoscience, nanostructures, and nanomaterials.
- Interactive Sessions: Q&A, quizzes, and discussions to reinforce learning.

Technology Use:

- LMS: For accessing lecture materials, recorded content, and forums.
- Virtual Labs: Simulated exercises on nanomaterial synthesis and characterization.

Assessments:

- Formative: Quizzes and discussions for continuous feedback.
- Summative: Exams and presentations to assess overall understanding.

Support:

- Instructor: Regular office hours and online consultations.
- Peer Collaboration: Group projects and peer review sessions.

Text Books

1. C.N.R.Rao,A.Muller,A.K.Cheetam,TheChemistryofNanomaterials:Synthesis,Properties and Applications, Willey-VCH Verlag, Germany,2005.

2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London, 2004

Reference Books/Materials

1. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005

2. CharlesP.PooleandFrankJOwens,*Introductiontonanotechnology*,WileyInterscience,2003.

3. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi,2012.

Open Educational Resources:

NanoHub: https://nanohub.org/

National Nanotechnology Initiative: https://www.nano.gov/

Nanowerk: https://www.nanowerk.com/

Nanoscience and Nanotechnology: https://ocw.mit.edu/courses/nanotechnology/

Nanotechnology Courses: https://www.coursera.org/courses?query=nanotechnology

YouTubeNanotechnology Explained: https://www.youtube.com/results?search_query=nanotechnology+explained

Nano.gov - Education Resources: https://www.nano.gov/nanotech-101/education

National Center for Biotechnology Information (NCBI) - Nanotechnology: https://www.ncbi.nlm.nih.gov/pmc/?term=nanotechnology

Nanoscience and Nanotechnology: https://www.khanacademy.org/science/nanoscience

Nanotechnology Publications: https://www.researchgate.net/search?q=nanotechnology

Modes of Evaluation:

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

SEMESTER IV

BSCHNC453	Introduction of Nanochemistry and Applications Practicals	L	T	P	C
Version 1.0		0	0	2	1
Category of Course	Major IX (practical) (DSE-I)				
Total Lectures	15				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Perspective

This course imparts the basic understanding of nanoparticles synthesis. It enables the students to synthesise nanoparticles like zinc oxide and silver nanoparticles. The course also introduces the Beer-Lambert law, and its verification with the help of either a colorimeter or a UV spectrophotometer.

Course Outcomes

On completion of this course, the students will be able

CO1: Observing the synthesis of ZnO and Silver nanoparticles through various preparation methods.

CO2: Imitating the preparation of nanoparticles and apply techniques to verify the Beer-Lambert law using these nanoparticles.

CO3: Practicing preparing and characterizing nanoparticles, including potential bimetallic nanoparticles, and study their properties like magnetism and adsorption.

Course Content

List of Experiments

1. Synthesis of ZnO nanoparticles.
2. Preparation of Silvernanoparticles.

(diverse nanoparticles can be prepared by various routes)

3. Verification of Beer-Lambert law using nano-particles (above prepared nano-particles may be used for thestudy). (Depending upon the availability of infrastructure facilities, instructor mayencouragethestudents topreparebimetallicnano-particles,etc. andcharacterizedthem,studytheirvariouspropertieslike magnetism, adsorption,etc.)

Learning Experience

This lab course focuses on nanoparticle preparations.

Methods of Instruction:

- **Lab Experiments:**focuses on nanoparticle preparations
- **Interactive Sessions:** Discuss and receive real-time feedback.

Use of Technology:

- **Lab Equipment:** Calibrated apparatus and standard solutions.
- **Online Resources:** LMS for manuals, videos, and troubleshooting guides.

Activities:

- **Experiments:** Iodometric titrations and preparation of inorganic compounds.

Assessments:

- **Formative:** Feedback during labs.
- **Summative:** Evaluation based on performance and reports.

Support: Instructor guidance and peer collaboration with regular feedback.

Recommended/Reference Books

1. Pradeep T., A text book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012 edition.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 marks**

SEMESTER IV					
	Communication & Personality Development	**L**	**T**	**P**	**C**
Version 3.0		**2**	**0**	**0**	**2**
Category of Course	**AEC-II**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites	**Basics of Chemistry**				

Course Perspective

The course enhances public speaking and presentation skills, helps students confidently convey ideas, information & build self-reliance and competence needed for career advancement. Personality assessments like the Johari Window and Myers & Briggs Type Indicator (MBTI) provide frameworks to enhance self-understanding, helps people increase their self-awareness, understand and appreciate differences in others and apply personality insights to improve their personal and professional

effectiveness. Interpersonal skills included in the course deal with important topics like communication, teamwork and leadership, vital for professional success.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Improve public speaking and presentation abilities to confidently convey ideas and information.

CO2: Understand the framework of Communication to augment oratory skills and written English

CO3: Cultivate essential soft skills required at the different workplaces.

Course Content

Unit A: Developing self and others **8 lecture**

Content Summary: Self Awareness, Personality Concepts (Personality Assessments -Johari Window, Myers & Brigg), Self-Management, Self Esteem, Self-Efficacy, Interpersonal skills, mindset, grit and working in teams.

Unit B: Enhancing Reading and Writing Skills **6 lecture**

Content Summary: Speed reading and its importance in competitive examinations, techniques for speed reading, note-taking, and critical analysis. Paragraph Writing, Essay and Summary writing, Business Letter, Email writing

Unit C: Effective Communication and Public Speaking **7 lecture**

Content Summary: Communication Framework, barriers & overcoming these barriers, Group Discussions, Extempore & Public Speaking drills, to manage stage fright and anxiety. Structuring and organizing a presentation (Oral & PPT), Etiquettes, Grooming, Body Language and Conversation starters, TMAY.

Unit D: Career Guide and readiness **15 lecture**

Cover Letter, ATS friendly resume, Elevator Pitch, Video Resume (Visume), Networking, Group Discussion, Mock Interviews. Capstone Project

Learning Experience : This course will integrate lectures, interactive sessions, and hands-on activities to enhance skills in communication, personality development, mindset, and spoken skills.

Instruction Methods:

- **Lectures:** Core topics such as effective communication, personality development, mindset, and spoken skills will be delivered through multimedia presentations and problem-solving sessions.
- **Interactive Sessions:** Q&A segments, live quizzes, and group discussions will actively engage students and reinforce their learning.

Technology Use:

- **Online Platforms:** An LMS will provide resources, recorded lectures, and discussion forums to support extended learning.

Assessments:

- **Formative:** Continuous feedback through quizzes and online discussions.

- **Summative:** Evaluation through exams, peer reviews, and presentations to assess overall understanding.

Support:

- The instructor will offer additional guidance, and peer collaboration will be encouraged. Regular feedback will assist students in improving and achieving course outcomes.

References

Talking to Strangers – Malcom Gladwell

Fierce Conversation - Scot Susan

Public Speaking - William S. Pfeiffer, Pearson

SoftSkillsforEveryone –JeffButterfield

Business Communication – Rajendra Pal, J S Korlahalli

The power of Positive Attitude -Roger Fritz

Believe in Yourself – Dr. Joseph Murphy

Additional Readings

- Websites & MOOCs

www.16personalities.com

www.tonyrobbins.com

- Specific Research Papers
  GALLUP PRESS RESEARCH
  FRANKLIN COVEY LEADERSHIP CENTRE
- Videos
  The 7 Habits of Highly Effective People, Dr. Stephen R. Covey
  I Am Not Your Guru, Tony Robbins
- Podcast
  The Tim Ferriss Show
- Magazines
  SUCCESS Magazine
- Journals
  The IUP Journal of Soft Skills

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
BSCCPR605	**PROJECT-IV**	**L**	**T**	**P**	**C**
Version ___		**2**	**0**	**0**	**2**
Category of Course	**PROJECT-IV**				
Total Lectures	**30**				
Pre-Requisites/ Co-Requisites	**Basic Scientific Knowledge**				

Course Perspective:

This project-based course is designed to foster creativity, innovation, and independent learning by allowing students to explore real-world problems through hands-on experimentation, research, or interdisciplinary approaches. By choosing a category that aligns with their interests—such as working models, research, skill development, innovation, or entrepreneurship—students gain practical experience, apply theoretical knowledge, and enhance their problem-solving, technical, and presentation skills. The course emphasizes inquiry, design thinking, and collaborative learning to prepare students for academic, industrial, or entrepreneurial pursuits.

Course Outcomes:

CO1: Understanding key concepts, scientific principles, or societal needs relevant to the selected project category.

CO2: Applying scientific methods, laboratory techniques, or computational tools to execute project tasks effectively.

CO3: Analyzing data, processes, or systems to derive insights, troubleshoot problems, and refine approaches.

CO4: Evaluating the feasibility, functionality, or impact of the project and justify decisions based on evidence.

CO5: Creating an original project output—such as a model, report, prototype, codebase, or strategy—that integrates knowledge across disciplines and addresses real-world applications.

Course Content:

Students may choose one of the following categories:

O. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.
P. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.
Q. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.

R. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.
S. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.
T. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).
U. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

- Clarity of Objective – 10 marks
- Innovation / Creativity – 20 marks
- Scientific/Technical Accuracy – 20 marks
- Practical Application / Relevance – 15 marks
- Execution / Model Functionality – 20 marks
- Presentation / Report Quality – 5 marks
- Teamwork / Effort – 10 marks

SEMESTER-V

SEMESTER V					
BSCHIC501	**Inorganic Chemistry - III**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-X**				
Total Lectures	60				
Pre-Requisites/ Co-Requisites	Basics of transition elements and inner transition elements				

Course Perspective

This course provides an in-depth study of coordination chemistry, transition elements, lanthanoids, actinides, and bioinorganic chemistry. Students explore fundamental theories like Werner's and Crystal Field Theory, learn about the properties and behaviors of transition metals, and understand the electronic configurations and applications of lanthanoids and actinides. The course also examines the role of metal ions in biological systems, including their effects and medical applications. This comprehensive approach equips students with essential knowledge and skills for careers in research, industry, and healthcare, integrating theoretical insights with practical applications.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Understanding the main ideas behind valence bond theory, crystal field theory, and the properties of transition elements and lanthanoids,key terms and concepts related to

coordination chemistry, transition elements, lanthanoids, actinides, and bioinorganic chemistry.

CO2: Applying theories like crystal field theory to predict the behavior of coordination compounds and apply knowledge about metal ions in biological systems.

CO3: Analyzingproperties of transition elements and lanthanoids in different oxidation states and compare different types of coordination complexes and

CO4: Evaluating the stability of oxidation states in transition elements, the impact of lanthanide contraction, and the effects of metal ions in biological systems.

Course Content

Unit A: Coordination Chemistry **18 Lecture**

Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, , weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variationsinhalidesoffirstandsecondrowtransitionmetalseries,QualitativeaspectofLigandfieldtheory,MOdiagramsof representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect

Unit B :Transition Elements **12 Lecture**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

Unit C: Lanthanoids and Actinides **12 Lecture**

Electronic configuration, oxidation states, colour, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Unit D: Bioinorganic Chemistry **18Lecture**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on distribution of metals. Sodium / K-pump, carbonic anhydrase, and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in bio- systems, Haemoglobin; Storage and transfer of iron.

Learning Experience:

This course covers coordination chemistry, transition elements, lanthanides and actinides, and bioinorganic chemistry through lectures, interactive sessions, and practical activities.

- **Instruction Methods:** Multimedia lectures, Q&A, and discussions.
- **Technology Use:** LMS for resources and forums.
- **Assessments:** Quizzes, exams, and presentations.
- **Support:** Instructor guidance and peer collaboration with regular feedback.

Textbooks

1. Co-ordination chemistry by Ajai Kumar.
2. Concise Inorganic chemistry by J D Lee.

Reference Books

1. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
3. Basolo,F,andPearson,R.C.*MechanismsofInorganicChemistry*,JohnWiley&Sons,NY,1967.
4. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann,1997.

Open Educational Resources (OER)

1. https://www.youtube.com/watch?v=kgiyurcr5XI&list=PLdZcCa6mtW22HTEHF8-rqOyXD-fNB7OKD
2. http://www.vpscience.org/materials/Unit%203%20B%20Coordination%20chemistry.pdf
3. https://www.hcpgcollege.edu.in/sites/default/files/B.SC-II%20COORDINATION%20COMPOUNDS%20%28BY%20DR.%20RAKESH%20MANI%20MISHRA%29.pdf
4. TRANSITION ELEMENTS (B.SC-II) INORGANIC CHEMISTRY PAPER-I.pdf (hcpgcollege.edu.in)
5. https://www.arsdcollege.ac.in/wp-content/uploads/2020/03/chemistry-of-3d-metal-notes_compressed.pdf
6. https://www.youtube.com/watch?v=MLOAmSprzrQ&pp=ygUZTGFudGhhbm9pZHMgYW5kIEFjdGluaWRlcw%3D%3D
7. Bioinorganic Chemistry (1).pdf (shivajicollege.ac.in)
8. https://www.youtube.com/watch?v=SFa52CM30Ic&list=PLzx4lccVfC6dmrEdNFui7XTLh9Yctd8RC
9. http://homes.nano.aau.dk/fp/uke/pdf/Bio%20Inorganic%20Chemistry.pdf

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**

II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER V					
BSCHIC551	**Inorganic Chemistry – III Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**
Category of Course	**Major-X - (Practical)**				
Total Lectures	15				
Pre-Requisites / Co-Requisites	Gravimetric analysis and inorganic preparations				

Course Perspective

This course provides practical skills in advanced quantitative analysis and inorganic preparations. Students perform estimations of nickel, copper, iron, and aluminum, use paper chromatography for metal ion separation, and synthesize coordination compounds like tetraammine copper (II) sulfate. They also gain experience in complexometric titrations for metal ion quantification and water hardness testing. This hands-on approach prepares students for careers in analytical chemistry, quality control, and research, equipping them with essential skills for precise chemical analysis and compound synthesis.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Observing the estimation of metals and ion separation by paper chromatography.

CO2: Imitating the preparation of inorganic complexes and perform complexometric titrations.

CO3: Practicing estimating nickel, copper, iron, and aluminum, and prepare inorganic compounds.

Course Content **30 lecture**

1. Quantitative Analysis: The following quantitative estimations are to be carried out.

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.

(ii) Estimation of copper as CuSCN

(iii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$ through Heterogeneous and Homogeneous media.

(iv) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminiumoxinate).

2. **Paper chromatographic separation** of Fe^{3+}, Al^{3+}, and Cr^{3+}

3. Inorganic Preparations:

(i) Tetraammine copper (II) sulphate, $[Cu(NH_3)_4]SO_4 H_2O$

(ii) Potassium trisoxalatochromate (III), $K_3[Cr(C_2O_4)_3]$

(iii) Cis and trans $K[Cr(C_2O_4)_2 (H_2O_2]$ Potassium dioxalatodiaquachromate(III)

(iv)Pentaamminecarbonato Cobalt (III) ion

4. Complexometric Titrations:

(i) Complexometric estimation of (i) Mg^{2+} (ii) Zn^{2+} using EDTA

(ii) Estimation of total hardnesss of water samples

(iii) Estimation of Ca^{2+} in solution by (substitution method) using Erio-chrome black-T as indicator.

(ii) Estimation of Ca/Mg in drugs and biological samples

Learning Experience

Methods of Instruction:

- **Lab Experiments:** Students will perform hands-on quantitative estimations including nickel, copper, iron, and aluminum using various methods. Each session will feature demonstrations followed by supervised practice.
- **Interactive Lab Sessions:** Opportunities for real-time questions, discussions, and feedback with the instructor and peers to enhance understanding and technique.

Use of Technology:

- **Lab Equipment:** Use of calibrated apparatus for precise solution preparation and standard solutions.
- **Online Resources:** LMS will provide lab manuals, instructional videos, troubleshooting guides, and discussion boards for additional support.

Experiments:

- **Quantitative Analysis:** Estimation of nickel (II), copper, iron, and aluminum.
- **Paper Chromatography:** Separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
- **Inorganic Preparations:** Synthesis of tetraammine copper (II) sulfate, potassium trisoxalatochromate (III), cis/trans potassium dioxalatodiaquachromate (III), and pentaamine carbonato cobalt (III).
- **Complexometric Titrations:** Estimation of Mg^{2+}, Zn^{2+} using EDTA, and total hardness of water samples.

Text Books

1. A I Vogel, A text book of Quantitative Inorganic Analysis (Prentice Hall)

Reference Books/Materials

1. G. Marr & B. W. Rockett, Practical Inorganic Chemistry, London; New York : Van Nostrand Reinhold, 1972.
2. O. P Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.
3. H.H Willard, L.L Meritt, I.A Dean, Instrumental Methods of Analysis, CBS Publishers, Delhi.
4. W. L. Jolly, The synthesis & characterization of Inorganic compounds, Prentice Hall. R.A. Day and A.L. Underwood, Quantitative Analysis- 3 edition, Prentice Hall India, Pvt. Ltd. New Delhi, 1977.

Open Educational Resources (OER)

1. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm206.pdf
2. https://www.youtube.com/watch?v=dLNsPqDGzms&pp=ygUTQWNpZC1CYXNlVGl0cmF0aW9ucw%3D%3D
3. https://www.ramauniversity.ac.in/online-studymaterial/pharmacy/bpharma/isemester/pharmaceuticalanalysis-i/lecture-8.pdf
4. https://www.youtube.com/watch?v=hZxP-Qdm55s&pp=ygUdT3hpZGF0aW9uLVJlZHVjdGlvblRpdHJpbWV0cnk%3D
5. https://www.youtube.com/watch?v=5rtJdjas-mY&pp=ygUdT3hpZGF0aW9uLVJlZHVjdGlvblRpdHJpbWV0cnk%3D
6. https://faculty.ksu.edu.sa/sites/default/files/unit_11_-_redox_titrations_-_subjects_1_0.pdf
7. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXII/chemistry/lelm106.pdf

Modes of Evaluation:

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.

SEMESTER V					
BSCHQC502	**Introduction to Quantum Chemistry**	**L**	**T**	**P**	**C**
Version 2.0		**3**	**1**	**0**	**4**
Category of Course	**Major-XI**				
Total Lectures	60				
Pre-Requisites / Co-Requisites	Basics of Chemistry and Calculus				

Course Perspective

This course covers core concepts in quantum chemistry, including black-body radiation, the photoelectric effect, wave-particle duality, and the Schrödinger equation. Students will study applications to models like free particles, hydrogen atoms, and harmonic oscillators, and explore both valence bond and molecular orbital theories. This foundational knowledge equips students with essential skills for research and theoretical chemistry, preparing them for careers in molecular modeling and chemical analysis.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Understanding: Name and explain key ideas in quantum mechanics, such as black-body radiation, the photoelectric effect, wave-particle duality, and Schrödinger's equation.: Explain key principles like the uncertainty principle, what wave functions are, and the basics of Schrödinger's equation.

CO2: Applying: Use Schrödinger's equation to solve problems for different scenarios and apply wave functions to understand hydrogen atom orbitals and simple molecules.

CO3: Analyzing: Compare solutions of Schrödinger's equation for different systems and evaluate the differences between valence bond theory and molecular orbital theory for hydrogen.

CO4: Evaluating: Judge the importance of wave function concepts and assess how well different quantum theories explain atomic and molecular systems.

Course Content **60 lecture**

Unit A: **15 Lectures**

Introduction to black-body radiation and distribution of energy, photo-electric effect, conceptofquantization, waveparticleduality(de-Broglie'shypothesis),Theuncertaintyprinciple, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values.

Unit B: **15 Lectures**

Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation inpolar coordinates,radialandangularpartsofthehydrogenicorbitals,degeneracies,sphericalharmonics, representations of hydrogenic orbitals.

Unit C: **15 Lectures**

Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions.Rigid rotator model and discussion of application of Schrodinger equation.idea about transformation to spherical polar coordinate, discussion on solution,

Unit D: **15Lectures**

Qualitativetreatmentofhydrogenatomandhydrogen-likeions:settingupofSchrödingerequation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches,

LCAO-MO treatment of H_2, H^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations

Learning Experience:

This course integrates lectures, interactive sessions, and hands-on activities to explore key concepts in quantum mechanics.

- **Instruction Methods:** Core topics such as black-body radiation, wave-particle duality, and the Schrödinger equation will be taught through multimedia presentations, Q&A, and discussions.
- **Technology Use:** LMS for resources, recorded lectures, and forums.
- **Assessments:** Continuous feedback through quizzes and online discussions, with exams and presentations for overall evaluation.
- **Support:** Instructor support and peer collaboration will be encouraged, with regular feedback to aid student improvement.

Text Books

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,*University Science Books, 1998.

Reference Books/Materials

1. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
2. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA(2004).
3. Levine I. N., Physical Chemistry, Fourth Edition), McGraw-Hill (International),1995.

Open Educational Resources

1. **https://www.khanacademy.org/**
2. **https://ocw.mit.edu/**
3. **https://www.coursera.org/**
4. **https://www.open.edu/openlearn/**
5. **https://www.edx.org/**
6. **https://libretexts.org/**
7. **https://nptel.ac.in/**
8. **https://www.saylor.org/**
9. **http://chemcollective.org/**
10. **https://openstax.org/**

Evaluation components	Weightage

Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER V					
	Arithmetic and Reasoning Skills- III	**L**	**T**	**P**	**C**
Version ___		**2**	**0**	**0**	**2**
Category of Course	AEC-III				
Total Lectures	30				
Pre-Requisites/ Co-Requisites	**Basics of Chemistry**				

Course Perspective

The course aims to improve basic arithmetic skills, speed, and accuracy in mental calculations, and logical reasoning. These abilities are essential for a strong math foundation, helping students succeed in academics and various practical fields.

Course Outcomes

Upon completion of the course the learner will be able:

CO 1: Understanding arithmetic algorithms required for solving mathematical problems**.**

CO 2: Applying arithmetic **algorithms** to improve proficiency in calculations**.**

CO 3: Analyzing cases, scenarios, contexts and variables, and understanding their inter-connections in a given problem.

CO 4: Evaluating & deciding approaches and algorithms to solve mathematical & reasoning problems.

Course Content

Unit A: Mathematical Essentials **12 Lectures**

Traditional Indian Calculation methods, Number types and divisibility principles, Practical uses of Percentage in calculating changes and discount, understanding Ratio and Proportion in everyday context.

Unit B: Fundamentals of Logical Reasoning **9 Lectures**

Blood Relations, Direction Sense, Coding Decoding

Unit C: ElementaryQuantitative Skills 13 Lectures

Simple and Compound Interest in everyday situations like loans, investment, Practical problems involving Averages, Real life examples and scenarios involving Partnership

Unit D: Reasoning Skills 11Lectures

Introduction to reasoning, logical reasoning, Analytical reasoning, deductive reasoning, Inductive reasoning, Abductive reasoning, Reasoning in Communication, reasoning in decision making, Reasoning in Research and analysis

Learning Experience

This course blends lectures, interactive sessions, and practical exercises to cover financial literacy, emotional intelligence, time management, and digital literacy.

- **Instruction Methods:** Multimedia lectures, Q&A, and discussions.
- **Technology Use:** LMS for resources and forums.
- **Assessments:** Quizzes, exams, and presentations.
- **Support:** Instructor guidance and peer collaboration with regular feedback.

Textbooks

1. Guha Abhijit: Quantitative Aptitude for Competitive Examinations, Tata McGraw Hill Publication
2. Quantitative Aptitude by R.S. Aggarwal

Reference Book

1. Verbal & Non-Verbal Reasoning by R.S. Aggarwal

Additional Readings:

https://www.indiabix.com/online-test/aptitude-test/

https://www.geeksforgeeks.org/aptitude-questions-and-answers/

https://www.hitbullseye.com/

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER V					
	Computer Aided Drug Design	**L**	**T**	**P**	**C**
Version 3.0		**2**	**0**	**2**	**3**
Category of Course	**Skill Enhancement Course SEC-IV**				
Total Lectures	**45**				
Pre-Requisites/ Co Requisites	**Basics of organic Chemistry**				

Course Perspective

This course explores the stages of drug discovery and development, including lead discovery through traditional medicine, screening techniques, and bioisosterism. It covers Quantitative Structure Activity Relationship (QSAR), focusing on physicochemical parameters and advanced 3D-QSAR methods. Students will learn virtual screening techniques, molecular docking, and de novo drug design. Additionally, the course introduces bioinformatics, chemo-informatics, and molecular modeling, with emphasis on energy minimization, conformational analysis, and drug design databases.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Understanding fundamental approaches in drug discovery and development.

CO2: Applying QSAR techniques and molecular modeling to predict and optimize drug activity.

CO3: Analyzing virtual screening, molecular docking, and drug design methods in drug discovery.

CO4: Evaluating the use of bioinformatics, chemoinformatics, and molecular modeling tools in drug design and optimization.

Course Content

Unit A: Introduction to Drug Discovery and Development **11 lectures**

Introduction to Drug Discovery and Development: Stages of drug discovery and development Rational approaches to lead discovery based on traditional medicine, Random screening, Non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observation. Bioisosterism, Classification, Bioisosteric replacement. Any two case studies.

Unit B: Quantitative Structure Activity Relationship (QSAR): **12 lectures**

SAR versus QSAR, History and development of QSAR, Types of physicochemical parameters, experimental and theoretical approaches for the determination of physicochemical parameters such as Partition coefficient, Hammet's substituent constant and Tafts steric constant. Hansch analysis, Free Wilson analysis, 3D-QSAR approaches like COMFA and COMSIA.

Unit C: Molecular Modeling and virtual screening techniques 11 lectures

- **Virtual Screening techniques:** Drug likeness screening, Concept of pharmacophore mapping and phar- macophore based Screening,
- **Molecular docking:** Rigid docking, flexible docking, manual docking, Docking based screening. De novo drug design.

Unit D: Informatics and Molecular Modeling 11 lectures

- **Informatics & methods in drug design** Introduction to Bioinformatics, chemoinformatics. ADME databases, chemical, biochemical and pharma- ceutical databases.
- **Molecular Modeling:** Introduction to molecular mechanics and quantum mechanics. Energy Minimiza- tion methods and Conformational Analysis, global conformational minima determination.

Learning Experience

This course on drug design will provide a comprehensive learning experience through a combination of lectures, interactive sessions, and practical activities.

Instruction Methods:

Lectures: Core topics such as Drug Discovery, Development, QSAR, molecular docking and molecular modeling, will be covered using multimedia presentations and problem-solving sessions.

Interactive Sessions: Engaging activities, Q&A segments, and discussions will enhance understanding and application of concepts.

Technology Use: Online Platforms: An LMS will offer resources, recorded lectures, and discussion forums to support extended learning and collaboration.

Assessments: Formative: Continuous feedback will be provided through quizzes and online discussions.

Summative: Student understanding will be evaluated via exams, peer reviews, and presentations.

Support: The instructor will be available for additional guidance, with peer collaboration encouraged. Regular feedback will aid students in improving and achieving the course outcomes.

Textbooks

1. Drug Discovery and Development: Technology in Transition, Raymond G. Hill and Humphrey P. Rang, Elsevier, 2020
2. Molecular Modeling Basics, Jan L. Berenbaum, Wiley-Interscience, 2019

Reference Books

1. Quantitative Drug Design: A Critical Introduction, George A. D. Williams, Elsevier, 2018
2. Introduction to Drug Design, Graham L. Patrick, CRC Press, 2017

3. Principles of Medicinal Chemistry, William Foye, David A. Lemke, and David A. Williams, Lippincott Williams & Wilkins, 2013.
4. Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems, David C. Young, Wiley-Interscience, 2001

Open Educational Resources (OER)

1. Introduction to Drug Discovery (PharmGKB - pharmacogenomics knowledgebase) Link: https://www.pharmgkb.org
2. Basic Principles of QSAR (Open Chemistry Database, LibreTexts) Link: https://chem.libretexts.org
3. Molecular Docking and Virtual Screening (Drug Discovery Training – YouTube) Link: https://www.youtube.com/watch?v=example
4. Pharmacophore Modeling and Molecular Docking (Bioinformatics.org) Link: https://bioinformatics.org
5. Introduction to Bioinformatics and Chemoinformatics (Coursera - University of California) Link: https://www.coursera.org
6. QSAR Modeling Techniques (ScienceDirect Open Access) Link: https://www.sciencedirect.com/science/article/pii/S2452074817300896

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER V					
BSCHIN503	**Evaluation of Summer Internship/Project**	**L**	**T**	**P**	**C**

Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Internship**				
Total Lectures					
Pre-Requisites/ Co-Requisites	**Practical Exposure**				

Course Perspective:

In the end of Semester IV, students will be asked to join research/academic organizations or industries to get hands on knowledge on the selected topics. The student will work on the assigned topic for 3-4 weeks in regular consultation with his/her assigned expert/guide. The student will write a report based on the work carried out during internship and prepare two copies to be submitted to the office of the Head of the Department duly signed by the student and the expert. The student will make a power point presentation based on the work carried out and mentioned in the report to the board of examiners appointed by the University in the fifth semester. The student will be evaluated based on a report and presentation.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Carrying out the extensive literature survey on the topic assigned by academicians and industry experts.

CO 2: Applying various methods and techniques applicable to their research topic to study and contributing to domain knowledge.

CO 3: Analyzing the result of the experiment carried out and presenting the results using data visualization methods.

CO 4: Evaluating the effectiveness of methods used and the significance of research findings.

CO 5: Writing and presenting technical reports/articles.

Learning Experience:

The internship course will be experiential through hands-on lab work, real-world research projects, and active participation in ongoing studies. Students will collaborate with faculty and researchers, applying theoretical knowledge to experimental tasks and data analysis. Regular group discussions, progress presentations, and peer feedback will enhance collaborative learning. The course will also include reflective journaling to encourage self-assessment and growth throughout the internship.

Evaluation Scheme:

Particular	**Weightage**

Internal Marks: - Internship completion certificate obtained from supervisor from host institute.	40 marks
External Marks (Practical): - Presentation Report Writing Viva Voce	70 Marks 25 25 20

SEMESTER-VI

SEMESTER-VI					
BSCHAC601	**Analytical Techniques of Chemistry**	L	T	P	C
Version 2.0		3	1	0	4
Category of Course	**Major-XII**				
Lectures	60				
Pre-requisites/ Co-requisites	Basics of Analytics techniques				

Course Perspective:

The course on Analytical Techniques of Chemistry provides students with a comprehensive introduction to the essential methodologies and principles underlying modern analytical chemistry. By covering a wide range of techniques, including spectroscopy, thermal analysis, electroanalytical methods, and separation techniques, the course emphasizes both theoretical knowledge and practical application. Students will gain an appreciation of how these techniques are employed to solve complex chemical problems, enhance their quantitative analysis skills, and understand the professional and safety standards required in a laboratory setting. This course is designed to prepare students for advanced studies or careers in chemistry, offering them a robust foundation in analytical methods that are crucial for scientific research and industry practices.

Course Outcomes

On completion of this course, the students will be able:

CO1: **Understanding** the principles and applications of modern chemical instrumentation, experimental design, and data analysis, chemical and physical principles underlying instrumental

methods of analysis, including electronic and vibrational spectroscopy, and electro-analytical techniques.

CO2: **Applying** scientific concepts to analyze data and communicate findings clearly in both oral and written forms.

CO3: **Analyzing**written laboratory reports that summarize experimental procedures and interpret data accurately.

CO4: **Creating and collaborating** with others as part of a team to solve scientific problems effectively.

Course Content

UNIT I - Qualitative and quantitative aspects of analysis **15 lecture**

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT II – Spectroscopy **15 lecture**

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra**.** UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT III - Thermal analysis **15 lecture**

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture. Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. determination of pKa values.

UNIT IV - Separation techniques **15 lecture**

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non- aqueous media. Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC.

Experiential Learning:

earning Experience Summary

Course Structure:

- **Lectures:** Fundamental topics in analytical chemistry.

- **Interactive Sessions:** Q&A, quizzes, and discussions.

Technology Use:

- **LMS:** Access to materials and forums.
- **Virtual Labs:** Simulated experiments.

Assessments:

- **Formative:** Quizzes and discussions.
- **Summative:** Exams and practical reports.

Support:

- **Instructor:** Office hours and consultations.
- **Peer Collaboration:** Group projects and peer feedback.

Textbooks:

1. D.A. Skoog, D.M. West, F.J. Holler, and S.R. Crouch - *Fundamentals of Analytical Chemistry*, 9th Edition, Brooks Cole.
2. R.A. Day Jr. and A.L. Underwood - *Quantitative Analysis*, 7th Edition, Prentice Hall.

Suggestive Readings:

1. H.D. Braun - *Introduction to Instrumental Analysis*, McGraw-Hill.
2. G.D. Christian - *Analytical Chemistry*, 7th Edition, John Wiley & Sons.
3. M. J. Clark and A. R. West - *Analytical Chemistry: Principles and Techniques*, Wiley.
4. R.E. Snyder, J. J. Kirkland, and J. L. Glajch - *Practical HPLC Method Development*, Wiley.

Open Educational Resources (OER):

1. MIT OpenCourseWare: Introduction to Solid State Chemistry
2. Khan Academy: Chemistry
3. Coursera: Data Analysis and Visualization with Python
4. LibreTexts: Analytical Chemistry
5. OpenStax: Chemistry

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Theory :

Evaluation components	**Weightage**
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**

II. internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.

SEMESTER-VI					
BSCHAC651	**Analytical Techniques of Chemistry Practicals**	L	T	P	C
Version 2.0		0	0	2	1
Category of Course	**Major-XII Practical**				
Lectures	15				
Pre-requisites/ Co-requisites	Basics of chromatography and solvent extraction				

Course Perspective:

The course on Analytical Techniques of Chemistry Practicals is designed to provide students with hands-on experience in a variety of analytical methods essential for modern chemistry. By engaging with practical techniques such as flame photometry, infra-red spectrophotometry, and chromatography, students will develop a deep understanding of how these methods are applied to analyze complex samples. The course covers crucial aspects such as water quality parameters, soil composition, and the analysis of aerated drinks, allowing students to connect theoretical knowledge with practical skills. This experiential approach ensures that students are well-prepared for careers in analytical chemistry, environmental science, and related fields, where accurate and reliable data analysis is paramount.

Course Outcomes

On completion of this course, the students will be able

CO1: **Observing** how to measure critical solution temperature, study reaction equilibria, and understand the basics of adsorption and thermochemistry.

CO2: **Imitating** procedures to measure critical solution temperature, study reaction rates, and verify adsorption methods.

CO3: **Practicing** techniques to measure reaction rates, calculate heat capacities, and study adsorption effects.

Course Content

(Recommended to carry out at least two experiments from each section)

I. Chromatography:

i.Paper chromatographic separation of Fe^{3+}, Al^{3+}, andCr^{3+}.

ii.Separation and identification of the monosaccharides present in the given mixture (glucose & fructose)

by paper chromatography. Reporting the Rfvalues.

iii. SeparateamixtureofSudanyellowandSudanRedbyTLCtechniqueandidentifythemonthe basis of their Rfvalues.

iv. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

i. To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}- DMG complex in chloroform and determine its concentration by spectrophotometry.

ii. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

iii. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

III. Analysis of soil:

i. Determination of pH of soil.

ii. Total soluble salt

iii. Estimation of calcium, magnesium, phosphate, nitrate

IV. Ion exchange:

i. Determination of exchange capacity of cation exchange resins and anion exchange resins.

ii. Separation of metal ions from their binary mixture.

iii. Separation of amino acids from organic acids by ion exchange chromatography.

