K.R. MANGALAM UNIVERSITY
THE COMPLETE WORLD OF EDUCATION

SCHOOL OF BASIC AND APPLIED SCIENCES

(SBAS)

Programme Handbook

(Programme Structure & Evaluation Scheme)

Bachelor of Science (Hons./ Hons. with Research) Mathematics

Programme Code: 211

FOUR YEAR UNDERGRADUATE PROGRAMME

As per National Education Policy 2020

(Multiple Entry and Exit in Academic Programmes)

(with effect from 2024-25 session)

Approved in the 34th Meeting of Academic Council Held on 29 June 2024

List of Contents		
S.No.	**Particulars**	**Page No**

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) Mathematics i.e. (B.Sc. (Hons. with Research) Mathematics) 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 2024-2028.

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 Mathematics 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 Mathematics. The K. R. Mangalam University hopes the NEP-2020 approach of this four-year undergraduate programme **B**.Sc. (Hons. with Research) Mathematics 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)	74
2	Minor	32
3	Multidisciplinary	10
4	Ability Enhancement Course (AEC)	09
5	Skill Enhancement Course (SEC)	15
6	Value-Added Course (VAC)	06
7	Summer Internship	04
8	Research Project/Dissertation	12
9	CO-CURRICULAR Activity	2
10	Discipline Specific elective	12
9	Total	176

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 Mathematics

The **B.Sc. (Hons. with Research) Mathematics** program is an undergraduate academic course designed to provide students with a strong and versatile foundation in mathematics while offering a complementary focus in Data Science. This rigorous and dynamic curriculum covers essential areas of pure and applied mathematics, including algebra, calculus, statistics, analysis, and more.

Students will also have the opportunity to explore foundational Data Science as well as AI/ML concepts through minor papers that cover topics such as data analytics using SQL, R programming, machine learning, and Data driven applications. This interdisciplinary approach equips students with the mathematical tools and data-driven skills essential for solving complex problems in today's data-centric world.

Throughout the program, students will develop critical thinking, analytical abilities, and problem-solving skills, preparing them for a wide range of career opportunities in academia, research, technology, finance, and industries where mathematics and data science converge.

This program is ideal for those looking to pursue advanced research in mathematics while acquiring the practical skills needed to navigate the evolving landscape of data science.

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

The aims of the B.Sc. (Hons. with Research) Mathematics program, in accordance with the National Education Policy (NEP), are multifaceted and comprehensive. The program aims to cultivate a strong foundation in Mathematics 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) Mathematics 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 Mathematics with other scientific disciplines and societal issues. Overall, the B.Sc. (Hons. with Research) Mathematics program aspires to produce well-rounded graduates with a passion for learning and a strong foundation in Mathematics, 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 behavior 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 contact hours/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 develop a strong foundation in mathematical principles, empowering them to excel in careers across academia, government, industry, and research, and to respond to evolving challenges in mathematics and interdisciplinary fields.

PEO 2: Graduates will commit to continuous learning and self-improvement, adapting their knowledge and skills to keep pace with advancements in mathematics and to make meaningful contributions to society.

PEO 3: Graduates will integrate ethical practices, human values, and a sense of responsibility toward environmental sustainability in their professional and personal lives, fostering a positive societal impact.

PEO 4: Graduates will be equipped with problem-solving and critical thinking skills in mathematical modeling, programming, and data analysis, enhancing their employability in diverse sectors.

PEO 5: Graduates will be prepared to pursue advanced studies and research in mathematics and related fields, contributing to the development of new mathematical knowledge and applications.

6.5. Programme Outcomes (PO)

At the end of the Programme students will be able

PO1: To understand the impact of mathematical research on the environment and society and show a commitment by using sustainable and ethical practices in work.

PO2: To apply mathematical techniques, modern tools, software and programming languages to identify and solve complex mathematical problems.

PO3: To analyze and evaluate mathematical arguments and solutions with a keen, logical approach.

PO4: To use mathematical knowledge in research that connects with other fields like physics, computer science, engineering, economics, and social sciences

PO5: To clearly present and explain mathematical concepts and research findings to both specialized and general audiences.

PO6: To collaborate effectively with peers and professionals, contributing positively to team settings and academic environments.

PO7: To understand and follow ethical standards in research and practice, ensuring integrity and social responsibility in the use of mathematical knowledge.

PO8: To stay dedicated to ongoing learning and keep up with new developments in mathematics and related fields.

6.6 Programme Specific Outcomes (PSO)

At the end of the Programme students will be:

PSO1: Understanding fundamental concepts, theories, principles and their applications in different areas of mathematics.

PSO2: Applying mathematical methods and tools to model, simulate, and solve mathematical problems, enhancing research capabilities and practical applications.

PSO3: Analyzing complex mathematical problems and research data to determine patterns, relationships, and underlying principles.

PSO4: Evaluating mathematical models, algorithms and tools for solving mathematical problems.

PSO5: Operating mathematical software tools like Mathematica, MATLAB, and LaTeX to *organize, demonstrate,* and *present* mathematical solutions with accuracy, preparing them for research and industry applications that require computational expertise.

6.7 Career Avenues

Graduates with a B.Sc. (Hons. with Research) Mathematics have a diverse range of career avenues to explore. This combination of mathematics and data science skills equips them to thrive in various industries and professions where data-driven decision-making and analytical expertise are highly sought-after. Some potential career avenues for such graduates include:

1. **Data Analyst**: Data analysts are responsible for collecting, cleaning, and analyzing data to extract valuable insights that inform business decisions and strategies.
2. **Data Scientist**: Data scientists apply mathematical and statistical techniques to large datasets to develop predictive models and make data-driven recommendations.
3. **Business Analyst:** Business analysts use data analysis to identify trends, opportunities, and potential areas for improvement within organizations.
4. **Financial Analyst**: Financial analysts apply mathematical and statistical techniques to analyze financial data, assess investment opportunities, and make informed financial decisions.
5. **Market Research Analyst**: Market research analysts gather and analyze data to help companies understand market trends, consumer preferences, and competitive landscapes.
6. **Operations Research Analyst**: Operations research analysts use mathematical modeling and optimization techniques to improve operational efficiency in various industries.
7. **Actuarial Analyst**: Actuarial analysts assess risk and uncertainty in insurance and finance industries, using mathematical and statistical methods to estimate future events' probabilities.

8. **Quantitative Analyst**: Quantitative analysts, or quants, develop and implement mathematical models for financial and investment strategies.
9. **Data Engineer**: Data engineers design, build, and maintain data infrastructure and systems for efficient data processing and storage.
10. **Research Scientist**: Graduates can pursue research roles in academia, government, or private organizations, contributing to the advancement of mathematical and data science knowledge.
11. **Consultant**: Graduates can work as data science or analytics consultants, helping businesses and organizations optimize their operations and decision-making processes.
12. **Machine Learning Engineer**: Machine learning engineers develop and deploy machine learning models for various applications, such as natural language processing, image recognition, and recommendation systems.
13. **Healthcare Analyst**: In the healthcare sector, graduates can work on analyzing medical data, improving patient outcomes, and conducting research in medical data analysis.
14. **Academic and Teaching Careers**: Graduates can pursue further studies and research in mathematics or data science and build careers as educators and professors in academic institutions.
15. **Government and Public Sector**: Graduates may find opportunities in government agencies and public sectors, where data analysis and policy-making go hand in hand.

6.8 Duration

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

6.9 Criteria for award of certificates and degree

Name of Degree	Credits requirement	Completion Year
UG Certificate Mathematics	45	First Year
UG Diploma Mathematics	96/97	Second Year
B.Sc. Mathematics	133/135	Third Year
B.Sc. (Hons. / Hons. With Research) Mathematics	173	Fourth Year

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 : The approach focuses on cognitive outcomes using student-centric learning methods. Techniques like problem-solving, simulations, and group projects promote active engagement and critical thinking. Tools such as Matlab, LaTeX, and Python language, R programming are integrated to

enhance practical understanding. Peer reviews and discussions further solidify theoretical knowledge through collaborative learning.

- Outside classroom: Activities aim to develop people and psychomotor skills through industry, community, and lab engagements. Internships, lab experiments, and community projects provide hands-on experience, fostering teamwork, communication, and technical expertise. Students apply theoretical knowledge in real-world settings, gaining essential skills for professional and interpersonal growth.

➢ **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 "what" of learning includes core subjects that lay a strong academic foundation, along with open electives, discipline-specific electives, Value-Added Courses (VAC), and Ability Enhancement Compulsory Courses (AECC) to broaden intellectual horizons. 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 "when" of 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.

The "how" of learning is diverse and adaptable, employing various teaching methodologies such as lectures, case-based learning, problem-based learning, and project-based learning to encourage critical thinking and problem-solving skills. 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. 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.

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.

- **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/ Research Project**– Students need to do summer internship after second and fourth semesters, which carries 2 credits, during the summer breaks. The same will be evaluated in the upcoming odd semester. In the eighth semester students of B.Sc. (Hons. / Hons. with Research) Physics will do Research Project (Dissertation). Projects are also mapped along with the Lab/ Practical Courses and Experiential Learning Activities.

✓ **Cocurricular Activities Credit Choices: 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 Relationship**

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 **Academic Counselling** 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 (30 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)	30 Marks
Mid Term Exam	20 Marks
External Marks (Theory): – End Term Examination	50 Marks

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

Overview of Internal Evaluation (30 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 30 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 separately 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): -	50 Marks
Presentation	20
Report Writing	10

Viva Voce	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.

1.
2.
3.
4.
5.
6.
7.
8.

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.

7.6 Academic Integrity and Ethics

The School of Basic and Applied Sciences (SBAS) is committed to promoting safety and academic integrity by enforcing rigorous behavioural standards. Alcohol consumption and substance abuses are strictly prohibited, with escalating penalties for repeat offenders, which may include rustication. Ragging is also banned, adhering to UGC regulations and Supreme Court directives, and is managed through a comprehensive anti-ragging policy. The Anti-Ragging Committee, led by student affairs advisors and comprising diverse members, is tasked with handling ragging complaints and making recommendations. The Anti-Ragging Squad plays a proactive role by monitoring the campus, patrolling potential ragging hotspots, and investigating incidents. Penalties for violations can range from suspension and withholding benefits to expulsion and filing an FIR, in line with UGC regulations.

Sexual harassment in any form is taken very seriously and will be addressed by the Internal Committee Against Sexual Harassment in accordance with the Institute's policies.

The school also enforces strict penalties for other forms of misconduct, including possession of weapons, theft, and misuse of Institute property or facilities. These actions are subject to severe disciplinary measures.

Academic integrity is a cornerstone of SBAS's research and educational missions. It encompasses honesty, responsibility, and the proper acknowledgment of others' contributions. Violations such as plagiarism and cheating are treated as serious offenses. Students are required to follow principles of academic integrity, including proper citation, ethical data

collection, and respect for others' work. Examples of misconduct include copying, falsifying data, and submitting purchased materials. The Institute provides guidelines for accurate record-keeping, truthful reporting, and proper attribution to uphold high academic standards.
Both individual and collective responsibility are emphasized in maintaining academic integrity. Students must ensure their theses are free from plagiarism and original before submission and are encouraged to report any violations. Faculty members are responsible for guiding students in proper research methods, ensuring accurate data recording, and reviewing student work. Additionally, faculty must educate students on academic integrity and address any breaches.
Reporting academic violations involves several steps. Faculty members should report breaches to the School Dean, and any student-faculty conflicts are managed by the Dean with committee support. The Director may appoint a committee to investigate scientific misconduct. Penalties for academic breaches are severe, with initial offenses resulting in warnings or an "F" grade, and repeat offenses potentially leading to expulsion.
Students must also seek permission before engaging with media on behalf of the Institute or recording classroom activities. Unauthorized sharing of audio/video clippings or posting derogatory comments on social media is prohibited. Misconduct can be reported by students, staff, or faculty, and penalties may include warnings, community service, restrictions, fines, withholding grades, suspension, expulsion, or a ban on reapplying for admission. The disciplinary process involves a hearing, documentation, and recommendations by a committee, with final actions decided by the Dean and enforced by the academic office. Repeat offenders face harsher penalties.