V. Spectrophotometry

i. Determination of pKa values of indicator using spectrophotometry.

ii. Structural characterization of compounds by infrared spectroscopy.

iii. Determination of dissolved oxygen in water.

iv. Determination of chemical oxygen demand (COD).

v. Determination of Biological oxygen demand (BOD).

vi. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Experiential Learning:

In this course, students gain practical experience through a series of laboratory experiments that reinforce their understanding of analytical techniques. Activities include chromatographic separation of metal ions and organic compounds, spectrophotometric analysis of water quality, and the estimation of various ions in soil and beverages. By performing these experiments, students learn to operate and interpret results from sophisticated instruments such as flame photometers and infra-red spectrophotometers. The course also emphasizes the importance of safety and risk assessment in chemical experiments, preparing students to handle real-world analytical challenges with confidence and precision.

Textbooks:

1. R.A. Day Jr. and A.L. Underwood - *Quantitative Analysis*, 7th Edition, Prentice Hall.

2. D.A. Skoog, D.M. West, F.J. Holler, and S.R. Crouch - *Fundamentals of Analytical Chemistry*, 9th Edition, Brooks Cole.

Suggestive Readings:

1. J.C. Laitinen, I.S. Miller, and E.A. Meyer - *Instrumentation and Techniques*, Wiley.
2. S. J. George - *Principles of Instrumental Analysis*, 6th Edition, Cengage Learning.
3. H.D. Braun - *Introduction to Instrumental Analysis*, McGraw-Hill.
4. G.D. Christian - *Analytical Chemistry*, 7th Edition, John Wiley & Sons.
5. W. Billmeyer - *Textbook of Polymer Science*, 3rd Edition, Wiley.
6. J.R. Fried - *Polymer Science and Technology*, PHI Publication.

Open Educational Resources (OER):

1. MIT OpenCourseWare: Introduction to Solid State Chemistry
2. Khan Academy: Chemistry
3. LibreTexts: Analytical Chemistry
4. Coursera: Data Analysis and Visualization with Python
5. OpenStax: Chemistry

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
BSCHOC602	**Organic Spectroscopy**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-XIII**				
Total Lectures	60				
Pre-Requisites / Co-Requisites	12th level Chemistry				

Course Perspective

In this course students will learn and understand the basic concepts of spectroscopy, difference between emission and absorption spectroscopy, laws of photochemistry, basic principles and working of UV-Visible, IR, NMR, Mass Spectroscope and how structure of organic molecules can be predicted based on UV-Visible, IR, NMR and mass spectrum.

Course Outcomes

Upon completion of the coursethe learner will be able:

CO1: Understanding Explain UV spectroscopy and how to use the Woodward-Fieser rule for predicting absorption maxima in organic compounds.

CO2: Applying: Use Woodward-Fieser rules to find the λmax\lambda_{max}λmax for conjugated dienes and α,β-unsaturated compounds.

CO3:Identifying: Recognize functional groups in organic compounds using IR spectroscopy and analyze their vibrations.

CO4: Interpreting: Read ^{1}Hand ^{13}C NMR spectra by understanding shifts, splitting, and spin interactions.

CO5: Analyzing: Examine mass spectrometry patterns and use rules to determine the structure of organic compounds.

CO6:Evaluating: Determine the structure of organic compounds using data from UV, IR, NMR, and mass spectrometry.

Course Content **60 Lecture**

Unit A: Basic Principles of UV Spectroscopy **17 lecture**

Application of Woodward-Fieser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronictransitions,λmax&εmax,chromophore,auxochrome,bathochromicandhypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds.

Unit B: Basic principles of IR Spectroscopy **17 lecture**

Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Unit C: NMR (^{1}H and ^{13}C NMR) **13 lecture**

Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange

Unit D: Basic principles Mass Spectrometry **13 lecture**

Applicationoffragmentationruleincharacterizationoforganiccompounds.Problemsonstructure elucidation of organic compounds based on spectraldata.

Learning Experience

This course combines lectures, interactive sessions, and hands-on learning on spectroscopy and mass spectrometry.

Instruction Methods:

- **Lectures:** Key concepts on UV, IR, NMR, and Mass Spectrometry.
- **Interactive Sessions:** Q&A, quizzes, and discussions.

Technology Use:

- **Online Platforms:** LMS for resources and discussions.

Assessments:

- **Formative:** Quizzes and discussions.
- **Summative:** Exams and presentations.

Support:

- Instructor guidance and peer collaboration with regular feedback.

Text Book:

1. Y. R. Sharma, Elementary Organic Spectroscopy, S. Chand

References Books:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of Organic Compounds*, John Wiley &Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India (2012).

Open Educational Resources (OER)

- Introduction to Organic Spectroscopy - Chemistry LibreTexts

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
	Managing People and Organizations	**L**	**T**	**P**	**C**
Version1.0		**2**	**0**	**0**	**2**
Category of Course	**Ability Enhancement Course**				
Total Contact Hours	**30**				
Pre-Requisites/					

Co-Requisites	

Course Objectives (COs)

CO1: Understand and apply the principles of Transactional Analysis for effective interpersonal interactions.

CO2: Develop interpersonal communication skills and enhance empathy, assertiveness, and social awareness.

CO3: Demonstrate teamwork, collaboration, and feedback processing in group settings.

CO4: Analyze and manage conflict, trust, and influence in professional relationships.

CO5: Understand organizational behavior through motivation, culture, leadership, and negotiation strategies.

Course Content

Session	Topic	Expanded Content Focus	Activities
1	Introduction to People Skills	Overview of course scope, importance of self-awareness and interpersonal effectiveness in academic and professional life. Introduction to people-centered behavior and workplace relevance.	Icebreaker + Group Values Exercise
2	Transactional Analysis (TA) Basics	Introduction to Eric Berne's model. Understanding Parent, Adult, and Child ego states; identifying types of transactions (complementary, crossed, ulterior); recognizing life positions (I'm OK – You're OK).	TA Role-play, Ego Quiz
3	Strokes & Life Positions	Concepts of recognition hunger, positive and negative strokes, impact of internal dialogue. Reaffirming life positions and fostering self-worth through conscious reinforcement.	Self-reflection sheet
4	Assertive vs Aggressive	Differentiating passive, aggressive, and assertive styles. Identifying behavioral cues and practicing verbal/non-verbal assertiveness techniques for conflict-free expression.	Assertiveness Practice Drill

5	Interpersonal Communication	Emphasis on active listening, empathetic feedback, and perspective-taking. Understanding barriers to communication and how empathy influences team behavior.	Empathy Circles
6	Relationships & Social Behavior	Exploring trust-building, establishing healthy boundaries, social contracts, and relational transparency. Recognizing signs of toxic vs supportive social behavior.	Case-based Discussion
7	Group & Team Dynamics	Exploring Tuckman's stages of team development (Forming, Storming, Norming, Performing). Role's people play in teams, synergy, and team cohesion.	Team Exercise – Marshmallow Challenge
8	Effective Teams & Feedback	Identifying feedback blind spots, Johari Window application, effective feedback loops. Emphasizing constructive critique, peer appreciation, and growth mindset.	360° Feedback Activity
9	Conflict Styles & Resolution	Thomas-Kilmann Conflict Mode Instrument (TKI): Competing, Avoiding, Accommodating, Collaborating, Compromising. Application of conflict resolution models in personal and professional settings.	Conflict Style Quiz + Scenario Roleplay
10	Influence & Trust	Examining influence mechanisms (authority, credibility, reciprocity), power dynamics, and the behavioral science behind trust-building in interpersonal and team contexts.	Trust Fall + Influence Mapping
11	Collaboration & Motivation	Dissecting intrinsic vs extrinsic motivators. Applying Maslow's and Herzberg's theories. Understanding motivational alignment in team and leadership settings.	Motivation Self-test
12	Psychological Safety	Understanding team psychological safety, signs of burnout, and emotional triggers. Encouraging vulnerability, shared goals, and inclusive culture for open communication.	Psychological Safety Diagnostic
13	Organizational Culture	Defining organizational culture and subculture. Analyzing Google vs Amazon	Culture Case Study:

		work culture case to understand morale, inclusivity, and value systems.	Google vs Amazon
14	Leadership & Change	Exploring leadership styles (transformational, servant, transactional), managing people through change, resistance management, and emotional intelligence in leadership.	Leadership Styles Activity
15	Negotiation & Persuasion	Introduction to BATNA, ZOPA, and Harvard's principles of negotiation. Understanding influence tactics and win-win frameworks in professional settings.	Mock Negotiation Simulation

Assessment Structure

Component	Weightage
Peer Feedback & Team Activities	20%
Conflict Case Analysis	15%
Communication Skills Practical	15%
Organizational Behavior Reflection	20%
Final Simulation (Leadership or Negotiation)	30%

Suggested Readings & Resources

- Eric Berne – *Games People Play*
- Dale Carnegie – *How to Win Friends and Influence People*
- Patrick Lencioni – *The Five Dysfunctions of a Team*
- Harvard Business Review – *On Emotional Intelligence*, *On Teams*

SEMESTER VI

BSCCRM606	Research Methodology	L	T	P	C
Version1.0		3	0	0	3
Category of Course	Major				
Total Contact Hours	45				
Pre-Requisites/ Co-Requisites	None				

Course Perspective: This course equips undergraduate science students with core research skills, including literature review, experimental design, data collection and analysis, and understanding of research ethics. It introduces learners to qualitative and quantitative methods and supports the development of critical thinking and problem-solving abilities for academic and applied research.

Course Outcomes

By the end of the course, students will be able to:

CO1: Understanding fundamental research concepts, including theory, hypothesis, variable, sampling, and ethics.
CO2: Applying appropriate research design methods and sampling techniques to structure basic research inquiries.
CO3: Analysing, organizing, comparing, and interpreting data using descriptive and inferential statistical methods.
CO4: Evaluating the credibility and ethical considerations in literature and research practices.
CO5: Creating structured research proposals, design experiments, and present data and conclusions effectively.

Course Content

Unit I: Introduction to Research and Fundamentals 6 Lecture Hours

- Meaning, objectives, and motivation for research
- Characteristics of scientific research
- Concepts: theory, hypothesis, concept, construct, variable
- Empiricism, deductive and inductive reasoning
- Types and definitions of research: basic vs. applied; theoretical vs. empirical

Unit II: Research Design **6 Lecture Hours**

Elements of research design

- Types: Exploratory, Descriptive, Experimental
- Variables: Independent, Dependent, Controlled
- Causality, generalization, replication
- Qualitative vs. Quantitative approaches
- Merging the two or more approaches.

Unit III: Literature Review and Sources of Information **8 Lecture Hours**

- Primary, secondary, and tertiary sources
- Abstracts, reviews, monographs, encyclopaedias, handbooks
- Chemical and scientific databases: ScienceDirect, PubMed, Scopus
- Citation metrics: impact factor, h-index, citation index
- How to identify high-quality publications and authorship standards
- Ethics in Literature Review

Unit IV: Sampling Techniques and Data Collection **10 Lecture Hours**

- Concepts: population, sample, sampling frame
- Sampling methods: simple random, stratified, systematic, multi-stage
- Sample size determination, sampling error
- Types of data: qualitative, quantitative
- Data collection tools: questionnaires, observations, interviews

Unit V: Data Analysis and Interpretation **15 Lecture Hours**

- Descriptive statistics: mean, median, mode, standard deviation, variance
- Graphical representation: bar charts, pie charts, histograms
- Inferential statistics: hypothesis testing, Chi-square test
- Analysis of variance (SPSS), regression, correlation
- Designing experiments and analyzing residuals
- Data interpretation and reporting findings

Learning Experience

The course will be conducted through a mix of interactive lectures, collaborative problem-solving sessions and following experiential learning activities:

Unit	Activities
Unit I	Concept mapping of research types and components
Unit II	Group discussions on ethical case studies
Unit III	Guided literature survey and reference evaluation
Unit IV	Sampling simulations and mock data collection
Unit V	Manual statistical analysis and interpretation of lab-generated data

Textbooks

1. Kothari, C.R. – *Research Methodology: Methods and Techniques*, New Age International
2. Panneerselvam, R. – *Research Methodology*, Prentice Hall of India

Suggested Readings

1. Kumar, R. – *Research Methodology: A Step-by-Step Guide for Beginners*
2. Hibbert, D.B. & Gooding, J.J. – *Data Analysis for Chemistry*
3. Moore, D.S. – *Introduction to the Practice of Statistics*
4. Ruxton, G.D. & Colegrave, N. – *Experimental Design for the Life Sciences*
5. Bryman, A. & Bell, E. – *Business Research Methods*
6. Heiman, G.W. – *Basic Statistics for the Behavioral Sciences*
7. Creswell, J.W. – *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*

Open Educational Resources (OER)

1. **https://www.coursera.org/learn/research-methodologies**
2. **https://www.coursera.org/learn/analysis-and-interpretation-of-data**
3. **https://www.coursera.org/learn/research-methods**
4. **https://www.coursera.org/learn/qualitative-research-methods-capturing-rich-insights**

Evaluation Scheme

Evaluation components	**Weightage**
I. Internal marks **Continuous Assessment** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal Marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER IV

BSCCPR405	PROJECT-III	L	T	P	C
Version ___		2	0	0	2
Category of Course	PROJECT-III				
Total Lectures	30				
Pre-Requisites/ Co-Requisites	Basic Scientific Knowledge				

Course Perspective:

This project-based course is designed to foster creativity, innovation, and independent learning by allowing students to explore real-world problems through hands-on experimentation, research, or interdisciplinary approaches. By choosing a category that aligns with their interests—such as working models, research, skill development, innovation, or entrepreneurship—students gain practical experience, apply theoretical knowledge, and enhance their problem-solving, technical, and presentation skills. The course emphasizes inquiry, design thinking, and collaborative learning to prepare students for academic, industrial, or entrepreneurial pursuits.

Course Outcomes:

CO1: Understanding key concepts, scientific principles, or societal needs relevant to the selected project category.

CO2: Applying scientific methods, laboratory techniques, or computational tools to execute project tasks effectively.

CO3: Analyzing data, processes, or systems to derive insights, troubleshoot problems, and refine approaches.

CO4: Evaluating the feasibility, functionality, or impact of the project and justify decisions based on evidence.

CO5: Creating an original project output—such as a model, report, prototype, codebase, or strategy—that integrates knowledge across disciplines and addresses real-world applications.

Course Content:

Students may choose one of the following categories:

V. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.
W. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.
X. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.
Y. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.
Z. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.
AA. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).
BB. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

- Clarity of Objective – 10 marks
- Innovation / Creativity – 20 marks
- Scientific/Technical Accuracy – 20 marks
- Practical Application / Relevance – 15 marks
- Execution / Model Functionality – 20 marks
- Presentation / Report Quality – 5 marks
- Teamwork / Effort – 10 marks

SEMESTER VII

Discipline Specific Elective I					
BSCHHC701	**Heterocyclic Chemistry**	L	T	P	C
Version 1.0		3	1	0	4
Total Lectures	**60**				
Pre-requisites/Exposure	Basics of organic chemistry				
Co-requisites	--				

Course Perspective

This course explores the chemistry of heterocyclic compounds, focusing on their structure, synthesis, and reactivity across various ring sizes and heteroatom configurations. Students will study three-membered rings with one or two heteroatoms, such as oxiranes and diaziridines, as well as four-membered heterocycles like oxitanes. The course also covers five-membered aromatic heterocycles with varying heteroatom combinations, including furans, pyrroles, and indoles. Emphasis will be placed on the synthesis of natural products like penicillin and cephalosporin and the detailed chemistry of these heterocyclic systems, providing a thorough understanding of their roles in organic synthesis and applications.

Course Outcomes

On completion of this course, the student-teacher will be able to:

CO1:Understanding heterocyclic compounds and their basic structures, synthetic approaches and reactivities of heterocyclic compounds with one or more heteroatoms.

CO3: Applying: Use knowledge of heterocyclic chemistry to synthesize specific compounds, such as oxiranes, furans, and indoles.

CO4:Analyzing: Compare the reactivities and properties of different heterocyclic compounds, including those with multiple heteroatoms.

CO5: Evaluating: Assess the significance of heterocyclic compounds in natural product synthesis, such as penicillin and cephalosporin.

Course Content

UNIT A: HeterocyclicChemistry **15 Lectures**

Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches and reactivities.

UNIT B:Three-membered heterocycles **15 Lectures**

with two heteroatoms: oxaziranes, diaziridines and diazirines

- synthetic approaches and reactivities.

UNIT C: Four-membered heterocycles: **15 Lectures**

oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products:synthesis of Penicilineandcephalosporine.

UNIT D:Five-membered aromatic heterocycle **15 Lectures**

1. With one heteroatom: furans, pyrroles and thiophenes - general synthetic approaches, properties andreactivities.

2. With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles and isothiazoles - general synthetic approaches andreactivities.

3. With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches, properties andreactivity.

Condensed five-memberedHeterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry ofIndoles.

Recommended TextBooks:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley,2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,

Reference Books:

1. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York,1968.
2. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London,1978.
3. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),. Vol 1-8, Pergamon Press,1984.
4. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press,1985.
5. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic Press, 1974.

Open Educational Resources (OER)

- https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/heterocy.htm
- https://www.youtube.com/watch?v=zyRRHfH9_Zg

- https://www.youtube.com/watch?v=089fZfDTrEs
- https://www.khanacademy.org/science/organic-chemistry
- http://www.rsc.org/learn-chemistry
- http://chemcollective.org/
- https://www.youtube.com/watch?v=LVGmOoPH10M

Modes of Evaluation:

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

Discipline Specific Elective I					
BSCHHC751	**Heterocyclic Chemistry Practicals**	L	T	P	C
Version 1.0		0	0	2	1
Total Lectures	15				
Pre-requisites/Exposure	Basics of organic compounds				
Co-requisites	--				

Course Perspective

This course provides hands-on laboratory experience in heterocyclic chemistry, including the identification of heteroatoms, separation of compounds via chromatography, and spectroscopic analysis. Students will also synthesize indigo and other heterocyclic compounds, performing at least eight experiments to build practical skills in organic chemistry.

Course Outcome:

On completion of this course, the students will be able to

CO1: Observing the identification of heteroatoms (S, N, X) in organic compounds and the use of column chromatography/TLC for separation.

CO2: Imitating spectroscopic identification of organic compounds using provided spectra and check purity through melting/boiling points.

CO3: Practicing the preparation of Indigo using aldol condensation and other heterocyclic compounds.

Course Content

List of suggested laboratory experiments

1. Identification of hetero atoms (S, N, X) in given organic compounds inlab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) inlab.
3. Spectroscopic identification of simple organic compounds (spectra may be provided to the students and teachers may help the students to identify the compounds using spectra). Melting point/boiling point of the compounds may be checked for itspurity.
4. Teacher may guide the students for preparation of : Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basiccondition);

(Depending upon laboratory facilities, more preparation of heterocyclic group of compoundsmay be incorporated byteacher).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.

Open Educational Resources:

https://youtu.be/w5A0mqVEYBI
https://www.ox.ac.uk/admissions/undergraduate/courses/course-listing/chemistry
https://www.exeter.ac.uk/undergraduate/courses/biosciences/biomed/
https://www.ox.ac.uk/admissions/undergraduate/courses/course-listing/chemistry
https://www.manchester.ac.uk/study/undergraduate/courses/2024/09453/mchem-chemistry-with-international-study/all-content/
https://www.qub.ac.uk/courses/undergraduate/biochemistry-bsc-c700/
https://byjus.com/chemistry/classification-organic-compounds/
https://www.qub.ac.uk/courses/undergraduate/medicinal-chemistry-bsc-f154/
Heterocycles Part 1: Furan, Thiophene, and Pyrrole
Pyrones (6 membered Heterocyclic compounds) Synthesis & Reaction #mscchemistrynotes #heterocyclic
https://www.youtube.com/watch?v=jScWkQEkpsI

Modes of Evaluation:

Evaluation components	**Weightage**
Internal marks (Practicals)	
I. Conduct of experiment	**10 Marks**
II . Lab Record	**10 Marks**
III. Lab Participation	**10 Marks**
IV. Lab Project	**20 Marks**

II. External Marks (practicals): End Term Examination	**50 Marks**

Discipline-Specific Elective I					
BSCHAM703	**Advanced Material Chemistry**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	Discipline Specific Elective				
Total Lectures	60				
Pre-Requisites/ Co-Requisites	Physical chemistry or an equivalent course is recommended				

Course Perspective: This course on the crystal structure of solids is crucial for students pursuing careers in materials science, nanotechnology, and engineering, as it lays the foundation for understanding how atomic arrangements influence material properties. Students will gain essential skills in analyzing crystal structures, synthesizing inorganic solids, and using advanced techniques like X-ray diffraction and electron microscopy. The knowledge acquired is directly applicable to real-world scenarios, such as designing materials with specific properties, developing nanodevices, and advancing semiconductor technology. Mastery of these concepts will prepare students to excel in both academic research and industry.

Course Outcomes

- **CO1: Understanding** the fundamental concepts of crystal structures, including lattices, unit cells, Bravais lattices, and crystal packing, and their role in solid-state chemistry.
- **CO2: Explaining** various synthesis techniques for inorganic solids and nanomaterials, including solid-state, solution-phase, vapor-phase, and surfactant-based methods.
- **CO3: Applying** techniques like X-ray diffraction, electron microscopy, and neutron diffraction to determine crystal structures and characterize nanomaterials.
- **CO4: Analyzing** problems related to the synthesis, characterization, and application of nanomaterials, particularly their magnetic properties and uses in medicine.
- **CO5: Evaluating** the applications of advanced materials such as conducting polymers, biodegradable polymers, fibers, and rubbers in technology, including biomedical applications like contact lenses and artificial organs.

COURSE CONTENT

Unit 1: Crystal structure of solids **15 lecture**

Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures. Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant-based synthesis. Growth of single crystals. Crystal structure determination by X-ray

diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by crystal. Single crystal and powder diffraction. Electron and neutron diffraction. Concept of reciprocal lattice. Electron microscopy techniques.

Unit 2: Nanomaterial fundamentals 15 lecture

Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role of surfactant in shape and size control of nanomaterials. Synthesis of nanowires and nanotubes by CVD and MOCVD method.

Unit 3: Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy). 15 lecture

Nanomaterial properties and applications: Magnetic properties of nanoparticles; super Paramagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition. Magnetic nanoparticles as MRI contrast agents.

Unit 4: Frontier areas of polymer science and technology 15 lecture

Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyaceticacid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Learning Experience

This course will be conducted through a blend of interactive lectures, hands-on laboratory sessions, and collaborative group work to ensure a rich learning experience. Instructional methods will include the use of multimedia presentations, simulations, and virtual lab demonstrations to visualize complex concepts such as crystal structures and nanomaterials. Students will engage in case studies and problem-solving activities to apply theoretical knowledge to real-world scenarios, while assignments will involve research projects and presentations that encourage critical thinking and creativity. Hands-on learning will be emphasized through lab experiments where students will synthesize materials, characterize them using advanced techniques like X-ray diffraction and electron microscopy, and analyze the results. Assessments will include quizzes, lab reports, group projects, and exams to evaluate understanding and application of course content.

Textbooks:

1. "Solid State Chemistry: An Overview" by D.K. Chakrabarty

2. "Inorganic Chemistry: Principles of Structure and Reactivity" by James E. Huheey, Ellen A. Keiter, and Richard L. Keiter”

Reference Books:

1. "Textbook of Nanoscience and Nanotechnology" by B.S. Murty, P. Shankar, Baldev Raj, B.B. Rath, and James Murday
2. "Principles of the Solid State" by H.V. Keer
3. Zhen Guo and Li Tan, Fundamentals and Applications of Nanomaterials. 2009, Artech House, London Publication.
4. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
5. Polymer science, V.R. Gowariker, N.V. Viswanathan, J.Sreedhar, New Age International(P) Ltd.,2015.
6. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
7. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
8. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

Open Educational Resources (OER)

https://www.youtube.com/playlist?list=PLUl4u3cNGP63W1vnAQ6Rdjysys7c2Cckr

https://www.youtube.com/watch?v=s-KvoVzukHo

https://www.coursera.org/lecture/nanotechnology-biomaterials-nanotechnology/nanotechnology-basics-part-1-ehFkx

https://www.youtube.com/playlist?list=PLbMVogVj5nJSrJpHTRcxsl5G1iMchE5GT

Evaluation Scheme

Modes of Evaluation: Quiz/ Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Evaluation components	**Weightage**
I. Internal marks (Theory) Continuous assessment All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	40 marks
II. Internal marks (Theory): **Mid Term Examination**	20 Marks

III. External Marks (Theory): **End Term Examination**	40 marks

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.

Discipline-Specific Elective I					
BSCHAM753	**Advanced Material Chemistry Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**
Category of Course	Discipline Specific Elective				
Total Lectures	15				
Pre-Requisites/ Co-Requisites	Basics of Analytical Chemistry				

Course Perspective: This course is designed to provide students with a comprehensive understanding of advanced experimental techniques and analytical methods used in material science and chemistry. By engaging in hands-on experiments such as the preparation of gold and silver nanoparticles, polymerization processes, and the analysis of crystalline structures using XRD, students will acquire critical skills in laboratory practices and data interpretation. The course bridges theoretical knowledge with practical applications, allowing students to gain proficiency in techniques like FTIR, NMR, UV-Vis spectroscopy, and advanced microscopy methods such as SEM and TEM. This experience is essential for students pursuing careers in research, chemical engineering, and materials science, as it equips them with the tools to analyze and manipulate materials at the molecular and atomic levels. The skills gained in this course are directly applicable to real-world situations, such as developing new materials, optimizing industrial processes, and contributing to innovations in nanotechnology and pharmaceuticals

Course outcomes (CO)

Upon completion of the course the learner will be able:

CO1: Observing Students will observe the synthesis of nanoparticles and gain an understanding of particle size estimation using techniques like BET, SEM, and TEM.

CO2: Imitating Students will imitate the process of interfacial polymerization and perform titrations for the determination of dolomite composition through complexometric methods.

CO3: Practicing Students will practice analyzing XRD patterns, interpreting FTIR, NMR, and UV-Vis data, and preparing and characterizing nanomaterials and polymers.

Course Content:

List of Laboratory experiments

(The lists of experiments are suggestive. However, faculties/academic bodies may add more

experiments/references or incorporate suitable revisions based on infrastructure facilities available).

1. Preparation of gold and silver nano-particles.
2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
3. Determination of composition of dolomite (by complexometric titration).
4. Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystalline system.
5. Interpretation of FTIR, NMR and UV-Vis data of given material.
6. Estimation of particle size from the BET, SEM, TEM techniques.

Learning Experience:

This course offers a dynamic, hands-on learning experience where students actively engage in experiments, group work, and case studies to bridge theory with real-world applications in material science and chemistry. Utilizing advanced instrumentation and technology, students will conduct experiments, analyze data, and collaborate on research projects. Assignments will include lab reports and presentations, with continuous feedback provided by the instructor and peers. The course is designed to foster critical thinking, teamwork, and practical skills, with ample support available to ensure students achieve their learning outcomes effectively.

Textbooks

1. Introduction to Nanotechnology" by Charles P. Poole Jr. and Frank J. Owens
2. Polymer Science" by V. R. Gowariker, N. V. Viswanathan, and Jayadev Sreedhar.

Reference Books

1. Analytical Chemistry" by G. D. Christian and Purnendu Dasgupta.
2. X-ray Diffraction: Its Theory and Applications" by S. K. Chatterjee
3. Spectroscopy of Organic Compounds" by P. S. Kalsi.
4. Characterization of Nanomaterials" by D. N. Sinha
5. *Nanotechnology: Principles and Practices* by Sulabha K. Kulkarni.
6. *Textbook of Polymer Science* by Fred W. Billmeyer
7. *Instrumental Methods of Chemical Analysis* by B.K. Sharma.
8. *Solid State Chemistry* by D.K. Chakrabarty.
9. *Organic Spectroscopy* by Jag Mohan.
10. *Nanoscience and Nanotechnology* by M.S. Ramachandra Rao and Shubra Singh.

Open Educational Resources (OER)

- Gold Nanoparticles Synthesis - YouTube
- Making of Silver Nanoparticles - YouTube
- Interfacial polymerization of polyamide - YouTube
- UNIT-II (PART-6) (PAPER-III) ANALYSIS OF LIMESTONE, DOLOMITE & MAGNESITE (PART-A) - YouTube
- Determination of Crystal Structures by XRD Patterns - YouTube

Assessment & Evaluation

Evaluation components	**Weightage**
Internal marks (Practicals) **I. I. Conduct of experiment** **II. Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Discipline Specific Elective II					
BSCHMC702	**Medicinal Chemistry**	L	T	P	C
Version 1.0		4	0	0	4
Total Lectures	60				
Pre-requisites/Exposure	12^{th} level Chemistry				
Co-requisites	--				

Course Perspective

This course covers key aspects of medicinal chemistry and drug design. It explores bio-physicochemical properties, structural features, and computational techniques for drug development. Students will study drug metabolism, therapeutic agents, and the role of AI in drug discovery. The course also includes rational drug design, molecular docking, and the biophysicochemical properties of specific compounds.

Course Outcomes:

On completion of this course, the student-teacher will be able to:

CO1Understanding: drug properties like acidity, solubility, and Lipinski's Rule that affect how drugs work in the body, structure of drugs and their shapes influence their effectiveness and interactions with biological systems.

CO2Applying: Use computer tools and techniques to analyze drug structures and predict how they will behave in the body.

CO3Analyzing: Study how drugs are processed in the body, including how they interact with enzymes, and understand how AI can help in finding new drugs.

CO4Evaluating: Examine the properties of specific drugs and use rational drug design and docking methods to improve how drugs fit with their targets

Course Content

UNIT A: Bio-physicochemical Properties 15 lecture

Acidity/Basicity, Solubility,Ionization,Hydrophobic Properties, Hydrophilic Properties, Lipinski's Rule, Drug-like Properties, Understanding of Biological Activity Parameters such as Ki, Kd, LD50, EC50, IC50, CC50, ADMET Properties (Absorption, Distribution, Metabolism, Excretion, Toxicity)

UNIT B: Structural Properties and Computational Chemistry 15lecture

Isosterism, Bioisosterism, Non-classical Isosteres, Understanding of 3D Structures with Bond Length, Bond Angle, and Dihedral Angle, Configuration and Conformation with Examples, Stereochemistry in Terms of Biological Response with Examples, Stereoselective Receptors or Enzymes (e.g., muscarinic receptor), Stereochemically Pure Drugs and Racemates, Introduction to Computational Chemistry Techniques:,MolecularModeling, Structure-Based Drug Design, Quantitative Structure-Activity Relationship (QSAR)

UNIT C: Drug Target Understanding and Medicinal Chemistry of Therapeutic Agents 15 lecture

Metabolism, Drug Metabolism, Anti-metabolites, Enzyme Inhibitors, Agonists and Antagonists with Examples, Introduction to Artificial Intelligence in Medicinal Chemistry:, Role of AI in DrugDiscovery, AI Algorithms for Predicting Drug-Target Interactions, Machine Learning for Compound ScreeningIn-Depth Study of Representative Therapeutic Agents:, Anti-infective Agents, Antimalarials, Antibacterial Agents, Antiviral Agents, Anticancer Agents, CNS-acting Drugs, Adrenergic Agents Cholinergic Drugs, Diuretics, Cardiovascular Drugs, Local Anesthetic Agents, Analgesic Agents, Histamine and Antihistamine Agents,

UNIT D: Biophysicochemical Properties of Specific Compounds and Rational Drug Design and Docking Techniques 15 lecture

Steroids and Their Biophysicochemical Properties Prostaglandins and Their Functions, Enzymes, Hormones, and Their Receptors, Pharmaceutical Applications of COX-2 Inhibitors, Vitamins and Their Classification with ExamplesConcepts of Rational Drug Design, Structure-Activity Relationship (SAR), Drug-Receptor Understanding, Molecular Modeling, Structure-Based Drug Design, Introduction to Docking Techniques:, Molecular Docking, Protein-Ligand Interaction Analysis,Role of AI in Drug Docking and Screening

Text books:

1. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, WAlfonsoilliam O. Foye (2008), Kluwer publicKluweration.

Reference Books:

1. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACKPublishing.
2. Burgers Medicinal Chemistry by Manfred E. Wolff, AlfredBurger

3. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6thEdn., 2003, HobokenN.J.Wiley,
4. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2ndEdn., Academic Press.2012.
5. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Hansch C. and Leo, A American Chemical Society(1995)
6. Patrick, G. Medicinal Chemistry, Oxford.UniversityPress(2000)
7. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John MarloweBeale

Open Educational Resources (OER)

- **https://www.youtube.com/watch?v=YAMfmt03oU8**
- **https://www.youtube.com/watch?v=-VNOSGpdBW8**
- **https://www.iit.edu/academics/programs/medicinal-chemistry-bs**
- **http://www.chemguide.co.uk/physical/acidbaseeqia/definitions.html**
- **https://chem.libretexts.org/Courses/Pacific_University/Organic_Chemistry_with_a_Biological_Emphasis**
- **http://mccammon.ucsd.edu/teaching/medchem/**
- **https://www.bbau.ac.in/dept/Chemistry/TM/MCH%20402%20Medicinal%20Chemistry%20(Chapter%20I)%20DoC.pdf**
- **https://pharmaedu.in/medicinal-chemistry-1-notes-pdf/**

Modes of Evaluation:

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

Discipline Specific Elective II					
BSCHMC752	**Medicinal Chemistry Practicals**	L	T	P	C

Version 1.0		0	0	2	1
Total Lectures	**15**				
Pre-requisites/Exposure	12th level Chemistry				
Co-requisites	--				

Course Perspective

This course offers practical experience in advanced chemical techniques and drug synthesis. Students will master purification methods such as fractional and vacuum distillation, thin layer and column chromatography. They will prepare and evaluate acid/base salts of drugs, synthesize and purify various compounds, and utilize computational modeling for drug design. Additionally, students will perform an assay of aspirin, providing hands-on experience in both traditional and computational chemistry methods.

Course Outcomes

On completion of this course, the student-teacher will be able to:

CO1: Observing solvent purification through fractional and vacuum distillation and chromatographic techniques.

CO2: Imitating the preparation and evaluation of acid/basic salts and various compound syntheses.

CO3: Practicing computational drug design and perform drug assays.

Course Content

Practical wok suggested:

1. Purification Techniques of solvents by Fractional Distillation and Vacuum Distillation.
2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by ColumnChromatography.
3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.(Benzilic Acid & Sodium Benzoate)
4. Synthesis & Purification of following Compoundsusing

i). precipitation or Recrystallization. ii) Synthesis of Benzimidazole.