Table 2: Programme Study

Semester-I								
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**
1	**Major-I**	SCMA101	Calculus	4	0	0	4	
2	**Major-I (Practical)**	SCMA151	Calculus Lab	0	0	2	2	
3	**Major-II**	SCMA103	Classical Algebra	4	0	0	4	
4	**Minor -I**	UNS101/ UEV101/ UDT101/ UDT101	Minor NS/EVS/DS/AI& ML			4	4	**Award: UG Certificate** [after completing 1 year of study (2 semesters with credits as prescribed), and an additional vocational course/internship of 4 credits to be covered within 6-8 weeks during the summer vacation of the first year]
5	**Skill Enhancement Course SEC-I**	SEC011	Statistics for Data Science	2	0	2	3	
6	**Skill Enhancement Course SEC-II**	SEC014	Documentation using Latex	1	0	2	2	
7	**Value Added Course VAC-I**		VACI	2	0	0	2	
8	**CS001**	CS001	CLUB/SOCIETY	0	0	0	1	

TOTAL (Minor NS/EVS/DS/AI&ML)							**22**
Semester-II							
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**
1	**Major-III**	SCMA102	Multivariate Calculus	4	0	0	4
2	**Major-III (Practical)**	SCMA152	Multivariate Calculus practical Lab	0	0	2	2
3	**Major-IV**	SCMA104	Modern Algebra	4	0	0	4
4	**Minor-II**	UNS102/ UEV102/ UDT102/ UDT102	Minor NS/EVS/DS/AI& ML				**4**
5	**Open Elective OE-I**		OE-I	3	0	0	3
6	**Value Added Course VAC-II**		VAC II	2	0	0	2
7	**Skill Enhancement Course SEC-III**	SEC013	Data Analytics with Tableau	1	0	4	3
8	Summer Internship/Project	SIMA001	Summer Internship I				
9	**CS002**	CS002	COMMUNITY SERVICES	0	0	0	1
TOTAL (Minor NS/EVS/DS/AI&ML)							**23**
Semester-III							
S. No.	**Category of Course**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	**Major-V**	SCMA201	Real Analysis	4	0	0	4
2	**Major-VI**	SCMA203	Ordinary Differential Equation	4	0	0	4
3	**Major-VI (Practical)**	SCMA251	Ordinary Differential Equation Lab	0	0	4	2
4	**AEC-I**	AEC006	VERBAL ABILITY	3	0	0	3
5	**Open Elective OE-II**		OE-II	3	0	0	3
6	**Value Added Course VAC-III**		**VACIII**	**1**	**0**	**2**	**2**
7	**Minor-III**	UNS103/	Minor				**4/4/**

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 vacation of the second year]

Entry: The student who took

		UEV103/ UDT103/ UDT103	NS/EVS/DS/AI& ML				**4**	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 so as to complete the programme within the stipulated time period of seven years.
8		SIMA001	**Evaluation of Summer Internship**	2	0	0	2	
TOTAL (Minor NS/EVS/DS/AI&ML)							**24**	
Semester-IV								
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**	
1	**Major-VII**	SCMA202	Linear Algebra	4	0	0	4	
2	**Major-VIII**	SCMA204	Complex analysis	4	0	0	4	
3	**Major-IX**	SCMA206	Partial Differential Equation and Calculus of Variation	4	0	0	4	
4	**Major-IX (Practical)**	SCMA254	Partial Differential Equation and Calculus of Variation, Lab	0	0	4	2	
5	**Open Elective OE-III**		OE-III	3	0	0	3	
6	**AECII**	AEC007	COMMUNICATION AND PERSONALITY DEVELOPMENT -II	3	0	0	3	
7	**Skill Enhancement Course SEC-IV/MOOC**	SEC075	Basic IT Tools				**3**	
8	**Minor-IV**	UNS104/ UEV104/ UDT104/ UDT109	Minor NS/EVS/DS/AI& ML				**4/5/ 4**	
9	Summer Internship/Project	SIMA002	Summer Internship II					
TOTAL (Minor NS/EVS/DS/AI&ML)							**27/28/27**	
Semester-V								
S. No.	**Category of Course**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**

1	**Major-X**	SCMA301	Numerical Methods	4	0	0	4	**Award: Bachelor's Degree** [after completing 3-year of 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 within the stipulated maximum period of seven years.
2	**Major-X (Practical)**	SCMA351	Numerical Methods Lab	0	0	4	2	
3	**Major-XI**	SCMA303	Metric Spaces	4	0	0	4	
4	**Major-XII-Discipline Specific Elective (Any One)**	SCMA305	Advanced Algebra	4	0	0	4	
		SCMA307	Linear Programming					
6	**MINOR-V**	UNS106/ UEV105/ UDT105/ UDT110	Minor NS/EVS/DS/AI& ML				**4/5/ 4**	
7	**AEC-III**	**AEC010**	ARITHMATIC REASONING	3	0	0	3	
8	**Summer internship/Project**	SIMA002	**Evaluation of Summer Internship**				**2**	
TOTAL (Minor NS/EVS/DS/AI&ML)							**23/24/23**	

Semester-VI								
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**	
1	**Major-XIII**	SCMA302	Probability and Statistics	4	0	0	4	
2	**Major-XIV-Discipline Specific Elective (Any One)**	SCMA304	Applied Mechanics	4	0	0	4	
		SCMA306	Mathematical Modeling					
3	**Minor-VI**	UNS108/ UEV106/ UDT106/ UDT106	Minor NS/EVS/DS/AI& ML				**4/5/4**	
		SCMA308	Minor Project				2	
TOTAL (Minor NS/EVS/DS/AI&ML)							**14/15/14**	

***Bachelor's Degree (Honours) Semester-VII**								
S.	**Category of**	**Course**	**Course**	**L**	**T**	**P**	**C**	**Multiple Entry**

No.	Course	Code						
1	**Major-XV**	SCMA4017	NUMBER THEORY	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	**Major-XVI**	SCMA4019	Combinatorial Mathematics	4	0	0	**4**	
3	**Major-XVII**	SCMA405	Integral Transform and Fourier Analysis	4	0	0	**4**	
4	**Minor-VII**	UNS110/ UEV 107/ UDT107/ UDT111	Minor NS/EVS/DS/AI&ML				**4/5/4**	
5	**Minor-VIII**	Minor 8	DS/AI-ML				**4**	
6	**Major-XVIII**	SCMA4021	Special Functions	5	1	0	**6**	
TOTAL (Minor NS/EVS/DS/AI&ML)							**26/27/26**	
***Bachelor's Degree (Honours) Semester-VIII**								
1	**Major-XIX**	SCMA404	Computer Algebra System and related Software's	2	0	0	2	
2	**Major-XIX-practical**	SCMA452	Computer Algebra System and related Software's Lab	0	0	4	2	
3	**Major-XX**	SCMA408	Finite Field	4	0	0	4	
4	**Major-XXI**	SCMA4010	q- analog and Fractional Calculus	5	1	0	6	
5	**Minor**		ES				4	
Total (Minor NS/EVS/DS/AI&ML)							**14/18**	
***Bachelor's Degree (Honours with Research) Semester-VII**								
S. No.	**Category of Course**	**Course Code**	**Course**	**L**	**T**	**P**	**C**	
1	**Major-XV Course on Research Tools**	SCMA401	Research Methodology	4	0	0	4	
2	**Major-XVI-Discipline**	SCMA403	(Guide specific paper)	4	0	0	4	

	Specific Elective Course on Research Tools							
3	**Skill Enhancement Course SEC-IV** **Course on Research Tools**	SEC076	Technology in Research	2	0	0	2	
4	**Skill Enhancement Course SEC-V** **Course on Research Tools**	SEC077	Research Ethics and Report writing	2	0	0	2	
5	**Major-XVII**	SCMA405	Integral Transform and Fourier Analysis	4	0	0	4	
6	**Minor 7**		DS/NS/ES/AI-ML				4/5/4	
7	**Minor 8**		DS/AI-ML				4	
Total							**24/25**	
***Bachelor's Degree (Honours with Research) Semester-VIII**								
1	**Major-XVIII**	SCMA404	Computer Algebra System and related Software's	2	0	0	2	
2	**Major-XVIII-practical**	SCMA452	Computer Algebra System and related Software's Lab	0	0	4	2	
3	**Major IX**	SCMA406	Research Project				12	
4	**Minor 8**		ES				4	
Total (Minor NS/EVS/DS/AI&ML)							**16/20**	

Total Credits: 173

DETAILS OF MINOR COURSES

Minor- Data Science

S.No.	Minor	Name	Code	Semester
I	Minor1	Data Analytics Using SQL	UDT101	I
II	Minor2	Data Analytics using R	UDT102	II
III	Minor 3	Python for Data Science	UDT103	III
IV	Minor 4	Data Preprocessing and Visualization Using Python	UDT104	IV
V	Minor5	Time Series Analysis & Forecasting Using Python	UDT105	V
VI	Minor6	Fundamental Of Machine Learning	UDT106	VI
VII	Minor7	Data Driven Applications	UDT107	VII
VIII	Minor8	Project and Case Study	UDT108	VIII

Minor- Artificial Intelligence & Machine Learning

S.No.	Minor	Name	Code	Semester
I	Minor 1	Data Analytics using SQL	UDT101	I
II	Minor 2	Data Analytics using R	UDT102	II
III	Minor 3	Python for Data Science	UDT103	III
IV	Minor 4	Data Structures and Algorithms	UDT109	IV
V	Minor 5	Fundamentals of Artificial Intelligence	UDT110	V

VI	Minor 6	Fundamental of Machine Learning	UDT106	VI
VII	Minor 7	Neural Network and Deep Learning	UDT111	VII
VII	Minor 8	Natural Language Processing	UDT112	VIII

Minor- Nanoscience

S.No.	Minor	Name	Code	Semester
I	Minor1	Study Of Materials	UNS101	I
II	Minor2	Elements Of Nanosciences and Nanomaterials	UNS102	II
III	Minor 3	Nanostructured Materials	UNS103	III
IV	Minor 4	Crystallography	UNS104	IV
IV	Minor 4 (Lab)	Crystallography Lab	UNS105	IV
V	Minor5	Synthesis Of Nanomaterials-I	UNS106	V
VI	Minor6	Synthesis Of Nanomaterials-II	UNS107	VI
VI	Minor 6 (Lab)	Synthesis Of Nanomaterials Lab	UNS108	VI
VII	Minor7	Characterisation Techniques of Nanomaterials	UNS109	VII

Minor- Environmental Science

S.No.	Minor	Name	Code	Semester
I	Minor1	Earth And Earth Surface Processes	UEV101	I
II	Minor2	Hydrology And Hydrogeology	UEV102	II
III	Minor 3	Natural Resources Management and Sustainability	UEV103	III
IV	Minor 4	Natural And Anthropogenic Hazards	UEV104	IV
V	Minor5	Environment Legislation Policies and ESG's	UEV105	V

VI	Minor6	Waste Management	UEV106	VI
VII	Minor7	Environmental Impact Assessment and Risk Assessment	UEV107	VII
VIII	Minor8	SDG's And Climate Change	UEV108	VIII

Syllabi

SEMESTER I					
SCMA101	**Calculus**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Major-I				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

Calculus is a transition course to upper-division mathematics and computer science courses. Students will extend their experience with functions as they study the fundamental concepts of calculus: limiting behaviors, derivatives, optimization, related rates, graphing and other applications of derivatives. Important objectives of the calculus sequence are to develop and strengthen the students' problem-solving skills and to teach them to read, write, speak, and think in the language of mathematics. In particular, students learn how to apply the tools of calculus to a variety of problem situations.