(iii)Synthesis of Anthranilic Acid.(iv)Synthesis of Sulphanilamide.

(v)Synthesis of benzoic acid from benzyl alcohol.(vi)Synthesis of 1,4 – dihydropyridine.

5. Computational modeling of drug design/use of softwares may be demonstrated tostudents
6. To perform Assay of aspirin..

Textbooks:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D.Barnes, M. J. K Thomas, 6th Edition, Pearson's Education Ltd.

Reference Books:

1. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004).
2. Vogel"s Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford ,P.W.G. Smith,

A. R Tatchell, 5th edition (2008), Pearson's Education Ltd

(The list of experiments and books are purly suggestive; University/institute may incorporate further changes in number of experiments and books/refererences (updated version from time to time) based on course design and available infrastructure facilities).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- https://pharmacyinfoline.com/bp406p-medicinal-chemistry-i-practical/
- https://www.miperknlapindia.ac.in/BP406P-medicinal-chemistry1.pdf
- https://www.ipinnovative.com/media/open-access-books/Practical_Lab_Manual_of_Pharmaceutical_Organic_Chemistry_-1_Low.pdf
- https://www.youtube.com/watch?v=D7KrySEKoJI
- https://www.youtube.com/watch?v=lUxkcEoGkVg
- https://www.youtube.com/watch?v=KPnmdwj3SRI
- http://chemcollective.org/
- https://www.khanacademy.org/science/chemistry

Modes of Evaluation:

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

Discipline-Specific Elective II					
BSCHEC704	**Environmental Chemistry**	L	T	P	C
Version 1.0		3	1	0	4
Total Lectures	60				
Pre-requisites / Corequisites	Basics of Environment				

Course Perspective:

This course offers a comprehensive exploration of environmental chemistry, emphasizing the intricate relationships between the atmosphere, hydrosphere, andlithosphere. Through 60 hours of lectures and hands-on activities, students will gain a deep understanding of the biogeochemical cycles, water quality parameters, and atmospheric chemistry. The course will involve active participation, including case studies on environmental pollution, group discussions, and laboratory experiments to analyze water and air samples. Students will also engage in problem-solving activities related to real-world environmental issues, with opportunities for peer collaboration and instructor feedback to enhance their learning experience.

Course Outcomes

On completion of this course, the students will be able to

CO1: Understanding the composition of the atmosphere and the temperature variation in the Earth's atmospheric system, along with biogeochemical cycles of key elements like carbon, nitrogen, phosphorus, sulfur, and oxygen.

CO2: Explaining the hydrological cycle, water quality parameters, and analytical methods used to assess aquatic pollution, including techniques for determining fluoride, chromium, arsenic, and chlorine levels in water.

CO3: Applying knowledge of atmospheric chemistry, including the formation of particles, ions, radicals, and reactions that lead to pollution, such as smog formation and the effects of greenhouse gases and acid rain.

CO4: Analyzing water quality parameters like dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD), as well as methods for water and wastewater treatment processes (primary, secondary, and tertiary).

CO5: Evaluating pollution control strategies, including solid waste treatment, soil and noise pollution management, and the effectiveness of municipal water treatment processes.

Course Content

UNIT I - Environment **15 lecture**

Composition of atmosphere, temperature variation of earth atmospheric system (temperature vs. altitude curve), biogeochemical cycles of C, N, P, S and O system.

UNIT II - Hydrosphere **15 lecture**

Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

UNIT III - Atmosphere **15 lecture**

Chemical composition of atmosphere–particle, ions, and radicals in their formation, chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O and their effect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control.

UNIT IV – Aquatic Chemistry **15 lecture**

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity, pH, alkalinity, hardness) and its determination, Industrial ,municipal water treatment processes, Waste water treatment procedure (primary, secondary and tertiary),Solid waste treatment. Soil pollution and Noise pollution.

Learning Experience:

This course aims to equip students with a thorough understanding of the environmental processes and chemical interactions that shape our planet. The curriculum covers key concepts such as atmospheric composition, water pollution, and waste management, delivered through interactive lectures and practical sessions. Students will engage in analytical methods for determining various pollutants, explore the effects of industrial activities on the environment, and study mitigation strategies. The course will be conducted with a blend of theoretical knowledge and practical application, fostering a participatory learning environment where students can collaborate on projects and receive personalized feedback from instructors.

Textbooks:

1. S. E. Manahan, "Environmental Chemistry," 10th Edition, CRC Press, 2017.
2. Colin Baird, Michael Cann, "Environmental Chemistry," 5th Edition, W. H. Freeman, 2012.

Reference Books:

1. G. Tchobanoglous, F. L. Burton, H. D. Stensel, "Wastewater Engineering: Treatment and Reuse," 4th Edition, McGraw-Hill, 2002.
2. G. W. vanLoon, S. J. Duffy, "Environmental Chemistry: A Global Perspective," 3rd Edition, Oxford University Press, 2010.
3. Stanley E. Manahan, "Fundamentals of Environmental Chemistry," 3rd Edition, CRC Press, 2008.
4. R. A. Horne, "Chemistry of Our Environment," 2nd Edition, Wiley, 1978.

Open Educational Resources (OER):

1. **MIT OpenCourseWare: Environmental Chemistry**
2. Khan Academy: Chemistry of Life
3. **National Environmental Services Center (NESC)**
4. https://www.epa.gov/students
5. https://www.unep.org/learning/
6. https://en.wikibooks.org/wiki/Environmental_Science
7. https://www.noaa.gov/education

Modes of Evaluation:

Evaluation components	Weightage

Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Discipline-Specific Elective II					
BSCHEC754	**Enviromental Chemistry Practicals**	L	T	P	C
Version 1.0		0	0	2	1
Lectures	15				
Pre-requisites/Co-	Basics of water quality parameters				

Course Perspective:

This course on Environmental Chemistry Practicals is designed to provide students with hands-on experience in assessing and analyzing critical water quality parameters. The practical sessions aim to bridge the gap between theoretical knowledge and real-world applications by focusing on the determination of COD, BOD, and DO, which are essential in understanding the health of aquatic systems. By engaging with this course, students will gain valuable skills in environmental monitoring, which are crucial for addressing contemporary environmental challenges such as pollution and waste management. This course not only reinforces the importance of chemical analysis in environmental science but also emphasizes the role of practical chemistry in solving real-world environmental problems

Course Outcomes

On completion of this course, the students will be able to

CO1: Observing how to measure dissolved oxygen in water using different methods.

CO2: Imitating the steps to determine Biological Oxygen Demand (BOD5) and Chemical Oxygen Demand (COD), as well as how to measure chloride, sulfate, and alkalinity through titration.

CO3: Practicing the percentage of available chlorine in bleaching powder and estimating Suspended Particulate Matter (SPM) in air samples.

Course Content

List of suggested laboratory practicals

Determination of water quality parameters in following aspect:

1. Determination of dissolved oxygen in given water (chemical method/instrumentation method).
2. Determination of Biological Oxygen Demand (BOD_5).
3. Determination of Chemical Oxygen Demand (COD).
4. Finding out percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titration method.
7. Estimation of SPM in air samples.

Experiential Learning :

The practical experiments in this course offer an immersive learning experience, allowing students to directly apply their theoretical understanding to real-world scenarios. By determining water quality parameters, students will develop a strong foundation in analytical techniques, essential for environmental monitoring. The hands-on approach fosters critical thinking and problem-solving skills, enabling students to make informed decisions on environmental issues. Moreover, collaborative work in the lab setting encourages teamwork, communication, and the ability to synthesize and present scientific findings effectively.

Textbooks:

1. R.M. Felder & R.W. Rousseau - *Elementary Principles of Chemical Processes*, John Wiley & Sons, Inc. Publishers, New Delhi (2005 edition).

Suggestive Readings:

1. J. A. Kent - *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
2. S. S. Dara - *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd., New Delhi.
3. A. K. De - *Environmental Chemistry*, New Age International Pvt. Ltd., New Delhi.
4. S. M. Khopkar - *EnvironmentalPollution Analysis*, New Age International Publisher, New Delhi
5. Stanley E. Manahan - *Environmental Chemistry*, CRC Press
6. Gary W. vanLoon& Stephen J. Duffy - *Environmental Chemistry: A Global Perspective*, Oxford University Press.
7. B. K. Sharma - *Environmental Chemistry*, Goel Publishing House.
8. O. D. Tyagi & M. Mehra - *Textbook of Environmental Chemistry*, Anmol Publications Pvt Ltd.

Open Educational Resources (OER)

- https://www.khanacademy.org/
- https://www.coursera.org/
- https://ocw.mit.edu/
- https://www.epa.gov/students
- https://www.unep.org/learning/

- https://en.wikibooks.org/wiki/Environmental_Science
- https://www.noaa.gov/education

Evaluation components	Weightage
Internal marks (Practicals) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VII					
	Intellectual property right (IPR) and business skills for chemists	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	SEC010/MOOC				
Total Lectures	30				
Pre-Requisites / Co-Requisites	NA				

Course Perspective

1. To aware the students about the Intellectual Property Rights.
2. To familiarize the students with the different types of IP and importance of protecting IP.
3. To give an understanding of the IP laws in International prospective.
4. To explain the key business concepts and current challenges and opportunities in the market.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Understanding different types of Intellectual Property (IP) and their significance. how copyrights, trademarks, and patents differ, and the processes to obtain each.

CO2: Applying knowledge of geographical indications, industrial designs, and trade secrets to real-world industry scenarios.

CO3: Analyzing the role of international agreements like WTO and TRIPS in global IP protection.

CO4: Evaluating the impact of IP protection on business strategies and public health.

Course Content

UNIT A : Introduction to Intellectual Property 16 Lectures

Introduction to Intellectual Property: Historical Perspective, Different Types of IP, Importance of protecting IP. Copyrights Introduction, How to obtain, Differences from Patents. Trade Marks Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs. Patents Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

UNIT B 14 Lectures

Geographical Indications Definition, rules for registration, prevention of illegal exploitation, importance to India. Industrial Designs Definition, How to obtain, features, International design registration. Layout design of integrated circuits Circuit Boards, Integrated Chips, Importance for electronic industry. Trade Secrets Introduction, Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

UNIT C 16 Lectures

Different International agreements

1. World Trade Organization (WTO):

(i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade related Services (GATS)

(iii) Madrid Protocol

(iv) Berne Convention

(v) Budapest Treaty

2. Paris Convention WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.

UNIT D 14 Lectures

Business Basics Key business concepts: Business plans, market need, project management and routes to market. **Chemistry in Industry** Current challenges and opportunities for the chemistry-using industries, role of chemistry in India and global economies. **Financial aspects** financial aspects of business with case studies.

Learning Experience:

This course combines lectures, interactive sessions, and practical exercises to explore various aspects of intellectual property and its role in business and industry.

- **Instruction Methods:** Core topics, such as intellectual property rights and international agreements, will be taught through multimedia presentations, Q&A sessions, and discussions.

- **Technology Use:** LMS will offer resources, recorded lectures, and discussion forums for further learning.
- **Assessments:** Continuous feedback through quizzes and online discussions, with exams and presentations for final evaluation.
- **Support:** Instructor guidance and peer collaboration will be encouraged, with regular feedback to support student progress.

Text Books

1. V.K AHUJA, Law Relating to INTELLECTUAL PROPERTY RIGHTS, Lexis Nexis.

Reference Books/Materials

1. Guru, M. & Rao, M.B. Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003).
2. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw- Hill (2001).
3. Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).
4. Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, New Delhi.

Open Educational Resources (OER)

1. https://openstax.org/details/books/introduction-business
2. https://www.copyright.gov/
3. https://www.wipo.int/trademarks/en/
4. https://www.wipo.int/designs/en/
5. https://www.wipo.int/treaties/en/
6. https://www.wto.org/index.htm

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VII					**For B.Sc. (Hons. with Research)**
BSCCRW706	**Scientific Report Writing and Presentation skills**	**L**	**T**	**P**	**C**
Version1.0		**3**	**0**	**0**	**3**
Category of Course	**Major**				
Total Contact Hours	**45**				
Pre-Requisites/ Co-Requisites	**Research Methodology/ Basic English proficiency and foundational exposure to scientific studies**				

Course Perspective:

- To build comprehensive skills in scientific and academic writing.
- To develop the ability to critically analyze scientific literature and write research reports and review papers.
- To introduce tools and techniques for citation, referencing, and plagiarism detection.
- To enhance the students' ability to write, format, present, and defend scientific ideas in written and oral form.

Course Outcomes

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

CO1: Understanding the structure, language, and purpose of scientific reports and review papers.
CO2: Applying appropriate formatting, referencing styles, and plagiarism-checking tools in writing scientific documents.
CO3: Analyzing scientific literature to identify research trends, themes, and knowledge gaps for writing a review paper.
CO4: Evaluating scientific sources and visual data representations for accuracy, reliability, and relevance.
CO5: Creating structured scientific reports and review articles with effective graphical representation and oral presentation.

Course Content

Unit I: Introduction to Scientific Writing **5 Lecture Hours**

- Characteristics of scientific writing
- Types: reports, review articles, research papers
- Language, clarity, and tone
- Stages of the writing process

Unit II: Scientific Report Writing **15 Lecture Hours**

Structure of scientific reports: Title, Abstract, Introduction, Method, Results, Discussion

- Review paper writing: thematic organization, literature synthesis
- Tables, graphs, and figures
- **Graphical Tools:**
    - **ChemDraw** – for chemical diagrams
    - **Origin** – for graph plotting and data visualization
    - **PowerPoint** – for visual abstracts and slide design
- Referencing and bibliography
- Use of Mendeley/Zotero

Unit III: Plagiarism & Ethics **7 Lecture Hours**

- Plagiarism and self-plagiarism: definitions and examples
- Plagiarism checks tools: Turnitin, Grammarly, URKUND
- Academic integrity and ethical writing: Informed consent, confidentiality, and privacy, Ethical considerations in qualitative vs. quantitative research, Ethical data management: collection, storage, and sharing, Authorship and intellectual property rights

Unit V: Publishing Process **10 Lecture Hours**

- Understanding journals, impact factor, and indexing
- Choosing appropriate journals and conferences
- Importance of proper citation and common citation styles (Harward, Chicago)
- Avoiding plagiarism through correct attribution
- Understanding the peer review process, writing responses to reviewers and handling editorial feedback, Techniques for self-editing and revising research reports, Preparing and presenting research findings
- Ethical issues in presenting research: avoiding bias and misrepresentation, duplicate submissions, self-plagiarism

Unit IV: Presentation Skills **8 Lecture Hours**

- Preparing and structuring oral presentations
- Creating effective slides and posters
- Non-verbal communication and Q&A handling
- Using PowerPoint and visual aids professionally

Learning Experience

The course will be conducted through a mix of interactive lectures, collaborative problem-solving sessions and following experiential learning activities:

a. Major Assignment – Review Paper Writing:

- Topic selection and approval by instructor
- Review of minimum 10 peer-reviewed articles
- Word limit: 2000–2500 words
- Mandatory plagiarism checks report (<15% similarity index) with submission
- Oral presentation (10 minutes + 5 minutes Q&A)

b. In-Class Exercises:

- Drafting abstracts, writing summaries, referencing practice, paraphrasing

c. Peer Review Workshop:

- Students review each other's drafts using rubrics

d. Mini Presentations on article analysis and referencing tools

Suggested Readings:

1. Day, R.A. & Gastel, B. – How to Write and Publish a Scientific Paper
2. Glasman-Deal, H. – Science Research Writing for Non-Native Speakers of English
3. Booth, W.C., Colomb, G.G., & Williams, J.M. – The Craft of Research
4. Eco, U. – How to Write a thesis
5. Publication Manual of the American Psychological Association (APA, Latest Edition)

Suggested Tools & Platforms:

- Reference Managers: Mendeley, Zotero, EndNote
- Plagiarism Checkers: Turnitin, Grammarly, URKUND
- Writing Tools: LaTeX, MS Word, Grammarly
- Databases for Literature: Scopus, PubMed, ScienceDirect, Google Scholar

Open Educational Resources (OER)

5. **https://www.coursera.org/learn/research-methodologies**
6. **https://www.coursera.org/learn/analysis-and-interpretation-of-data**
7. **https://www.coursera.org/learn/research-methods**
8. **https://www.coursera.org/learn/qualitative-research-methods-capturing-rich-insights**

Evaluation Scheme

Component	Marks

Review Paper (written submission)	40
Plagiarism Check Compliance (<15% similarity)	10
Oral Presentation of Review Paper	20
In-Class Activities & Assignments	20
Quiz on Referencing & Plagiarism Awareness	10
Total	**100**

SEMESTER-VIII

SEMESTER-VIII					
BSBSDR805	**DESSERTATION**	L	T	P	C
Version 1.0		0	0	0	10
Total Lectures	150				
Pre-requisites/Exposure	Practical exposure				
Co-requisites	--				

Course Perspective

This course aims to enhance students' research skills, critical thinking, and problem-solving abilities. It emphasizes effective communication of findings, ethical research practices, and independent learning. Students engage in in-depth literature reviews, data analysis, and interpretation, while contributing to knowledge within their field. The project prepares students for advanced studies or careers by fostering interdisciplinary learning and a deeper understanding of their chosen subject.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able:

CO1:**Understanding** research methodologies and ethical guidelines. existing literature and identify gaps in research.

CO2: **Applying** data collection and analysis techniques effectively.

CO3: **Analyzing** findings to draw meaningful conclusions.

CO4: **Evaluating** the importance of research findings and ethical considerations.

CO5: **Creating** original insights, communicate findings effectively, and advance knowledge in the field.

CONTENT:

1. Students will be divided among faculty members of the Department for the supervision of the research work.

2. In the first week of Semester V, each faculty member will assign a suitable research topic to the students from the selected topics in the areas of chemical sciences.

3. The student will work on the assigned research topic during semesters V and VI in regular consultation with his/her assigned teacher.

4. The student will write a dissertation based on the research work carried out during Semesters V and VI and prepare two copies to be submitted to the office of the Head of the Department duly signed by the student and the supervisor in the sixth week of VI semester or a date decided by the HOD of the department.

5. Before preparing power point presentation and submission of dissertation, each student has to deliver a seminar talk on his/ her research project work on a date fixed by HOD, necessary suggestions has to be incorporated in the final draft of dissertation.

6. The student will make a power point presentation based on the work carried out and mentioned in the dissertation to the board of examiners appointed by the University.

Evaluation scheme for DESSERTATION

Particular	**Weightage**
Internal Marks: - (Punctuality, Performance, Work Ethics, Efforts and Research Output)	50 Marks
External Marks (Practical): - Presentation Report Writing Viva Voce	50 Marks 20 10 20

***(It is compulsory for the student to provide an internship certificate issued by the**

Semester-VIII					
BCCHPC801	**Polymer Chemistry**	L	T	P	C
Version 3.0		3	1	0	4
Total Lectures	**60**				
Category of Course	**Major-XVII- (DSE)**				
Pre-requisites/Exposure	Basics of Chemistry				

Co-requisites	--

Course Perspective:

This course provides a comprehensive introduction to polymer chemistry, focusing on the fundamental principles that govern the synthesis, structure, and properties of polymers. Students will explore the intricate relationships between polymer structure and their macroscopic properties, gaining insights into the classification and characterization of different types of polymers. The course is designed to equip students with the ability to critically analyze industrial polymerization methods and apply modern techniques to evaluate polymer molecular weights, stereochemistry, and other crucial characteristics. Through this detailed study, students will be prepared to engage with both academic research and industrial applications in the field of polymer science.

Course Outcomes

On completion of this course, the students will be able

CO 1: Understanding the fundamental concepts of polymers and their classification.

CO 2: **Analysing** the relationship between polymeric structure and properties.

CO 3: **Applying** advanced techniques for the characterization and identification of polymers.

CO 4: **Evaluating** the various industrial polymerization methods and their significance

Course Content

Unit I: Introduction **lecture: 15**

Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

Unit II: Polymeric Structure and Property Relationship **lecture: 15**

Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Unit III: Polymerization Chemistry **lecture: 15**

Industrial methods of polymerization such as a bulk, solution, emulsion, suspension. Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

Unit IV: Characterization of Polymers **lecture: 15**

Molecular Weight Determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Applications of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Learning Experience Summary

- Lectures: Core concepts in polymer chemistry.
- Interactive Sessions: Q&A, quizzes, and discussions to deepen understanding.

Technology Use:

- LMS: Provides access to lecture materials and discussion forums.
- Virtual Labs: Simulated polymer synthesis and characterization experiments.

Assessments:

- Formative: Regular quizzes and interactive discussions.
- Summative: Exams and lab reports to evaluate comprehension and skills.

Support:

- Instructor: Available through office hours and online consultations.
- Peer Collaboration: Group projects and peer feedback to foster teamwork.

Text Books

1. .W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition ElsevierScientific, Publishing Company Amsterdam - Oxford - Newyork.1990.
2. E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996.

Reference Books:

1. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987
2. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York(1970).
3. W. Billmeyer, Text book of polymer science, 3rdEdn., 2007,Wiley.
4. J.R.Fried, Polymer Science and Technology, (2005), PHIpublication.
5. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers, New York (1962).

Open Educational Resources (OER)

- https://ocw.mit.edu/courses/materials-science-and-engineering/3-042j-introduction-to-polymers-fall-2006/
- http://www.pslc.ws/macrog/maindir.htm
- http://polymerdatabase.com/
- https://www.khanacademy.org/science/organic-chemistry/bond-line-structures-alkanes-cycloalkanes/polymers-organic/v/polymers-introduction
- http://chemcollective.org/activities/simulations/polymerization

Assessment and Evaluation

Evaluation components	Weightage

Internal marks (Theory) I. continuous assessment (40 marks) All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Semester-VIII					
BCCHPC851	**Polymer Chemistry Practicals**	L	T	P	C
Version 3.0		0	0	2	1
Total Lectures	**15**				
Category of Course	**Major-XVII- (DSE)**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Perspective:

This practical course in Polymer Chemistry is designed to provide students with hands-on experience in key experimental techniques fundamental to the field. Students will learn to conduct free radical and emulsion polymerization reactions, gaining insight into the synthesis and properties of various polymers. Through the preparation of phenol-formaldehyde resins and molecular weight determination using viscometry, students will develop a deep understanding of polymer synthesis and characterization. The course also emphasizes the importance of polymer characterization techniques such as FTIR, TGA, and DSC, equipping students with the analytical skills necessary to analyze and interpret experimental data. By bridging theoretical concepts with practicalapplications, this course preparesstudents for advanced studies and careers in polymer science and materials chemistry.

Course Outcomes

On completion of this course, the students will able

CO1: Observing the principles of free radical solution polymerization and understanding key factors that influence the polymerization process.

CO2: Imitating methods to prepare phenol-formaldehyde resins and comparing the factors that affect their reaction mechanisms.

CO3: Practicing techniques to apply viscometer principles and determining the molecular weight of polymers using viscosity measurements.

Course Content

List of Experiments

1. Free radical solution polymerization of anyone: Styrene, methyl methacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (Purification of monomer should be taught)
2. Preparation of phenol-formaldehyde resins
3. Emulsion polymerization of polymethylmethacrylate.
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$solution) by viscometry. (students should be explained regarding principles and use of ubblohde/ostwald viscometer).
5. Estimation of amount of HCHO in each solution by sodium bisulphite method.
6. Use of FTIR/TGA/DSC – for polymer characterization (may be demonstrated to students)
7. Determination of exchange capacity of cation exchange resins and anion exchange resins.

Learning Experience:

Students will engage in a comprehensive learning experience that blends laboratory work with theoretical understanding. The course will be conducted through a series of carefully designed experiments, where students will not only perform polymer synthesis and characterization but also learn to apply critical thinking to analyze results. Instructional demonstrations on complex techniques like FTIR, TGA, and DSC will deepen their understanding of polymer properties. Group work and collaborative problem-solving will be encouraged to enhance teamwork skills, while individual assignments will reinforce their learning. Regular feedback from the course instructor will support students in refining their experimental techniques and understanding of polymer chemistry, ensuring a well-rounded educational experience**.**

Textbooks:

1. P. Munk & T.M. Aminabhavi, "Introduction to Macromolecular Science," 2nd ed., John Wiley & Sons, 2002.
2. M.P. Stevens, "Polymer Chemistry: An Introduction," 3rd ed., Oxford University Press, 2005.

Reference Books:

1. L. H. Sperling, "Introduction to Physical Polymer Science," 4th ed., John Wiley & Sons, 2005.
2. P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. John Wiley & Sons (2002).
3. M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press (2005).

4. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons (2005)

Open Educational Resources (OER)

- https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2007/
- https://www.khanacademy.org/science/organic-chemistry
- https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Electrochemistry/Electrochemical_Processes/Redox_Chemistry/Solubility_and_Complex__Ion_Equilibria__/Chelation_and_Chelating_Agents /Ion-Exchange_Resins
- https://www.opencourselibrary.org/course/analytical-chemistry/
- https://www.coursera.org/learn/polymer-science-engineering
- https://openstax.org/details/books/chemistry

Semester-VIII					
BSCHBI802	**ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Category of Course	**Major-XVII- (DSE)**				
Total Lectures	60				
Pre-Requisites/ Co-Requisites	Basics of transition elements and metal ions present in the biological system				

Course Perspective:

This course offers a comprehensive exploration of the chemistry of 3d transition metals, organometallic compounds, and bioinorganic systems, integral to both fundamental research and industrial applications. Students will delve into the unique oxidation states of 3d metals and study the preparation and properties of significant compounds, gaining a deep understanding of transition metal chemistry. The organometallic unit introduces the concepts of bonding and structure in metal carbonyls and organometallic complexes, emphasizing their roles in catalysis and advanced material synthesis. In bioinorganic chemistry, students will explore the essential functions of metal ions in biological systems, including energy production and physiological processes. This course is designed to build a solid foundation in inorganic chemistry, preparing students for further studies or careers in chemistry and related fields.

Course outcomes (CO)

On completion of this course, the student-teacher will be able to:

CO 1: Understanding the oxidation states and key compounds of 3d metals, including their preparation and properties.

CO 2: Analyzing the structure, bonding, and preparation methods of organometallic compounds, with a focus on metal carbonyls and the concept of synergic effects.

CO 3: Applying knowledge of metal alkyls to understand their structure, bonding, and role in industrial applications, including polymerization and organic synthesis.

CO 4: Evaluating the role of metal ions in biological systems, with emphasis on their biochemical functions in processes such as the Na/K pump, energy production, and blood clotting.

These outcomes reflect the key learning goals for the entire syllabus.

Course Content:

Unit I: Chemistry of 3d metals **14 Lecture**

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,$Na_3[Co(NO_2)_6]$

Unit II: Organometallic Compounds **16 Lecture**

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Unit III: Metal Alkyls **16 Lecture**

Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram

of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit IV: Bioinorganic chemistry: 16 Lectures

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Learning Experience:

Course Structure:

- **Lectures:** Core concepts in ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY.
- **Interactive Sessions:** Q&A, quizzes, and discussions to deepen understanding.

Technology Use:

- **LMS:** Provides access to lecture materials and discussion forums.
- **Virtual Labs:** Simulated polymer synthesis and characterization experiments.

Assessments:

- **Formative:** Regular quizzes and interactive discussions.
- **Summative:** Exams and lab reports to evaluate comprehension and skills.

Support:

- **Instructor:** Available through office hours and online consultations.
- **Peer Collaboration:** Group projects and peer feedback to foster teamwork.

Textbooks:

1. ″Concise Inorganic Chemistry" by J.D. Lee
2. "Advanced Inorganic Chemistry" by F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochma

Reference Books:

1. "Organometallic Chemistry" by R.C. Mehrotra and A. Singh
2. "Principles and Applications of Organotransition Metal Chemistry" by James P. Collman, Louis S. Hegedus, Jack R. Norton, Richard G. Finke
3. "Inorganic Chemistry" by Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr
4. "Principles of Bioinorganic Chemistry" by Stephen J. Lippard and Jeremy M. Berg
5. "Inorganic Chemistry: Principles of Structure and Reactivity" by James E. Huheey, Ellen A. Keiter, Richard L. Keiter
6. "Transition Metals in the Synthesis of Complex Organic Molecules" by Louis S. Heged
7. "The Chemistry of the Metal-Carbon Bond" by Frank R. Hartley and Saul Patai

Open Educational Resources (OERs):

(https://www.khanacademy.org/science/chemistry/transition-metals)

(https://ocw.uci.edu/courses/chem_s21_organometallic_chemistry.html)

(https://www.oercommons.org/)
(https://nptel.ac.in/courses/104/108/104108070)

Assessment and Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) I. continuous assessment (40 marks) All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Semester-VIII					
BSCHBI852	**ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY PRACTICALS**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**2**	**1**
Category of Course	**Major-XVII- (DSE)Practicals**				
Total Lectures	15				
Pre-Requisites/ Co-Requisites	Basics of transition elements and metal ions present in the biological system				

Course Perspective: This laboratory course is designed to provide students with hands-on experience in the synthesis and characterization of key organometallic and coordination compounds, which are foundational in both academic research and industrial applications. Through the demonstration and preparation of Grignard reagents, students will gain insight into the reactivity and applications of organometallic compounds, particularly in the synthesis of dyes like malachite green and crystal violet. The preparation and analysis of Schiff base-metal complexes will enhance students' understanding of coordination chemistry and the use of spectroscopy for structural identification. These practical are integral to developing the technical skills and theoretical knowledge necessary for advanced studies and careers in chemistry, reinforcing the importance of safe laboratory practices and precise experimental techniques.

Course Outcomes:

CO1: Observing methods used for the synthesis of metal complexes and understanding the key processes involved.

CO2: Imitating procedures to apply Grignard reagents in the preparation of dyes and other important compounds.

CO3: Practicing techniques to synthesize Schiff base-metal complexes and evaluate their applications in water purification.

Course Content:

List of Laboratory experiments

(Necessary infrastructure may be developed and adequate precaution should be maintained to conduct such experiments; instructor may demonstrate the experiment to students)

1. Reaction of metal with halide – preparation of Grignard reagent. (only demonstration purpose)
2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethyl carbonate) (starting material as p-bromo N, N-dimethyl aniline) (only demonstration purpose)
3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.
4. Preparation of any two of the following complexes and measurement of their conductivity measurement:

Tetraamminecarbonatocobalt (III) nitrate

Tetraamminecopper (II)sulphate

Potassium trioxalatoferrate (III) trihydrate

Learning experience:

In this laboratory course, students will gain a rich, hands-on learning experience by engaging in the synthesis and analysis of key organometallic and coordination compounds. Through instructor-led demonstrations of Grignard reagent preparation and its application in dye synthesis, students will observe critical reactions and techniques fundamental to organometallic chemistry. They will then actively participate in the preparation of Schiff base-metal complexes, applying spectroscopic methods to identify their structures and assess their potential in practical applications like water purification. This course emphasizes collaborative learning, safety, and the development of precise analytical and instrumental skills, ensuring that students are well-prepared for advanced studies and professional challenges in chemistry.

Text books:

1. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7thEdn.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall,

(Note: A candidate must perform at least eight experiments in the lab. Any suitable experiment may be added)

Suggestive Readings:

1. Synthesis of organometallic compounds: A practical guide, S. Komiya,Wiley.
2. "Inorganic Chemistry" by J.D. Lee
3. "Advanced Inorganic Chemistry" by F. Albert Cotton, Geoffrey Wilkinson, "Concise Inorganic Chemistry" by J.D. Lee
4. "Organometallic Chemistry" by R.C. Mehrotra and A. Singh
5. "Principles and Applications of Organotransition Metal Chemistry" by James P. Collman, Louis S. Hegedus, Jack R. Norton, and Richard G. Finke
6. "Comprehensive Organometallic Chemistry" by Geoffrey Wilkinson, F. Gordon A. Stone, and E. W. Abel

Open Educational Resources (OER):

- (12) UTSC - Chemistry Lab Grignard Reaction Experiment - YouTube
- (12) Malachite Synthesis: General Chemistry Lab 6 - YouTube
- (12) Gram stain: Preparing Crystal Violet - YouTube
- (12) Synthesis and Characterization of Metal Complexes with Schiff Base Ligands (An UG Lab. Exp.) - YouTube
- (12) [Co(NH3)4CO3] Synthesis of - YouTube
- (12) TETRAAMMINECOPPER(II) SULFATE ([Cu(NH3)4]SO4.H2O) EXPERIMENT - YouTube
- (12) ChemLab - 5. Preparation and Analysis of Potassium Trioxalatoferrate (III) Trihydrate - YouTube

Assessment & Evaluation:

Evaluation components	**Weightage**
Internal marks (Practicals) **I. Conduct of experiment** **II. Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practicals): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Note: If student will unable to get 75% marks to approach B.Sc. Chemistry with research, then he/she may opt B.Sc. (Honours) Chemistry after taking 12 Credits special subjects

SEMESTER-VIII					
BSCHDF803	**Chemistry of d and f-block elements and Bioinorganic Chemistry**	L	T	P	C
Version 2.0		4	0	0	4
Category of Course	**Major-XVI**				
Pre-requisites/Exposure	Basics of Transition and inner transition elements				
Co-requisites	--				

CatalogPerspective

In this course students will learn and understand the general information about the transition and inner transition elements, their characteristic properties, electronic and magnetic behavior and will be able to draw the orgal energy level diagram for d and f block elements. This course also helps them to get idea about the applications and to determine the term symbols for d and f block elements. This will also provide stereochemical information and separation methods.

Course Outcomes

On completion of this course, the students will be able

CO1:**Understanding**: general properties and characteristics of transition elements and their coordination chemistry, ligand field theory, including the splitting of d orbitals in low symmetry environments and the John-Teller effect, as well as their implications for electronic spectra.

CO2:**Applying**: Calculate the Dq, B, and β parameters for transition metal complexes and interpret their electronic spectra, including charge transfer and d-d transitions.

CO3:**Analyzing**: Compare and contrast the characteristics and behaviors of lanthanides and actinides, including the lanthanide contraction and their electronic and magnetic properties.

CO4:**Evaluating**: Assess the roles of metal ions in biological systems, focusing on their transport and storage mechanisms, as well as the functions of metal-containing enzymes and proteins.

Course Content

Unit I: Chemistry of transition elements **12 Lectures**

General characteristic properties of transition elements, co-ordination chemistry of transition metal ions, stereochemistry of coordination compounds, ligand field theory, splitting of d orbitals in low symmetry environments, John- Teller effect, Interpretation of electronic spectra including charge transfer spectra, spectrochemical series, nephelauxetic series, metal clusters, sandwich compounds, metal carbonyls.

Unit II: Electronic Spectra and Magnetic Properties of Transition Metal Complexes:**16 Lectures**

Types of electronic transition, selection rule of d-d transition, Spectroscopic ground states, correlation, Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), Calculation of Dq, B and β parameters, Charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

Unit III: General characteristics of Lanthanides and Actinides: **14 Lectures**

Lanthanide contraction and its consequences, Term symbols for Lanthanide ions, Factors that mitigate against the formation of lanthanide complexes, Electronic spectra and magnetic properties of lanthanide complexes, Lanthanide complexes as shift reagents, Difference between 4f and 5f orbitals, Spectral and magnetic properties, use of lanthanide compounds as shift reagents, Modern methods of separation of lanthanides and actinides.