Course Outcomes

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

CO1: Understanding the principles and applications of differential and integral calculus.
CO2: Identifying and classifying various types of differential and integral calculus techniques to solve real-world problems.
CO3: Analyzing the behaviour of functions using calculus tools such as derivatives, integrals, and limits.
CO4: Evaluating: Assess the validity of solutions to calculus problems by verifying results and determining the appropriateness of methods used.

Course Content

Unit 1: Sequences and Integration **Contact Hours:** 15

Real numbers, Sequences of real numbers, Convergence of sequences and series, Bounded and monotonic sequences; Definite integral as a limit of sum, Integration of irrational algebraic functions and transcendental functions, Reduction formulae, Definite integrals.

Unit II: Limit and Continuity **Contact Hours:** 15

Definition of limit of a real valued function, Limit at infinity and infinite limits;Continuity of a real valued function, Properties of continuous functions, Intermediate value theorem, Geometrical interpretation of continuity, Types of discontinuity; Uniform continuity.

Unit III: Differentiability **Contact Hours:** 15

Differentiability of a real valued function, Geometrical interpretation of differentiability, Relation between differentiability and continuity, Differentiability and monotonicity, Chain rule of differentiation; Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems; Successive differentiation, Leibnitz's theorem.

Expansions of Functions: Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange, Cauchy and Roche–Schlomilch forms of remainder; Maxima and minima.

Unit IV: Curvature, Asymptotes and Curve Tracing **Contact Hours:** 15

Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Symmetry, Concavity and convexity, Points of inflection, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves.

Learning Experience

In this calculus course, learning is experiential and participatory, blending lectures with hands-on problem-solving and group discussions. Students will engage with real-world applications of calculus through collaborative group work and peer reviews. Technology, including online platforms and Matlab Labs, will enhance understanding through interactive exercises. Continuous assessment will be done via quizzes, assignments, and reflective journals. The course instructor will provide ongoing support and feedback, encouraging students to seek help as needed. Group activities will foster collaboration and critical thinking, ensuring students actively apply and deepen their understanding of calculus concepts.

Textbooks

1. Gorakh Prasad (2016). *Differential Calculus* (19th edition). Pothishala Pvt. Ltd

Suggested Readings

1. Howard Anton, I. Bivens& Stephan Davis (2016). *Calculus* (10th edition). Wiley India.
2. Gabriel Klambauer (1986). *Aspects of Calculus*. Springer-Verlag.
3. WieslawKrawcewicz&Bindhyachal Rai (2003). *Calculus with Maple Labs*. Narosa.
4. George B. Thomas Jr., Joel Hass, Christopher Heil& Maurice D. Weir (2018). *Thomas' Calculus* (14thedition). Pearson Education.

Open Educational Resources (OER)

1. https://openlearninglibrary.mit.edu/courses/course-v1:MITx+18.01.1x+2T2019/about
2. https://openlearninglibrary.mit.edu/courses/course-v1:MITx+18.01.2x+3T2019/about
3. https://openlearninglibrary.mit.edu/courses/course-v1:MITx+18.01.3x+1T2020/about

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/attendance/case studies/reflective journals(minimum of five components to be evaluated)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER I					
SCMA151	**Calculus Lab**	**L**	**T**	**P**	**C**
Version		0	0	4	2
Category of Course	Major-I (Practical)				
Total	30 Hours				

Contact Hours	
Pre-Requisites/ Co-Requisites	Nil

Course Perspective

The purpose of these labs is to help students talk and write in meaningful ways about mathematics. Specifically, to describe quantities and changes in quantities clearly in terms of context, to make rigorous arguments about how such quantities are related, and to make connections between these features in the contexts and on graphs.

Course Outcomes

Upon completion of the course, the learner will be able to:
CO1: Observing and analyzing mathematical models and simulations to understand calculus concepts visually and intuitively.

CO2: Imitating demonstrated methods to perform basic calculus operations using lab tools such as Maple, MATLAB, or Mathematica.

CO3: Practicing and applying calculus techniques in lab settings to solve computational problems efficiently.

Course Content:

List of practical

- Evaluate the integration of the function
- Evaluate the double/ triple integral integration of the function
- Evaluate the area of closed curve
- Evaluate the arc length of curve
- Evaluate the Volume of closed curve
- Find the critical points and use Mathematica to graph the surface and determine the max/min/saddle nature of these points.
- Calculate the dot and cross product of vectors
- Calculate the Gradient of a vector, Divergence and Curl of vector

Learning Experience

In this calculus lab course, students will engage in hands-on learning through practical exercises such as evaluating integrals, areas, volumes, and arc lengths of curves, and exploring vector calculus concepts like divergence and curl. Instruction will blend guided practice with the use of technology, such as Matlab/Mathematica, for graphing and visualizing results. Collaborative group work and peer reviews will promote active participation and critical thinking. Continuous assessment through lab assignments will ensure mastery of techniques. The instructor will provide support and feedback, encouraging students to seek help and collaborate to enhance their learning experience.

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. Lisa Oberbroeckling, Programming Mathematics Using MATLAB, Academic Press
2. Ronald L. Lipsman, Jonathan M. Rosenberg, Multivariable Calculus with MATLAB: With Applications to Geometry and Physics, Springer International Publishing

Open Educational Resources (OER)

1. https://online.stanford.edu/courses/math51-linear-algebra-multivariable-calculus-and-modern-applications
2. https://ocw.mit.edu/courses/18-02-multivariable-calculus-fall-2007/video_galleries/video-lectures/
3. https://archive.nptel.ac.in/courses/111/107/111107108/

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SCMA103	**Classical Algebra**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Core Course**				
Total Contact Hours	**60**				
Pre-requisites/ Co-requisites	**Senior Secondary level knowledge of Algebra and Geometry**				

Course Perspective

This course provides a comprehensive introduction to advanced topics in algebra, number theory, and linear algebra. Students will explore the theory of equations, polynomial roots, factorization techniques, and complex numbers, with applications such as Cardan's and Ferrari's methods for solving cubic and biquadratic equations. They will study equivalence relations, congruence relations, and set theory, enhancing their understanding of functions and cardinality. The course also covers fundamental number theory concepts, such as the division algorithm and modular arithmetic. Additionally, students will gain hands-on experience with linear algebra, focusing on matrix operations, row echelon forms, and applications to linear systems, culminating in discussions on eigenvalues, eigenvectors, and the Cayley-Hamilton theorem.

Course Outcomes (CO)

CO1: Recalling and defining key theorems and methods related to polynomial equations, equivalence relations, DeMoivre's Theorem and number theory (e.g., Cardano's method, the fundamental theorem of arithmetic).

CO2: Solving mathematical problems using various methods and theorems.

CO3: Examining the structure of systems of linear equations, Modular arithmetic, properties of congruences and bijective function.

CO4: Assessing the invertibility of matrices and evaluate the solution sets of linear systems by applying matrix operations, inverse matrix characterizations, and the Cayley-Hamilton theorem.

Course Contents:

Unit 1: Theory of Equations and Complex Numbers 20 Contact hours

Elementary theorems on the roots of an equation, Polynomials, The remainder and factor theorem, Synthetic division, Factored form of a polynomial, Descarte's rule of signs, Strum's theorem (statement only), Symmetric functions of roots, Solution of cubic equation by Cardon's method, Solution of biquadratic equation by Ferrari's method. The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Imaginary roots occur in pairs, Integral and rational roots;

Polar representation of complex numbers, The nth roots of unity, De Moivre's theorem for integer and rational indices and its applications.

Unit 2: Equivalence Relations and Functions 10 Contact hours

Equivalence relations, Binary relation, well ordering principle, Equivalence relation, congruence relation in integers, Equivalence class, Relation induced by a partition of a set, Fundamental theorem on Equivalence relation, Partial order relation, Functions, Composition of functions, Invertibility and inverse of functions, One-to-one correspondence and the cardinality of a set.

Unit 3: Basic Number Theory 10 Contact hours

The division algorithm, Divisibility and the Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences; Principles of mathematical induction and well ordering principle.

Unit 4: Row Echelon Form of Matrices and Applications 20 Contact hours

Systems of linear equations, Row reduction and echelon forms, Vector equations, The matrix equation AX = B, Solution sets of linear systems, Linear independence, The rank of a matrix and applications; Introduction to linear transformations, The matrix of a linear transformation; Matrix operations, The inverse of a matrix, Characterizations of invertible

matrices, Applications to Computer Graphics, Eigenvectors and eigenvalues, The characteristic equation and the Cayley-Hamilton theorem.

Learning Experience:
The learning experience in this course is designed to foster deep understanding and practical application of advanced mathematical concepts through a blend of theoretical exploration and hands-on problem-solving. Students will engage with the material through a combination of lectures, problem sets, and collaborative discussions that emphasize the connections between abstract theory and real-world applications.

Instruction Methods:

- **Lectures with Visual Aids:** Core concepts and theories will be explained through detailed lectures, supported by visual aids like PowerPoint slides, diagrams, and animations to help students grasp complex ideas such as polynomial factorization, matrix operations, and complex number representations.
- **Interactive Discussions:** Class discussions will be encouraged, particularly when exploring challenging topics like theorems, proofs, and their applications. This method promotes critical thinking and allows students to clarify doubts in a collaborative environment.
- **Assignments and Quizzes:** Regular assignments and quizzes will be used to assess understanding and provide continuous feedback. These will include both theoretical questions and practical problems that require application of learned concepts.
- **Peer Learning:** Group activities and peer-review sessions will encourage collaboration among students, allowing them to learn from each other's approaches and perspectives, particularly in solving intricate mathematical problems.

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. Andreescu, Titu & Andrica Dorin. (2014). Complex Numbers from A to...Z. (2nd ed.). Birkhäuser. Department of Mathematics, University of Delhi 17
2. Dickson, Leonard Eugene (1922). First Course in The Theory of Equations. John Wiley & Sons, Inc. New York. The Project Gutenberg EBook.
3. Goodaire, Edgar G., & Parmenter, Michael M. (2005). Discrete Mathematics with Graph Theory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2015.
4. Kolman, Bernard, & Hill, David R. (2001). Introductory Linear Algebra with Applications (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
5. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). Linear Algebra and its Applications (5th ed.). Pearson Education

Suggested Readings

1. Andrilli, Stephen, & Hecker, David (2016). Elementary Linear Algebra (5th ed.). Academic Press, Elsevier India Private Limited.
2. Burton, David M. (2007). Elementary Number Theory (7th ed.). Tata Mc-Graw Hill Edition, Indian Reprint.
3. Schaum's outline series, "Linear Algebra", McGraw Hills.

Open Educational Resources (OER)

1. https://www.askiitians.com/iit-study-material/iit-jee-mathematics/algebra/
2. https://www.mathplanet.com/
3. https://ocw.mit.edu/courses/mathematics/18-701-algebra-i-fall-2010/study-materials/
4. https://www.edx.org/learn/algebra
5. https://tutorial.math.lamar.edu/
6. https://www.freebookcentre.net/Mathematics/Basic-Algebra-Books.html
7. https://www.khanacademy.org/math/algebra

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER I					
SEC011	**Statistics for Data Science**	**L**	**T**	**P**	**C**
Version		1	0	2	2
Category of Course	Minor				
Total Contact Hours	42 Hours				
Pre-Requisites/ Co-Requisites	**Nil**				

Course Perspective

Statistics for Data Science is a fundamental course designed to introduce students to essential statistical methods and their applications in data science. This course is crucial for students pursuing careers in data analysis, business intelligence, and related fields as it builds a solid foundation in statistical techniques used to interpret and analyze data. Students will gain proficiency in statistical methods, data visualization, and predictive analytics, which are critical skills in the data-driven job market. The knowledge and skills acquired in this course are applicable in real-world scenarios such as business decision-making, market analysis, and data-driven research. For instance, understanding regression analysis can help businesses forecast sales trends, while data visualization skills can enhance the presentation of analytical findings to stakeholders.

Course Outcomes

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

CO1: Identifying and describing fundamental statistical concepts such as measures of central tendency and dispersion to summarize data effectively.

CO2: Applying techniques for visualizing data using charts, graphs, and plots to reveal insights and communicate findings clearly.

CO3: Analyzing relationships between variables through correlation and regression methods to interpret the strength and direction of relationships.

CO4: Evaluating and interpreting results from statistical analyses to make informed decisions based on data insights.

Course Content

Unit 1: Statistical Methods *No. of Hours: 10*

- Introduction to Statistics and Data Collection
- Summarizing and Presenting Statistical Data
- Measures of Central Tendency
- Measures of Variation
- Measures of Skewness and Kurtosis

Unit 2: Correlation and Regression *No. of Hours: 10*

- Introduction to Correlation Analysis
- Simple Correlation Analysis
- Rank Correlation
- Regression Analysis

Unit 3: Time Series Analysis *No. of Hours: 10*

- Introduction to Time Series
- Components of Time Series
- Forecasting Techniques
- Applications in Statistical Data

Unit 4: Data Visualization *No. of Hours: 12*

- Introduction to Data Visualization
- Creating Effective Charts and Graphs
- Visualizing Statistical Data in Excel
- Practical Applications of Visualization Techniques

Learning Experience

This course will be a blend of lectures, hands-on sessions, and collaborative activities to develop practical skills in statistical methods and data visualization for data science.

Instruction Methods:

- **Lectures:** Core statistical concepts will be introduced through multimedia presentations and real-world applications.

- **Hands-on Sessions:** Practical exercises using Excel will allow students to apply statistical techniques and create data visualizations.
- **Group Activities:** Collaborative projects will involve case studies and real-world problem-solving.

Technology Use:

- **Excel:** 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. Richard I. Levin, David S. Rubin, *Statistics for Management*, Seventh Edition, Prentice – Hall of India, 2017.
2. T. Veerarajan, *Statistics*, Third Edition, McGraw Hill, 2008.

Suggested Readings

1. Allen B. Downey, *Think Stats: Exploratory Data Analysis*, 2nd Edition, O'Reilly Publications, 2015.
2. Peter Bruce, Andrew Bruce, Peter Gedeck, *Practical Statistics for Data Scientists*, O'Reilly Publications, 2020.
3. Dr. B.S. Grewal, *Higher Engineering Mathematics*, Sixth Edition, Khanna Publishers, 2017.

Open Educational Resources (OER)

1. Think Stats: Exploratory Data Analysis (eBook)
2. Statistics for Data Science and Business Analysis (Udemy Course)
3. Data Science: Statistics and Machine Learning (Coursera Specialization)

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEC014	**Documentation using Latex**	**L**	**T**	**P**	**C**
Version 1.0		**1**	**0**	**2**	**2**
Category of Course	**Skill Enhancement Course**				
Total Contact Hours	**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

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

Creating Lists, Typing Math Formulas, Environments – equations, arrays, matrices, Footnotes, Fonts, Title and headers, Sectioning, Listing references, Math styles – cases, braces, math symbols

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.
3. Lamport, Leslie, LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Addison-Wesley, 1994.

Suggested Readings

1. **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.

2. **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.

3. **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.

4. **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.

5. **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 accessment (30 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)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 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

SEMESTER II					
SCMA102	**Multivariate Calculus**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Major-III				
Total	60 Hours				

Contact Hours	
Pre-Requisites/ Co-Requisites	Nil

Course Perspective

Multivariate Calculus is a gateway to advanced studies in mathematics, physics, and engineering, extending foundational calculus into higher dimensions. Students explore functions of multiple variables, learning how to describe changes and rates in multidimensional spaces. The course emphasizes key concepts like partial derivatives, optimization, and integration over complex regions, fostering a deeper understanding of mathematical modelling. Students are introduced to techniques for solving real-world problems involving rates of change, optimization with constraints, and spatial calculations. The course also emphasizes the application of key theorems that connect abstract mathematical principles with practical scenarios. Through this course, students strengthen their problem-solving skills while learning to think critically and communicate effectively in the language of higher mathematics.

Course Outcomes

Upon completion of the course, the learner will be able to:
CO1: Identifying the behaviour of functions in multiple dimensions and demonstrate an **understanding** of key theorems, including Green's, Stokes', and Gauss' divergence theorems.
CO2: Applying multivariate calculus techniques to solve real-world problems involving optimization, rates of change, and integration in different coordinate systems.
CO3: Analysing complex problems by breaking them into manageable components and utilize the tools of multivariate calculus to explore relationships between variables and their applications in various fields.
CO4: Evaluating the accuracy and appropriateness of calculus methods used in various physical and geometrical applications, verifying results through theorems and integrals.

Course Content

Unit 1: Partial Differentiation: **Contact Hours:** 15

Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal andnormal properties of the gradient, Tangent planes and normal lines.

Unit 1I: Differentiation: **Contact Hours:** 15

Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two variables and more variables, Envelopes and evolutes.

Unit III: Extrema of Functions and Vector Field: **Contact Hours:** 15

Extrema of functions of two and more variables, Method of Lagrange multipliers, Constrained optimization problems, Definition of vector field, Divergence, curl, gradient and vector identities.

Double and Triple Integrals: Double integration over rectangular and nonrectangular regions, Double integrals in polar co-ordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals, Dirichlet integral.

Unit IV: Green's, Stokes' and Gauss Divergence Theorem: **Contact Hours:** 15

Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Learning Experience

The "Multivariate Calculus" course offers an engaging and participatory learning experience. Lectures will be supplemented with interactive discussions, case studies, and real-world applications to help students grasp complex concepts. Hands-on learning will be promoted through regular assignments and problem-solving activities, using technology such as graphing software and online platforms for simulations and visualizations. Group work will foster collaboration, with peer reviews allowing for deeper understanding and shared feedback. Assessments will include quizzes, exams, and project-based tasks to evaluate progress. The course instructor will provide ongoing support and feedback, encouraging students to seek help and collaborate with peers for a successful learning experience.

Textbooks

1. Gorakh Prasad (2016). *Differential Calculus* (19th edition). Pothishala Pvt. Ltd

Suggested Readings

1. Jerrold Marsden, Anthony J. Tromba& Alan Weinstein (2009). Basic MultivariableCalculus, Springer India Pvt. Limited.
2. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage.
3. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd edition). Pearson Education. Dorling Kindersley (India) Pvt. Ltd.

Open Educational Resources (OER)

1. https://online.stanford.edu/courses/math51-linear-algebra-multivariable-calculus-and-modern-applications

2. https://ocw.mit.edu/courses/18-02-multivariable-calculus-fall-2007/video_galleries/video-lectures/
3. https://archive.nptel.ac.in/courses/111/107/111107108/

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/attendance/case studies/reflective journals(minimum of five components to be evaluated)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 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					
SCMA152	**Multivariate Calculus Practical Lab**	**L**	**T**	**P**	**C**
Version		0	0	4	2
Category of Course	Major-III (Practical)				
Total Contact Hours	30 Hours				
Pre-Requisites/ Co-Requisites	MATLAB software/Mathematica/Maple software				

Course Perspective

The "Multivariate Calculus Practical Labs" course focuses on applying calculus concepts to solve real-world problems involving functions of multiple variables. Students will work with integrals to compute areas, volumes, and arc lengths, and explore techniques for analysing the behaviour of functions, including identifying critical points and using software for graphing. Vector operations and concepts such as gradients, divergence, and curl will also be introduced. Through practical exercises, students will develop a deeper understanding of multivariable calculus, enhance their analytical skills, and gain proficiency in mathematical tools for complex problem-solving.

Course Outcomes

Upon completion of the course, the learner will be able to:
CO1: Observing and analyzing multivariate functions, interpreting their geometric and analytic behaviors in practical applications.

CO2: Imitating standard computational techniques for solving multivariate calculus problems, including partial derivatives, gradients, and optimization in lab settings.

CO3: Practicing problem-solving methods by applying multivariate calculus principles to real-world situations and computational simulations.

Course Content:

List of practical

- Evaluate the integration of the function
- Evaluate the double/ triple integral integration of the function
- Evaluate the area of closed curve
- Evaluate the arc length of curve
- Evaluate the Volume of closed curve
- Find the critical points and use Mathematica to graph the surface and determine the max/min/saddle nature of these points.
- Calculate the dot and cross product of vectors
- Calculate the Gradient of a vector, Divergence and Curl of vector

Learning Experience

In the "Multivariate Calculus Practical Labs" course, students will engage in a dynamic, hands-on learning experience designed to deepen their understanding of complex calculus concepts. Instruction will blend lectures with interactive technology, including software for computational simulations and graphical analysis. Activities will encompass case studies, group projects, and individual assignments, fostering both collaborative and independent problem-solving skills. Students will tackle real-world problems through practical exercises and lab work, supported by regular feedback from the course instructor, who will be available for additional guidance. Peer reviews and group discussions will enhance collaborative learning. Assessments will include practical tasks, written reports, and presentations to evaluate both theoretical and applied knowledge.

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. Lisa Oberbroeckling, Programming Mathematics Using MATLAB, Academic Press
2. Ronald L. Lipsman, Jonathan M. Rosenberg, Multivariable Calculus with MATLAB: With Applications to Geometry and Physics, Springer International Publishing

Open Educational Resources (OER)

1. https://online.stanford.edu/courses/math51-linear-algebra-multivariable-calculus-and-modern-applications

2. https://ocw.mit.edu/courses/18-02-multivariable-calculus-fall-2007/video_galleries/video-lectures/

3. https://archive.nptel.ac.in/courses/111/107/111107108/

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SCMA104	**Modern Algebra**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Core Course**				
Total Contact Hours	**60**				
Pre-requisites/ Co-requisites	**Classical Algebra**				

Course Perspective

This course provides a fundamental understanding of the structure of algebraic systems, focusing primarily on groups, rings, and fields. It is designed for students who have a basic background in algebra and are looking to explore the deeper theoretical aspects of the subject.

Course Outcomes (CO)

CO1: Recalling the definitions and key properties of groups, subgroups, cyclic groups, rings, and fields, including specific groups such as dihedral, permutation, and quaternion groups.

CO2: Applying Lagrange's theorem to determine the possible orders of subgroups within a group and using Cauchy's theorem to identify elements of specific orders in finite abelian groups.

CO4: Analyzing the structure of groups by examining their normal subgroups and cosets, and classifying subgroups of cyclic groups.

CO5: Evaluating the properties of group, group homomorphisms and isomorphisms.

Course Content

Unit I: **14 lecture hours**

Groups and their Elementary Properties: Symmetries of a square, Definition and examples of groups including dihedral, permutation and quaternion groups, Elementary properties of groups. Subgroups and examples of subgroups, Cyclic groups, Properties of cyclic groups, Lagrange's theorem,

Unit II: **16 lecture hours**

Normal Subgroups: Properties of cosets, Normal subgroups, Simple groups, Factor groups, Cauchy's theorem for finite abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups; Classification of subgroups of cyclic groups

Unit III: **14 lecture hours**

Permutation Groups: Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups, Cayley's theorem and its applications

Unit IV: **16 lecture hours**

Group Homomorphisms, Rings and Fields: Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Properties of isomorphisms; First, second and third isomorphism theorems for groups; Definitions and elementary properties of rings and fields.