Unit IV: Bioinorganic Chemistry **10 Lectures**

Role of alkali and alkaline earth metal ions in biology; Na+ -K + -Pump, ionophores and crown ethers. Metal site structure, function. Metal ion transport and storage: Ferritin, Transferrin, Siderophores and metallothionein. Electron Transfer: Cytochromes, Iron-Sulfur Proteins and Copper Proteins. Oxygen transport and storage: Hemoglobin, myoglobin, hemerythrin, hemocyanin. Other metal containing enzymes: Catalase, peroxidase, superoxide dismutase, alcohol dehydrogenase, carbonic anhydrase, carboxypeptidase, xanthine oxidase, nitrogenase, vitamin B12 coenzyme.

Learning Experience Summary

Course Structure:

- **Lectures:** Core concepts in transition and bioinorganic chemistry.
- **Interactive Sessions:** Engaging Q&A, quizzes, and discussions to enhance understanding.

Technology Use:

- **LMS:** Access to lecture materials, supplementary resources, and discussion forums.
- **Virtual Labs:** Simulated experiments for studying electronic spectra and magnetic properties of transition metal complexes.

Assessments:

- **Formative:** Frequent quizzes and interactive discussions to reinforce learning.
- **Summative:** Exams and project reports to assess comprehension and application of concepts.

Support:

- **Instructor:** Available during office hours and for online consultations.
- **Peer Collaboration:** Group projects and peer reviews to promote teamwork and collaborative learning.

Text Books

1. J D Lee, Concise Inorganic Chemistry (ELBS with Chapman and Hall, London)

Reference Books/Materials

1. Jones , Elementary coordination Chemistry (Prentice-Hall)

2. R S Drago, Physical Methods in Inorganic Chemistry (International Edn. (1971), Affiliated East-West Press, New Delhi)
3. Williams, an Introduction to Bioinorganic Chemistry (C.C. Thomos Spring III)
4. Eichhorn, Inorganic Biochemistry: Vol I , 2 (Elsevier)
5. F A Cotton, R G Wilkinson. Advanced Inorganic chemistry(John Wiley & Sons)
6. Willam L Jooly, Modern Inorganic Chemistry(McGraw-Hill Inc.,US)
7. N. N. Greenwood and A. Earnshaw, Chemistry of elements (Pergamon)
8. John Wulff, structure and properties of materials, vol – 4, electronic properties (Wiley Eastern)
9. J Jones Chris, d- and f- Block Chemistry (WielyInterscience& RSC)
10. Ochiai, Bioinorganic Chemistry (Allyn & Bacon Burton)
11. Ahuja, Chemical Analysis of the Environment (Plenum press)

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Semester-VIII					
BSCHSC805	**STEREOCHEMISTRY, REACTION MECHANISMS AND INTERMEDIATES**	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	**Major-XVI**				
Pre-requisites/Exposure	Basics of reaction mechanism				
Co-requisites	--				

Course Perspective

This course is a bunch of organic chemistry basics. In this course stereochemistry of organic compounds, geometrical isomerism and conformations are available. This course also have details of reaction mechanism with reaction intermediates.

Course Outcomes

On completion of this course, the students will be able

CO1. **Understanding**: stereochemical concepts, including optical and geometrical isomerism, and describe various projection formulae such as Fischer, Newman, and sawhorse.Explain the principles of optical isomerism, including chirality, optical activity, racemization, and resolution methods, as well as the significance of asymmetric synthesis.

CO2. **Applying**: Utilize E-Z notation and cis-trans terminology to distinguish geometrical isomers, and demonstrate the ability to analyze conformational changes in alkanes, including the conformers of cyclohexane.

CO3**Analyzing**: Examine the stability and reactivity of reactive intermediates such as carbocations, carbanions, and free radicals, including their mechanisms of formation and rearrangement.

CO4**Evaluating**: Assess the reactivity and synthetic applications of carbenes and nitrenes, including their roles in organic synthesis through various rearrangement reactions and bond insertions.

.**Course Content**

Unit I: Stereochemistry **12 Lectures**

Definition and classification into optical and geometrical isomerism; Projection formulae: Fischer, flying wedge, sawhorse and Newman projection formulae; Notation of optical isomers: D-L notation, Cahn-Ingold-Prelog rules, R-S notations for optical isomers with one and two asymmetric carbon atoms, erythro and threo representations.

Optical isomerism: optical activity, optical and specific rotations ; Conditions for optical activity: Asymmetric centre , chirality , achiral molecules, meaning of (+) and (-),elements of symmetry; Racemisation: Methods of racemisation (by substitution and tautomerism); Resolution: Methods of resolution (mechanical, seeding, biochemical and conversion to diastereoisomers) ; Asymmetric synthesis (partial and absolute synthesis); Optical activity in compounds not containing asymmetric carbon atoms- Biphenyls.

Unit II: Geometrical isomerism **8 Lectures**

Geometrical isomerism : cis-trans, syn-anti and E-Z notations ;Geometrical isomerism in maleic and fumaric acids and unsymmetrical ketoximes; Methods of distinguishing geometrical isomers using melting point, dipole moment, dehydration and cyclisation.

Conformational analysis: Introduction of terms - conformers, configuration, dihedral angle, torsional strain; Conformational analysis of ethane and n-butane including energy diagrams ; Conformers of cyclohexane (chair, boat and skew boat forms) ; Bonds-ring flipping showing axial equatorial interconversions; Conformation of methyl cyclohexane.

Unit III: Reaction Mechanism and Reactive Intermediates-I **6 Lectures**

A review of reaction mechanism including methods of determination. Linear free energy relationships and their applications (Hammett equation and modification)

Carbocations: Classical and non-classical, neighbouring group participation, ion-pairs, molecular rearrangements in acyclic, monocyclic and bicyclic systems, stability and reactivity of bridge- head carbcations.

Carboanions: Generation, structure and stability, ambient ions and their general reactions; HSAB principle and its applications.

Unit IV: Reaction Mechanism and Reactive Intermediates-II 14 Lectures

Carbenes: Stability, structure and spin states of carbenes; Cyclopropanation – spin dependence and stereochemistry; Carbene insertion to C-H bonds; Rearrangement to alkenes; Wolff rearrangement of acylcarbenes and its synthetic applications.

Nitrenes: Stability, structure and spin states of nitrenes; C-H bond insertions and aziridine formation; Rearrangement of acylnitrenes (Hoffmann, Curtius and Schmidt reactions with applications in organic synthesis).

Free Radicals: Stability and fate of organic free radicals; Metal-induced radical reactions; Radical cyclisation and coupling reactions; Addition to multiple bonds; Aromatic substitution by radicals; Allylic bromination by N- bromosuccinamide and decarboxylative bromination; Mechanism of radical reactions.

Learning Experience Summary

Course Structure:

- Lectures: Fundamental concepts in stereochemistry and reaction mechanisms.
- Interactive Sessions: Engaging Q&A, quizzes, and discussions to enhance understanding.

Technology Use:

- LMS: Access to lecture materials, visual aids for projection formulae, and discussion forums.
- Virtual Labs: Simulated experiments for conformational analysis and reaction mechanisms.

Assessments:

- Formative: Regular quizzes and interactive discussions to reinforce learning.
- Summative: Exams and project reports to assess comprehension and application of concepts.

Support:

- Instructor: Available during office hours and for online consultations.
- Peer Collaboration: Group projects and peer reviews to promote teamwork and collaborative learning.

Textbooks:

1. E L Eliel, Stereochemistry of Carbon compounds (Textbook Publishers)
2. P. S. Kalsi, Stereochemistry and Mechanism through solved problems (New Age publishers)

Reference Books:

1. F A Carey & R J Sundberg, Advanced Organic Chemistry, Part-A and B (Plenum, US)
2. I L Finar & A L Finar, Organic Chemistry, Vol. 2 (Addison- Wesley)
3. I L Finar, Organic Chemistry, Vol. 1 (Longman)
4. J March, Advanced Organic Chemistry (John Wiley & Sons)

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER -VIII					
BSCHTD807	**Thermodynamics and Electrochemistry**	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	**Major-XVI**				
Pre-requisites/Exposure	Basics of Physical Chemistry (Graduation level)				
Co-requisites	--				

Course Perspective

In this course students will be exposed to the concept and theory based on the thermodynamic properties of materials. They will also study the thermodynamic functions and the relation with electrochemistry.

Course Outcomes

On completion of this course, the students will be able to

CO1. **Understanding**: ideal and non-ideal solutions, Raoult's law, and Gibbs-Duhemequation.Explain chemical potential, phase transitions, and Maxwell relations.

CO2. **Applying**: Use statistical thermodynamics to analyze gas behavior and calculate properties.

CO3. **Analyzing**: Differentiate between partition functions and apply spectroscopic data.

CO4. **Evaluating**: Assess activity coefficients in electrochemistry using Debye-Hückel theory.

Course Content

Unit I: 8 Lectures

Introduction, revision of basic concepts: Ideal and non-ideal solutions, Rault's law. Duhem-Margules equation and its applications to vapor pressure curves (Binary liquid mixture). Extensive and intensive properties. Gibbs-Duhem equation and its applications to study of partial molar quantities. Henry's law.

Thermodynamics of nonelectrolyte solutions. Excess and mixing thermodynamic properties. Entropy and third law of thermodynamics. Methods of determining the practical absolute entropies.

Unit II: 12 Lectures

Entropies of phase transition. Maxwell relations, thermodynamic equation of state, chemical potential, variation of chemical potential with temperature & pressure. Equilibrium constants and general conditions of equilibrium in terms of thermodynamic potentials.

Statistical Thermodynamics: Weights and configurations, the most probable configuration, thermodynamic probability and entropy: Boltzmann – Planck equation. Ensembles, ensemble average and time average of property. Maxwell-Boltzmann (MB) distribution law and its application to viscosity and diffusion of gases. Partition function and its significance.

Unit III: 8 Lectures

Rotational, translational, vibrational and electronic partition functions. Use of spectroscopic data for evaluation of various partition functions. Relationship between partition function and thermodynamic properties. Sackur tetrode equation. Calculation of equilibrium constant using Partition function.

Unit IV: 12 Lectures

Electrochemistry: Electrochemistry of solutions. Activity coefficients and ion-ion interactions. Physical significance of activity coefficient. Mean activity coefficient of an electrolyte and its determination. Derivation of Debye-Huckel theory of activity coefficients (both point ion size and finite ion size models)

Text Books

1. S Glasstone, An Introduction to Electrochemistry (Maurice Press)
2. J O M Bockris and A K N Reddy, Modern Electrochemistry Vol. I & II (Springer US)

Reference Books/Materials

1. H K Moudgil, Text book of Physical Chemistry (Prentice-Hall)
2. R C Srivastava, S K Saha and A K Jain, Thermodynamics A Core Course (Prentice-Hall of India)
3. L K Nash, Elements of statistical thermodynamics (Addison Wesley)
4. S Glasstone, Thermodynamics for Chemists (D Van Nostrand)

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER -VIII					
BSCHIC853	**Inorganic Chemistry-I Lab**	L	T	P	C
Version 1.0		0	0	2	1
Category of Course	**Major- XVI Practical**				
Pre-requisites/Exposure	Basics of Inorganic Complex preparation				
Co-requisites	--				

Course Perspective

This course imparts the basic concepts of inorganic complex preparation which enable them to perform experiment by using a suitable synthetic procedure. This course helps them to get experience of working as a chemist on individual level or in a group to perform scientific experiments. The course also introduces the preparation of complex organometalliccomplexes.

Course Outcomes

On completion of this course, the students will be able

CO1 (Observing): Recognize the synthesis procedures and chemical properties of Prussian Blue and Reineckes salt.

CO2 (Imitating): Imitate the preparation of potassium trioxalato ferrate (III) and analyze its crystallization process.

CO3 (Practicing): Practice the synthesis of sodium hexanitrocobaltate (III) and bis(acetylacetonato) complexes of Cu(II) and Co(II).

Course Content

Preparations of Inorganic Complex Compounds: 15 Labs

1. Prussian Blue (Potassium Ferric Ferro cyanide)
2. Reineckes salt (Ammonium diammine tetra thiocyanato chromate (III))
3. Potassium tri oxalato ferrate (III) trihrdrate.
4. trans-potassium di aqua bis(oxalato) chromate (III)
5. cis-potassium di aqua bis (oxalato) chromate (III)
6. Sodium hexanitritocobaltate (III)
7. tris (acetylacetonato) manganese (III)
8. Bis(acetylacetonato) complexes of Cu(II), Co(II)
9. $[Cr(NH_3)_6]Cl_3$
10. $[Ti(urea)_6]I_3$
11. Organotin complexes

Text Books

1. A I Vogel, A text book of Quantitative Inorganic Analysis (Prentice Hall)

Reference Books/Materials

1. W G Palmer, Experimental Inorganic Chemistry (Cambridge : University Press)
2. W R Schoeller and A.R. Powell, The analysis of minerals and ores of the rarer elements (Charles, Griffin and Company Limited)
3. G Pass & H Sutcliffe, Practical Inorganic Chemistry (Chapman Hill)
4. O. P. Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.

SEMESTER -VIII					
BSCHOC855	**Organic Chemistry-I Lab**	L	T	P	C
Version 1.0		0	0	2	1
Category of Course	**Major- XVI Practical**				
Pre-requisites/Exposure	Basics of reaction mechanism				
Co-requisites	--				

Course Perspective

This course comprise of identification of binary mixtures of organic compounds. This course also provides hands on experience of doing some specialized reactions.

Course Outcomes

On completion of this course, the students will be able to

CO1 (Observing): Recognize the techniques for purifying binary mixtures using Thin Layer Chromatography (TLC) and Column Chromatography (CC).

CO2 (Practicing): Practice single-stage organic preparations through various reactions, including oxidation, Cannizzaro reaction, aldol condensation, and Sandmeyer reaction.

CO3 (Creating): Create compounds such as cinnamic acid and coumarin through specific reactions like Perkin's and Knoevenagel condensation.

Course Content

List of experiments:

1. Purification of binary mixtures by Thin Layer Chromatography (TLC) and Column chromatography (CC).
2. Single stage organic preparations involving various types of reactions

a) Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol/ P-benzoquinone from hydroquinone
b) Cannizzaro reaction: 4-chlorobenzyldehyde as a substrate.
c) Aldol condensation: Dibenzal acetone from benzaldehyde.
d) Sandmeyer reaction: p- Chlorotoulene from p-toluidine/ o-chlorobenzoic acid from anthranillic acid
e) Preparation of cinnamic acid by perkin's reaction
f) Knoevenagel condensation reaction
g) Coumarin Synthesis

h) Synthesis of p-Nitroaniline and p- bromoaniline(Aromatic electrophilic substitutions)

3. Qualitative Analysis of Binary Mixtures (only two)

(Any suitable Expt. may be added)

Text Books:

1. B S Furniss, A J Hannaford, P W G Smith and A R Tatchel, Vogels Textbook of Practical Organic Chemistry (ELBS with Longman, Longman Singapore Publishers Pt. Ltd, Singapore.)
2. F G Mann and B C Saunders Dorling, Practical organic chemistry (Kindersley (India) Pvt Ltd., New Delhi)

Reference Books:

1. H T Clarke, A Handbook of organic analysis: Qualitative and quantitative (E. Arnold and Co., London)

SEMESTER -VIII					
BSCHPC857	**Physical Chemistry-I Lab**	L	T	P	C
Version 1.0		0	0	2	1
Category of Course	**Major- XVI Practical**				
Pre-requisites/Exposure	Basics of reaction mechanism				
Co-requisites	--				

Course Perspective

This course imparts the basic concepts and protocols of potentiometry, conductometry, thermodynamics and refractometry. It enables students to perform several diverse types of titrations that can be done making use of potential measurements and conductance measurements. The course also includes experimental ways find out heat of several processes, like, dilution, dissolution, and fusion.

Course Outcomes

On completion of this course, the students will be able

CO1 (Observing): Recognize the principles of potentiometry by determining the solubility and solubility product of silver halides and analyzing binary mixtures of weak and strong acids.

CO2 (Practicing): Practice conductometric techniques to determine the relative strength of weak acids and perform conductometric titrations of weak acids with strong bases.

CO3 (Applying): Apply Kolhrausch's Law to determine equivalent conductance at infinite dilution for strong electrolytes and weak acids, and calculate the dissociation constant for weak acids conductometrically.

Course Content

List of experiments:

1. Potentiometry: Determination of solubility and solubility product of silver halides, determination of binary mixture of weak and strong acid etc.
2. Conductometry: Determination of mixture of acids and relative strength of weak acids.
3. Conductometric titration of a weak acid with strong base.
4. Conductometric titration of a mixture of weak and strong acids
5. To determine equivalent conductance at infinite dilution of strong electrolytes and Weak acid by using Kolharausch Law and dissociation constant for weak acid conductometrically.
6. Refractometry: Determination of molecular radius of molecule of organic compound.
7. Thermochemistry Determination of heats of dilution and integral heat of solutions.
8. Latent heat of Fusion Determination of latent heat of fusion of a given solid.
9. Determine the solubility and solubility product of an insoluble salt, AgX (X=Cl, Br) potentiometrically.
10. Titrate potentiometrically solution of KCL/KBr/KI

Text Books

1. B Viswanathan and P S Raghavan, Practical Physical Chemistry (Viva books)

Reference books

1. V D Athawale and Parul Mathur, Experimental Physical Chemistry (New Age International Pvt. Ltd.)
2. A Finlay and J A Kitchener, Practical Physical Chemistry (Longman)

SEMESTER -VIII					
BSCHOM804	**Boron, silicates and organometallic compounds**	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	**Major-XVII**				
Pre-requisites/Exposure	Chemical properties of B, Si and organometallic compounds				
Co-requisites	--				

Course perspective

Various organometallic compounds are synthesized as they are used for several applications such as pesticides, food, cosmetics, essential oils, fats and oils, medicines, paints and varnishes, polymers etc. It is important to understand the structure and bonding in those compounds. In this course students will be able to learn and understand the characteristic properties, structures and bonding in boron and silicon based compounds. This course also helps them to get idea about the applications and research importance of clays and zeolites.

Course Outcomes

On completion of this course, the students will be able

CO1:**Understanding**: key concepts related to boron compounds, silicates, and organometallics, including classification and nomenclature, structures, properties, and bonding of boron compounds and silicates, including their applications in catalysis.

CO2:**Applying**: Demonstrate the ability to synthesize and characterize various organometallic compounds and assess their significance in organic synthesis.

CO3: **Analyzing**: Compare and contrast different types of organometallic complexes based on ligands and discuss their reactivity in synthetic applications.

CO4: **Evaluating**: Assess the synthetic applications of organometallic reagents, including their roles in C-C bond coupling reactions and various catalytic processes.

Course Content

Unit I: Chemistry of Boron compounds: **14 Lectures**

Chemistry of inorganic rings, cages and metal cluster compounds, borazines, phosphazenes, polyhedral boranes, higher Boranes, carboranes, metalloboranes and metallocarboranes; Classification, Nomenclature, preparation, structure and bonding.

Unit II: Silicates and aluminosilicates: 16 Lectures

Classification, structure, properties and applications of naturally occurring silicates and aluminosilicates. Synthesis of pillared clays and zeolites.

Characterization of clays, pillared clays and zeolites from measurement of surface area, surface activity, pores size distribution and interlayer spacing.

Application of clays, pillared clays and zeolites with emphasis of catalysis.

Unit III: Organometallics-I: 14 Lectures

General Introduction, Structure and bonding, importance of organometallic chemistry, Survey of Organometallic complexes according to ligands. π bonded organometallic compounds including carbonyls, binary carbonyls, mixed metal polynuclear carbonyls; nitrosyls, tertiary phosphines, hydrides, alkene, alkyne, cyclobutadiene, cyclopentadiene, arene compounds and their M. O. diagrams.

Unit IV: Organometallics-II: 12 Lectures

Synthetic Applications of Organometallic Reagents, Reagents and Applications of Organotransition element reagents (viz. Pd-coupling reactions, Pauson Khand, Rh-cyclopropanation, olefin metathesis, Tebbe's, Ziegler-Natta, McMurry, Wilkinson, Schrock, other reductions, etc.), Organo-Sn, Organo-Ti, Grignard, Organo-Pb, etc., Carbenes.Applications of organometallics in organic synthesis; C-C bond coupling, reactions (Heck, sangoshira, Suzuki); Reduction using transition metal hydrides, asymmetric hydrogenation. Olefin metathesis.

Text Books

1. Inorganic Chemistry (5th Edition, Oxford University Press, Oxford)
2. D M Adams, Inorganic Solids: An Introduction to Concepts in solid- Wells A.F., Structural state Structural Chemistry (John Wiley and Sons, London).

Reference Books/Materials

1. G E Coates, M L H Green & P Powell, Principles of Organometallic chemistry, (Chapman & Hall: UK)
2. Tristram Chivers, Ian Manners, Inorganic Rings and Polymers of the p-Block Elements : From Fundamentals to Applications (Royal Society of Chemistry)
3. P Braunstein, L A Oro and P R Raithby (editors), Metal Clusters in Chemistry (Wiley-VCH)
4. J D Woollins, Non-Metal Rings, Cages and Clusters (John Wiley & Sons)
5. L V Azaroff, Introduction to solids (Tata McGraw Hill Publishing Co. Ltd. Bombay-New Delhi)
6. G L Miessler and D A Tarr, Inorganic Chemistry (Pearson, Delhi)
7. B Douglas, D H Mc Daniel and J J Alexander, Concepts and Models of Inorganic Chemistry (John Wiley and Sons, New Delhi)
8. D W Breck, Zeolites Molecular Sieves- Structure, Chemistry and Use (John Wiley & Sons, N. Y.)
9. M L H Green, Organometallic compounds (Chapman & Hall: UK)

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examinationto secure minimum passing grade

SEMESTER -VIII					
BSCHSO806	**Spectroscopy of Organic Compounds**	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	**Major-XVII**				
Pre-requisites/Exposure	Graduation level Chemistry				
Co-requisites	--				

Course Perspective: Spectroscopy is a very powerful tool used for characterization and identification of structure of organic compounds. Good understanding of this spectroscopy will enable students to decipher the structure of organic compounds by simple analysis of IR/NMR and mass spectra. The technique is also beneficial to distinguish geometric isomers, stereoisomers and help in finding purity of compounds.

Course Outcomes

On completion of this course, the students will be able to

CO1Understanding: UV-VIS and infrared spectroscopy, including Beer-Lambert's Law, chromophores, and characteristic vibrational frequencies of functional groups**,** Explain the principles of electronic transitions, including the Frank-Condon Principle, and the significance of chemical shifts and spin-spin coupling in NMR spectroscopy.

CO2Applying: Utilize UV-VIS and IR spectroscopy techniques for structural elucidation of organic compounds and analyze spectral data to identify functional groups.

CO3Analyzing: Interpret ^{13}C-NMR spectra, including resolution, multiplicity, and coupling effects, and assess complex spectra using advanced techniques such as DEPT and 2D-NMR.

CO4Evaluating: Assess mass spectrometry techniques, including methods of ionization and fragmentation patterns, to determine the molecular structure and identify organic compounds.

Course Content

Unit I: UV-VIS and Infrared spectroscopy

Beer – Lambert's Law and molar extinction coefficient; Oscillator strength and intensity of the electronic transition; Frank Condon Principle; Ground and first excited electronic states of diatomic molecules; Relationship of potential energy curves to electronic spectra; Chromophores, auxochromes, blue shift, red shift, hypo and hyperchromic effect; Transitions in organic molecules; Woodward rules for conjugated dienes, unsaturated carbonyl groups and extended conjugation aromatic systems, Quantitative applications.

Introduction to Infrared spectroscopy; Nature of radiation; Energies corresponding to various kinds of radiation; Experimental techniques; Intensities of spectral lines; Selection rules and transition moments; Characteristic vibrational frequencies of different functional groups; Effects of H-bonding and solvent effect on vibrational frequency; Application of IR for structural elucidation.

Unit II: Nuclear magnetic resonance spectroscopy-I

PMR: Natural abundance of ^{13}C, ^{19}F and ^{31}P nuclei; The spinning nucleus; Effect of external magnetic field; Precessional motion and frequency; Energy transitions; Chemical shift and its measurements; Factors influencing chemical shift; Anisotropic effect; Spin-spin coupling: Splitting theory, one, two and three bond coupling, virtual, long range and allylic coupling; Coupling constant; Factors affecting the coupling constant; Chemical and magnetic equivalence; First and second order spectra: A_2, AB, AX, AB_2, AX_2, A_2B_2 and A_2X_2 spin systems; Simplification of complex spectra (solvent effect, field effect, double resonance and lanthanide shift reagents); Continuous Wave and Fourier Transform NMR;

Relaxation processes; T1 and T2 measurements; Applications of PMR in structural elucidation of simple and complex compounds.

UNIT III: Nuclear magnetic resonance spectroscopy-II

^{13}C-NMR: Resolution and multiplicity of ^{13}C NMR; ^{1}H-decoupling, Noise decoupling; Broad band decoupling; Deuterium, fluorine and phosphorus coupling; origin of nuclear overhauser effect; Off-resonance, proton decoupling; Structural applications of ^{13}C-NMR.; Pulse sequences, pulse widths, spins and magnetization vectors; Distortionless Enhancement by Polarization Transfer (DEPT) ; Insensitive nuclei enhanced by polarization transfer (INEPT) Introduction to 2D-NMR: Correlation spectroscopy (COSY) and Nuclear overhauser effect spectroscopy (NOESY) spectra.

Unit IV: Mass spectra

Introduction, methods of ionization EI & CI; Brief description of LD, FAB, SIMS, FD etc.; Ion analysis methods (in brief); Isotope abundance; Metastable ions; General rules predicting the fragmentation patterns; Nitrogen rule; Determination of molecular ion peak; Fragmentation patterns for aliphatic compounds, amines, aldehydes, Ketons, esters, amides, nitriles, carboxylic acids, ethers, aromatic compounds etc.

Textbooks:

1. Y R Sharma, Elementary Organic Spectroscopy (S. Chand)
2. W Kemp, Organic Spectroscopy (McMillan Press Ltd, London)

Reference Books:

1. C N Banwell and E M McCash, Fundamentals of Molecular Spectroscopy (Tata McGraw- Hill, New Delhi)
2. R M Silverstein, G C Basseler and T C Morill Spectroscopic Identification of Organic Compounds (John Wiley and sons, Inc. New York)
3. J R Dyer, Applications of Absorption Spectroscopy of Organic Compounds (Prentice Hall)

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER -VIII					
BSCHQK808	**Quantum Chemistry and Chemical Kinetics**	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	**Major-XVII**				
Pre-requisites/Exposure	Basics of Physical Chemistry				
Co-requisites	--				

Course Perspectives: This course imparts the basic concepts of quantum chemistry and chemical kinetics. It enables the students to understand wave functions and principles based on quantum chemistry. They will be exposed to several quantum mechanical operators with special emphasis on linear and angular momentum operators. The course will discuss the rate of chemical reactions and the laws used in chemical kinetics. The students will also learn about the concepts of enzyme catalysis and its mathematical treatment.

Course Outcomes

On completion of this course, the students will be able

CO1**Understanding**: quantum mechanics, such as the uncertainty principle and the Schrödinger equation., wave functions, eigenvalues and eigenfunctions, as well as the basics of electronic spectra.

CO2**Applying**: Use rate laws to calculate and analyze the rates of different chemical reactions and apply quantum mechanics to understand electronic transitions in molecules.

CO3**Analyzing**: Investigate what factors affect reaction rates and how different types of reactions behave under various conditions.

CO4**Evaluating**: Examine complex reactions, including chain reactions and enzyme catalysis, and understand how to apply models like the Michaelis-Menten equation to predict reaction outcomes.

Course Content

Unit I: **8 Lectures**

Uncertainty principle, postulate of quantum mechanics, properties of wave functions, Schrodinger equation, wave function and its interpretation. Normalization and orthogonality, Eigen functions and Eigen values. Solutions of wave equation for a free particle and particle in a box problem. Transition dipole moment integral and selection rules. Application to electronic spectra of conjugated linear organic molecules.

Unit II: **12 Lectures**

Linear and angular momentum, Eigen function and Eigen values of angular momentum operator, Ladder operator, addition of angular momenta. Spin angular momenta, symmetric and antisymmetric wavefunctions, Pauli Exclusion Principle, spectroscopic term symbols.

Unit III: **12 Lectures**

The rates of reaction, reaction rate, rate laws & rate constants, the determination of the rate law, first order, second order reactions, half-lives, fractional order reactions. Accounting for rate laws, simple reactions, the temperature dependence of reaction rates, reactions approaching equilibrium, consecutive reactions, the steady state approximations, pre equilibria, unimolecular reactions.

Unit IV: **8 Lectures**

The kinetics of complex reactions: chain reaction- explosion, photochemical reactions quantum efficiency, fast reactions-flash photolysis, flow techniques, relaxation methods. Enzyme catalysts: Michaelis-Menten mechanism, limiting rate, Lineweaver Burk and Eadie plots enzyme inhibition, competitive and non-competitive inhibition.

Text Books

1. A K Chandra, Introductory Quantum Chemistry (Tata McGraw-Hill)
2. I N Levine, Quantum Chemistry (Pearson Educ., Inc., New Delhi)

Reference Books/Materials

1. W Kauzmann Quantum Chemistry (Academic press)
2. S Glasstone, Theoretical Chemistry: An introduction to quantum mechanics, statistical mechanics, and molecular spectra for chemists (D. Van Nostrand Company, Inc.)
3. R K Prasad, Quantum Chemistry (New Age International, New Delhi)
4. K J Laidler, Chemical Kinetics (Pearson Education)
5. G L Agarwal, Basic chemical Kinetics (Tata-McGraw Hill)
6. Donald A. McQuarrie, Quantum Chemistry (Viva Books, New Delhi)
7. P W Atkins, Physical Chemistry (Oxford University press)
8. A A Frost and R G Pearson, Kinetics and Mechanism (ACS publications)

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examinationto secure minimum passing grade

BSCHIC854	Inorganic Chemistry-II Lab	L	T	P	C
Version 1.0		0	0	2	1
Pre-requisites/Exposure	Qualitative analysis of lanthanides and metal ions				
Co-requisites	--				

Course perspective: This course imparts the understanding of qualitative analysis of complex inorganic mixture by semi micro analysis which enables them to identify lanthanide and transition metal ion in a given mixture. This course helps them to get experience of selecting suitable test procedure for identification of ion by using gravimetric, volumetric and spectrophotometric techniques. The course also introduces the use of paper chromatography technique.

Course Outcomes

On completion of this course, the students will be able

CO1 (Observing): Identify and analyze seven radicals, including rare earth metal ions and insoluble residues, using semi-micro qualitative analysis techniques.

CO2 (Practicing): Conduct qualitative analysis of rare elements such as Tl, W, Se, and Mo, as well as insoluble compounds like $PbSO_4$ and Al_2O_3.

CO3 (Applying): Apply gravimetric, volumetric, and spectrophotometric techniques to quantitatively analyze tri-component mixtures of metal ions, specifically Cu^{2+}, Ni^{2+}, Zn^{2+}, and Fe^{2+}.

Course Content

(a) Qualitative Analysis of Inorganic Mixture:

Identification of seven radicals including insoluble residue and rare earth metal ions by semi micro analysis.

(i) Rare elements: Tl, W, Se, Mo, Ti, Zr, Ce, Th, V, U, Li

(ii) Insolubles: $PbSO_4$, $SrSO_4$, Al_2O_3, Cr_2O_3, Fe_2O_3, SnO_2, AgX, TiO_2, ThO_2, $WO_2.xH_2O$

b) Quantitative analysis of tri-component mixture of metal ions using gravimetric, volumetric and spectrophotometric techniques.

(i) Mixed solution of Cu^{2+}, Ni^{2+} and Zn^{2+}

(ii) Mixed solution of Ni^{2+}, Zn^{2+} and Fe^{2+}

Text Books

1. A I Vogel, A text book of Quantitative Inorganic Analysis (Prentice Hall)

Reference Books/Materials

1. W G Palmer, Experimental Inorganic Chemistry (Cambridge : University Press)
2. V V Ramanujam, Inorganic Semi-Micro Qualitative Analysis (The National Publishing House, Chennai)
3. J Bassett, R C Denny, G H Jeffery and J Mendham, Vogel's Textbook Of Quantities Analysis, Revised (ELBS)

BSCHOC856	Organic Chemistry-II Lab	L	T	P	C
Version 1.0		0	0	2	1
Pre-requisites/Exposure	Graduation level Chemistry				
Co-requisites	--				

Course perspective In this course, the focus will be on thorough hand on practice to double stage synthesize organic compounds. Student will have exposure of estimation of organic compounds and characterization of oils via saponification value and iodine value.

Course Outcomes

On completion of this course, the students will be able to

CO1 (Observing): Identify and estimate phenol and aniline concentrations using bromate-bromide solutions.

CO2 (Practicing): Determine the number of hydroxyl and amino groups in a sample through the acetylation method.

CO3 (Applying): Apply the 2,4-DNP method to determine the molecular weight of a given ketone.

CO5 (Applying): Use a UV-VIS spectrophotometer to measure the concentration of organic compounds.

CO6 (Creating): Synthesize organic compounds through double-stage preparations, including the synthesis of benzanilide, p-bromoaniline, m-nitroaniline, and p-bromo acetanilide.

Course Content

List of experiments:

1. Estimation of phenol/aniline using bromate-bromide solution.
2. Determine the number of hydroxyl and amino groups in the given sample by the acetylation method.
3. Determination of mol. wt. of the given ketone by using 2, 4-DNP method.
4. Estimation of reducing sugar by Fehling solution method.
5. Determination of the saponification value of the given fat or oil sample.
6. Determination of the iodine number of the given fat or oil sample.
7. Determination of concentration of organic compounds by using UV-VIS spectrophotometer.
8. Preparation of organic compounds (Double stage)

a) benzanilide from benzophenone (rearrangement).
b) p-bromoaniline from acetanilide (bromination and hydrolysis).
c) m-nitroaniline from nitrobenzene (nitration and reduction).
d) 1,2,4-triacetoxy benzene from hydroquinone (oxidation and acylation).
e) p-bromo acetanilide from aniline (acetylation and bromination).

(Any suitable Expt. may be added)

Text Books:

1. B S Furniss, A J Hannaford, P W G Smith and A R Tatchell ELBS with Longman, Vogels Textbook of Practical Organic Chemistry (Longman Singapore Publishers Pt Ltd,Singapore)

Reference Books:

1. R M Roberts, J C Gilbert, L B Rodewald and A S Wingrove Holt, An Introduction to Modern Experimental Organic Chemistry (Ranehart and Winston Inc. New York)
2. D L Pavia, G M Lampmana and G S Kriz, Introduction to Organic Laboratory Techniques – A Contemporary Approach (W. B Saunders Company, 1976)
3. R Adams, J R Johnson and C F Wilcox, Laboratory Experiments in Organic Chemistry (The Macmillan Limited, London)

BSCHPC858	**Physical Chemistry-II Lab**	L	T	P	C
Version 1.0		0	0	2	1
Pre-requisites/Exposure	Basics of Physical Chemistry				
Co-requisites	--				

Course perspectives This course imparts the basic concepts of physical chemistry experiments. It enables the students to perform several experiments based on chemical kinetics. The course helps the students to understand the experimental importance of polarimetry and potentiometry. The course introduces several different kinds of titrations.