Learning Experience:
The learning experience in this Abstract Algebra course is designed to be dynamic and immersive, combining interactive lectures, hands-on problem-solving, and collaborative group work to deepen students' understanding of algebraic structures. Students will engage with real-world applications of abstract concepts, such as group theory's role in cryptography, while regular assessments and feedback will ensure they are continuously progressing. The course leverages technology, including mathematical software and online resources like MIT Open Course Ware, to enhance learning and provide additional support.

Instruction Methods:

1. Interactive Lectures

- **Approach**: Lectures will be conducted interactively, incorporating questions, discussions, and real-time problem-solving. Concepts will be explained with visual aids such as diagrams, animations, and geometric interpretations to help students visualize abstract ideas.
- **Tools**: Use of slides and smart board.

2. Problem-Based Learning (PBL)

- **Approach**: Students will regularly engage in problem-based learning, where they tackle algebraic problems and case studies that require the application of theoretical concepts. This method encourages active learning and critical thinking.
- **Tools**: Problem sets distributed through a learning management system (LMS), with in-class problem-solving sessions.

3. Flipped Classroom

- **Approach**: Some portions of the course will use a flipped classroom model, where students are assigned pre-class readings or video lectures. Class time will then be devoted to discussing the material, solving problems, and addressing any misconceptions.
- **Tools**: Pre-recorded lectures, online readings, and interactive quizzes to assess pre-class learning.

4. Continuous Assessment and Feedback

- **Approach**: The course will include frequent assessments such as quizzes, short assignments, and in-class activities to gauge understanding and provide timely feedback. This will help students stay engaged and identify areas for improvement.
- **Tools**: Online quizzes via the LMS, peer assessments during group work, and in-class formative assessments.

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:

Support for students in this Abstract Algebra course is comprehensive and multifaceted, ensuring a conducive learning environment for all. Regular office hours and peer tutoring sessions will be available, offering personalized assistance to help students grasp challenging concepts and work through problem sets. The course will also provide timely and

constructive feedback through continuous assessments, quizzes, and in-class activities, allowing students to monitor their progress and address any difficulties promptly. Additionally, online resources, including pre-recorded lectures, tutorials, and discussion forums, will be accessible to support learning outside the classroom. For collaborative projects, students will have access to digital tools and platforms to facilitate group work and communication, ensuring that they can effectively collaborate and succeed in their assignments. Overall, these support mechanisms are designed to help every student thrive academically and fully engage with the course material.

Text Books

1. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.

2. I.S. Luthar & I.B.S. Passi (2013). Algebra: Volume 1: Groups. Narosa.

Suggested Readings

1. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
2. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.

Open Educational Resources (OER)

1. Abstract Algebra: Theory and Applications
2. Algebra: Abstract and Concrete
3. MIT Open CourseWare - Abstract Algebra
4. NPTEL Abstract Algebra

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory): End Term Examination	**50 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					
SEC013	**Data Analytics with Tableau**	**L**	**T**	**P**	**C**
Version		1	0	4	3
Category of Course	Minor				
Total Contact Hours	40 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course is designed to equip students with essential skills in Data Warehousing and Tableau, key tools in modern data management and visualization. Students will explore the architecture and characteristics of data warehouses, learning how to efficiently store and retrieve data in support of business intelligence and decision-making processes. The course emphasizes hands-on experience with Tableau, where students will connect to various data sources, create and format visualizations, and develop interactive dashboards. Additionally, the course covers Tableau Server, enabling students to manage, share, and embed visualizations across platforms. By mastering these concepts and tools, students will be prepared to handle complex data analytics tasks, making them valuable assets in fields such as business, finance, healthcare, and beyond.

Course Outcomes

Upon completion of the course, the learner will be able to:
CO1: Explaining the fundamental concepts of data visualization and Tableau's interface, including different types of charts and graphs.
CO2: Applying basic visualizations like bar charts, line charts, and pie charts using Tableau, applying data visualization techniques to represent data effectively.
CO3: Analyzing datasets by using filters, sorting, and grouping features in Tableau to derive meaningful insights from data.
CO4: Evaluating different visualization options in Tableau to choose the most appropriate one based on the type of data and the objective of the analysis.

Course Content

Unit 1: Introduction to Tableau and Data Visualization **Contact Hours:** 10

- Overview of Data Visualization
- Introduction to Tableau Interface and Workflow
- Connecting to Data Sources (Excel, CSV, etc.)
- Basic Charts and Graphs (Bar, Line, Pie Charts)
- Hands-on Practice: Creating First Visualizations

Unit 2: Working with Data in Tableau **Contact Hours:** 10

- Data Import and Data Preparation
- Sorting and Filtering Data
- Grouping and Aggregating Data
- Creating Hierarchies and Drill-downs
- Hands-on Practice: Exploring Data Using Tableau

Unit 3: Advanced Visualization Techniques **Contact Hours:** 10

- Using Calculated Fields and Table Calculations
- Advanced Charts (Heat Maps, Tree Maps, Scatter Plots, etc.)
- Creating Dual-axis and Combined Charts
- Applying Parameters and Filters
- Hands-on Practice: Creating Advanced Visualizations

Unit 4: Dashboards and Storytelling with Data **Contact Hours:** 10

- Introduction to Dashboards in Tableau
- Designing Interactive Dashboards
- Creating Storylines for Presenting Data Insights
- Publishing and Sharing Dashboards
- Hands-on Practice: Building a Complete Dashboard

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on projects to deepen understanding of data warehousing concepts and Tableau. Students will engage in practical exercises to design data warehouses, create complex visualizations, and manage Tableau Server environments, ensuring a comprehensive grasp of both theoretical knowledge and real-world application. Through collaborative projects, learners will apply these skills to solve industry-relevant problems, enhancing their ability to transform data into actionable insights.

Instruction Methods:

- **Lectures:** Core concepts of data warehousing and Tableau will be taught using multimedia presentations, case studies, and real-world examples to illustrate the practical applications of these tools.
- **Interactive Sessions:** Students will participate in Q&A sessions, live demonstrations of Tableau features, and group discussions to actively engage with the material and reinforce their understanding.

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. Getting Started with Tableau 2019.2: Effective data visualization and business intelligence with the new features of Tableau 2019.2, Tristan Guillevin, Packt Publishing Ltd
2. Mastering Tableau 2019.1: An expert guide to implementing advanced business intelligence and analytics with Tableau 2019.1, Marleen Meier and David Baldwin, Packt Publishing Ltd.

Suggested Readings

1. Data Warehousing: Concepts, Techniques, Products and Applications" by A. M. Sarma.
2. Learning Tableau 2020: Create effective data visualizations, build interactive visual analytics, and transform your organization" by Joshua N. Milligan.
3. Data Visualization: A Practical Introduction" by Kieran Healy

Open Educational Resources (OER)

1. Data Warehousing Concepts - Coursera - A course offering a comprehensive introduction to data warehousing concepts.
2. Khan Academy's Data Management - Free tutorials on SQL and data management concepts.
3. Data Warehouse Concepts - Data Warehouse Concepts - Resources and articles on various data warehousing concepts.

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER III					
SCMA201	**Real Analysis**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Major-V				

Total Contact Hours	60 Hours
Pre-Requisites/ Co-Requisites	Limit, Continuity and Differentiability

Course Perspective

In the undergraduate course "Real Analysis," students delve into the rigorous study of the real number system, focusing on its properties such as completeness, the behavior of sequences, and the nature of infinite series. The course starts by exploring foundational concepts like the algebraic and order properties of real numbers, supremum and infimum, and various types of intervals. Students learn about sequences, emphasizing convergence, limit theorems, and Cauchy sequences. The study of infinite series includes convergence tests and concepts of absolute and conditional convergence. The course also focuses on Riemann integration, addressing the integrability of functions, uniform convergence, and improper integrals, providing a comprehensive foundation in real analysis.

Course Outcomes

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

CO1: Identifying and recalling key definitions, theorems, and properties of real numbers, sequences, series, and integrals.

CO2: Applying various techniques and theorems to solve problems related to sequences, series, and integrals, including applying convergence tests and integration methods to practical mathematical problems.

CO3: Analyzing complex real analysis problems by breaking them down into simpler parts, such as examining the convergence behavior of sequences and series using different criteria.

CO4: Evaluating the validity and effectiveness of different mathematical proofs, methods, and solutions in real analysis.

Course Content

Unit 1: Real Number System: **Contact Hours:** 15

Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$,The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$, Definition and types of intervals, Nested intervals property; Neighborhood of a point in $\mathbb{R}$, Open, closed and perfect sets in $\mathbb{R}$, Connected subsets of $\mathbb{R}$, Cantor set and Cantor function

Unit 1I: Sequences of Real Numbers: **Contact Hours:** 15

Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequences, Bolzano Weierstrass theorem for sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion.

Unit III: Infinite Series: **Contact Hours:** 15

Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series**;** Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Integral test; Alternating series, Leibniz test, Absolute and conditional convergence, Rearrangement of series and Riemann's theorem.

Unit IV: Riemann Integration: **Contact Hours:** 15

Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, First mean value theorem, Bonnet and Weierstrass forms of second mean value theorems.

Uniform convergence and Improper integral: Pointwise and uniform convergence of sequence and series of functions, Weierstrass's M-test, Dirichlet test and Abel's test for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiability, Improper integrals, Dirichlet test and Abel's test for improper integrals.

Learning Experience

The Real Analysis course will be conducted through a blend of interactive methods to ensure a participatory learning experience. Instruction will combine lectures, multimedia presentations, online simulation tools, etc. Students will engage in hands-on learning through problem-solving sessions, case studies, and group work, fostering collaborative skills. Assignments will include both individual and group tasks, encouraging peer review and feedback. Classroom activities will be complemented by outside assignments and research projects. The course in charge will provide additional support and feedback during office hours, and students are encouraged to seek help as needed. Opportunities for collaboration and mutual support will be embedded throughout the course, enhancing learning outcomes and promoting a supportive academic community.

Textbooks

1. Robert G. Bartle & Donald R. Sherbert (2015). Introduction to Real Analysis (4^{th} edition).Wiley India.

2. Gerald G. Bilodeau, Paul R. Thie & G. E. Keough (2015). An Introduction to Analysis (2nd edition), Jones and Bartlett India Pvt. Ltd.

Suggested Readings

1. K. A. Ross (2013). Elementary Analysis**:** The Theory of Calculus (2nd edition). Springer.

Open Educational Resources (OER)

1. https://nptel.ac.in/courses/111106142

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/attendance/case studies/reflective journals (minimum of five components to be evaluated)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER III					
SCMA203	ORDINARY DIFFERENTIAL	**L**	**T**	**P**	**C**

	EQUATION				
Version 1.0		**4**	**0**	**0**	**4**
Category of Course					
Total Contact Hours	60				
Pre-Requisites/ Co Requisites	Differentiation, Integration				

Course Perspective

The course on Ordinary Differential Equations (ODEs) provides a thorough exploration of methods for analysing and solving differential equations that involve functions and their derivatives. Students will learn key techniques such as separation of variables, integrating factors, and characteristic equations, and apply them to solve first-order and higher-order ODEs. The course emphasizes real-world applications in physics, engineering, and other fields, demonstrating how ODEs model dynamic systems. With a focus on both theoretical foundations and practical problem-solving, this course equips students with essential skills to tackle complex differential equations encountered in various scientific and engineering contexts.

Course Outcomes

Upon completion of the ordinary differential equation course, the learner will be able to:

CO1: Understanding the genesis of ordinary differential equations and their significance in mathematical modeling.

CO2: Applying various techniques to obtain exact solutions of solvable first-order differential equations and linear differential equations of higher order.

CO3: Analyzing the solutions of first-order differential equations that pass through a given point in the plane, and employing power series methods for higher-order linear equations, particularly when traditional methods are insufficient.

CO4: Evaluating the concept of a general solution of linear differential equations of arbitrary order and applying various methods to derive such solutions.

Course Content

UNIT-I First Order Differential Equations: **14 Lectures**

Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, Equations in which variables are separable, Homogeneous equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree equations solvable for x, y and p. Clairaut's form and singular solutions.

UNIT-II Second Order Linear Differential Equations: 14 Lectures

Statement of existence and uniqueness theorem for linear differential equations, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients, Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters and method of undetermined coefficients, Reduction of order, Coupled linear differential equations with constant coefficients.

UNIT-III Higher Order Linear Differential Equations: 17 Lectures

Principle of superposition for a homogeneous linear differential equation, Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties, Concept of a general solution of a linear differential equation, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Method of variation of parameters and method of undetermined coefficients, Inverse operator method.

UNIT-IV Series Solutions of Differential Equations: 15 Lectures

Power series method, Legendre's equation, Legendre polynomials, Rodrigue's formula, Orthogonality of Legendre polynomials, Frobenius method, Bessel's equation, Bessel functions and their properties, Recurrence relations.

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on projects to deepen understanding of Ordinary Differential Equations (ODEs) and their applications in various fields.

Instruction Methods:

- **Lectures:** Core concepts of ODEs, including first-order and higher-order differential equations, methods of solutions, and applications, will be taught using multimedia presentations and real-world examples.
- **Interactive Sessions:** Q&A sessions, problem-solving exercises, and group discussions will engage students in active learning and reinforce theoretical knowledge.

Technology Use:

- **Online Platforms:** A Learning Management System (LMS) will host course resources, recorded lectures, assignments, and discussion forums, facilitating extended learning and peer interaction.

Assessments:

- **Formative:** Regular quizzes, problem sets, and online discussions will provide continuous feedback and help students track their progress.
- **Summative:** Exams, project presentations, and peer reviews will assess students' mastery of the material, with a focus on both theoretical understanding and practical application.

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

Textbooks

1. Belinda Barnes & Glenn Robert Fulford (2015). Mathematical Modelling with Case Studies: A Differential Equation Approach Using Maple and MATLAB (2nd edition). Chapman & Hall/CRC Press, Taylor & Francis.

2. H. I. Freedman (1980). Deterministic Mathematical Models in Population Ecology. Marcel Dekker Inc.

3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.

4. Daniel A. Murray (2003). Introductory Course in Differential Equations, Orient.

Suggested Readings

1. B. Rai, D. P. Choudhury & H. I. Freedman (2013). A Course in Ordinary Differential Equations (2nd edition). Narosa.

2. Shepley L. Ross (2007). Differential Equations (3rd edition), Wiley India.

3. George F. Simmons (2017). Differential Equations with Applications and Historical Notes (3rd edition). CRC Press. Taylor & Francis.

Open Educational Resources (OER)

http://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/
https://www.saylor.org/courses/mth302/
https://www.khanacademy.org/math/differential-equations
https://openstax.org/books/calculus-volume-2/pages/9-differential-equations

Evaluation Scheme

Evaluation components	Weightage

Internal marks (Theory) **I. Continuous assessments (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER III					
SCMA251	ORDINARY DIFFERENTIAL EQUATION LAB	**L**	**T**	**P**	**C**
Version		0	0	4	2
Category of Course	Minor				
Total Contact Hours	30 Hours				
Pre-Requisites/ Co-Requisites	MATLAB SOFTWARE				

Course Perspective

The Ordinary Differential Equations Lab equips students with practical skills to solve and analyze differential equations using computational tools. The course focuses on applying numerical methods to find solutions to first and second-order differential equations, systems of differential equations, and boundary value problems. Students will gain hands-on experience with software such as MATLAB enhancing their understanding of theoretical concepts.

Course Outcomes

Upon completion of the ordinary differential equations lab course, the learner will be able to:

CO1: Observing and evaluating the accuracy of program output by performing hand calculations and plotting graphs for various types of differential equations.

CO2: Imitating techniques to solve second-order differential equations, including the computation of double and triple integrals of functions, by following established methods.

CO3: Practicing the determination and assessment of the area of closed curves and arc lengths, demonstrating proficiency in integration techniques through repetitive application.

Course Content

List of Practical

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model.
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Predatory-prey model (basic volterra model)
9. Basic Epidemic model of influenza.
10. Basic Battle model.

Learning Experience
This lab course offers an immersive experience through practical exercises, interactive discussions, and collaborative projects focused on the application of Ordinary Differential Equations (ODEs).

Methods of Instruction:
Lab Experiments:
Students will engage in hands-on lab activities, solving various ODEs using numerical and analytical methods. Each session includes demonstrations, followed by supervised practice to ensure accurate problem-solving and analysis.

Interactive Lab Sessions:
Students will actively participate in discussions, pose questions, and collaborate with peers and instructors to explore different approaches to solving ODE problems.

Use of Technology:
Lab Software and Tools:
Students will utilize computational tools, such as MATLAB, to solve ODEs, visualize solutions, and analyze results. The focus is on using numerical methods for real-world applications.

Online Resources:
An LMS will provide access to lab manuals, instructional videos, and interactive tutorials. Discussion boards will facilitate collaboration and knowledge-sharing outside lab hours.

Textbooks

1. "Differential Equations with Boundary-Value Problems," 9th Edition by Dennis G. Zill and Michael R. Cullen (2018), Vol. 9, ISBN: 9781337569151
2. "Ordinary Differential Equations" by Morris Tenenbaum and Harry Pollard (1985), Vol. 1, ISBN: 9780486649405
3. "Ordinary Differential Equations: An Elementary Textbook for Students of Mathematics, Engineering, and the Sciences," 2nd Edition by Edward L. Ince (1956), Vol. 2, ISBN: 9780486603490

Suggested Readings

1. "Applied Numerical Methods with MATLAB for Engineers and Scientists," 4th Edition by Steven C. Chapra (2017), Vol. 4, ISBN: 9780073397962
2. "Introduction to Ordinary Differential Equations," 4th Edition by Shepley L. Ross (1989), Vol. 4, ISBN: 9780471098812
3. "Schaum's Outline of Differential Equations," 4th Edition by Richard Bronson and Gabriel Costa (2014), Vol. 4, ISBN: 9780071824859

Open Educational Resources (OER)
http://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/
http://tutorial.math.lamar.edu/Classes/DE/DE.aspx
http://learn.saylor.org/course/MA221
http://www.khanacademy.org/math/differential-equations
http://www.ck12.org/c/algebra/differential-equations/

Assessment & Evaluation

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**

SEMESTER III					
VAC	**Introduction to Statistics using SPSS**	**L**	**T**	**P**	**C**
Version		1	0	2	2
Category of Course	VAC				
Total Contact Hours	30 Hours				
Pre-Requisites/ Co-Requisites	NIL				

Course Perspective

The "Introduction to Statistics using SPSS" course offers a foundational understanding of statistical analysis through SPSS software, catering to students from diverse disciplines. The curriculum emphasizes both theoretical and practical aspects of data management, descriptive and inferential statistics, and effective communication of statistical findings. Through hands-on experience, students will learn to import, clean, and analyse datasets, generate visualizations, and perform hypothesis testing and regression analysis. By the course's conclusion, students will be equipped with the skills to manage real-world data, interpret statistical results, and present findings through reports and presentations using SPSS.

Course Outcomes

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

CO1: Observing key features and functions of SPSS by examining its interface and understanding various data types and formats.

CO2: Imitating and applying basic data management techniques, such as data entry, cleaning, and preparation, by replicating demonstrated methods.

CO3: Practicing descriptive and inferential statistical methods (e.g., mean, variance, t-tests) to analyze and visualize data in SPSS effectively.

Course Content:

Unit 1:

Module 1: Introduction to SPSS **5 hours**

- Overview of SPSS
- Navigating the SPSS interface
- Understanding data types and formats

Module 2: Data Management **5 hours**

- Importing and exporting data
- Data entry and coding
- Data cleaning and preparation

Unit 2:

Module 3: Descriptive Statistics **5 hours**

- Measures of central tendency (mean, median, mode)
- Measures of variability (range, variance, standard deviation)
- Data visualization (charts, graphs, histograms)

Module 4: Inferential Statistics **5 hours**

- Probability and distributions
- Hypothesis testing (t-tests, chi-square tests)
- Analysis of variance (ANOVA)
- Correlation and regression analysis

Unit 3:

Module 5: Reporting and Interpretation **5 hours**

- Writing up statistical results
- Creating tables and figures for reports

Module 6: Practical Applications **5 hours**

- Case studies and real-world examples
- Hands-on practice with datasets
- Group projects and presentations

Learning Experience

In the "Introduction to Statistics using SPSS" course, students will engage in a dynamic and participatory learning experience. The course will blend lectures, hands-on practice, and interactive activities to foster understanding. Instruction will incorporate SPSS software to explore data management, descriptive, and inferential statistics. Students will work on real-world case studies, participate in group projects, and create reports and visualizations, applying their skills to practical problems. Technology will be utilized for demonstrations and

assignments, enhancing learning outcomes. The course includes regular feedback sessions, with the instructor available for additional support. Collaborative activities and peer reviews will encourage student interaction and mutual assistance.

Instruction Methods:

- **Lectures:** Core SPSS 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

"Using SPSS for Windows and Macintosh: Analyzing and Understanding Data" by Samuel B. Green and Neil J. Salkind

Open Educational Resources (OER)

1. https://nptel.ac.in/courses/109107190
2. https://www.youtube.com/watch?v=PN-H8GikRQ0&list=PLVI_iGT5ZuRmXlbuwMKi04R6Oe1G3De8G

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**

II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER-IV

SEMESTER IV					
SCMA202	**Linear Algebra**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Major-VII				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	--				

Course Perspective

In the undergraduate course "Linear Algebra," students explore foundational concepts and applications of vector spaces and linear transformations. The course begins with an introduction to vector spaces, including subspaces, bases, and dimensions. It focuses on linear transformations, covering their properties, matrices, and coordinate changes, and the Rank-Nullity Theorem. Students gets deep understanding of properties such as isomorphisms, canonical forms, and eigenvalues, including the Cayley-Hamilton theorem and diagonalization. The final unit focuses on inner product spaces, emphasizing orthogonality, the Cauchy-Schwarz inequality, and the Gram-Schmidt process. Overall, the course equips students with essential tools for understanding and applying linear algebra in various mathematical and practical contexts.

Course Outcomes

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

CO1: **Understanding** the fundamental definitions and properties related to vector spaces, subspaces, bases, dimensions, linear transformations, and inner product spaces, principles of linear transformations, the Rank-Nullity Theorem, matrix representation, and the significance of canonical and Jordan forms.

CO2: Applying methods for solving problems such as computing eigenvalues and eigenvectors, diagonalizing matrices, and performing change of basis transformations

CO3: Analyzing the relationships within vector spaces and linear transformations, change of bases, the matrix representations, canonical form

CO4: Evaluating the correctness and efficiency of various methods used in linear algebra, such as diagonalization and orthogonalization techniques

Course Content

Unit I: **15 lecture hours**

Vector Space: Definition and examples, Subspace, Linear span, Quotient space and direct sum of subspaces, linearly independent and dependent sets, Bases and dimension.