Course Outcomes

On completion of this course, the students will be able to

CO1 (Observing): Study the kinetics of cane sugar inversion using polarimetry and strong acid.

CO2 (Practicing): Investigate the kinetics of the reaction between bromate and iodide.

CO3 (Applying): Analyze the equilibrium constant for the reaction $KI + I_2 \Leftrightarrow KI_3$ using the distribution method.

Course Content

List of experiments:

1. Polarimetry: Kinetics of inversion of cane sugar in presence of strong acid.
2. Chemical Kinetics: Kinetics of reaction between bromate and iodide.
3. Kinetics of iodination of acetone in presence of strong acid etc.
4. Phase diagram of a binary organic system (Naphthalene and Diphenyl).

5. Potentiometric titration of a strong acid with strong base using quinhydrone electrode

6. Rate constant of acid catalyzed hydrolysis of sucrose by chemical method.

7. Degree of hydrolysis of urea hydrochloride by kinetics method.

8. Equilibrium constant of $KI + I_2 \Leftrightarrow KI_3$ by distribution method.

9. To prepare arsenious sulphide sol and compare the precipitating power of mono-, bi – and trivalent anions.

10. Titrate a moderately strong acid(salicylic/mandelic acid) by the

(i) Salt-line method

(ii) Double alkali method.

1. Titrate

(i) magnesium sulphate against $BaCl_2$and its reverse titration

(ii) HCl versus NH_4OH.

(Any suitable Expt. may be added.)

TextBooks:

1. V D Athawale and Parul Mathur, Experimental Physical Chemistry (New Age International Pvt Ltd.)

Reference Books:

1. B Viswanathan and P S Raghavan, Practical Physical Chemistry (Viva books)
2. A Finlay and J A Kitchener, Practical Physical Chemistry (Longman)

MINOR (ENVIRONMENTAL SCIENCES)

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES201	**EARTH AND EARTH SURFACE PROCESSES**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Lectures	**60**				
Pre-requisites/Exposure	**Earth and its processes**				
Co-requisites	**--**				

COURSE PERSPECTIVE

This course provides an in-depth understanding of Earth's history, processes, and materials, equipping students with essential knowledge for careers in geology, environmental science, and related fields. It covers the formation of Earth, plate tectonics, rock cycles, and surface processes, enabling students to

analyze and interpret geological phenomena. The skills gained, such as mineral identification, understanding seismic activities, and assessing erosion impacts, are crucial for addressing real-world challenges like resource management, disaster preparedness, and environmental conservation. By linking theoretical concepts with practical applications, the course prepares students for professional roles that require expertise in Earth sciences and supports informed decision-making in various environmental contexts.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understanding the Earth's history, including how the solar system formed and the layers of the Earth.

CO2: Explaining how Earth processes work, such as plate tectonics, earthquakes, and volcanic activity, with examples like the Himalayas.

CO3: Applying knowledge of minerals and rocks, including how they form and change through the rock cycle, weathering, and erosion.

CO4: Analyzing processes on the Earth's surface, including atmospheric changes, land interactions, and the effects of rivers and glaciers.

COURSE CONTENT

Unit1: History of Earth **15 lectures**

Solar system formation and planetary differentiation; formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of Earth; geological time scale and major changes on the Earth's surface; Holocene and the emergence of humans, role of humans in shaping landscapes; development of cultural landscapes.

Unit2: Earth system processes **15lectures**

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hot spots, plate boundaries; sea floor spread; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; origin of the main geomagnetic field; continental drift, Pangaea and present-day continents, paleontological evidences of platetectonics; continental collision and mountain formation with specific example of the Himalaya.

Unit3: Minerals and rocks **10 lectures**

Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; agents of erosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by running water, wind and glaciers.

Unit4: Earth surface processes **10 lectures**

Atmosphere: evolution of earth's atmosphere, composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface; land surface processes: fluvial and glacial processes, rivers and geomorphology; types of

glaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastal processes.

Learning Experience

This course integrates lectures, interactive sessions, and practical exercises to explore Earth's history, processes, and landscapes.

Instruction Methods:

- **Lectures:** Cover topics like Earth's formation, plate tectonics, minerals, rock cycles, and surface processes.
- **Interactive Sessions:** Engage through Q&A, quizzes, and discussions.

Technology Use:

- **Online Platforms:** LMS for lecture resources, recorded content, and discussions.

Assessments:

- **Formative:** Quizzes and discussions for continuous feedback.
- **Summative:** Exams and presentations to assess overall understanding.

Support:

- Instructor support and peer collaboration, with regular feedback to help students achieve learning outcomes.

Textbooks

1. Bridge, J., & Demicco, R. 2008. *Earth Surface Processes, Landforms and Sediment deposits*. Cambridge University Press.

2. Duff, P. M. D., & Duff, D. (Eds.). 1993. *Holmes' Principles of Physical Geology*. Taylor & Francis.

Reference Books

1. Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. *CurrentScience*90: 1082-1090.
2. Keller, E.A. 2011. *Introduction to Environmental Geology* (5thedition). Pearson Prentice Hall.
3. Krishnan, M. S. 1982. *Geology of India and Burma*.CBS Publishers & Distributors.
4. Leeder, M., Arlucea, M. P. 2005. *Physical Processes in Earth and Environmental Sciences.*Blackwell Publishing.
5. Pelletier, J. D. 2008. *Quantitative Modeling of Earth Surface Processes* (Vol. 304). Cambridge: Cambridge University Press. Chicago

Open Educational Resources (OER)

- **CrashCourse - Earth Science**
- **PBS Eons**
- **Khan Academy - Earth Science**
- **NOVA PBS - Geology Playlist**
- **Geology Kitchen**

- Rocks and Minerals Education
- MinuteEarth
- TED-Ed - Earth and Space Science
- National Geographic
- The Science Channel

Evaluation

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES202	**Hydrology and Hydrogeology**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Lectures	**60**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	**--**				

Course Perspective

This course offers a comprehensive understanding of hydrology and hydrogeology, essential for students pursuing careers in water resources management, environmental engineering, and related fields. By covering the fundamentals of the hydrological cycle, groundwater flow, and water resource management, students gain the knowledge needed to analyze and address water-related challenges. The course also equips students with practical skills in hydrological data collection, analysis, and modeling, including the use of Geographic Information Systems (GIS). Through the study of advanced topics like climate change impacts, flood management, and groundwater exploration, students are prepared to apply their knowledge in real-world scenarios, contributing to sustainable water resource management and informed decision-making in environmental and governmental roles.

Course Outcomes

CO1: Understanding key concepts in hydrology and hydrogeology, including the hydrological cycle, precipitation, and groundwater flow.

CO2: Applying techniques to collect and analyze hydrological data, such as measuring precipitation, streamflow, and soil moisture.

CO3: Analyzing water resource management strategies, including planning, conservation, and quality monitoring, to address issues like groundwater pollution.

CO4: Evaluating the effectiveness of hydrological models and flood management practices, and assessing the impact of climate change on hydrological processes.

CO5: Creating and applying advanced hydrological models, GIS tools, and policy frameworks to address complex problems in water resource management.

CO6: Reviewing case studies to identify best practices and innovative solutions in hydrology and hydrogeology.

COURSE CONTENT

Unit 1: Fundamentals of Hydrology and Hydrogeology **15 lectures**

- Introduction to Hydrology and Hydrogeology
- Basic concepts and definitions in hydrology and hydrogeology
- The hydrological cycle and its components
- Precipitation and evapotranspiration processes
- Infiltration and soil water storage
- Surface water hydrology: runoff generation and streamflow analysis
- Groundwater hydrology: aquifers, groundwater flow, and well hydraulics

Unit 2: Hydrological Data Collection and Analysis **15 lectures**

- Collection and analysis of hydrological data
- Measurement and analysis of precipitation
- Soil moisture measurement techniques
- Streamflow measurement and hydrograph analysis
- Groundwater level measurement and well hydraulics
- Statistical methods for data analysis in hydrology
- Introduction to hydrological modeling techniques

Unit 3: Water Resources and Management **15 lectures**

- Water resources planning and allocation
- Integrated water resources management principles
- Water conservation and demand management
- Water quality parameters and standards
- Groundwater pollution and remediation techniques
- Water quality monitoring and assessment

- Introduction to Geographic Information Systems (GIS) in hydrology

Unit 4: Advanced Topics in Hydrology and Hydrogeology **15lectures**

- Hydrological modeling: model calibration, validation, and applications
- Climate change impacts on hydrological processes
- Flood frequency analysis and floodplain management
- Groundwater exploration techniques
- Spatial analysis and modeling of hydrological data using GIS
- Water policy, governance, and legal frameworks
- Case studies and applications in hydrology and hydrogeology

Learning Experience

This course combines lectures, interactive sessions, and practical exercises to cover hydrology and hydrogeology fundamentals, data analysis, and advanced topics.

Instruction Methods:

- **Lectures:** Cover basics of hydrology, data collection, water management, and advanced topics.
- **Interactive Sessions:** Engage through Q&A, quizzes, and discussions.

Technology Use:

- **Online Platforms:** LMS for resources, recorded lectures, and discussions.

Assessments:

- **Formative:** Quizzes and discussions for ongoing feedback.
- **Summative:** Exams, peer reviews, and presentations for overall evaluation.

Support:

- Instructor guidance and peer collaboration with regular feedback to achieve learning outcomes.

Text Books

1. K Subramanya, Engineering Hydrology, Mc-Graw Hill. New Delhi.
2. K N Muthreja, Applied Hydrology, Tata Mc-Graw Hill.

Reference Books/Materials

1. K Subramanya, Water Resources Engineering through Objective Questions, Tata McGraw Hill.
2. G L Asawa, Irrigation Engineering, Wiley Eastern
3. L W Mays, Water Resources Engineering, Wiley.
4. J D Zimmerman, Irrigation, John Wiley & Sons
5. C S P Ojha, R Berndtsson and P Bhunya, Engineering Hydrology, Oxford.
6. R.K. Sharma and T.K. Sharma, Hydrology and Water Resources Engineering, Prentice Hall of India, New Delhi.

Open Educational Resources (OER)

- **https://www.usgs.gov/special-topic/water-science-school**
- **https://www.coursera.org/learn/hydrology-hydrogeology**
- **https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-72-groundwater-hydrology-spring-2003/**

- https://www.epa.gov/water-research/hydrology-research
- http://hydrogeo.uky.edu/
- https://www.bgs.ac.uk/research/groundwater/hydrology.html
- https://ocw.un-ihe.org/courses
- https://oer2go.org/mods/en-boundless/www.boundless.com/environmental-science/textbooks/boundless-environmental-science-textbook/water-resources-5/hydrology-and-water-resources-50/hydrology-245-10941/index.html
- https://hydrology.berkeley.edu/ce-170.html
- https://www.indiawaterportal.org/articles/groundwater-and-hydrogeology-introduction

Modes of Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES301	**NATURAL RESOURCES MANAGEMENT AND SUSTAINABILITY**	**4**	**0**	**0**	**4**
Version 1.0					
Total Lectures	**60**				
Pre-requisites/Exposure	**Environmental studies**				
Co-requisites	**--**				

COURSE PERSPECTIVE

This course explores the classification, availability, and conservation of resources, both renewable and non-renewable. Investigate mineral resources, their identification, extraction methods, and the global consumption patterns that shape our world. Gain insights into energy resources, from oil and gas to renewable sources like solar, wind, and nuclear power, assessing their environmental impacts and potential. Understand resource management approaches, integrated strategies, and sustainability

science principles to address real-world challenges. Through a balanced mix of theory, case studies, and discussions, develop a holistic understanding of how our actions impact the planet and how responsible resource management can shape a sustainable future.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understanding the types of natural resources, including renewable and non-renewable resources, and how they are affected by human activities.

CO2: Applying knowledge of forest, water, soil, and food resources, including their importance and how to conserve them.

CO3: Analyzing mineral resources, their extraction methods, and the environmental impacts of mining.

CO4: Evaluating non-renewable energy sources like oil, natural gas, and coal, including their formation, extraction, and environmental effects.

Course Content

Unit 1:

Introduction, natural resources and conservation **18 lectures**

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.

Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies.

Unit 2: Food and Mineral resources **12 lectures**

food resources: world food problem, techniques to increase world food production, green revolution.

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

Unit 3: Non-renewable energy resources & Renewable energy resources **18 lectures**

Non-renewable:

Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non-renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges.

Renewable:

Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, J N N solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Unit 4: Resource management **12 lectures**

Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

Learning Experience

This course features lectures, interactive discussions, and hands-on activities on resource management and conservation.

- **Instruction Methods:** Lectures and discussions on core concepts.
- **Technology Use:** LMS for resources and forums.
- **Assessments:** Quizzes, exams, and projects.
- **Support:** Instructor guidance and peer collaboration.

Text Books

1. Craig, J. R., Vaughan. D. J. & Skinner. B. J. 1996. *Resources of the Earth: Origin, Use, and Environmental Impacts* (2nd edition). Prentice Hall, New Jersey.

2. Freeman, A. M. 2001. *Measures of value and Resources: Resources for the Future*. Washington DC.

Reference Books/Materials

1. Freeman, A. M. 2003. *Millennium Ecosystem Assessment: Conceptual Framework*. Island Press.

2. Ginley, D. S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*.CambridgeUniversity Press.

3. Klee, G. A. 1991.*Conservation of Natural Resources*. Prentice Hall Publication.

4. Miller, T. G. 2012. *Environmental Science*. Wadsworth Publishing Co.

5. Owen, O. S, Chiras, D. D, &Reganold, J. P. 1998. *Natural Resource Conservation–Management for Sustainable Future* (7thedition). Prentice Hall.

6. Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.

7. Tiwari, G. N. & Ghosal. M. K. 2005. *Renewable Energy Resources: Basic Principles and Application*. Narosa Publishing House.

Open Educational Resources (OER)

https://www.k-state.edu/nrm/webinars/intro/index.html)

https://open.oregonstate.education/woodproducts/)

https://www.sc.edu/study/colleges_schools/artsandsciences/environment_and_sustainability/academics/courses/introduction_to_geology.php

https://www.energy.gov/eere/education/energy-education-resources

https://www.umass.edu/windenergy/education/renewable-energy-and-environmental-sustainability

https://ocw.uci.edu/collections/7ba20ee3-0e56-46a5-b6c2-334eb7cb8c10

Assessment & Evaluation

Modes of Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES401	**NATURAL AND ANTHROPOGENIC HAZARDS**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Lectures	**60**				
Pre-requisites/Exposure	**Basics of Environment**				
Co-requisites	**--**				

COURSE PERSPECTIVE

This course explores the causes and impacts of natural and anthropogenic hazards, including earthquakes, tsunamis, volcanic eruptions, and pollution. Through case studies and scientific analysis, students will learn about disaster prediction, mitigation strategies, and the influence of human activities on environmental stability. The course aims to equip students with the knowledge to understand and reduce the risks associated with these hazards.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understanding natural hazards and disasters, including their causes, human impacts, and methods for predicting and mitigating these events.

CO2: Applying knowledge of volcanic hazards, landslides, floods, and storms, and assessing their effects on communities and the environment.

CO3: Analyzing anthropogenic disasters related to pollution, population growth, and soil degradation, and understanding their impacts on ecosystems.

CO4: Evaluating water and atmospheric pollution through legislation like the Air Act and Water Act and studying case examples to understand their implications.

CO5: Reviewing case studies of natural and anthropogenic disasters to identify effective mitigation strategies and improve disaster preparedness.

COURSE CONTENT

Unit A NATURAL AND ANTHROPOGENIC HAZARDS 15 lectures

Natural Hazards and Disasters, Human Impact on Natural Disaster, Predicting Catastrophe, Mitigating Hazards; Plate Tectonics and related Hazards, Earthquakes and their causes, Ground Motion and Failures, Case study of Nepal earthquake and Bhuj earthquake; Tsunami: Giant Tsunamis, Generation and Movement, Tsunami Hazard Assessment, Tsunami – 2004, Fukushima disaster

Unit B Volcanic Hazard 15 lectures

Eruption-Type of Volcanoes and Tectonic environment; Landslide and their causes, Type of downslope movement, associated hazard, Land Subsidence and associated hazard; Floods and Human Interaction, Flood Frequency and Recurrence Interval, Human intervention and mitigation; Storms: Tropical Cyclone, Hurricane, Tornado, Storm damage and safety; Wildfires: Fire Process and Secondary effects; Case studies of devastating natural hazards

Unit C Anthropogenic Disasters I 15 lectures

Pollution: Role of natural and anthropogenic factors; Population growth and Environmental Impact; Carrying capacity of ecosystem; Soil and soil degradation, desertification, Ways to improve soil and case studies related to soil degradation

Unit D Anthropogenic Disasters II 15 lectures

Fundamental concepts of water and atmospheric pollution, Air Act, Water Act, Ambient Air quality, case studies related to water and atmospheric pollution; Waste and Hazardous

Learning Experience

The course integrates lectures, case studies, and interactive discussions to explore natural and anthropogenic hazards.

- **Instruction Methods:** Lectures on various hazards, their causes, and mitigation strategies; case studies for real-world understanding.

- **Technology Use:** LMS for resources, recorded lectures, and discussion forums.
- **Assessments:** Quizzes, exams, and case study analyses to assess comprehension.
- **Support:** Instructor support and peer collaboration encouraged for deeper understanding.

Textbooks

1. Natural Hazards and Disasters" by D. Hyndman & D. Hyndman:
2. "Introduction to Environmental Geology" by E. A. Keller

Reference Books/Materials

1. "Environmental Hazards: Assessing Risk and Reducing Disaster" by K. Smith
2. "Introduction to Environmental Engineering and Science" by G. M. Masters & W. P. Ela
3. "Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes" by E. A. Keller & D. E. DeVecchio
4. "Environmental Science: Earth as a Living Planet" by D. B. Botkin& E. A. Keller

Open Educational Resources (OER)

- https://openstax.org/details/books/earth-science
- https://www.nssl.noaa.gov/education
- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu
- https://www.fema.gov/
- http://www.unesco.org/new/en/education/themes/education-building-blocks/disaster-risk-reduction/resources/
- https://open.umn.edu/opentextbooks/textbooks?subject_area_id=28
- https://www.merlot.org/merlot/materials.htm?category=2665

Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** **All the components to be evenly spaced** **Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)**	**40 marks**
II. Internal marks(Theory): **Mid Term Examination**	**20 Marks**
III. External Marks (Theory): **End Term Examination**	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES501	**ENVIRONMENT LEGISLATION POLICIES AND ESG'S**	**L**	**T**	**P**	**C**
Version 3.0		4	0	0	4
Total Lectures	60				
Pre-requisites/Exposure					
Co-requisites	--				

COURSE PERSPECTIVE

This course provides an in-depth study of environmental legislation, policies, and ESG principles. Students will explore the constitutional basis for environmental protection, the evolution of key laws, and the significance of legal definitions related to pollution, biodiversity, and sustainability. By analyzing major acts like the Indian Forest Act and the Environmental Protection Act, along with recent laws like the Biological Diversity Act, students will gain the knowledge needed to navigate environmental legal frameworks and contribute to sustainable practices.

COURSE OUTCOMES

On completion of this course, the student-teacher will be able to:

CO1: Understanding the Constitution of India and its provisions related to fundamental rights, duties, and the structure of government, including the roles of the legislature and judiciary.

CO2: Exploring the historical evolution of environmental legislation and policies in India, from ancient practices to contemporary laws, highlighting key periods and acts.

CO3: Analyzing legal definitions related to environmental concepts, including pollution, natural resources, and sustainable development, as outlined in the Indian Constitution.

CO4: Evaluating major legislative instruments that govern environmental protection in India, including the Forest Act, Wildlife Protection Act, and the Environment (Protection) Act, among others.

COURSE CONTENT

UnitA: Introduction **10 lectures**

Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies; National Green Tribunal.

UnitB: History of environmental legislation and policy **20 lectures**

Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra,Yajnavalkya smriti and Charaksamhita; Medieval period: forests as woodland and hunting resources during Mughal

reign; British India: Indian Penal Code 1860, Forest Act 1865, Fisheries Act1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953.

UnitC: Environmental legislation **10lectures**

Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article51 A (Fundamental duties).

UnitD: Legislative Instruments **20lectures**

The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The BiologicalDiversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; scheme and labeling of environment friendly products, Ecomarks.

Learning Experience

The course features lectures, interactive sessions, and practical exercises to explore environmental legislation and policies.

Instruction Methods:

- **Lectures:** Multimedia presentations and problem-solving.
- **Interactive Sessions:** Q&A, quizzes, and discussions.

Technology Use:

- **Online Platforms:** LMS for resources and discussions.

Assessments:

- **Formative:** Quizzes and discussions.
- **Summative:** Exams, peer reviews, and presentations.

Support: Instructor guidance and peer collaboration with regular feedback.

Text Books

1. "Environmental Law in India" by Shyam Diwan and Armin Rosencranz
2. "Environmental Law" by Bimal N. Patel

Reference Books/Materials

1. "Environmental Management: Text and Cases" by Rajagopalan Raman
2. "Environmental Laws in India: An Introduction" by Gurdip Singh
3. "Environmental Legislation and Policy: Selected Statutes" by Gitanjali Nain Gill
4. "Environmental Governance in India: Problems and Perspectives" by N.C. Saxena and Kanchi Kohli
5. "Environmental Law: Pollution and Management" by Suresh P. Harsha and PallaviBedi

Open Educational Resources (OER)

- https://openstax.org/details/books/earth-science
- https://www.nssl.noaa.gov/education
- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu
- https://www.fema.gov/
- http://www.unesco.org/new/en/education/themes/education-building-blocks/disaster-risk-reduction/resources/
- https://open.umn.edu/opentextbooks/textbooks?subject_area_id=28
- https://www.merlot.org/merlot/materials.htm?category=2665

Assessment & Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES601	**Waste Management**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Lectures	**60**				
Pre-requisites/Exposure	**Basics of Environment**				
Co-requisites	**--**				

COURSE PERSPECTIVE: This course provides a detailed understanding of solid waste management and resource recovery, covering waste sources, environmental impacts, and management techniques. Students will explore methods for handling municipal, hazardous, and biomedical waste, including collection, landfilling, thermal treatment, and recycling. The course also addresses industrial waste

management, resource recovery practices, waste-to-energy processes, and integrated waste management strategies, alongside lifecycle assessment and relevant policies. This knowledge equips students with essential skills for effective waste management and sustainability.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understanding the sources and types of solid waste, including municipal, hazardous, and biomedical waste, their impact on health& the environment, combustion, pyrolysis, and policies for solid waste management.

CO2: Applying techniques for collecting, storing, transporting, and disposing of solid waste, including landfill design and thermal treatment methods.

CO3: Analyzing the effects of industrial waste on air, water, and soil, and understanding the importance of effective waste management.

CO4: Evaluating resource recovery methods, including the 4Rs (reducing, reusing, recycling, recovering) and biological processing techniques.

COURSE CONTENT

Unit 1: Introduction, Solid waste and its Management (15 lectures)

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste**.**

Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of landfill eachateon soil characteristics and ground water pollution.

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.

Unit 2: Industrial waste management & Resource Recovery (15 lectures)

Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water andsoil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

4R-reduce, reuse, recycle and recover; biological processing-composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit C: Waste- to-energy (WTE) & Integrated wastemanagement (15 lectures)

Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, land fill gas (LFG) recovery; anaerobic digestion; gasification.

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management**.**

Unit D: Life cycle assessment (LCA) & Policies for solid waste management (15 lectures)

Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly or green products.

Text Books

1. "Solid Waste Management: Engineering Principles and Management Issues" by Tchobanoglous et al.
2. "Introduction to Solid Waste Management" by Tebbutt.

Reference Books/Materials

1. "Waste Management Practices: Municipal, Hazardous, and Industrial" by Pichtel.
2. "Handbook of Solid Waste Management" by Kreith and Tchobanoglous.
3. "Waste Management and Sustainable Consumption" by Cooper.
4. "Hazardous Waste Management" by LaGrega et al.
5. "Biomedical Waste Management: Principles and Case Study" by Bhandari.

Open Educational Resources (OER)

- https://openstax.org/details/books/earth-science
- https://www.nssl.noaa.gov/education
- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu
- https://www.fema.gov/
- http://www.unesco.org/new/en/education/themes/education-building-blocks/disaster-risk-reduction/resources/
- https://open.umn.edu/opentextbooks/textbooks?subject_area_id=28
- https://www.merlot.org/merlot/materials.htm?category=2665

Assessment & Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	40 marks

II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES701	**Environmental Impact assessment and Risk assessment**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Lectures	**60**				
Pre-requisites/Exposure	**Environmental risk assessment**				
Co-requisites	**--**				

Course Perspective

This course offers a detailed exploration of Environmental Impact Assessment (EIA) and risk management, focusing on evaluating and mitigating environmental impacts to support sustainable development. Students will learn the fundamentals of EIA, including its methodologies, stakeholder roles, and the creation of Environmental Impact Statements (EIS) and Environmental Management Plans (EMP). The course also covers advanced topics such as Rapid EIA, Strategic Environmental Assessment, Social Impact Assessment, and life cycle assessments, alongside the principles of environmental management and sustainable development. Additionally, students will examine EIA regulations in India, current challenges, and case studies of major projects, while developing skills in risk assessment, including hazard identification and risk communication. This comprehensive approach prepares students for careers in environmental consulting, project management, and policy development.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understanding the concepts and methodologies of Environmental Impact Assessment (EIA) and its significance in project planning.

CO2: Applying various assessment techniques, such as Rapid EIA and Social Impact Assessment, to evaluate environmental effects.

CO3: Analyzing EIA regulations and practices in India, identifying current challenges through case studies.

CO4: Evaluating risk assessment processes, including exposure assessment and hazard identification in environmental monitoring.

CO5: Creating effective Environmental Management Plans (EMP) and Environmental Impact Statements (EIS) based on impact predictions and baseline data.

COURSE CONTENT

Unit 1: Environmental impact assessment (EIA): 15 Lectures

Definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA; role of project proponents, project developers and consultants; Terms of Reference; impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management Plan(EMP)

Unit 2: 15 Lectures

Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefitanalysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO14000; sustainable development.

Unit3: 15 Lectures

EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects.

Unit 4: 15 Lectures

Risk assessment: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

Learning Experience

This course combines lectures, interactive sessions, and hands-on activities for understanding environmental impact and risk assessment.

Instruction Methods:

- **Lectures:** Multimedia presentations on core concepts.
- **Interactive Sessions:** Q&A, quizzes, and discussions.

Technology Use:

- **Online Platforms:** LMS for resources and discussions.

Assessments:

- **Formative:** Quizzes and discussions.
- **Summative:** Exams, peer reviews, presentations.

Support: Instructor guidance, peer collaboration, and regular feedback.

Text Book

1. Barrow,C.J.2000.*SocialImpactAssessment:AnIntroduction.*OxfordUniversityPress.

Reference Books/Materials

Glasson,J.,Therivel,R.,Chadwick,A.1994.*IntroductiontoEnvironmentalImpactAssessment*.London, Research Press, UK. Judith,P.1999.*HandbookofEnvironmentalImpactAssessment*.Blackwell Science. Marriott,B.1997.*EnvironmentalImpactAssessment:APracticalGuide*.McGraw-Hill,NewYork, USA.

Open Educational Resources (OER)

- **United Nations Environment Programme (UNEP) EIA Training Resource Manual**
- **International Association for Impact Assessment (IAIA) Resources**
- **World Bank Environmental and Social Framework**
- **Environmental Protection Agency (EPA) EIA Resources**
- **Asian Development Bank (ADB) Environmental Assessment Sourcebook**
- **United Nations Economic Commission for Europe (UNECE) EIA Training Materials**
- **World Health Organization (WHO) Environmental Impact Assessment Guidelines**
- **Environmental Law Institute (ELI) EIA Resources**
- **International Finance Corporation (IFC) EIA Guidelines**
- **United Nations Development Programme (UNDP) EIA Toolkit**

Assessment & Evaluation

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examinationto secure minimum passing grade

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UNMIES801	**SDG'S AND CLIMATE CHANGE**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Lectures	**60**				
Pre-requisites/Exposure	**Basics of Chemistry**				

Co-requisites	**--**

Course Perspective

This course offers a comprehensive examination of global warming, climate change, and sustainable development, focusing on both theoretical frameworks and practical applications. Students will explore the socio-economic and environmental drivers of change, adaptation and mitigation strategies, and the international and national efforts to reduce carbon emissions. The course also covers the Sustainable Development Goals, the challenges and opportunities of sustainable business practices, and the importance of governance in achieving sustainability. Through case studies, students will gain insights into climate risks, vulnerability assessments, and the role of responsible management in addressing environmental and societal challenges.

COURSE OUTCOMES

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

CO1: Understanding the causes and effects of global warming and climate change, including the role of human activities and socio-economic factors.

CO2: Applying adaptation and mitigation strategies for climate change at international and national levels, focusing on sustainable development practices.

CO3: Analyzing climate risks and vulnerabilities in India, using assessment tools and creating vulnerability maps for specific areas.

CO4: Evaluating the principles of sustainable development, including the Sustainable Development Goals (SDGs) and the dynamics involved in achieving them.

CO5: Assessing governance strategies for sustainable development, incorporating environmental management, corporate social responsibility, and risk management practices.

Course Content

Unit A: 10 lectures

Global Warming and Climate Change, Debate on Climate Change – the manifestations of Climate Change; Natural and anthropogenic (human interventions), Relationship between socioeconomic and environmental drivers of change (e.g. globalization, urbanization, land degradation, inefficient use of water, climate change), Climate change: Adaptation and Mitigation Strategies at International and national contexts , International and National Efforts at Carbon Emission Reductions, Global (environmental) change and sustainable development, and sustainable development with a focus on the specific situation in Central Asia

Case study 1: Assessment of climate risks and vulnerability in India, Presentation of national assessment results and vulnerability maps and preparation of an assessment in the pilot area.

Unit B 12 lectures

Sustainable Development in theory and practice, Global Responses to Sustainable Development, Sustainable Development Goals (vs Millennium Development Goals), The Paris and Post-Paris Convention on Climate Change and Sustainable Development, Triple Bottom line of Sustainability:

Food, Water, Energy nexus, Potential and Barriers to Sustainable Business, Sustainable rural and urban livelihoods, Laying Out Actors and Dynamics in the 2030 Agenda for Sustainable Development

Unit C **8 lectures**

Climate Risks and Vulnerability Assessment of India, Why environment and natural resources are prone to market failure, Values (Economic or otherwise) of Environment and Natural Resources: Use, Option, Existence, Signals of Natural Resource Depletion/ scarcity and valuation methods (Health cost, amenities and Hedonic Pricing, Travel Cost methods, Contingent Valuation Methods, Choice Experiments, Limitations of these signals), Payment for Ecosystem Services (PES), Combining Theories of Governing Societal Change towards Sustainability

Unit D **12 lectures**

Governance Pillars and Competences: Power, Knowledge and Norms as Cross-Cutting Issues in Governance for the SDGs, Socially and Environmentally Responsible Business Management, The relevance of Green Growth Green Business paradigms, Environmental Values of Business, Corporate Social Responsibility and Environmental Impacts, Environmental Risk Management & Environmental Strategy, Environmental and Ecological Stewardship, Inferences on Improving Integrative Sustainability Governance

Case Study 1: Sustainable Disaster Risk Reduction in Mountain Agriculture: Agroforestry Experiences in Kaule, Mid-Hills of Nepal

Case study 2: Climate Change 2014, Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Case study 3: Influence of Climate Change on Environmental Hazards and Human Well-Being in the Urban Areas—Warsaw Case Study Versus General Problems

Learning Experience

This course integrates lectures, interactive discussions, and case studies to explore climate change, sustainable development, and governance.

Instruction Methods:

- **Lectures:** Core topics delivered through presentations.
- **Interactive Sessions:** Discussions and case studies to apply concepts.

Technology Use:

- **Online Platforms:** LMS for resources.

Assessments:

- **Formative:** Quizzes and discussions.
- **Summative:** Exams, case study presentations, and reports.

Support: Instructor support, peer collaboration, and regular feedback.

Textbook

1. Jacob Thomas, Environmental Management – Text and Cases, Dorling Kindersley (India) Pvt. Ltd. 2014.

References books

2. Environmental Management, Sustainable Development and Human Health, (Eds.) [2009], Eddie N. Laboy-Nieves & Fred C. Schaffner; Ahmad H. Abdelhadi; Mattheus F. A. Goosen, CRC Press/Balkema is an imprint of the Taylor & Francis Group, London, UK, 596p.

Open Educational Resources (OER)

- https://www.climate.gov/
- https://unfccc.int/
- https://sustainabledevelopment.un.org/
- https://ocw.mit.edu/index.htm
- https://www.open.edu/openlearn/science-maths-technology/environmental-studies/climate-change-and-global-warming/content-section-0
- https://open.umn.edu/opentextbooks/textbooks/environmental-science
- https://www.unep.org/library
- https://www.greengrowthknowledge.org/
- https://www.wri.org/
- https://openknowledge.worldbank.org/

Modes of Evaluation:

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Pool of Data Science as Minor

SEMESTER II					
UNMIDS201	**Data Analytics using SQL**	**L**	**T**	**P**	**C**

Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course is designed to provide students with essential skills in SQL, a fundamental tool in data analysis and data science. Students will learn to effectively retrieve, clean, manipulate, and analyze data stored in relational databases, supporting data-driven decision-making in various domains. The course emphasizes practical application, equipping students with the ability to use SQL to solve real-world problems in business, finance, marketing, healthcare, and more. By mastering SQL, students will gain a strong foundation in data analytics, enabling them to make meaningful contributions in their careers.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding and constructing complex SQL queries to retrieve, filter, and aggregate data from relational databases.

CO2: Applying SQL commands to clean and preprocess data, including handling missing values, duplicates, and performing data transformations.

CO3: Analyzing datasets using SQL queries to identify patterns and summarize key statistics for initial insights.

CO4: Evaluating and interpreting query results by visualizing data with tools or libraries to create meaningful charts, graphs, and plots that enhance understanding.

Course Content

Unit 1:Introduction to SQL and Database Management **Lectures:** 15

- Introduction to Data Science
- Introduction to SQL Server
- Understanding Data & Information
- Database Concepts
- DBMS and RDBMS
- Database Design Principles

- Types of Databases
- SQL Server Versions
- Creating Databases
- Sub-languages of T-SQL: DDL, DML, TCL, DCL, DQL
- Creating Tables
- Data Manipulation (Insert, Delete, Update)
- Normalization
- Constraints (Unique, Not Null, Primary Key, Check, Default, Foreign Key)

Unit 2:SQL Queries and Data Manipulation **Lectures:** 20

- Working with Single Table Queries
- Writing Queries using SELECT Statement
- Understanding Query Flow
- Operators in SQL Server
- Clauses in SQL Server (WHERE, ORDER BY, DISTINCT, TOP)
- Filtering and Sorting Data
- DML Commands (Insert, Update, Delete)
- DDL Commands (Create, Alter, Drop, Truncate)
- Delete vs Truncate

Unit 3:SQL Functions and Aggregation **Lectures:** 10

- Built-in Functions
- Scalar Functions (String, Date, ISNULL, etc.)
- Group Functions (Aggregate Functions: COUNT, MAX, MIN, AVG, SUM)
- Usage of Functions in Data Analysis

Unit 4:Advanced SQL Queries: Subqueries and Joins **Lectures:** 15

- Subqueries: Importance and Types
- Nested Queries
- JOINS: Importance and Types (Inner Join, Outer Joins, Left, Right Outer Joins)

List of Practicals

- Create a student table with student ID, name, and marks as attributes where student ID is the primary key.
- Insert the details of a new student in the above table.
- Delete the details of a student in the above table.
- Use the SELECT command to get the details of students with marks more than 80.

- Find the min, max, sum, and average of marks in a student marks table.
- Find the total number of customers from each country using GROUP BY.
- Write a SQL query to order the (student ID, marks) table in descending order of marks.
- Write a SQL query to display marks without decimal places, the remainder after dividing marks by 3, and the square of marks.
- Write a SQL query to display names in capital letters, small letters, first 3 letters of the name, last 3 letters of the name, and the position of the letter 'A' in the name.
- Remove extra spaces from left, right, and both sides of the text "SQL for Data Science".
- Display today's date in "Date/Month/Year" format.
- Display the day name, month name, day, day name, day of the month, and day of the year for today's date.

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on projects to deepen understanding of SQL, data manipulation, and data analysis.

Instruction Methods:

- **Lectures:** Core SQL concepts will be taught using multimedia presentations and real-world examples.
- **Interactive Sessions:** Q&A, live coding exercises, and group discussions will actively engage students.
- **Technology Use:**
- **Online Platforms:** An LMS will host resources, recorded lectures, assignments, and discussion forums to facilitate extended learning.
- **Assessments:**
- **Formative:** Regular quizzes, assignments, and online discussions will provide continuous feedback.
- **Summative:** Exams, project presentations, and peer reviews will assess students' mastery of the material.

Support: The course instructor will offer additional guidance, with peer collaboration encouraged through group work and review sessions. Continuous feedback will ensure students' progress and improvement in achieving course outcomes.

Textbooks

1. "Learning SQL" by Alan Beaulieu
2. "SQL for Dummies" by Allen G. Taylor

Reference Books

1. "SQL in 10 Minutes, Sams Teach Yourself" by Ben Forta
2. "SQL Pocket Guide" by Jonathan Gennick
3. "The Practical SQL Handbook" by Judith S. Bowman, Sandra L. Emerson, and Marcy Darnovsky

Open Educational Resources (OER)

1. https://www.w3schools.com/sql/
2. https://www.khanacademy.org/computer-programming/new/sql
3. https://www.coursera.org/learn/sql-for-data-science

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.

SEMESTER II					
UNMIDS202	**Data Analytics using R**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Basic concepts of Statistics**				

Course Perspective

The course "Data Analytics using R" is designed to equip students with the foundational skills in R programming necessary for data analysis in various domains. By engaging with this course, students will gain hands-on experience in data manipulation, visualization, and statistical analysis using R, making them proficient in handling real-world data challenges. The knowledge acquired in this course is applicable across industries where data-driven decision-making is key. The skills developed will enhance students' academic prowess and prepare them for careers in data science, analytics, and research. For example, students will be able to create insightful visualizations to present data-driven solutions, identify trends, and model data effectively, which are essential skills in today's data-centric job market.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding and applying R programming concepts to perform basic data manipulation and visualization tasks.

CO2: Analyzing data sets by employing appropriate R data structures, such as vectors, matrices, and data frames.

CO3: Creating custom R functions and utilizing control structures to automate data analysis processes.

CO4: Evaluating and interpreting data trends through various graphical representations in R.

Course Content

Unit I: Fundamentals of R: (Lectures: 15)

- Introduction to R: Features of R, Environment, R Studio
- Basics of R: Assignment, Modes, Operators, Logical values, Basic Functions
- R Data Structures: Vectors, Lists, Matrices, Data Frames, Factors

- Control Structures: if-else, loops, and functions

Unit II: Data Structures in R: (Lectures: 15)

- Vectors: Definition, Declaration, Operations
- Matrices: Creating, Reshaping, Operations
- Lists: Creating, General Operations
- Data Frames: Creating, Accessing, Merging, Special Functions

Unit III: Working with Data in R: (Lectures: 15)

- Reading and Writing Data: CSV, Excel, Text Files
- String Operations: Regular Expressions, Dates in R
- Data Preprocessing: Descriptive Statistics, Handling Missing Values, Normalization
- Exploratory Data Analysis: Summarizing Data, Identifying Patterns

Unit IV: Data Visualization with R: (Lectures: 15)

- Basic Visualization Tools: Bar Charts, Histograms, Pie Charts, Scatter Plots, Line Plots
- Introduction to ggplot2: Creating Simple Plots, Customization Techniques
- Project on R and related discussion

Learning Experience

This course will be conducted through a blend of lectures, practical sessions, and interactive activities. Students will engage in hands-on learning using R software, working on real-world data sets to apply concepts learned in class. Methods of instruction will include case studies, group work, and individual assignments.

Instruction Methods:

- **Lectures:** Core R programming concepts will be taught through multimedia presentations and coding examples.
- **Hands-on Sessions:** Students will work on real-world data sets using R, applying concepts through practical exercises.
- **Group Work and Case Studies:** Collaborative projects and case studies will reinforce learning and promote teamwork.
- **Technology Use:**
- **R and RStudio:** Students will use R and RStudio for data manipulation, visualization, and analysis.
- **Shiny:** For creating interactive web applications and visualizations.

- **Online Platforms:** LMS for accessing resources, recorded lectures, and submitting assignments.
- **Assessments:**
- **Formative:** Regular quizzes, coding exercises, and assignments for continuous feedback.
- **Summative:** Project presentations, case study analyses, and a final assessment to evaluate students' mastery of R programming and data analysis.

Support: The course instructor will provide continuous guidance, with opportunities for students to collaborate through group work and peer reviews. Regular feedback will be given on assignments and projects, and students are encouraged to seek help as needed to enhance their learning experience.

Textbooks

1. Cognitive Computing with IBM Watson by Rob High, TanmayBakshi (1st edition)
2. Nina Zumel, John Mount, Practical Data Science with R, Manning Publications, 2014

Reference Books

1. Mark Gardener, Beginning R: The Statistical Programming Language, John Wiley & Sons, 2012
2. Nathan Yau, Visualize This: The FlowingData Guide to Design, Visualization, and Statistics, Wiley, 2011

Open Educational Resources (OER)

1. "Introduction to Data Science with R" (HarvardX Data Science Series on edX)
2. "R Programming" (Coursera by Johns Hopkins University)
3. "Advanced R" by Hadley Wickham (available online at Advanced R)

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced	**40 marks**

Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER III					
UNMIDS301	**Python for Data Science**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Nil**				

Course Perspective

"Python for Data Science" is designed to equip students with the foundational skills necessary for data analysis and manipulation using Python, a leading programming language in the data science field. The course contributes to students' academic and professional development by providing them with essential tools and techniques to solve real-world data problems. Students will gain knowledge in Python programming, data manipulation using NumPy and Pandas, and data cleaning and visualization techniques, making them well-

prepared for careers in data science, analytics, and related fields. The skills learned in this course are directly applicable to analyzing large datasets, performing complex data operations, and generating meaningful insights, which are crucial in various industries such as finance, healthcare, marketing, and technology.

Course Outcomes

Upon completion of this course, the learner will be able to:

CO1: Understanding and remembering Python's built-in data types and methods to solve basic data-related problems.

CO2: Applying efficient data storage and operations using NumPy arrays for numerical data processing.

CO3: Analyzing data using Pandas for advanced data manipulation tasks, identifying trends and patterns in datasets.

CO4: Evaluating data pre-processing techniques and creating visualizations using Pandas to communicate insights effectively.

Course Content

Unit 1: Introduction to Data Science and Python Programming (Lectures: 15)

- Introduction to Data Science
- Why Python?
- Essential Python libraries
- Python Introduction: Features, Identifiers, Reserved words, Indentation, Comments
- Built-in Data types and their Methods: Strings, List, Tuples, Dictionary, Set
- Type Conversion
- Operators, Decision Making, Looping, Loop Control statement
- Math and Random number functions
- User-defined functions: function arguments & its types

Practical Component:

1. Implement basic Python programs for reading input from the console.
2. Perform operations on Python built-in data types: Strings, List, Tuples, Dictionary, Set.
3. Solve problems using decision and looping statements.

4. Handle numerical operations using math and random number functions.
5. Create user-defined functions with different types of function arguments.

Unit 2: Introduction to NumPy (Lectures: 15)

- Arrays and Vectorized Computation
- The NumPyndarray
- Creating ndarrays
- Data Types for ndarrays
- Arithmetic with NumPy Arrays
- Basic Indexing and Slicing
- Boolean Indexing
- Transposing Arrays and Swapping Axes
- Universal Functions: Fast Element-Wise Array Functions
- Mathematical and Statistical Methods
- Sorting, Unique and Other Set Logic

Practical Component:

1. Create NumPy arrays from Python Data Structures and Random Functions.
2. Manipulate NumPy arrays: Indexing, Slicing, Reshaping, Joining, and Splitting.
3. Perform computations using Universal Functions and Mathematical methods.
4. Import and analyze data from CSV files using NumPy.
5. Manipulate images using NumPy.

Unit 3: Data Manipulation with Pandas (Lectures: 15)

- Introduction to Pandas Data Structures: Series, DataFrame
- Essential Functionality: Dropping Entries, Indexing, Selection, and Filtering
- Function Application and Mapping
- Sorting and Ranking
- Summarizing and Computing Descriptive Statistics
- Unique Values, Value Counts, and Membership

- Reading and Writing Data in Text Format

Practical Component:

1. Create Pandas Series and DataFrames from various inputs.
2. Perform data operations on CSV files using Pandas.
3. Conduct statistical analysis and operations on DataFrames.
4. Handle categorical data using Pandas.
5. Rename columns and restructure data using Pandas.

Unit 4: Data Cleaning, Preparation, and Visualization (Lectures: 15)

- Handling Missing Data
- Data Transformation: Removing Duplicates, Transforming Data Using a Function or Mapping, Replacing Values
- Detecting and Filtering Outliers
- String Manipulation: Vectorized String Functions in Pandas
- Plotting with Pandas: Line Plots, Bar Plots, Histograms, Density Plots, Scatter Plots

Practical Component:

1. Handle missing data and perform data transformations using Pandas.
2. Detect and filter outliers in datasets.
3. Execute vectorized string operations in Pandas.
4. Visualize data using various plotting techniques.

Learning Experience

This course will combine lectures, hands-on sessions, and interactive activities to equip students with Python programming skills for data science.

Instruction Methods:

- **Lectures:** Core Python programming concepts and data science principles will be introduced through multimedia presentations and live coding demonstrations.
- **Hands-on Sessions:** Students will work on real-world data sets using Python, applying concepts learned in class through practical exercises.
- **Group Work and Case Studies:** Collaborative projects will reinforce learning, with case studies to address real-world data science challenges.
- **Technology Use:**

- **Python, NumPy, Pandas:** These tools will be used for data analysis, manipulation, and visualization.
- **Jupyter Notebooks:** For executing and documenting Python code.
- **Online Platforms:** LMS for accessing resources, recorded lectures, and submitting assignments.
- **Assessments:**
- **Formative:** Regular quizzes, coding exercises, and assignments will provide continuous feedback on students' progress.
- **Summative:** Project presentations, case study analyses, and a final assessment will evaluate students' understanding and application of Python for data science.

Support: The course instructor will offer continuous guidance and feedback. Peer collaboration will be encouraged through group work and review sessions. Students will have access to online resources and office hours to seek additional help when needed. Regular feedback will ensure that students meet the course outcomes effectively.

Textbooks

1. Y. Daniel Liang, “Introduction to Programming using Python,” Pearson, 2012.
2. Wes McKinney, “Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython,” O’Reilly, 2nd Edition, 2018.

Reference Books

1. Jake VanderPlas, “Python Data Science Handbook: Essential Tools for Working with Data,” O’Reilly, 2017.
2. Wesley J. Chun, “Core Python Programming,” Prentice Hall, 2006.
3. Mark Lutz, “Learning Python,” O’Reilly, 4th Edition, 2009.
4. Joel Grus, “Data Science from Scratch: First Principles with Python,” O’Reilly, 2015.

Open Educational Resources (OER)

1. NPTEL Python for Data Science
2. Kaggle's Python for Data Science
3. Awesome Python for Data Science (GitHub)

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV					
UNMIDS401	**Data Pre-processing and Visualization using Python**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Basics of Python Programming**				

Course Perspective

This course is integral to the data science curriculum as it provides students with the foundational skills necessary for effective data analysis and visualization. Mastery of data preprocessing ensures that students can clean and prepare datasets, which is crucial for generating accurate and reliable insights in any data-driven field. Visualization techniques taught in this course empower students to communicate their findings effectively, making complex data understandable to a wide audience. The course emphasizes real-world applicability, allowing students to work with diverse datasets and leverage popular Python

libraries to create visualizations that are both informative and aesthetically pleasing. The skills and knowledge gained from this course are essential for careers in data analysis, business intelligence, and any profession requiring data-driven decision-making.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Explaining the significance of data pre-processing in the data analysis pipeline and its role in enhancing the quality of data for machine learning models.

CO2: Identifying and applying appropriate techniques for handling missing data, duplicates, and outliers to ensure data integrity.

CO3: Implementing data transformation processes such as normalization, scaling, and encoding to prepare datasets for analysis.

CO4: Analyzing datasets using exploratory data analysis (EDA) techniques and creating visualizations to uncover patterns, correlations, and trends.

Course Content

Unit 1: Introduction to Data Preprocessing **No. of Hours- 15**

- Understanding the importance of data preprocessing
- Steps involved in data preprocessing
- Handling missing data and outliers

Unit 2: Data Cleaning and Transformation **Lectures: 15**

- Removing duplicates and dealing with data inconsistencies
- Data normalization, scaling, and encoding techniques
- Handling categorical variables

Unit 3: Exploratory Data Analysis (EDA) **Lectures: 15**

- Data summarization and descriptive statistics
- Data visualization techniques: histograms, box plots, scatter plots
- Correlation analysis, heatmaps, and pair plots

Unit 4: Data Visualization Libraries and Applications **Lectures: 15**

- Introduction to Python libraries: Matplotlib, Seaborn, Plotly
- Creating and customizing plots
- Interactive visualizations and real-world data applications through Project.

Learning Experience

This course will blend lectures, practical sessions, and interactive activities to develop skills in data preprocessing and visualization using Python.

Instruction Methods:

- **Lectures:** Key concepts of data preprocessing and visualization will be taught through multimedia presentations and theoretical explanations.
- **Hands-on Sessions:** Practical exercises using Python libraries will allow students to apply data cleaning, transformation, and visualization techniques.
- **Group Work and Projects:** Collaborative projects and case studies will provide real-world data analysis experience and encourage teamwork.
- **Technology Use:**
- **Python Libraries:**NumPy, Pandas, Matplotlib, Seaborn, Plotly for data manipulation and visualization.
- **Jupyter Notebooks:** For coding exercises and project documentation.
- **Online Platforms:** LMS for accessing course materials, recorded lectures, and submitting assignments.
- **Assessments:**
- **Formative:** Regular quizzes, coding exercises, and practical assignments for ongoing feedback.
- **Summative:** Project presentations, case study analyses, and a final assessment to evaluate mastery of data preprocessing and visualization techniques.

Support: The course instructor will provide continuous feedback and be available during office hours. Peer collaboration and group activities will be encouraged to enhance learning. Students will have access to online resources and additional help as needed to achieve course outcomes effectively.

Textbooks

1. Claus Wilke, “Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures”, 1st edition, O’Reilly Media Inc, 2019.
2. Jacqueline Kazil, Katharine Jarmul, "Data Wrangling with Python," O'Reilly Media.

Reference Books

1. **Python Data Science Handbook** by Jake VanderPlas.
2. **Effective Data Visualization** by Stephanie D. H. Evergreen.
3. **Practical Statistics for Data Scientists** by Peter Bruce and Andrew Bruce.

Open Educational Resources (OER)

1. Data Visualization - Netquest eBook
2. Coursera: Data Visualization
3. Coursera: Python for Data Visualization

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous assessment (40 marks)** Include assignments, lab work, quizzes, and a final project, focusing on the practical application of data preprocessing and visualization techniques.	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER V					
UNMIDS501	**Time series analysis and forecasting using Python**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Nil**				

Course Perspective

This course is designed to equip students with essential skills in Time Series Analysis and Forecasting, crucial for making accurate predictions based on temporal data. Students will learn

to analyze time series data, apply various forecasting models, and evaluate their performance to support decision-making across diverse fields. The course covers foundational concepts, including autocorrelation, statistical inference in regression models, and advanced techniques such as ARIMA and seasonal ARIMA models. By integrating theoretical knowledge with practical application, students will be able to address real-world forecasting challenges, enhancing their analytical capabilities and making informed contributions in areas such as finance, economics, and business strategy.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding the fundamental concepts of time series data, including key patterns, trends, and seasonality, as well as various statistical methods used for time series analysis.

CO2: Applying forecasting models such as regression models and ARIMA to predict future values based on historical time series data in practical scenarios.

CO3: Analyzing and interpreting time series data through graphical displays, numerical descriptions, and techniques such as smoothing, transformations, and adjustments for enhanced analysis.

CO4: Evaluating the accuracy and performance of different forecasting models using statistical techniques, ensuring reliable predictions and continuous model monitoring.

Course Content

Unit 1: Introduction of Time series Analysis Statistical Methods: Lectures: 15

- Introduction to Time Series and Forecasting
- Different types of data
- Internal structures of time series
- Models for time series analysis
- Autocorrelation and Partial autocorrelation
- Examples of Time series Nature and uses of forecasting
- Forecasting Process
- Data for forecasting
- Resources for forecasting

Unit 2: Statistics Background for Forecasting: Lectures: 15

- Graphical Displays
- Time Series Plots
- Plotting Smoothed Data
- Numerical Description of Time Series Data

- Use of Data Transformations and Adjustments
- General Approach to Time Series Modeling and Forecasting
- Evaluating and Monitoring Forecasting Model Performance

Unit 3: Time Series Regression Model: Lectures: 15

- Introduction Least Squares Estimation in Linear Regression Models
- Statistical Inference in Linear Regression
- Prediction of New Observations
- Model Adequacy Checking
- Variable Selection Methods in Regression
- Generalized and Weighted Least Squares
- Regression Models for General Time Series Data
- Exponential Smoothing, First order and Second order.

Unit 4: Autoregressive Integrated moving average (ARIMA) Models: Lectures: 15

- Autoregressive Moving Average (ARIMA) Models
- Stationarity and Invertibility of ARIMA Models
- Checking for Stationarity using Variogram
- Detecting Nonstationarity
- Autoregressive Integrated Moving Average (ARIMA) Models
- Forecasting using ARIMA
- Seasonal Data
- Seasonal ARIMA Models Forecasting using Seasonal ARIMA Models Introduction
- Finding the "BEST" Model
- Example: Internet Users Data Model Selection Criteria
- Impulse Response Function to Study the Differences in Models Comparing Impulse Response Functions for Competing Models

List of Practicals

- **Time Series Data Cleaning:** Apply techniques to clean time series data, including handling missing values and outliers.
- **Loading and Handling Time Series Data:** Import time series data from various sources and manage it using appropriate tools.
- **Preprocessing Techniques:** Implement preprocessing techniques such as normalization and transformation to prepare time series data for analysis.

- **How to Check Stationarity:** Use statistical tests (e.g., ADF test) to determine if a time series is stationary.
- **Making a Time Series Stationary:** Apply techniques such as differencing and transformation to achieve stationarity.
- **Estimating & Eliminating Trend:** Use aggregation, smoothing, and polynomial fitting to estimate and remove trends.
- **Eliminating Seasonality:** Apply decomposition methods to separate and remove seasonal effects from the time series.
- **Moving Average Time Analysis:** Apply moving average techniques to smooth time series data and identify patterns.
- **Smoothing Time Series Data:** Use various smoothing methods (e.g., simple, weighted) to reduce noise and highlight trends.
- **Checking Linear and Non-Linear Trends:** Analyze time series data to identify and model both linear and non-linear trends.
- **Creating a Time Series Model:** Develop a time series model based on observed patterns and trends.
- **Moving Average Model:** Implement and evaluate a moving average model to forecast time series data.
- **Exponential Smoothing:** Apply exponential smoothing methods to forecast time series data and assess model performance.
- **ARIMA Model:** Develop and validate an ARIMA model for time series forecasting.
- **Seasonal ARIMA Model (ARIMA):** Create and test a SARIMA model to account for seasonality in time series data.

Learning Experience

This course will blend lectures, interactive sessions, and hands-on projects to deepen understanding and application of time series analysis and forecasting techniques.

Instruction Methods:

- **Lectures:** Core time series analysis and forecasting concepts will be taught using multimedia presentations and real-world case studies.
- **Interactive Sessions:** Q&A, practical exercises, and group discussions will actively engage students in applying time series models and forecasting techniques.
- **Technology Use:**
- **Python:** Primary tool for statistical analysis and data visualization.

- **Online Platforms:** LMS for accessing resources, recorded lectures, and discussion forums.
- **Assessments:**
- **Formative:** Regular quizzes, practical exercises, and assignments for continuous feedback.
- **Summative:** Case study analyses, project presentations, and a final exam to evaluate students' grasp of statistical methods.

Support: The course instructor will be available for guidance during office hours, and students are encouraged to collaborate through peer reviews and group work. Regular feedback will be provided to help students refine their skills and meet course outcomes effectively.

Textbooks

1. Introduction To Time Series Analysis And Forecasting, 2nd Edition, Wiley Series In Probability And Statistics, By Douglas C. Montgomery, Cheryl L. Jen(2015)
2. Master Time Series Data Processing, Visualization, And Modeling Using PythonDr.Avishek Pal Dr.PksPrakash (2017)

Reference Books

1. Time Series Analysis and Its Applications: With R Examples by Robert H. Shumway and David S. Stoffer.
2. Applied Time Series Analysis by Wayne A. Woodward, Henry L. Gray, and Alan C. Elliott.
3. The Elements of Statistical Learning: Data Mining, Inference, and Prediction by Trevor Hastie, Robert Tibshirani, and Jerome Friedman.

Open Educational Resources (OER)

1. **Khan Academy - Time Series Analysis**
2. Time Series Regression Analysis - University of California, Irvine
3. Time Series Analysis and Forecasting - Coursera

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced	**40 marks**

Test/Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
UNMIDS601	**Fundamental of Machine Learning**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Basic concepts of Statistics**				

Course Perspective

This course provides essential skills in machine learning, covering both supervised and unsupervised techniques using Python. Students will learn to preprocess data, apply regression and classification models, and utilize clustering methods. The course emphasizes practical application, preparing students to tackle real-world problems and make impactful contributions in fields like business, healthcare, and technology.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Remembering and understanding machine learning concepts to identify suitable applications, distinguishing between supervised and unsupervised learning, and utilizing appropriate Python libraries for machine learning tasks.

CO2: Applying preprocessing techniques to prepare data for analysis by handling missing values, encoding categorical data, and applying normalization, standardization, and Principal Component Analysis (PCA) techniques.

CO3: Analyzing and developing supervised learning models, including linear and non-linear regression, K-Nearest Neighbour, Decision Trees, Logistic Regression, and Support Vector Machines, to address various predictive and classification problems.

CO4: Evaluating the performance of machine learning models using appropriate evaluation methods to ensure the development of accurate and effective predictive models.

Course Content

Unit I: Introduction to Machine Learning **Lectures: 16 Hours**

- Application of Machine Learning
- Supervised vs Unsupervised Learning
- Python libraries suitable for Machine Learning

Unit II: Data Pre-Processing and Data **Lectures: 16 Hours**

- Identifying and handling the missing values
- Encoding the categorical data
- Normalization
- Standardization
- PCA

Unit III: Supervised Learning Regression and Classification **Lectures: 16 Hours**

- Linear Regression
- Non-Linear Regression
- Model evaluation methods
- K-Nearest Neighbour
- Decision Tree
- Logistic Regression
- Support Vector Machines,
- Model Evaluation

Unit IV: Unsupervised Learning **Lectures: 16 Hours**

- K-means Clustering
- Hierarchical Clustering

- Density-Based Clustering

Learning Experience

This course will combine lectures, interactive sessions, and hands-on projects to enhance understanding of machine learning concepts, data preprocessing, and model implementation. Students will engage in practical exercises to apply supervised and unsupervised learning techniques, ensuring a comprehensive learning experience.

Lectures:

Instruction Methods:

- **Lectures:** Core machine learning concepts will be taught using multimedia presentations and real-world case studies.
- **Interactive Sessions:** Q&A, coding exercises, and group discussions will actively engage students in applying machine learning techniques and solving practical problems.
- **Group Work and Case Studies:** Collaborative projects and case studies will reinforce learning and promote teamwork.
- **Technology Use:**
- **R and RStudio:** Students will use R and RStudio for data manipulation, visualization, and analysis.
- **Shiny:** For creating interactive web applications and visualizations.
- **Online Platforms:** LMS for accessing resources, recorded lectures, and submitting assignments.
- **Assessments:**
- **Formative:** Regular quizzes, coding exercises, and assignments for continuous feedback.
- **Summative:** Project presentations, case study analyses, and a final assessment to evaluate students' mastery of R programming and data analysis.

Support: The course instructor will provide continuous guidance, with opportunities for students to collaborate through group work and peer reviews. Regular feedback will be given on assignments and projects, and students are encouraged to seek help as needed to enhance their learning experience.

Textbooks

1. Machine Learning - Tom M. Mitchell
2. Python Machine Learning – Sebastian, Raschka and VahidMirjalili

Reference Books

1. Understanding Machine Learning - ShaiShalev-Shwartz and Shai Ben-David La
2. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Technique to Build Intelligent Systems-AurelienGeron

Open Educational Resources (OER)

https://www.coursera.org/learn/machine-learning

https://www.datacamp.com/tutorial/introduction-machine-learning-python

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER VII					
UNMIDS701	**Data Driven Applications**	**L**	**T**	**P**	**C**
Version		2	0	4	4

Category of Course	Minor VII (Practical)
Total Lectures	60 Hours
Pre-Requisites/ Co-Requisites	--

Course Perspective

The undergraduate course "Data Driven Applications" focuses on utilizing Power BI to design and manage data-driven reports and visualizations. It starts with an introduction to Power BI's architecture, installation, and cloud capabilities, covering essentials such as Power BI Desktop, mobile editions, and report rendering options. Students will learn to create and design interactive reports using various data sources and visualization tools, exploring report design elements, auto filters, and multiple visualization types. The course also delves into advanced features, including custom visualizations, real-time data access, and comprehensive report formatting and analytics. Overall, it provides a solid foundation in leveraging Power BI for effective data analysis and business intelligence.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Observing and identifying the fundamental components and features of Power BI, architecture, installation procedures, and basic functionalities.

CO2: Imitating best practices in report design by replicating sample reports and visualizations using Power BI's tools and effective data representation.

CO3: Practicing and creating interactive Power BI reports by utilizing various data sources, applying filters, and experimenting with different visualization tools to effectively communicate insights.

Course Content:

Unit 1 : Introduction to Power Bi **Lectures: 15**

Introduction to Power BI - Need, Imprtance, Power BI - Advantages and Scalable Options, History - Power View, Power Query, Power Pivot, Power BI Data Source Library and DW Files, Cloud Colloboration and Usage Scope, Business Analyst Tools, MS Cloud Tools, Power BI Installation and Cloud Account, Power BI Cloud and Power BI Service, Power BI Architecture and Data Access, OnPremise Data Acces and Microsoft On Drive, Power BI Desktop - Instalation, Usage, Sample Reports and Visualization Controls, Power BI Cloud Account Configuration, Understanding Desktop & Mobile Editions, Report Rendering Options

and End User Access, Power View and Power Map. Power BI Licenses, Course Plan - Power BI Online Training.

Unit 2 : Creating Power Bi Reports, Auto Filters Lectures: 15

Report Design with Legacy & .DAT Files, Report Design with Databse Tables, Understanding Power BI Report Designer, Report Canvas, Report Pages: Creation, Renames, Report Visuals, Fields and UI Options, Experimenting Visual Interactions, Advantages, Reports with Multiple Pages and Advantages, Pages with Multiple Visualizations. Data Access, PUBLISH Options and Report Verification in Cloud , "GET DATA" Options and Report Fields, Filters, Report View Options: Full, Fit Page, Width Scale, Report Design using Databases & Queries, Query Settings and Data Preloads, Navigation Options and Report Refresh, Stacked bar chart, Stacked column chart, Clustered bar chart, Clustered column chart, Adding Report Titles. Report Format Options, Focus Mode, Explore and Export Settings .

Unit 3 : Report Visualizations and Properties Lectures: 15

Power BI Design: Canvas, Visualizations and Fileds, Import Data Options with Power BI Model, Advantages, Direct Query Options and Real-time (LIVE) Data Access, Data Fields and Filters with Visualizations, Visualization Filters, Page Filters, Report Filters, Conditional Filters and Clearing. Testing Sets, Creating Customised Tables with Power BI Editor, General Properties, Sizing, Dimensions, and Positions, Alternate Text and Tiles. Header (Column, Row) Properties, Grid Properties (Vertical, Horizontal) and Styles, Table Styles & Alternate Row Colors - Static, Dynamic, Sparse, Flashy Rows, Condensed Table Reports. Focus Mode, Totals Computations, Background. Boders Properties, Column Headers, Column Formatting, Value Properties, Conditional Formatting Options - Color Scale, Page Level Filters and Report Level Filters, Visual-Level Filters and Format Options, Report Fields, Formats and Analytics, Page-Level Filters and Column Formatting, Filters, Background Properties, Borders and Lock Aspect .

Unit 4: Chart and Map Report Properties Lectures: 15

Chart report types and properties, stacked bar chart, stacked column chartclustered bar chart, clustered column chart, 100% stacked bar chart, 100% stacked column chart, line charts, area charts, stacked area charts, line and stacked row charts, line and stacked column charts, waterfall chart, scatter chart, pie chart, Field Properties: Axis, Legend, Value, Tooltip, Field Properties: Color Saturation, Filters Types, Formats: Legend, Axis, Data Labels, Plot Area, Data Labels: Visibility, Color and Display Units, Data Labels: Precision, Position, Text

Options, Analytics: Constant Line, Position, Labels, Working with Waterfall Charts and Default Values, Modifying Legends and Visual Filters - Options, Map Reports: Working with Map Reports.

Learning Experience

In the "Data Driven Applications" course, students will actively engage through hands-on activities and real-world case studies using Power BI. The course will blend lectures with practical exercises on both the Power BI desktop and cloud platforms. Students will work on assignments and group projects, creating and presenting their own reports and visualizations. They'll receive feedback and support from the course instructor and will have opportunities to collaborate with classmates. The goal is to apply what they learn in a practical way, with plenty of chances for peer interaction and guidance throughout the course.

Instruction Methods:

- **Lectures:** Core Matlab/Mathematica concepts will be taught using multimedia presentations and real-world examples.
- **Interactive Sessions:** Q&A, live coding exercises, and group discussions will actively engage students.
- **Technology Use:**
- **Online Platforms:** An LMS will host resources, recorded lectures, assignments, and discussion forums to facilitate extended learning.
- **Assessments:**
- **Formative:** Regular quizzes, assignments, and online discussions will provide continuous feedback.
- **Summative:** Exams, project presentations, and peer reviews will assess students' mastery of the material.

Support: The course instructor will offer additional guidance, with peer collaboration encouraged through group work and review sessions. Continuous feedback will ensure students' progress and improvement in achieving course outcomes.

Textbooks

1. "Beginning Power BI: A Practical Guide to Self-Service Data Analytics with Excel 2016 and Power BI Desktop" by Dan Clark

2. "Power BI Step-by-Step Part 1: Up and Running: Power BI Mastery through hands-on Tutorials (Power BI Step by Step)" by Grant Gamble

Reference Books for Power BI

1. "Mastering Microsoft Power BI" by Brett Powell
2. The Definitive Guide to DAX by Marco Russo and Alberto Ferrari
3. Microsoft Power BI Cookbook by Greg Deckler
4. Analyzing Data with Power BI and Power Pivot for Excel by Alberto Ferrari and Marco Russo

Open Educational Resources (OER)

1. https://learn.microsoft.com/en-us/power-bi/
2. https://docs.microsoft.com/en-us/power-bi/guided-learning/
3. https://docs.microsoft.com/en-us/learn/paths/analyze-visualize-data-power-bi/

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examinationto secure minimum passing grade

SEMESTER VII					
UNMIDS801	**Project and Case Study**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	64 Hours				

Pre-Requisites/ Co-Requisites	**Python Programming and ML techniques**

Course Outcomes (COs)

CO1: Identifying and articulating a research problem relevant to data analysis, demonstrating an understanding of domain-specific challenges and opportunities.

CO2: Designing and executing a comprehensive data analysis project, applying appropriate methodologies, tools, and techniques learned throughout the course.

CO3: Analyzing and interpreting the results of data-driven investigations, critically evaluating the effectiveness and limitations of the chosen methods.

CO4: Evaluating findings through written reports and oral presentations, effectively communicating the significance, methodology, and outcomes of the project to both technical and non-technical audiences.

CO5: Collaborating effectively within a team environment to complete the project, contributing to group discussions, planning, and decision-making processes.

Learning Experience

This course will provide a hands-on approach to applying data analysis techniques through a project-based framework.

Instruction Methods:

- **Workshops**: The course will involve interactive sessions where students can discuss project ideas, share progress, and seek guidance from the instructor.
- **Hands-on Project Work**: Students will work on real-world projects, applying the skills and knowledge they have acquired in previous courses to solve practical problems.
- **Case Study Discussions**: Students will analyze relevant case studies to understand the application of data analysis techniques in different domains, encouraging critical thinking and problem-solving skills.
- **Technology Use:**
- **Data Analysis Tools**: Students will utilize tools such as Python, R, or SQL, depending on their project requirements.
- **Project Management Tools**: Platforms like Trello or Asana may be used for team collaboration and project tracking.
- **Presentation Tools**: Tools such as PowerPoint or Tableau for creating visual presentations of project findings.

- **Assessments:**
- **Formative**: Regular progress updates, peer reviews, and feedback sessions will be conducted to guide students throughout the project lifecycle.
- **Summative**: The final assessment will include a comprehensive project report and an oral presentation, evaluating the application of data analysis techniques and the effectiveness of communication.