Unit II: **15 lecture hours**

Linear transformations: Definition and examples, Linear Transformation, Null space, Range space, Rank nullity theorem, Algebra of linear transformations, Matrix of a linear transformation, Change of coordinates.

Unit III: **16 lecture hours**

Further Properties of Linear Transformations: Representation of linear transformations by matrices, change of basis, Singular and nonsingular transformation, Isomorphism of vector space, Canonical forms, Jordan forms, Triangular forms, Dual space.

Eigen value & Eigen vectors of linear transformation, Characteristic polynomial, Characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding the inverse of a matrix, Mini mal polynomial, Diagonalization, Linear transformations

Unit IV:

14 lecture hours

Inner Product Spaces: Inner product spaces and orthogonality, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalisation, Diagonalization of symmetric matrices.

Learning Experience

Course Integration Approach:

This course blends theoretical instruction with practical problem-solving exercises to provide students with a deep understanding of linear algebra concepts. Through a combination of lectures, interactive sessions, and collaborative projects, students will master essential topics such as matrices, vector spaces, and linear transformations. Practical applications will be explored through hands-on exercises, allowing students to apply linear algebra techniques to real-world problems and enhance their analytical skills.

Instruction Methods:

Lectures:

Core concepts of linear algebra, such as matrix operations, eigenvalues, eigenvectors, and vector spaces, will be presented through multimedia presentations. Real-world examples and applications, such as solving systems of equations and transformations, will be used to highlight the importance of linear algebra in various fields.

Interactive Sessions:

Interactive Q&A sessions, problem-solving workshops, and group discussions will provide students with opportunities to engage actively with the material. Live demonstrations of solving linear algebra problems will help reinforce understanding and encourage collaboration among students.

Hands-on Projects:

Students will participate in hands-on exercises, such as matrix manipulations and eigenvalue computations, and work on projects that apply linear algebra to practical problems in areas like computer graphics, machine learning, and optimization. These projects will help students see the relevance of linear algebra in real-world scenarios and develop their problem-solving skills.

Technology Use:

Online Platforms:

A Learning Management System (LMS) will host course materials, including recorded lectures, assignments, and quizzes. Discussion forums will facilitate extended learning, allowing students to interact with peers and instructors, ask questions, and engage in collaborative problem-solving.

Assessments:

Formative Assessments:

Quizzes and Assignments: Regular quizzes and problem sets will assess students' understanding of core concepts and provide continuous feedback to guide their learning.
Online Discussions: Students will participate in online discussions to reflect on course material and collaborate on problem-solving strategies.

Summative Assessments:

Exams: Written exams will assess students' mastery of linear algebra concepts, including matrix operations, vector spaces, and linear transformations.
Project Presentations: Students will present projects that demonstrate their ability to apply linear algebra to practical problems.

Peer Reviews: Peer assessments of projects will encourage critical thinking and allow students to provide and receive feedback on their work.

Support:

- **Instructor Guidance**: The course instructor will offer additional support through office hours and review sessions, providing personalized feedback to help students overcome challenges and master the material.
- **Peer Collaboration**: Group work and peer-review sessions will encourage collaboration and foster a supportive learning environment where students can learn from each other and enhance their understanding of linear algebra concepts.

Textbooks

1. R. Vasishtha, J.N. Sharma, A. K. Vasishtha; *Linear Algebra*; Krishna Prakashan, Meerut.
2. Kenneth Hoffman, Ray Alden Kunz; *Linear Algebra*; Prentice-Hall of India Pvt.

Suggested Readings

1. S. Lang; *Introduction to Linear Algebra*; Springer.
2. S. Kumaresan; *Linear Algebra- A Geometric* Approach; Prentice Hall of India.

Open Educational Resources (OER)

1. https://archive.nptel.ac.in/courses/111/106/111106135/

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/attendance/case studies/reflective journals (minimum of five components to be evaluated)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER IV					
SCMA204	**Complex Analysis**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Major-VIII				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	--				

Course Perspective

The undergraduate course "Complex Analysis" provides an in-depth exploration of complex numbers and functions, focusing on their properties and applications. The course begins with an introduction to the complex plane, including the representation of complex numbers, complex functions, and linear fractional transformations. It then covers analytic functions, emphasizing the Cauchy-Riemann equations, differentiability, and the behavior of functions like exponentials and logarithms. Key theorems such as Cauchy's Theorem and the Fundamental Theorem of Algebra are studied, along with their applications in complex integration. The course also explores power series, singularities, and contour integration, equipping students with the tools to analyze and solve complex-valued problems.

Course Outcomes

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

CO1: Understanding and explaining the principles behind analytic functions and the Cauchy-Riemann equations, as well as the significance of concepts like branch cuts, residues, and singularities.

CO2: Using methods of complex integration and series expansion to solve problems involving complex functions, including Cauchy's Residue Theorem and determining the radius of convergence for power series.

CO3: Analyzing complex functions and their properties by applying theorems such as the Maximum Modulus Theorem and Picard's Theorem to identify singularities, poles, and zeros, assessing their impact on function behavior.

CO4: Evaluating the effectiveness and accuracy of different techniques, including contour integration and series expansion.

Course Content

Unit I: **15 Contact hours**

Complex Plane and functions: Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity, Linear fractional transformations and their geometrical properties.

Unit II: **15 Contact hours**

Analytic Functions and Cauchy-Riemann Equations: Differentiability of a complex valued function, Cauchy-Riemann equations, Harmonic functions, necessary and sufficient conditions for differentiability, Analytic functions; Analyticity and zeros of exponential, trigonometric and logarithmic functions; Branch cut and branch of multi-valued functions.

Unit III: **12 Contact hours**

Cauchy's Theorems and Fundamental Theorem of Algebra: Line integral, Path independence, Complex integration, Green's theorem, Anti-derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula, Cauchy's inequality, Derivative of analytic function, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem and its consequences.

Unit IV: **18 Contact hours**

Power Series: Sequences, series and their convergence, Taylor series and Laurent series of analytic functions, Power series, Radius of convergence, Integration and differentiation of power series, Absolute and uniform convergence of power series.

Singularities and Contour Integration: Meromorphic functions, Zeros and poles of meromorphic functions, Nature of singularities, Picard's theorem, Residues, Cauchy's residue theorem, Argument principle, Rouche's theorem, Jordan's lemma, Evaluation of proper and improper integrals.

Learning Experience

This course focuses on developing a deep understanding of complex analysis through theoretical instruction and interactive learning. The content will cover fundamental concepts such as complex functions, analyticity, contour integration, and series expansions. Students will engage with the material through lectures, interactive discussions, and conceptual exercises to ensure a thorough grasp of both the foundational theories and their applications in various fields of mathematics and science.

Instruction Methods:

Lectures:

Core concepts of complex analysis will be presented through detailed lectures, using multimedia presentations and mathematical proofs. Topics will include complex numbers, analytic functions, Cauchy's theorems, residue calculus, and more. Emphasis will be placed on the theoretical foundations, supported by examples from physics and engineering.

Interactive Sessions:

Interactive sessions will involve group discussions, problem-solving activities, and Q&A sessions. These will allow students to engage actively with the content, clarify doubts, and deepen their understanding through collaborative exploration of key ideas. Conceptual exercises will be used to reinforce learning.

Theoretical Exercises:

Students will be tasked with solving theoretical problems and engaging in discussions on the proofs and implications of major theorems in complex analysis. This will help them build the analytical skills necessary for tackling more advanced topics in mathematics.

Technology Use:

Online Platforms:

An LMS will be utilized to host lecture notes, recorded sessions, and assignment submissions. Online discussion forums will be available for students to discuss theoretical problems and collaborate on understanding complex concepts outside of class.

Assessments:

Formative Assessments:

- **Quizzes and Assignments**: Regular quizzes and assignments will be provided to assess students' understanding of the theoretical concepts. These will focus on the application of theorems, problem-solving, and proof-writing.
- **Discussion Participation**: Active participation in discussions, both in-class and online, will be encouraged to facilitate continuous engagement with the material.

Summative Assessments:

- **Exams**: Written exams will test students on their comprehension of complex analysis concepts, focusing on problem-solving, proofs, and theoretical applications.
- **Essay Assignments**: Students may be required to write essays on specific topics within complex analysis, demonstrating a deeper understanding of advanced concepts and their broader implications.

Support:

- **Instructor Guidance**: The instructor will provide additional support through office hours, where students can seek help with difficult concepts and receive personalized feedback on their progress. Regular review sessions will also be conducted to reinforce key topics before exams.
- **Peer Collaboration**: Group discussions and peer-review sessions will be integral to the course, encouraging students to collaborate and refine their understanding through shared insights and collective problem-solving.

Textbooks

1. A.R. Vashisth, Complex Analysis, krishana prakashan Media, Meerut, 1942.i.

Suggested Readings

1. J.B. Conway, Functions of One Complex Variable, 2nd ed., Narosa, New Delhi, 1978.
2. T.W. Gamelin, Complex Analysis, Springer International Edition, 2001.
3. R. Remmert, Theory of Complex Functions, Springer Verlag, 1991.
4. A.R. Shastri, An Introduction to Complex Analysis, Macmilan India, New Delhi, 1999.

Open Educational Resources (OER)

1. https://www.edx.org/course/complex-analysis
2. https://www.youtube.com/playlist?list=PLyqSpQzTE6M9gCgajvQbc68Hk_JKGBAYT
3. https://nptel.ac.in/courses/111/105/111105129/
4. https://open.umn.edu/opentextbooks/textbooks/complex-analysis-with-applications

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/attendance/case studies/reflective journals(minimum of five components to be evaluated)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER IV					
SCMA206	**PARTIAL DIFFERENTIAL EQUATIONS AND CALCULUS OF VARIATIONS**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course					
Total Contact Hours	60				
Pre-Requisites/ Co Requisites	-				

Course Perspective

This course covers key techniques in Partial Differential Equations (PDEs) and Calculus of Variations, essential for solving complex problems in science and engineering. Students will learn to classify and solve PDEs using methods like Fourier series and Green's functions, with applications such as the heat and wave equations. The course also introduces the Calculus of Variations, focusing on optimizing functionals and solving related problems like geodesics and minimal surfaces. Designed for advanced students and professionals, it requires a solid background in Calculus, Linear Algebra, and Ordinary Differential Equations.

Course Outcomes

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

CO1: Identifying and understanding physical situations whose behavior can be described by ordinary differential equations.

CO2: Applying competence in solving applied problems in both linear and nonlinear forms.

CO3: Analyzing problems to choose the most suitable method for finding solutions.

CO4: Evaluating the solutions of differential equations with initial and boundary conditions.

Course Content

Unit No I: First Order Partial Differential Equations No. of Hours 15

First Order Partial Differential Equations Order and degree of Partial differential equations (PDE), Concept of linear and non-linear partial differential equations, Partial differential equations of the first order, Lagrange's method, Some special type of equation which can be solved easily by methods other than the general method, Charpit's general method.

Unit No II: Second Order Partial Differential Equations No. of Hours 15

Second Order Partial Differential Equations with Constant Coefficients Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients.

Unit No III: Classification of Partial Differential Equations No. of Hours 15
Second Order Partial Differential Equations with Variable Coefficients Partial differential equations reducible to equations with constant coefficient, Second order PDE with variable coefficients, Classification of second order PDE, Reduction to canonical or normal form; Monge's method; Solution of heat and wave equations in one and two dimensions by method of separation of variables

Unit No IV: Calculus of Variations No. of Hours 15

Calculus of Variations-Variational Problems with Fixed Boundaries Euler's equation for functional containing first order and higher order total derivatives, Functionals containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.