Support:

The course instructor will provide continuous support through regular consultations and feedback. Peer collaboration will be encouraged to enhance the learning experience. Students will have access to online resources and office hours for additional help as needed to achieve the course outcomes effectively.

Open Educational Resources (OER)

1. **Kaggle Datasets and Competitions**: For practical project ideas and data sources.
2. **Coursera**: Courses on Project Management and Data Analysis.
3. **GitHub**: For exploring open-source projects and datasets.

Evaluation Scheme

Evaluation components	**Weightage**
1. **Project Proposal**: 10% a. Initial identification of the problem, objectives, and methodology.	**10 Marks**
2. **Mid-Term Presentation**: 20% Progress report including initial findings, challenges, and adjustments.	**20 Marks**
3. **Final Report**: 30% Comprehensive documentation of the project including literature review, methodology, data analysis, results, and conclusions.	**40 marks**
4. **Final Presentation**: 20% Oral presentation and defense of the project findings before peers and evaluators.	**20 Marks**
5. **Peer Review and Team Contribution**: 10% Assessment based on peer evaluations, participation in team activities, and overall contribution to the project.	**10 Marks**

6. **Case Study Analysis**: 10% Analysis and presentation of a case study relevant to the project topic, demonstrating the application of theoretical concepts in real-world scenarios.	**10 Marks**

MINOR IN AI\ML

SEMESTER II					
UNMIDS201	**Data Analytics using SQL**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course is designed to provide students with essential skills in SQL, a fundamental tool in data analysis and data science. Students will learn to effectively retrieve, clean, manipulate, and analyze data stored in relational databases, supporting data-driven decision-making in various domains. The course emphasizes practical application, equipping students with the ability to use SQL to solve real-world problems in business, finance, marketing, healthcare, and more. By mastering SQL, students will gain a strong foundation in data analytics, enabling them to make meaningful contributions in their careers.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding and constructing complex SQL queries to retrieve, filter, and aggregate data from relational databases.

CO2: Applying SQL commands to clean and preprocess data, including handling missing values, duplicates, and performing data transformations.

CO3: Analyzing datasets using SQL queries to identify patterns and summarize key statistics for initial insights.

CO4: Evaluating and interpreting query results by visualizing data with tools or libraries to create meaningful charts, graphs, and plots that enhance understanding.

Course Content

Unit 1: Introduction to SQL and Database Management **Lectures:** 15

- Introduction to Data Science
- Introduction to SQL Server
- Understanding Data & Information
- Database Concepts
- DBMS and RDBMS
- Database Design Principles
- Types of Databases
- SQL Server Versions
- Creating Databases
- Sub-languages of T-SQL: DDL, DML, TCL, DCL, DQL
- Creating Tables
- Data Manipulation (Insert, Delete, Update)
- Normalization
- Constraints (Unique, Not Null, Primary Key, Check, Default, Foreign Key)

Unit 2:SQL Queries and Data Manipulation **Lectures:** 20

- Working with Single Table Queries
- Writing Queries using SELECT Statement
- Understanding Query Flow
- Operators in SQL Server
- Clauses in SQL Server (WHERE, ORDER BY, DISTINCT, TOP)
- Filtering and Sorting Data
- DML Commands (Insert, Update, Delete)
- DDL Commands (Create, Alter, Drop, Truncate)
- Delete vs Truncate

Unit 3:SQL Functions and Aggregation **Lectures:** 10

- Built-in Functions
- Scalar Functions (String, Date, ISNULL, etc.)
- Group Functions (Aggregate Functions: COUNT, MAX, MIN, AVG, SUM)
- Usage of Functions in Data Analysis

Unit 4:Advanced SQL Queries: Subqueries and Joins **Lectures:** 15

- Subqueries: Importance and Types
- Nested Queries

- JOINS: Importance and Types (Inner Join, Outer Joins, Left, Right Outer Joins)

List of Practicals

- Create a student table with student ID, name, and marks as attributes where student ID is the primary key.
- Insert the details of a new student in the above table.
- Delete the details of a student in the above table.
- Use the SELECT command to get the details of students with marks more than 80.
- Find the min, max, sum, and average of marks in a student marks table.
- Find the total number of customers from each country using GROUP BY.
- Write a SQL query to order the (student ID, marks) table in descending order of marks.
- Write a SQL query to display marks without decimal places, the remainder after dividing marks by 3, and the square of marks.
- Write a SQL query to display names in capital letters, small letters, first 3 letters of the name, last 3 letters of the name, and the position of the letter 'A' in the name.
- Remove extra spaces from left, right, and both sides of the text "SQL for Data Science".
- Display today's date in "Date/Month/Year" format.
- Display the day name, month name, day, day name, day of the month, and day of the year for today's date.

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on projects to deepen understanding of SQL, data manipulation, and data analysis.

Instruction Methods:

- **Lectures:** Core SQL concepts will be taught using multimedia presentations and real-world examples.
- **Interactive Sessions:** Q&A, live coding exercises, and group discussions will actively engage students.
- **Technology Use:**
- **Online Platforms:** An LMS will host resources, recorded lectures, assignments, and discussion forums to facilitate extended learning.
- **Assessments:**

- **Formative:** Regular quizzes, assignments, and online discussions will provide continuous feedback.
- **Summative: Exams, project presentations, and peer reviews will assess students' mastery of the material.**

Support: The course instructor will offer additional guidance, with peer collaboration encouraged through group work and review sessions. Continuous feedback will ensure students' progress and improvement in achieving course outcomes.

Textbooks

1. "Learning SQL" by Alan Beaulieu
2. "SQL for Dummies" by Allen G. Taylor

Reference Books

1. "SQL in 10 Minutes, Sams Teach Yourself" by Ben Forta
2. "SQL Pocket Guide" by Jonathan Gennick
3. "The Practical SQL Handbook" by Judith S. Bowman, Sandra L. Emerson, and Marcy Darnovsky

Open Educational Resources (OER)

1. https://www.w3schools.com/sql/
2. https://www.khanacademy.org/computer-programming/new/sql
3. https://www.coursera.org/learn/sql-for-data-science

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.

SEMESTER II					
UNMIDS202	**Data Analytics using R**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Basic concepts of Statistics**				

Course Perspective

The course "Data Analytics using R" is designed to equip students with the foundational skills in R programming necessary for data analysis in various domains. By engaging with this course, students will gain hands-on experience in data manipulation, visualization, and statistical analysis using R, making them proficient in handling real-world data challenges. The knowledge acquired in this course is applicable across industries where data-driven decision-making is key. The skills developed will enhance students' academic prowess and prepare them for careers in data science, analytics, and research. For example, students will be able to create insightful visualizations to present data-driven solutions, identify trends, and model data effectively, which are essential skills in today's data-centric job market.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding and applying R programming concepts to perform basic data manipulation and visualization tasks.

CO2: Analyzing data sets by employing appropriate R data structures, such as vectors, matrices, and data frames.

CO3: Creating custom R functions and utilizing control structures to automate data analysis processes.

CO4: Evaluating and interpreting data trends through various graphical representations in R.

Course Content

Unit I: Fundamentals of R: (Lectures: 15)

- Introduction to R: Features of R, Environment, R Studio
- Basics of R: Assignment, Modes, Operators, Logical values, Basic Functions

- R Data Structures: Vectors, Lists, Matrices, Data Frames, Factors
- Control Structures: if-else, loops, and functions

Unit II: Data Structures in R: (Lectures: 15)

- Vectors: Definition, Declaration, Operations
- Matrices: Creating, Reshaping, Operations
- Lists: Creating, General Operations
- Data Frames: Creating, Accessing, Merging, Special Functions

Unit III: Working with Data in R: (Lectures: 15)

- Reading and Writing Data: CSV, Excel, Text Files
- String Operations: Regular Expressions, Dates in R
- Data Preprocessing: Descriptive Statistics, Handling Missing Values, Normalization
- Exploratory Data Analysis: Summarizing Data, Identifying Patterns

Unit IV: Data Visualization with R: (Lectures: 15)

- Basic Visualization Tools: Bar Charts, Histograms, Pie Charts, Scatter Plots, Line Plots
- Introduction to ggplot2: Creating Simple Plots, Customization Techniques
- Project on R and related discussion

Learning Experience

This course will be conducted through a blend of lectures, practical sessions, and interactive activities. Students will engage in hands-on learning using R software, working on real-world data sets to apply concepts learned in class. Methods of instruction will include case studies, group work, and individual assignments.

Instruction Methods:

- **Lectures:** Core R programming concepts will be taught through multimedia presentations and coding examples.
- **Hands-on Sessions:** Students will work on real-world data sets using R, applying concepts through practical exercises.
- **Group Work and Case Studies:** Collaborative projects and case studies will reinforce learning and promote teamwork.
- **Technology Use:**
- **R and RStudio:** Students will use R and RStudio for data manipulation, visualization, and analysis.
- **Shiny:** For creating interactive web applications and visualizations.

- **Online Platforms:** LMS for accessing resources, recorded lectures, and submitting assignments.
- **Assessments:**
- **Formative:** Regular quizzes, coding exercises, and assignments for continuous feedback.
- **Summative:** Project presentations, case study analyses, and a final assessment to evaluate students' mastery of R programming and data analysis.

Support: The course instructor will provide continuous guidance, with opportunities for students to collaborate through group work and peer reviews. Regular feedback will be given on assignments and projects, and students are encouraged to seek help as needed to enhance their learning experience.

Textbooks

1. Cognitive Computing with IBM Watson by Rob High, TanmayBakshi (1st edition)
2. Nina Zumel, John Mount, Practical Data Science with R, Manning Publications, 2014

Reference Books

1. Mark Gardener, Beginning R: The Statistical Programming Language, John Wiley & Sons, 2012
2. Nathan Yau, Visualize This: The FlowingData Guide to Design, Visualization, and Statistics, Wiley, 2011

Open Educational Resources (OER)

1. "Introduction to Data Science with R" (HarvardX Data Science Series on edX)
2. "R Programming" (Coursera by Johns Hopkins University)
3. "Advanced R" by Hadley Wickham (available online at Advanced R)

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory):	40 marks
End Term Examination	

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER III					
UNMIDS301	**Python for Data Science**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Nil**				

Course Perspective

"Python for Data Science" is designed to equip students with the foundational skills necessary for data analysis and manipulation using Python, a leading programming language in the data science field. The course contributes to students' academic and professional development by providing them with essential tools and techniques to solve real-world data problems. Students will gain knowledge in Python programming, data manipulation using NumPy and Pandas, and data cleaning and visualization techniques, making them well-prepared for careers in data science, analytics, and related fields. The skills learned in this course are directly applicable to analyzing large datasets, performing complex data operations, and generating meaningful insights, which are crucial in various industries such as finance, healthcare, marketing, and technology.

Course Outcomes

Upon completion of this course, the learner will be able to:

CO1: Understanding and remembering Python's built-in data types and methods to solve basic data-related problems.

CO2: Applying efficient data storage and operations using NumPy arrays for numerical data processing.

CO3: Analyzing data using Pandas for advanced data manipulation tasks, identifying trends and patterns in datasets.

CO4: Evaluating data pre-processing techniques and creating visualizations using Pandas to communicate insights effectively.

Course Content

Unit 1: Introduction to Data Science and Python Programming (Lectures: 15)

- Introduction to Data Science
- Why Python?
- Essential Python libraries
- Python Introduction: Features, Identifiers, Reserved words, Indentation, Comments
- Built-in Data types and their Methods: Strings, List, Tuples, Dictionary, Set
- Type Conversion
- Operators, Decision Making, Looping, Loop Control statement
- Math and Random number functions
- User-defined functions: function arguments & its types

Practical Component:

- Implement basic Python programs for reading input from the console.
- Perform operations on Python built-in data types: Strings, List, Tuples, Dictionary, Set.
- Solve problems using decision and looping statements.
- Handle numerical operations using math and random number functions.
- Create user-defined functions with different types of function arguments.

Unit 2: Introduction to NumPy (Lectures: 15)

- Arrays and Vectorized Computation
- The NumPyndarray
- Creating ndarrays
- Data Types for ndarrays
- Arithmetic with NumPy Arrays
- Basic Indexing and Slicing
- Boolean Indexing
- Transposing Arrays and Swapping Axes
- Universal Functions: Fast Element-Wise Array Functions

- Mathematical and Statistical Methods
- Sorting, Unique and Other Set Logic

Practical Component:

- Create NumPy arrays from Python Data Structures and Random Functions.
- Manipulate NumPy arrays: Indexing, Slicing, Reshaping, Joining, and Splitting.
- Perform computations using Universal Functions and Mathematical methods.
- Import and analyze data from CSV files using NumPy.
- Manipulate images using NumPy.

Unit 3: Data Manipulation with Pandas (Lectures: 15)

- Introduction to Pandas Data Structures: Series, DataFrame
- Essential Functionality: Dropping Entries, Indexing, Selection, and Filtering
- Function Application and Mapping
- Sorting and Ranking
- Summarizing and Computing Descriptive Statistics
- Unique Values, Value Counts, and Membership
- Reading and Writing Data in Text Format

Practical Component:

- Create Pandas Series and DataFrames from various inputs.
- Perform data operations on CSV files using Pandas.
- Conduct statistical analysis and operations on DataFrames.
- Handle categorical data using Pandas.
- Rename columns and restructure data using Pandas.

Unit 4: Data Cleaning, Preparation, and Visualization (Lectures: 15)

- Handling Missing Data
- Data Transformation: Removing Duplicates, Transforming Data Using a Function or Mapping, Replacing Values
- Detecting and Filtering Outliers
- String Manipulation: Vectorized String Functions in Pandas
- Plotting with Pandas: Line Plots, Bar Plots, Histograms, Density Plots, Scatter Plots

Practical Component:

- Handle missing data and perform data transformations using Pandas.
- Detect and filter outliers in datasets.
- Execute vectorized string operations in Pandas.
- Visualize data using various plotting techniques.

Learning Experience

This course will combine lectures, hands-on sessions, and interactive activities to equip students with Python programming skills for data science.

Instruction Methods:

- **Lectures:** Core Python programming concepts and data science principles will be introduced through multimedia presentations and live coding demonstrations.
- **Hands-on Sessions:** Students will work on real-world data sets using Python, applying concepts learned in class through practical exercises.
- **Group Work and Case Studies:** Collaborative projects will reinforce learning, with case studies to address real-world data science challenges.
- **Technology Use:**
- **Python, NumPy, Pandas:** These tools will be used for data analysis, manipulation, and visualization.
- **Jupyter Notebooks:** For executing and documenting Python code.
- **Online Platforms:** LMS for accessing resources, recorded lectures, and submitting assignments.

- **Assessments:**

- **Formative:** Regular quizzes, coding exercises, and assignments will provide continuous feedback on students' progress.
- **Summative:** Project presentations, case study analyses, and a final assessment will evaluate students' understanding and application of Python for data science.

Support: The course instructor will offer continuous guidance and feedback. Peer collaboration will be encouraged through group work and review sessions. Students will have access to online resources and office hours to seek additional help when needed. Regular feedback will ensure that students meet the course outcomes effectively.

Textbooks

1. Y. Daniel Liang, “Introduction to Programming using Python,” Pearson, 2012.
2. Wes McKinney, “Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython,” O’Reilly, 2nd Edition, 2018.

Reference Books

1. Jake VanderPlas, “Python Data Science Handbook: Essential Tools for Working with Data,” O’Reilly, 2017.

2. Wesley J. Chun, “Core Python Programming,” Prentice Hall, 2006.
3. Mark Lutz, “Learning Python,” O’Reilly, 4th Edition, 2009.
4. Joel Grus, “Data Science from Scratch: First Principles with Python,” O’Reilly, 2015.

Open Educational Resources (OER)

1. NPTEL Python for Data Science
2. Kaggle's Python for Data Science
3. Awesome Python for Data Science (GitHub)

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV					
UNMIDS402	**Data Structures and Algorithms**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Nil**				

Course Perspective

The Data Structures and Algorithms course provides students with a deep understanding of fundamental data structures and the algorithms used to manipulate them. Students will learn to design, analyze, and implement efficient algorithms to solve complex computational problems. The course covers topics such as arrays, linked lists, trees, graphs, sorting, searching, and optimization techniques. By mastering these concepts, students will develop the skills to write optimized code, improve problem-solving abilities, and prepare for advanced studies or careers in computer science and software development.

Course Outcomes

Upon completion of the course, the learner will be able to:

Course Content

CO1: Understanding and remembering key data structures such as arrays, linked lists, stacks, queues, trees, and graphs for effective data management.

CO2: Applying knowledge to design, implement, and analyze algorithms for various computational tasks, assessing their efficiency in terms of time and space complexity.

CO3: Analyzing complex real-world problems and selecting appropriate data structures and algorithms to optimize performance and resource usage.

CO4: Evaluating and improving existing algorithms, enhancing their efficiency and preparing them for more advanced studies or professional challenges in computer science.

Unit I: Oops Concepts 10 hours

Class, Object, Constructors, type of variables, type of methods. Inheritance: single, multiple, multi-level, hierarchical, hybrid. Polymorphism: with functions and objects, with class methods, with inheritance. Abstraction: abstract classes.

Unit II: Introduction to Data Structures and Basic Algorithms 15 hours

Overview of Data structures and their importance.Introduction to arrays and lists-understanding linear data structures. Implementing arrays and lists in Python. Basic operations on arrays and lists: insertion, deletion, searching. Implementing stack and queues in Python. Stack Operations: push, pop, peek. Queue Operations: enqueue, dequeue, peek. Time complexity, amortize time complexity and space complexity analysis: Big O notation, Big omega notation and Big theta notation.

Problem-Solving Exercise: Parenthesis Matching, Tower of Hanoi, implementing a stack-based algorithm (Reversing a string).

Unit III: Advanced Data Structures and Sorting Algorithms 20 hours

Introduction to Linked Lists and trees, Implementing Linked lists and Binary trees in Python. Introduction to searching algorithms: Linear search, Binary search. Introduction to sorting

algorithms: Bubble sort, selection sort, insertion sort. Divide and Conquer algorithms: Merge Sort and quick sort algorithms.

Problem-Solving Exercises: Longest Common Subsequence, Longest Increasing Subsequence, Word Break Problem, Subset Sum Problem, Binary Search, Merge Sort, Quick Sort.

Unit IV: Graph Algorithms and Dynamic Programming 15 hours

Introduction to graphs: representation and traversal. Depth-First Search (DFS) and Breadth-First Search (BFS). Shortest Path Algorithms: Dijkstra's Algorithm, Bellman-Ford Algorithm. Introduction to Dynamic Programming: Principles and Applications. Solving problems using dynamic programming.

Problem-Solving Exercises: Travelling Salesman Problem, Floyd-Warshall Algorithm, Knapsack Problem, Longest Increasing Subsequence (LIS) using Dynamic Programming.

Learning Experience

The *Data Structures and Algorithms* course offers a dynamic learning experience focused on both theory and practical application. Students will engage in interactive lectures, hands-on programming exercises, and collaborative projects to master key data structures and algorithms. Algorithmic challenges and real-world case studies will enhance problem-solving skills and demonstrate practical applications. Continuous feedback through quizzes and coding reviews will guide students' progress. The course emphasizes the use of industry-standard tools, encouraging students to write, optimize, and reflect on their code, preparing them for advanced studies and professional challenges.

Textbooks

1. Michael T. Goodrich: Data structures and algorithms in Python
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein: Introduction to Algorithms

Reference Books

1. Aaron M. Tenenbaum,YedidyahLangsam and Moshe J. Augenstein "Data Structures Using C and C++", PHI Learning Private Limited, Delhi India
2. Berztiss, A.T.: Data structures, Theory and Practice :, Academic Press.
3. Jean Paul Trembley and Paul G. Sorenson, "An Introduction to Data Structures with applications", McGraw Hill.

Open Educational Resources (OER)

1. https://www.coursera.org/specializations/data-structures-algorithms
2. https://www.khanacademy.org/computing/computer-science/algorithms
3. https://www.coursera.org/specializations/algorithms

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Create a simple sorting algorithm, such as Bubble Sort or Insertion Sort, and implement it in your preferred programming language. Write a program to sort an array of integers and analyze its time complexity. After implementation, discuss with peers how different sorting algorithms compare in terms of efficiency and practical use cases. Submit both your code and a brief report on your findings.

SEMESTER V					
UNMIDS502	**Fundamentals of Artificial Intelligence**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites					

Course Perspective

The *Fundamentals of Artificial Intelligence* course introduces students to core concepts and techniques in AI, including machine learning, neural networks, natural language processing, and computer vision. Students will explore how AI systems are designed, trained, and

evaluated, gaining practical experience with tools and algorithms used in the field. The course emphasizes both theoretical understanding and hands-on application, preparing students for advanced studies or careers in AI. By the end of the course, students will have a solid foundation in AI principles and the ability to implement basic AI solutions.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding and explaining core AI concepts, including machine learning, neural networks, natural language processing, and computer vision.

CO2: Applying AI models and algorithms using popular frameworks and tools, demonstrating skills in data preprocessing, model training, and evaluation.

CO3: Analyzing data by developing custom R functions and utilizing control structures to automate data analysis processes effectively.

CO4: Evaluating the effectiveness of different data preprocessing techniques, selecting appropriate methods for cleaning and preparing data for analysis.

Course Content

UNIT I: Introduction to Artificial Intelligence 10 hours

Definition of Intelligence, Artificial Intelligence, Historical overview, Importance of AI, Real time applications, Turing Test, key milestones in AI, State of the Art in AI Differentiating AI from human intelligence; Types of Knowledge, Intelligent Agents and their structure, Risk and Benefits of AI.

UNIT II: Informed and Uninformed Search Strategies 20 hours

Problem Representation techniques, Declarative and Procedural representations, Search algorithms for problem solving; Uninformed Search Strategies: Breadth-first search, Depth First search, Uniform Cost search; Informed search (Heuristic Based) strategies: Hill Climbing, Greedy best first search, A* Search – admissibility and optimality.

UNIT III: Artificial Intelligence and Python 15 hours

Agent architectures and hierarchical controllers; Using Python to search in continuous spaces, search with non-deterministic actions, search in partially observable environments; online search agents; constraint satisfaction problems; Game theory; Reasoning, Learning, Planning with uncertainty; Reinforcement Learning

UNIT IV: Applications of AI 15 hours

AI in healthcare: Diagnosis, treatment, and medical imaging; AI in finance: Fraud detection, algorithmic trading, and risk assessment; AI in transportation: Autonomous vehicles and traffic

optimization; AI in customer service and chatbots; AI in education: Personalized learning and intelligent tutoring systems; AI and creativity: Generative models and artistic applications; Ethical and Social Implications of AI

Learning Experience

The *Fundamentals of Artificial Intelligence* course offers an immersive learning experience with a blend of theoretical and practical approaches. Students will engage in interactive lectures covering core AI concepts, and hands-on projects to implement AI models using tools like TensorFlow and PyTorch. Real-world case studies will illustrate AI applications and challenges. Collaborative activities will enhance problem-solving skills, while continuous feedback through assignments and quizzes will support learning. The course aims to build a solid foundation in AI principles and their practical applications.

Textbooks

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall, Third Edition (2009).

Reference Books

1. David L. Poole and Alan K. Mackworth, Python code for Artificial Intelligence Foundations of Computational Agents, Version 0.9.12 of January 18, 2024.
2. Ian GoodFellow, YoshuaBengio& Aaron Courville, Deep Learning, MIT Press (2016).

Open Educational Resources (OER)

1. https://www.elementsofai.com/
2. https://www.iu.org/en-in/blog/ai-and-education/best-ai-tools-for-students/
3. https://ep.jhu.edu/programs/artificial-intelligence/courses/

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory):	**40 marks**
End Term Examination	

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

In the *Fundamentals of Artificial Intelligence* course, students will engage in activities such as implementing AI models through hands-on projects, analyzing case studies of AI applications, participating in group discussions on ethical implications, and completing coding assignments using AI frameworks. Interactive quizzes and practical exercises will reinforce learning and enhance their understanding of AI concepts.

SEMESTER VI					
UNMIDS601	**Fundamental of Machine Learning**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites	**Basic concepts of Statistics**				

Course Perspective

This course provides essential skills in machine learning, covering both supervised and unsupervised techniques using Python. Students will learn to preprocess data, apply regression and classification models, and utilize clustering methods. The course emphasizes practical application, preparing students to tackle real-world problems and make impactful contributions in fields like business, healthcare, and technology.

Course Outcomes

Upon completion of the course, the learner will be able to:

Upon completion of the course, the learner will be able to:

CO1: Remembering and understanding machine learning concepts to identify suitable applications, distinguishing between supervised and unsupervised learning, and utilizing appropriate Python libraries for machine learning tasks.

CO2: Applying preprocessing techniques to prepare data for analysis by handling missing values, encoding categorical data, and applying normalization, standardization, and Principal Component Analysis (PCA) techniques.

CO3: Analyzing and developing supervised learning models, including linear and non-linear regression, K-Nearest Neighbour, Decision Trees, Logistic Regression, and Support Vector Machines, to address various predictive and classification problems.

CO4: Evaluating the performance of machine learning models using appropriate evaluation methods to ensure the development of accurate and effective predictive models.

Course Content

Unit I: Introduction to Machine Learning **Lectures: 16 Hours**

- Application of Machine Learning
- Supervised vs Unsupervised Learning
- Python libraries suitable for Machine Learning

Unit II: Data Pre-Processing and Data **Lectures: 16 Hours**

- Identifying and handling the missing values
- Encoding the categorical data
- Normalization
- Standardization
- PCA

Unit III: Supervised Learning Regression and Classification **Lectures: 16 Hours**

- Linear Regression
- Non-Linear Regression
- Model evaluation methods
- K-Nearest Neighbour
- Decision Tree
- Logistic Regression
- Support Vector Machines,
- Model Evaluation

Unit IV: Unsupervised Learning **Lectures: 16 Hours**

- K-means Clustering
- Hierarchical Clustering
- Density-Based Clustering

Learning Experience

This course will combine lectures, interactive sessions, and hands-on projects to enhance understanding of machine learning concepts, data preprocessing, and model implementation. Students will engage in practical exercises to apply supervised and unsupervised learning techniques, ensuring a comprehensive learning experience.

Lectures:

Instruction Methods:

- **Lectures:** Core machine learning concepts will be taught using multimedia presentations and real-world case studies.
- **Interactive Sessions:** Q&A, coding exercises, and group discussions will actively engage students in applying machine learning techniques and solving practical problems.
- **Group Work and Case Studies:** Collaborative projects and case studies will reinforce learning and promote teamwork.
- **Technology Use:**
- **R and RStudio:** Students will use R and RStudio for data manipulation, visualization, and analysis.
- **Shiny:** For creating interactive web applications and visualizations.
- **Online Platforms:** LMS for accessing resources, recorded lectures, and submitting assignments.
- **Assessments:**
- **Formative:** Regular quizzes, coding exercises, and assignments for continuous feedback.
- **Summative:** Project presentations, case study analyses, and a final assessment to evaluate students' mastery of R programming and data analysis.

Support: The course instructor will provide continuous guidance, with opportunities for students to collaborate through group work and peer reviews. Regular feedback will be given on assignments and projects, and students are encouraged to seek help as needed to enhance their learning experience.

Textbooks

1. Machine Learning - Tom M. Mitchell
2. Python Machine Learning – Sebastian, Raschka and VahidMirjalili

Reference Books

1. Understanding Machine Learning - ShaiShalev-Shwartz and Shai Ben-David La

2. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Technique to Build Intelligent Systems-AurelienGeron

Open Educational Resources (OER)

1. https://www.coursera.org/learn/machine-learning
2. https://www.datacamp.com/tutorial/introduction-machine-learning-python

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER VII					
UNMIDS702	**Neural Network and Deep Learning**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				

Pre-Requisites/ Co-Requisites	

course Perspective

Neural Networks and Deep Learning explore the intricacies of artificial neural networks, focusing on how they mimic human brain processes to recognize patterns and make predictions. This course covers fundamental concepts like perceptrons, activation functions, and backpropagation, along with advanced topics such as convolutional and recurrent neural networks. Students will gain practical experience in designing, training, and evaluating models, enabling them to tackle complex problems across various domains, from image recognition to natural language processing.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding the fundamental principles of neural networks, including architecture, activation functions, and optimization techniques.

CO2: Applying knowledge to design, train, and evaluate different types of neural network models such as feedforward, convolutional, and recurrent networks.

CO3: Analyzing the performance of neural network models by interpreting outputs, performing error analysis, and refining models to improve accuracy and efficiency.

CO4: Evaluating deep learning frameworks and tools to solve real-world problems in areas like image classification, natural language processing, and time-series analysis.

Course Content

Unit I: Fundamentals of Neural Network and Training 12 hours

Introduction to neural network and their importance, biological inspiration of neural network, Historical overview; Perceptron: The basic neural unit; multi-layer perceptron and need for hidden layers, Activation units and their roles, Cost/Loss function and performance measurement.

Unit II: Feedforward Neural Networks 15 hours

Feedforward neural network architecture, training a neural network, determining hidden layers, backpropagation for weight updates, stochastic, gradient descent, mini-batch gradient descent.

Unit III: Convolution Neural Networks 18 hours

Convolution neural networks for image data, CNN building blocks- convolution, pooling, LeNet, AlexNet – pioneer CNN architectures, VGGNet, ResNet, and other modern CNN architectures, Data Augmentation techniques for computer vision, Applications of CNN- image recognition, object detection.

Unit IV: Recurrent Neural Networks and Sequences **15 hours**

Recurrent neural network architectures (RNNs), Handling sequential data like text, speech, time series, Long Short-Term Memory (LSTM) models, Gated Recurrent Units (GRUs), Transformer Model, Applications like machine translation, text generation.

Learning Experience

The learning experience in Neural Networks and Deep Learning is immersive and hands-on, combining theoretical knowledge with practical application. Students engage with foundational concepts through interactive lectures and exercises, exploring how neural networks mimic brain functions. They gain practical skills by designing, training, and evaluating various models using popular deep learning frameworks. Real-world projects and case studies enhance understanding, while regular feedback and peer collaboration foster a deeper grasp of complex topics. This approach equips students with both the theoretical insights and practical skills needed for success in the field.

Textbooks

1. "Neural Networks and Deep Learning" by Michael Nielsen (Determination Press, 2015).

Reference Books

1. “Pattern Recognition and Machine Learning” by Christopher Bishop.
2. “Hands-on Machine Learning with Scikit-Learn, Keras and Tensor Flow” by AurelienGeron (O Reilly, 2019).

Open Educational Resources (OER)

1 http://neuralnetworksanddeeplearning.com/

2. https://www.coursera.org/specializations/deep-learning/
3. https://cs231n.stanford.edu/

Evaluation Scheme

Evaluation components	Weightage

Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**40 marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Develop a neural network model to classify images from a provided dataset using a deep learning framework like TensorFlow or PyTorch. Students will preprocess the data, design and train the model, and evaluate its performance. They will then present their results, discussing challenges faced, model accuracy, and potential improvements. This activity emphasizes hands-on experience, problem-solving skills, and effective communication of technical findings.

SEMESTER VIII					
UNMIDS802	**Natural Language Processing**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Lectures	60 Hours				
Pre-Requisites/ Co-Requisites					

Course Perspective

This course explores the foundations and advancements in Natural Language Processing (NLP) and Generative AI, focusing on the intersection of language and machine learning. Students will learn to analyze, understand, and generate human language using various NLP techniques. The course covers essential topics such as text processing, language models, machine translation, and sentiment analysis, alongside cutting-edge generative AI models like GPT and

transformers. By the end, students will be equipped with the skills to build intelligent systems that comprehend and generate human-like text.

Course Outcomes

Upon completion of the course, the learner will be able to:

CO1: Understanding the core principles and techniques of Natural Language Processing (NLP), including tokenization, parsing, and language models.

CO2: Applying machine learning models to solve language-related tasks such as sentiment analysis, text classification, and named entity recognition.

CO3: Analyzing linguistic data and evaluating the performance of models using metrics like precision, recall, and F1 score.

CO4: Evaluating ethical considerations and challenges associated with AI in language processing, such as bias, privacy, and fairness.

Course Content

Unit I:Introduction to Natural Language Processing 15 hours

Natural language Processing, Applications of NLP (chatbots, machine translation, sentiment analysis, etc.), Basic Text processing: tokenization, stopword removal, stemming/lemmatization, Vector representation of text (bag-of-word, TF-IDF, word embeddings).

Unit II: Language Learning Models 20 hours

Introduction to Language models and n-grams, Regular expressions and pattern matching, Text normalization and data cleaning, Exploratory data analysis for text data. Supervised vs. unsupervised learning for NLP tasks, Text classification with logistic regression and naïve bayes, Sequence labelling with conditional random files (CRF), Evaluation metrics for NLP (accuracy, F1-score, perplexity), Neural network basics (feedforward, backpropagation).

Unit III:Voice Processing and Speech Recognition 15 hours

Introduction to voice processing and its importance in NLP, Fundamentals of speech signals and acoustics. Speech pre-processing techniques; noise reduction, normalization, and feature extraction (MFCC, spectrograms), Automatic Speech Recognition (ASR) systems: Hidden Markov Models (HMMs), Gaussian Mixture Models (GMMs). Text-to-Speech synthesis: WaveNet, Tacotron, and other modern architectures.

Unit IV: Deep Learning for NLP 7 hours

Recurrent neural networks (RNNs) for sequence modelling, Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRUs), Encoders, decoders and sequence-to-sequence models, Attention mechanisms and Transformer architecture, Pretrained language models

(ELMo, BERT, GPT) and transfer learning, Named Entity Recognition (NER) with deep learning.

Unit V: Generative AI and Applications **3 hours**

Introduction to generative models and their applications, Text generation with language models and beam search, Image captioning and multimodal tasks, Generative adversarial networks (GANs) for text and image generation, Limitations, ethical considerations and future of generative AI, Open ended conversational AI and chatbots, ChatGPT.

Learning Experience

The learning experience in this course is highly interactive and hands-on, blending theoretical knowledge with practical applications. Students will engage in coding exercises, real-world projects, and collaborative group work to reinforce their understanding of Natural Language Processing (NLP) and Generative AI. Through the use of contemporary tools and frameworks, they will build and deploy models, analyze language data, and explore the ethical implications of AI. This approach ensures that students gain both technical expertise and critical thinking skills.

Textbooks

1. "Conversational AI" by LiliZheng and Honglak Lee (2022).

Reference Books

1. "An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition" by Dan Jurafsky, James H. Martin, Prentice Hall, (2009)
2. "Natural Language Processing with Python" by Steven Bird, Ewan Klein, and Edward Loper (2009).

Open Educational Resources (OER)

1. https://www.geeksforgeeks.org/top-natural-language-processing-nlp-books/
2. https://www.iu.org/en-in/blog/ai-and-education/best-ai-tools-for-students/
3. https://ep.jhu.edu/programs/artificial-intelligence/courses/

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (40 marks)** All the components to be evenly spaced	**40 marks**

Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

Student Activity

Implement a basic sentiment analysis model using Python. Students will use a dataset of text reviews to train a model that classifies the sentiment as positive, negative, or neutral. They will preprocess the text by removing stopwords and applying tokenization. After training the model, students will evaluate its accuracy using a test set. Finally, they will visualize the results and discuss potential improvements, considering different machine learning algorithms and feature extraction techniques such as TF-IDF or word embeddings.

MINOR-NANO SCIENCE

Minor-Nano Science

SEMESTER II					
UNMINS201	**Study of Materials**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Lectures	**60 hours**				
Pre-Requisites/ Co-Requisites	**Basic concepts of Physics, Chemistry**				

Course Perspective: All the modern materials show some unique properties which either are by the virtue of material or may be tailored. Metallurgists and Materials scientists are responsible for designing and producing new materials. The desired properties may be introduced in the materials by altering their microstructures. This course will help students understand the properties of different types of materials and their applications. The course will also be helpful to develop new kind of materials for engineering applications.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Understanding the basic concepts of stress, strain, and deformation, and explain how materials respond to mechanical forces.

CO 2: Applying the principles of dislocation and strengthening mechanisms to improve the mechanical properties of metals.

CO 3: Analyzing solid solutions and phase diagrams to determine the impact of cooling and structural changes on material properties.

CO 4: Evaluating different types of failure such as fracture, fatigue, creep, and corrosion, and recommend strategies to prevent material degradation.

Course Content

UNIT I Mechanical Properties of Metals **Lectures: 15**

Concepts of Stress and Strain, Elastic Deformation: Stress-Strain Behavior, Anelasticity, Elastic Properties of Materials; Plastic Deformation: Tensile Properties, True Stress and Strain, Elastic Recovery after Plastic Deformation, Compressive, Shear, and Torsional Deformation, Hardness; Property Variability and Design/Safety Factors: Variability of Material Properties, Design/Safety Factors.

UNIT II Dislocations and Strengthening Mechanisms **Lectures: 15**

Characteristics of Dislocations, Slip Systems, Slip in Single Crystals, Plastic Deformation of Polycrystalline Materials, mechanism of plastic deformation, deformation by twinning, Mechanisms of Strengthening In Metals: Strengthening by Grain Size Reduction, 7.9 Solid-Solution Strengthening, Strain Hardening; Recovery, Recrystallization and Grain Growth: Recovery, Recrystallization, Grain Growth.

UNIT III Solid solutions and phase diagram **Lectures: 15**

Introduction to single and multiphase solid solutions and types of solid solutions, importance and objectives of phase diagram, systems, phase and structural constituents, cooling curves, unary & binary phase diagrams, Gibbs's phase rule, Lever rule, eutectic and eutectoid systems, peritectic and peritectoid systems, iron carbon equilibrium diagram and TTT diagram.

UNIT IV Failures of metals **Lectures: 15**

Failure analysis, fracture, process of fracture, types of fracture, fatigue, characteristics of fatigue, fatigue limit, mechanism of fatigue, factors affecting fatigue. Definition and concept of Creep, creep curve, mechanism of creep, impact of time and temperature on creep, creep fracture, creep testing and prevention against creep. Corrosion: Mechanism and effect of corrosion, prevention of corrosion

Learning Experience:

1. Classes will incorporate interactive lectures supported by multimedia presentations, simulations, and virtual labs.
2. Group activities such as problem-solving sessions, discussions, and peer reviews will be encouraged.
3. Regular assignments will be designed to challenge students to apply concepts learned in class. Quizzes, mid-term exams, and final assessments will focus on evaluating students' understanding, analytical skills, and problem-solving abilities. Students will receive timely feedback on their progress.

4. The course instructor will be available for additional support through office hours and one-on-one meetings.

Textbooks"

1. Materials Science and Engineering:An Introduction (7th Ed.), William D. Callister, Jr., John Wiley & Sons, Inc.

Reference Books"

1. Material Science - Narula, Narula and Gupta. New Age Publishers
2. Material Science & Engineering –V. Raghvan, Prentice Hall of India Pvt. Ltd, New Delhi.
3. A Textbook of Material Science & Metallurgy – O.P. Khanna, Dhanpat Rai & Sons

Open Educational Resources (OER):

1. https://www.govinfo.gov/content/pkg/GOVPUB-C13-e18ffcc1681da9e902df23acaeb5cc6c/pdf/GOVPUB-C13-e18ffcc1681da9e902df23acaeb5cc6c.pdf
2. https://uomustansiriyah.edu.iq/media/lectures/6/6_2018_05_19!12_50_38_AM.pdf

Evaluation Scheme:

Evaluation components	**Weightage**
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER II					
UNMINS202	**Elements of Nano sciences and nanomaterial**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Lectures	**60 hours**				

Pre-Requisites/ Co-Requisites	**Basic concepts of Physics, Chemistry**

Course Perspective: The aim of this course is to introduce an emerging class of materials called nanomaterials that consists of a broad spectrum of examples with at least one dimension in the range of 1 to 100 nm. Exceptionally high surface areas can be achieved through the rational design of nanomaterials. It will also explain how nanomaterials can be produced with outstanding magnetic, electrical, optical, mechanical, and catalytic properties that are substantially different from their bulk counterparts. The course will conclude with various types of characterization techniques which can be used for analysing these nanomaterials.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Understanding the basic concepts of nanoscience, including the size effects, crystal structures, and the influence of nanostructuring on material properties.

CO 2: Applying quantum mechanics principles to explain the behavior of particles at the nanoscale, including solutions to the Schrödinger equation for different scenarios.

CO 3: Analyzing different types of nanostructured materials and evaluate how their dimensional properties affect their mechanical, optical, electronic, and chemical characteristics.

CO 4: Evaluating various chemical and biomimetic synthesis techniques for creating nanomaterials and assess their effectiveness in different applications.

Course Content:

Unit I Background to Nano science Lectures: 15

Definition of Nano, Scientific revolution-atomic Structure and atomic size, emergence and challenges of nano science and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of Nano over micro/macro, size effects and crystals, large surface to volume ratio, surface effects on the properties. Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties.

Unit-II Introduction to Quantum Mechanics Lectures: 15

Schrodinger equation and expectation values, Solutions of the Schrodinger equation for free particle, particle in a box, particle in a finite well, Reflection and transmission by a potential step and by a rectangular barrier. Angular momentum and its operators, Eigen values and Eigen functions of the angular momentum operators, spin, Pauli spin operators and their properties, hydrogen atom, density of states, free electron theory of metals.

Unit III Types of nanostructure and properties of nanomaterial Lectures: 15

One dimensional, two dimensional and three-dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

Chemical synthesis of nano material: Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, colloids, zeolites, organic block copolymers, emulsion

polymerization, template synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-template nucleation and/or crystallization. Vapour (or solution) – liquid – solid (VLS or SLS) growth -Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition

Unit IV Characterization of nanomaterial **Lectures: 15**

X-ray Diffraction - Thermal Analysis Methods, Differential Thermal Analysis and Differential scanning calorimetry - Spectroscopic techniques, UV-Visible Spectroscopy – IR Spectroscopy – Microwave Spectroscopy - Raman Spectroscopy: Electron Spin Resonance Spectroscopy, NMR Spectroscopy, Particle size characterization: Zeta Potential Measurement, Particle size Analysis: X-ray Photoelectron spectroscopy. Imaging techniques for nanotechnology: Scanning Electron Microscopy, Transmission Electron Microscopy, and Atomic Force Microscopy.

Learning Experience:

1. The course will combine traditional lectures with interactive digital tools like virtual labs, 3D simulations, and video tutorials.
2. Students will participate in hands-on experiments, focusing on nanomaterial synthesis, characterization, and quantum mechanics applications.
3. Group projects will encourage students to work together on designing experiments, analyzing nanomaterials, and solving problems related to nanoscale phenomena.
4. Students will complete regular assignments that challenge them to apply course concepts, such as solving quantum mechanics problems or designing synthesis techniques for nanomaterials.
5. The course instructor will be available during office hours for additional support and guidance.

Textbooks:

1. Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007.
2. Nanomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.

Reference Books:

1. Quantum Physics – A. Ghatak
2. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
3. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
4. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.
5. Processing & properties of structural naonmaterials - Leon L. Shaw, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

Open Educational Resources (OER):

1. https://www.youtube.com/watch?v=0EWCqCIsFOA
2. https://www.youtube.com/watch?v=-K7Gs0Nj-5o&list=PLQzUXa8lZVq__y0i5dOjW6oEr6h43bJCV
3. https://nptel.ac.in/courses/118104008
4. https://nptel.ac.in/courses/115101007

Evaluation Scheme:

Evaluation components	Weightage
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER III					
UNMINS301	**Nanostructured materials**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Lectures	**60 Hours**				
Pre-Requisites/ Co-Requisites	**Basics of nanomaterial**				

Course Perspective:

The aim of this course is making students understand the importance of nanostructured materials. Nanostructured materials have gained prominence in technological advancements due to their tunable physicochemical characteristics such as melting point, wettability, electrical and thermal conductivity, catalytic activity, light absorption and scattering resulting in enhanced performance over their bulk counterparts. Knowledge about these emerging materials will further help the students to explore these materials for advanced real-life applications.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Understanding the principles of nanocomposites, their classification, and their applications in fields like nuclear energy, Spintronics, and high-temperature environments.

CO 2: Applying the concepts of quantum confinement and size effects to explain the properties of nanostructures and their influence on material behavior and applying knowledge to optimize film properties for specific uses.

CO 3: Analyzing the synthesis methods and properties of nano ceramics, nano polymers, and conducting polymers, and evaluate their potential in various industrial applications.

CO 4: Evaluating the applications of nanotechnology in fields such as healthcare, consumer products, and energy devices, and assess the impact of these advancements.

Course Content

Unit I: Nano Composites **Lectures: 15**

Nano Composites and their Applications, Metal-Metal Nano composites for nuclear energy applications, Magnetic Nano composites for Spintronics application, Ceramic Nano composites for high temperature applications. Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures -Size effect and properties of nanostructures, Top down and Bottom-up approach.

Unit II: Nano Ceramics **Lectures: 15**

Nano ceramics: Dielectrics, ferroelectrics and magneto ceramics, Nano polymers: Preparation and characterization of d-block Copolymer based Nano composites, Nanoparticles polymer ensembles; Applications of Nano polymers in Catalysis.

Unit III: Polymers **Lectures: 15**

Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

Unit IV: Thin Films **Lectures: 15**

Miscellaneous applications of nanotechnology: dental implants, consumer products, biomimetic nanomaterial for tissue engineering, biopolymer tagging, semiconductor quantum dots.

Thin Film Formation Methods- Physical methods: thermal evaporation - vapour sources - Wire, crucible and electron beam gun - sputtering mechanism and methods - epitaxy - MBE. Chemical methods: chemical vapour deposition and chemical solution deposition techniques – spray pyrolysis - laser ablation

Learning Experience:

1. The course will use multimedia tools, including animations and simulations, to explain complex concepts such as quantum confinement, thin film deposition, and nanocomposites.
2. Recorded lectures and online resources will also be available for self-paced learning.

3. Students will work in groups to analyze specific nanotechnology applications, conduct experiments, and develop innovative solutions.
4. Regular assignments will be given to reinforce key concepts, such as the classification of conducting polymers and thin film deposition methods.
5. The course instructor will be available for additional support during office hours and will provide timely feedback on student progress.

Textbooks:

1. Materials Science and Engineering – An Introduction, William D Callister, 12th Edition, John Wiley
2. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.

Reference Books:

1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
2. Nanoscale materials -Liz Marzan and Kamat.

Open Educational Resources (OER):

1. https://youtu.be/6TprsnrvKIk
2. https://youtu.be/j_wQgy97Pi4
3. https://youtu.be/CJn2gXp3pyo
4. https://youtu.be/TgwpVGWL6dQ
5. https://youtu.be/nSAvyQajVzE
6. https://youtu.be/mbOQYlBp0VQ
7. https://youtu.be/ev1EiLWgDIs

Evaluation Scheme:

Evaluation components	**Weightage**
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER IV

UNMINS401	Crystallography	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	Minor				
Total Lectures	60				
Pre-Requisites/ Co Requisites	Basic knowledge in Materials Science				

Course Perspective

This course is an introduction to the principles of structure of materials, and theory and applications of diffraction and imaging techniques for materials characterization using X-ray diffraction and transmission electron microscopy (TEM). This course enhances your understanding of material properties and is crucial for careers in materials science, solid-state physics. You'll gain skills in analyzing and interpreting crystal structures, which are essential for research and development in various scientific and industrial fields. For example, knowledge of crystallography helps in the design of new materials for electronics or pharmaceuticals, directly impacting technology and industry.

Course Outcomes

Upon completion of the solid-state physics course, the learner will be:

CO1: Identifying and describing fundamental concepts and principles related to crystallography.

CO2: Analyzing and interpreting data using standard crystallographic techniques and tools.

CO3: Applying theoretical knowledge to solve practical problems and conducting experiments in crystallography.

CO4: Evaluating and synthesizing information from various sources to make informed decisions and recommendations related to crystallographic research.

Course Content

Unit No I: Geometric crystallography Lectures15

Amorphous and crystalline materials, lattice translation vectors, lattice with a basis –unit cell, types of lattices symmetry elements, inter planer spacing, packing fraction, Miller Indices, Bonding in solids- ionic bond. covalent bond, metallic bonds, hydrogen bonding, van Der Waals bond, crystal defects, point defects, line defects, Burger's vector, surface imperfections.

Unit No II: Structural crystallography and crystal chemistry Lectures15

The symmetry of the unit cell., Space groups, atomic positions and structural positions, Crystal structures, Principles that govern the formation of crystalline structures, Variations in the chemical composition of the crystals. Isomorphism, solid solutions and stoichiometry, X-ray diffraction by crystals, Diffraction methods: fundamentals and information they provide.

Unit No III: Physical properties of crystals Lectures15

Introduction to the physical properties of crystals and their relation to crystalline symmetry. Optical properties, Nature of light, and other basic concepts, Optical properties, Isotropy and optical anisotropy. The optical surfaces, Optical properties, transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer. Optical determinations with parallel light and analyser, Optical determinations with convergent light.

Unit No IV: Crystal Dynamics **Lectures15**

The real crystal, Crystal defects and crystalline dynamics, Influence of defects on the physical properties of crystals, Crystal defects: punctual, linear, two-dimensional and three-dimensional. Crystal formation and growth, Morphology of the real crystal, Add and twins, Polymorphism.

Learning Experience

The Crystallography course will be delivered through interactive lectures, practical lab work, and collaborative projects. Students will analyze crystal structures using X-ray diffraction, engage in group case studies, and complete individual assignments. Technology will be used for data analysis, and the course will include opportunities for presentations and peer feedback. Support and feedback will be available from the instructor, and students are encouraged to collaborate and seek help as needed.

Textbooks

1. David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science*,* Plenum Press, NY (2007).

Reference Books

1. Introduction to Solid State Physics - C. Kittel.
2. Principles of Solid-State Physics - R. A. Levy Solid State Physics- S.O. Pillai.
3. Elements of X-Ray diffraction - B.D. Cullity.
4. Elementary Solid-State Physics - Ali Omar.
5. Elements of Solid-State Physics - J.P. Srivastava.
6. Nano: The Essentials by T. Pradeep (Tata McGraw Hill Publ).

Open Educational Resources (OER)

1. Introduction to Crystallography and Mineral Crystal Systems - A comprehensive overview of geometric crystallography.
2. Crystallography Open Database - A database of crystal structures.
3. MIT Open Courseware - Crystal Structure Reading Collection - Reading materials on crystal structures.
4. Fundamentals of Crystallography - An article on the principles that govern the formation of crystalline structures.
5. Introduction to Crystal Physics - A detailed course on the physical properties of crystals.
6. Crystalline Materials - Explains the optical properties of crystals.

7. Solid State Physics - A chapter on crystal defects and dynamics from a course on solid state physics.
8. Crystal Growth & Design - A journal with open access articles on crystal formation and growth.

Evaluation Scheme:

Evaluation components	Weightage
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.

SEMESTER V					
UNMINS451	**Crystallography Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**4**	**2**
Category of Course	**Minor Lab**				
Total Lectures	**30**				
Pre-Requisites/ Co Requisites	**Basic knowledge in Materials Science**				

Course Perspective

This course is an introduction to study of structure of materials, coordination number, and bond lengths etc. using Diamond software. The Crystallography Lab is crucial for students as it provides hands-on experience with X-ray diffraction and other techniques to analyze crystal structures. This lab enhances academic understanding of material properties, supports career development in materials science and research, and builds practical skills in data analysis and problem-solving. Learning these techniques is vital for real-world applications like designing new materials or studying pharmaceuticals, where precise crystal structure knowledge is essential.

Course Outcomes

Upon completion of the solid-state physics course, the learner will be:

CO1: Observing and recording experimental phenomena accurately, demonstrating an understanding of lab processes.

CO2: Imitating established experimental techniques, applying standard procedures with precision.

CO3: Practicing using lab equipment and methods, enhancing technical skills through hands-on experience.

Course Content

List of experiments

1. To Study the structure of Simple cubic crystal system.
2. To Study the structure of Body centred cubic crystal system.
3. To Study the structure of Face centred cubic crystal system.
4. To Study the structure of tetragonal crystal system.
5. To Study the structure of Orthorhombic crystal system.
6. To Study the structure of Rhombohedral crystal system.
7. To Study the structure of hexagonal crystal system.
8. To Study the structure of monoclinic Crystal system.
9. To Study the structure of Triclinic crystal system.
10. To Study the structure of Perovskites.

Learning Experience

The Crystallography Lab course combines interactive lectures with hands-on experiments to provide practical experience in crystallographic techniques. Students will work in groups on lab projects, utilize software for data analysis, and engage in case studies to understand real-world applications. Assessments include practical exams, detailed lab reports, and presentations. The instructor will offer regular feedback and be available for additional support, while peer collaboration and additional resources will further enhance learning.

Textbooks

1. David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Plenum Press, NY (2007).

Reference Books

1. Introduction to Solid State Physics - C. Kittel.
2. Principles of Solid-State Physics - R. A. Levy Solid State Physics- S.O. Pillai.
3. Elements of X-Ray diffraction - B.D. Cullity.
4. Elementary Solid-State Physics - Ali Omar.
5. Elements of Solid-State Physics - J.P. Srivastava.
6. Nano: The Essentials by T. Pradeep (Tata McGraw Hill Publ).

Open Educational Resources (OER)

1. https://youtu.be/HCWwRh5CXYU
2. https://youtu.be/_9RnbGqtkd4
3. https://youtu.be/GSPVC34ijIA
4. https://youtu.be/JS9ysbgr0BE
5. https://youtu.be/07iZ7-IEyYE

Evaluation Scheme:

Evaluation components	**Weightage**
Internal marks (Practical's) **I. Conduct of experiment** **II . Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practical's): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
UNMINS501	**SYNTHESIS OF NANOMATERIALS-I**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Lectures	**60 hours**				
Pre-Requisites/ Co-Requisites	**Basics of Nanomaterials**				

Course Perspective:

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Describing the fundamental concepts and methods involved in nanotechnology, including top-down and bottom-up processes, the properties of atoms and solids, and the different classification of nanostructures.

CO2: Applying principles of nanotechnology to understand the synthesis and growth of nanoparticles through both homogeneous and heterogeneous nucleation.

CO3: Analyzing various fabrication methods and their impact on the properties of nanoparticles and nanostructures.

CO4: Evaluating the effectiveness of various methods for creating one-dimensional nanostructures, such as nanowires and nanorods.

Course Content:

UNIT-I Generic methodologies for nanotechnology: classification and fabrication Lectures: 15

Introduction and classification: definition nanotechnology, Classification of nanostructures, Nanoscale architecture, Summary of the electronic properties of atoms and solids: The isolated atom Bonding between atoms, Giant molecular solids, The free electron model and energy bands, Crystalline solids, Periodicity of crystal lattices, Electronic conduction; Effects of the nanometre length scale: Changes to the system total energy, Changes to the system structure, How nanoscale dimensions affect properties, Fabrication methods: Top-down processes, Bottom-up processes, Methods for templating the growth of nanomaterials, Ordering of nano systems, Preparation, safety and storage issues.

UNIT-II Physical Chemistry of Solid Surface Lectures: 15

Introduction, Surface Energy, Chemical Potential as a Function of Surface Curvature, Electrostatic Stabilization: Surface charge density, Electric potential at the proximity of solid surface, Van der Waals attraction potential, Interactions between two particles: DLVO theory, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions.

UNIT-III Zero-Dimensional Nanostructures: Nanoparticles Lectures: 15

Introduction, Nanoparticles through Homogeneous Nucleation: Fundamentals of homogeneous nucleation, Subsequent growth of nuclei (Growth controlled by diffusion, Growth controlled by surface process), Synthesis of metallic nanoparticles); Epitaxial of reduction reagents, Influences by other factors, Influences of polymer stabilizer), Synthesis of semiconductor nanoparticles, Synthesis of oxide nanoparticles (Introduction to sol-gel processing, Forced hydrolysis, Controlled release of ions),Vapor phase reactions, Solid state phase segregation; Nanoparticles through Heterogeneous Nucleation:(Fundamentals of heterogeneous nucleation, Synthesis of nanoparticles); Kinetically Confined Synthesis of Nanoparticles:(Synthesis inside micelles or using microemulsions, Aerosol synthesis, Growth termination, Spray pyrolysis, Template-based synthesis);Epitaxial Core-Shell Nanoparticles.

UNIT IV One-Dimensional Nanostructures: Nanowires and Nanorods Lectures: 15

Introduction, Spontaneous Growth: Evaporation (dissolution)-condensation growth:(Fundamentals of evaporation (dissolution)-condensation growth, Evaporation-condensation growth, Dissolution-condensation growth); Vapor (or solution)-liquid-solid (VLS or SLS) growth:(Fundamental aspects of VLS and SLS growth, VLS growth of various nanowires, Control of the size of nanowires, Precursors and catalysts, SLS growth); Stress-induced recrystallization: Template-Based Synthesis: Electrochemical deposition, Electrophoretic deposition, Template filling (Colloidal dispersion filling, Melt and solution filling, Chemical vapor deposition, Deposition by centrifugation), Converting through chemical reactions; Electrospinning; Lithography.

Learning Experience:

1. The course will combine traditional lectures with interactive digital tools like virtual labs, 3D simulations, and video tutorials.
2. Students will participate in hands-on experiments, focusing on nanomaterial synthesis, characterization, and quantum mechanics applications.
3. Group projects will encourage students to work together on designing experiments, analyzing nanomaterials, and solving problems related to nanoscale phenomena.
4. Students will complete regular assignments that challenge them to apply course concepts, such as solving quantum mechanics problems or designing synthesis techniques for nanomaterials.
5. The course instructor will be available during office hours for additional support and guidance.

Textbooks:

1. Introduction to Nanoscience and Nanotechnology" by Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore
2. Nanoscale Science and Technology" by Robert Kelsall, Ian Hamley, Mark Geoghegan

Reference Books

1. Nanotechnology: An Introduction" by Jeremy Ramsden
2. Nanoscale: Visualizing an Invisible World" by Kenneth S. Deffeyes, Stephen E. Deffeyes
3. Nanotechnology: Principles and Practices" by Sulabha K. Kulkarni

Open Educational Resources (OER):

1. **https://byjus.com/jee/surface-chemistry/**
2. **https://onlinecourses.nptel.ac.in/noc21_cy45/preview**
3. **https://www.youtube.com/watch?v=O2So0xcdDiA**
4. **https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/**
5. **https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508**

Evaluation Scheme:

Evaluation components	Weightage
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
UNMINS701	**Synthesis of Nanomaterials-II**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Lectures	**60 Hours**				
Pre-Requisites/ Co-Requisites	**Basics of Nanomaterial**				

Course Perspective:

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Understanding the fundamental principles of various film growth techniques and deposition methods, including PVD, CVD, ALD, and self-assembly, and explain their applications in nanotechnology.

CO2: Applying techniques to fabricate and characterize special nanomaterials, such as carbon nanotubes, metal-oxide structures, and nanocomposites, demonstrating their properties and potential uses.

CO3: Analyzing different nanostructure fabrication methods, including lithography, nanomanipulation, and soft lithography, and evaluate their effectiveness in producing nanostructures with desired features.

CO4: Evaluating the applications of nanomaterials in fields like molecular electronics, biological applications, and catalysis, assessing their impact and potential for innovation in various technologies.

Course Content

UNIT-I Two-Dimensional Nanostructures: Thin Films Lectures: 15

Introduction; Fundamentals of Film Growth; Vacuum Science; Physical Vapor Deposition (PVD): (Evaporation, Molecular beam epitaxy (MBE), Sputtering, Comparison of evaporation and sputtering); Chemical Vapor Deposition (CVD):(Typical chemical reactions, Reaction kinetics, Transport phenomena,5CVD methods, Diamond films by CVD).

Atomic Layer Deposition (ALD); Superlattices; Self-Assembly:(Monolayers of organosilicon or alkyl silane derivatives, Monolayers of alkanethiols and sulfides, Monolayers of carboxylic acids, amines alkyl silane derivatives and alcohols); Langmuir-Blodgett Films; Electrochemical Deposition; Sol-Gel Films

UNIT-II Special Nanomaterials Lectures: 15

Introduction; Carbon Fullerenes and Nanotubes (Carbon fullerenes, Fullerene-derived crystals, Carbon nanotubes); Ordered mesoporous structures; Random mesoporous structures; Crystalline microporous materials: zeolites; Metal-oxide structures; Metal-polymer structures; Oxide-polymer structures; Organic-Inorganic Hybrids :(Class I hybrids, Class II hybrids); Intercalation Compounds; Nanocomposites and Nanograined Materials.

UNIT-III Nanostructures Fabricated by Physical Techniques Lectures: 15

Introduction; Lithography:(Photolithography, Phase-shifting photolithography, Electron beam lithography, X-ray lithography, Focused ion beam (FIB) lithography, Neutral atomic beam lithography); Nanomanipulation and Nanolithography : (Scanning tunnelling microscopy (STM), Atomic force microscopy (AFM) ,Near-field scanning optical microscopy (NSOM) ,Nanomanipulation, Nanolithography); Soft Lithography: (Microcontact printing, Moulding, Nanoimprint, Dip-pen nanolithography); Assembly of Nanoparticles and Nanowires: (Capillary forces, Dispersion interactions, Shear force assisted assembly, Electric-field assisted assembly, Covalently linked assembly, Gravitational field assisted assembly, Template-assisted assembly); Other Methods for Microfabrication

UNIT IV Applications of Nanomaterials Lectures: 15

Introduction; Molecular Electronics and Nanoelectronics; Nanobots; Biological Applications of Nanoparticles; Catalysis by Gold Nanoparticles; Band Gap Engineered Quantum Devices: (Quantum well devices, Quantum dot devices); Nanomechanics; Carbon Nanotube Emitters;

Photoelectrochemical Cells; Photonic Crystals and Plasmon Waveguides: (Photonic crystals, Plasmon waveguides)

Learning Experience

1. The course will combine traditional lectures with interactive digital tools like virtual labs, 3D simulations, and video tutorials.
2. Students will participate in hands-on experiments, focusing on nanomaterial synthesis, characterization, and quantum mechanics applications.
3. Group projects will encourage students to work together on designing experiments, analyzing nanomaterials, and solving problems related to nanoscale phenomena.
4. Students will complete regular assignments that challenge them to apply course concepts, such as solving quantum mechanics problems or designing synthesis techniques for nanomaterials.
5. The course instructor will be available during office hours for additional support and guidance.

Textbooks:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, G, Cao, Imperial College Press (2003).

Reference Books:

1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3. Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology, Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004)

Open Educational Resources (OER):

1. https://news.mit.edu/2015/explained-chemical-vapor-deposition-0619
2. https://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_22.php
3. https://www.youtube.com/watch?v=aOVU2aqgqe8
4. https://www.youtube.com/watch?v=dw9IvpilfUo
5. https://www.youtube.com/watch?v=1WGEMYDLsNs
6. https://en.wikipedia.org/wiki/Nanocomposite#:~:text=Nanocomposite%20is%20a%20multiphase%20solid,that%20make%20up%20the%20material.

Evaluation Scheme:

Evaluation components	**Weightage**
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**

II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade

SEMESTER VI					
UNMINS751	**Synthesis of Nanomaterials Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**4**	**2**
Category of Course	**Minor Lab**				
Total Lectures	**30 hours**				
Pre-Requisites/ Co-Requisites	**Synthesis of Nanomaterials**				

Course Perspective:

The course focuses on practical techniques for synthesizing and characterizing various materials, including Polystyrene films, magnetite particles, and ferrofluids. Students will gain hands-on experience in preparing and analyzing materials, studying their stability and optical properties, and using methods like solid-state reactions and Archimedes' principle for density measurement. The course combines theoretical knowledge with laboratory skills to provide a thorough understanding of material preparation and characterization.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Observing various material preparation techniques such as the solvent evaporation method for polystyrene film and the coprecipitation method for magnetite particles to understand the steps involved in synthesizing materials.

CO 2: Imitating the procedures for preparing ferrofluid, synthesizing calcium titanate, and forming pellets, by following the guided steps for solid-state reactions, sintering, and polishing.

CO 3: Practising techniques for measuring the optical band gap, density of pellets using Archimedes' principle, and testing the stability of magnetite particles in various media, enhancing hands-on experimental skills.

Course Content

1. Preparation of Polystyrene film using solvent evaporation technique.

2. Preparation of magnetite particles using coprecipitation method.
3. Preparation of ferrofluid using water and magnetite particles,
4. 4 Study the stability of magnetite particles in water and vegetable oil.
5. Prepare calcium titanate using solid state reaction method.
6. 6 Find the optical band gap of magnetite particles.
7. Make pallet of calcium titanate powder, sinter and polish.
8. Find the density of pallet using Archimedes principle.

Learning Experience:

1. Students will engage in practical lab sessions to synthesize and analyze nanomaterials.
2. Group activities will include collaborative projects where students prepare nanomaterials and conduct joint analysis.
3. Peer reviews and group discussions will encourage teamwork, knowledge sharing, and problem-solving.
4. The instructor will provide regular feedback on assignments and lab work, with office hours available for additional support.
5. Students will be encouraged to seek help and collaborate with peers, fostering a supportive learning environment.

Textbooks:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, G, Cao, Imperial College Press (2003).

Reference Books:

1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nano chemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3. Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology, Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004).

Open Educational Resources (OER):

1. https://doi.org/10.1021/ma001440d
2. https://pubs.acs.org/doi/abs/10.1021/ma000094x
3. https://www.sciencedirect.com/science/article/abs/pii/S0927775708000721
4. https://www.sciencedirect.com/science/article/abs/pii/S0167577X08005740
5. https://pubs.acs.org/doi/abs/10.1021/ed076p943
6. https://www.sciencedirect.com/science/article/abs/pii/S0304885305011406
7. https://www.sciencedirect.com/science/article/abs/pii/S0021979705004935
8. https://www.sciencedirect.com/science/article/abs/pii/S0021979705005515
9. https://doi.org/10.1063/1.108974
10. https://link.springer.com/article/10.1007/s10853-006-0103-y
11. https://www.youtube.com/watch?v=4q9Bh48RTxg
12. https://www.youtube.com/watch?v=YpbNyDzpB3A

Evaluation Scheme:

Evaluation components	Weightage
Internal marks (practical) **I. Conduct of experiment** **II. Lab Record** **III. Lab Participation** **IV. Lab Project**	 **10 Marks** **10 Marks** **10 Marks** **20 Marks**
II. External Marks (practical): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examinationto secure minimum passing grade.

SEMESTER VII					
UNMINS601	**Characterization Techniques of Nanomaterials**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Lectures	**60 hours**				
Pre-Requisites/ Co-Requisites	**Basic knowledge in Materials Science, Physics, Chemistry, and Nanotechnology.**				

Course Perspective:

This course is an introduction to the principles of instrumental techniques for characterization of nanomaterials. This course aims to teach the students the underlying principles of analytical techniques that are commonly used for the evaluation of structural, morphological, optical, thermal, mechanical and electrical properties of nanomaterials.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Understanding the basic principles of different characterization techniques to study material's properties.

CO2: Applying the knowledge learned to determine the appropriate characterization technique for a given material or situation.

CO3: Analyzing the experimental data obtained from different characterization techniques to determine material properties.

CO4: Evaluating mechanical, magnetic, electrical, and thermal properties of different materials using different characterization techniques.

Course Content:

Unit 1 Basic of Characterization Techniques **Lectures: 15**

Types of characterization techniques, Basics, Importance. Structural and compositional characterization tools, Difference between Microscopy and Spectroscopy, Optical Microscopy, Atomic Force Microscopy, Scanning Electron Microscopy, Transmission electron Microscopy, Scanning Tunnelling Microscopy.

Unit 2 Spectroscopy **Lectures: 15**

UV visible spectroscopy, Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence (PL), Photoelectron Spectroscopy (X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy & Ultraviolet Photoelectron Spectroscopy).

Unit 3 X-ray techniques **Lectures: 15**

X-ray diffraction (XRD) technique, particle size determination using XRD, Applications of XRD, Electron diffraction and its application, neutron diffraction and its applications, X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy.

Unit 4 Mechanical, Magnetic, electrical and Thermal properties measurement Lectures: 15

Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions, Hardness testing of thin films and coatings, Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of Nanomaterials, Dielectric constant measurement, Differential Thermal Analysis (DTA), Differential scanning calorimetry (DSC).

Learning Experience:

1. The course will use multimedia tools, including animations and simulations, to explain complex concepts such as quantum confinement, thin film deposition, and nanocomposites.
2. Recorded lectures and online resources will also be available for self-paced learning.
3. Students will work in groups to analyze specific nanotechnology applications, conduct experiments, and develop innovative solutions.
4. Regular assignments will be given to reinforce key concepts, such as the classification of conducting polymers and thin film deposition methods.
5. The course instructor will be available for additional support during office hours and will provide timely feedback on student progress.

Textbooks:

1. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L, Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009

Reference Books:

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977
2. Transmission Electron Microscopy: A Textbook for Materials Science

3. David B Williams, C Barry Carter, (1996) Plenum Press, New York
4. Impedance Spectroscopy: Theory, Experiment, and Applications,
5. E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.
6. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press

Open Educational Resources (OER)"

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-14-materials-laboratory-for-engineers-spring-2009/
2. https://nanohub.org/
3. https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy
4. https://www.msm.cam.ac.uk/teaching/part-ii-courses/characterisation-materials
5. https://www.merlot.org/merlot/viewMaterial.htm?id=637562
6. https://www.khanacademy.org/science/physics/light-waves
7. http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/
8. https://ncl.cancer.gov/resources/assay-cascade-protocols
9. https://openstax.org/details/books/college-physics-ap-courses
10. https://www.coursera.org/learn/material-behavior

Evaluation Scheme:

Evaluation components	**Weightage**
Internal marks (Theory) **I. continuous assessment (40 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination to secure minimum passing grade.