Learning Experience

This course will combine lectures, interactive discussions, and practical projects to enhance students' understanding of Partial Differential Equations (PDEs) and the Calculus of Variations, focusing on both theoretical insights and practical applications.

Instruction Methods:

- **Lectures:** Key topics in PDEs, such as equation classification, solution techniques, and real-world applications, along with fundamental concepts of the Calculus of

Variations, will be delivered through multimedia presentations and contextual examples.
- **Interactive Sessions:** Students will engage in Q&A sessions, collaborative problem-solving activities, and group discussions to deepen their comprehension and apply what they've learned to complex problems.

Technology Use:

- **Online Platforms:** Course materials, recorded lectures, assignments, and discussion boards will be available on a Learning Management System (LMS), fostering extended learning opportunities and student interaction.

Assessments:

- **Formative:** Students will receive ongoing feedback through regular quizzes, assignments, and participation in online discussions, ensuring they can monitor their progress and understanding.
- **Summative:** Comprehensive exams, project-based presentations, and peer evaluations will be used to assess students' proficiency in both Partial Differential Equations and the Calculus of Variations, emphasizing their ability to apply concepts in practical scenarios.

Support: The course instructor will provide additional support during office hours, and students will be encouraged to collaborate through group projects and study sessions. Continuous feedback will help students achieve their learning objectives and improve their understanding of the course material.

Textbooks

1. A. S. Gupta (2004). Calculus of Variations with Applications. PHI Learning.

2. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.

3. TynMyint-U & Lokenath Debnath (2013). Linear Partial Differential Equation for Scientists and Engineers (4th edition). Springer India.

Suggested Readings

1. M.D. Raisinghania: Advanced Differential Equations, S. Chand & Co.

2. Walter A. Strauss: An Introduction to Partial Differential Equation, Wiley

3. S. B. Rao & H. R. Anuradha (1996). Differential Equations with Applications. University Press.

4. Ian N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications.

Open Educational Resources (OER)

https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/

https://ocw.mit.edu/courses/mathematics/18-100c-real-analysis-fall-2003/
https://openstax.org/books/calculus-volume-2/pages/1-introduction
https://www.saylor.org/courses/mth302/
https://www.khanacademy.org/math/differential-equations

Evaluation Scheme (Please refer to Notice Ref No: KRMU/CoE/Even/2023-24/018 dated 10 May 2025)

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessments (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

SEMESTER IV					
SCMA254	PARTIAL DIFFERENTIAL EQUATIONS AND CALCULUS OF VARIATIONS LAB	**L**	**T**	**P**	**C**
Version		0	0	4	2
Category of Course	Minor				
Total Contact Hours	30Hours				

Pre-Requisites/ Co-Requisites	MATLAB SOFTWARE

Course Perspective

The purpose of these labs is to help students talk and write in meaningful ways about mathematics. Specifically, to describe quantities and changes in quantities clearly in terms of context, to make rigorous arguments about how such quantities are related, and to make connections between these features in the contexts and on graphs.

Course Outcomes

Upon completion of the partial differential equations and calculus of variations lab course, the learner will be able to:

CO1: Observing and documenting the output of numerical experiments, including using hand calculations and debugging techniques to ensure accuracy.

CO2: Replicating established numerical methods for approximating derivatives and integrals, analyzing their accuracy and how it varies with grid resolution.

CO3: Applying and practicing the accuracy of matrix-based numerical solutions for linear systems of equations, demonstrating practical skills in using these methods.

Course Content

List of Practical

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Correlation coefficient for a bivariate frequency distribution.
9. Lines of regression, angle between lines and estimated values of variables.
10. Spearman rank correlation with and without ties.

11. Partial and multiple correlations.

12. Planes of regression and variances of residuals for given simple correlations.

13. Planes of regression and variances of residuals for raw data.

14. Fitting of binomial distributions for n and p = q = ½.n *and* $p = q = ½$.

15. Fitting of binomial distributions for given n and p.

16. Fitting of binomial distributions after computing mean and variance.

17. Fitting of Poisson distributions for given value of lambda.

18. Fitting of Poisson distributions after computing mean.

19. Fitting of negative binomial.

20. Application problems based on binomial distribution.

21. Application problems based on Poisson distribution.

22. Application problems based on negative binomial distribution.

23. Problems based on area property of normal distribution.

24. To find the ordinate for a given area for normal distribution.

25. Application based problems using normal distribution.

26. Fitting of normal distribution when parameters are given.

27. Fitting of normal distribution when parameters are not given.

28. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit

Learning Experience

This lab course will be conducted through hands-on experiments, interactive sessions, and collaborative group work, focusing on the practical application of Partial Differential Equations (PDEs) and the Calculus of Variations.

Methods of Instruction:

- **Lab Experiments :**
  Students will participate in extensive hands-on lab work, solving various PDEs and optimization problems using numerical and analytical methods. Each session will include detailed demonstrations of techniques, followed by supervised practice to ensure accuracy in solving and analyzing complex problems.
- **Interactive Lab Sessions:**
  During lab work, students will have opportunities to ask questions, engage in

problem-solving discussions with the instructor and peers, and explore different approaches to solving PDEs and variational problems.

Use of Technology:

- **Lab Software and Tools:**
  Students will use computational tools and software for solving PDEs and variational problems, including MATLAB or equivalent platforms. This will involve using numerical methods, visualizing solutions, and analyzing data.
- **Online Resources:**
  An LMS will be used to provide access to lab manuals, instructional videos, and interactive tutorials. Discussion boards will be available for students to collaborate, seek help, and share insights outside of lab hours.

Textbooks

1. M.D. Raisinghania: Advanced Differential Equations, S. Chand & Co.

2. Walter A. Strauss: An Introduction to Partial Differential Equation, Wiley

3. Rudra Pratap; Getting Started with MATLAB 7, Oxford Press. 88 Modes of Eva

Suggested Readings

1. "Introduction to Partial Differential Equations" by David B. Wilson, University of Toronto Press, 2016.
2. "Calculus of Variations" by I. M. Gelfand and S. V. Fomin, Dover Publications, 2000.
3. "Applied Partial Differential Equations" by Richard Haberman, 5th Edition, Pearson, 2012.
4. "Introduction to the Calculus of Variations" by Charles Fox, Dover Publications, 1966.

Open Educational Resources (OER)

https://www.math.washington.edu/~strauss/
http://www.math.csi.cuny.edu/Calculus/ODEs/PDEs/IntroductionPDEs.pdf
https://www.math.ualberta.ca/~kunkel/teaching/calculus-of-variations/
https://archive.org/details/introductiocalcu00foxr

Assessment & Evaluation

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**

SEMESTER IV					
Course Code	Basic IT Tools	**L**	**T**	**P**	**C**
Version 1.0		**1**	**0**	**2**	**3**
Category of Course					
Total Contact Hours	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 of the ordinary differential equation course, the learner will be able to:

CO1: Remembering and understanding of spreadsheet functions and formulas to manage and analyze data in worksheets and workbooks.

CO3: Applying data evaluation techniques using spreadsheets to make informed decisions and draw conclusions.

CO4: Analyzing data to create meaningful representations through charts and pivot tables for enhanced data analysis.

Course Content

Unit 1: Introduction to Spreadsheets **Lecture: 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 **Lecture: 15 hours**

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 **Lecture: 15 hours**

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.

his 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.
3. Jelen, B. (2013). Excel 2013 Charts and Graphs. United Kingdom: Que.

Suggested Readings

1. Alexander, M., Jelen, B. (2013). Excel 2013 Pivot Table Data Crunching. United Kingdom: Pearson Education.
2. 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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

SEMESTER-V

SEMESTER V					
SCMA301	**Numerical Methods**	**L**	**T**	**P**	**C**
Version		**4**	**0**	**0**	**4**
Category of Course	Core				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	Basic Mathematics				

Course Perspective

This course provides a comprehensive introduction to numerical methods, equipping students with essential tools for solving a wide range of mathematical problems encountered in science and engineering. It covers techniques for finding roots of algebraic and transcendental equations, such as the bisection and Newton's methods, along with strategies for solving linear systems using LU decomposition and iterative methods like Gauss-Seidel. Interpolation methods, including Lagrange and cubic spline, are explored for estimating values between data points. The course also delves into numerical differentiation and integration, discussing rules like the trapezoidal and Simpson's rules, alongside advanced extrapolation techniques. Finally, it addresses solving differential equations through methods like Euler's and Runge-Kutta, with applications extending to real-world problems such as weather forecasting and search engine algorithms.

Course Outcomes

This course will enable the students to:

CO1: Understanding numerical methods to solve algebraic and transcendental equations.

CO2: Applying numerical methods to solve systems of linear equations effectively.

CO3: Analyzing interpolating and extrapolating methods for various data sets.

CO4: Evaluating and applying numerical methods to solve initial and boundary value problems in differential equations.

Course Content

Unit I 15 lecture hours

Numerical Methods for Solving Algebraic and Transcendental Equations Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.

Unit II 15 lecture hours

Numerical Methods for Solving Linear Systems Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a matrix and its applications, Gauss-Jacobi, Gauss-Seidel and successive over-relaxation (SOR) methods.

Unit III 15 lecture hours

Interpolation Lagrange and Newton interpolations, Cubic spline interpolation, Finite difference operators, Gregory-Newton forward and backward difference interpolations.

Unit IV 15 lecture hours

Numerical Differentiation and Integration First order and higher order approximation for first derivative, Approximation for second derivative; Numerical integration: Trapezoidal rule, Simpson's rules and error analysis. Initial and Boundary Value Problems of Differential Equations Euler's method, Runge-Kutta methods, Milne's Method, Finite difference method. Real life examples: Google search engine, 1D and 2D simulations, Weather forecasting.

Learning Experience

Students will engage in both theoretical understanding and practical application of numerical methods, working on real-world problems and case studies. The course will emphasize hands-on computational work and critical thinking to apply the correct numerical techniques in diverse scenarios.

Instruction Methods

The course will use a blend of lectures, hands-on lab sessions, and group discussions. Interactive problem-solving sessions and demonstrations will be incorporated to facilitate better understanding. Students will also be encouraged to work on projects and collaborate in teams.

Technology Use

Students will utilize computational tools and software such as MATLAB software to implement algorithms, perform calculations, and visualize results. These tools will help bridge the gap between theory and practical application.

Assessments

Assessments will include a combination of assignments, quizzes, lab exercises, and project work. Mid-term and final exams will evaluate both theoretical knowledge and practical application skills. Projects will focus on real-life problem-solving using numerical methods.

Support

Students will have access to office hours for one-on-one help from instructors, tutoring sessions, and online forums for peer-to-peer assistance. Additional resources such as lecture notes, sample codes, and tutorial videos will be provided to aid learning.

Textbooks

1. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson
2. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.

3. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2nd edition). Dover Publications.
4. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition). New Age International Publishers.
5. 5.Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole.

Suggested Readings

1. B. S. Grewal, *Numerical Methods in Engineering and Science*, Khanna Publishers.

Open Educational Resources (OER)

1. Numerical methods - Course (nptel.ac.in)
2. Numerical Methods for Engineers | Coursera
3. Introduction to Numerical Methods | Mathematics | MIT OpenCourseWare

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER V					
SCMA351	**NUMERICAL ANALYSIS LAB**	**L**	**T**	**P**	**C**
Version		2	0	2	4
Category of Course	Core				
Total Contact Hours	30 Hours				
Pre-	**Nil**				

Requisites/ Co-Requisites	

Course Perspective

In this lab course, students engage with fundamental numerical methods and algorithms essential for solving a variety of computational problems. The practicals cover a range of topics from basic operations and sorting algorithms to advanced numerical techniques such as root-finding methods (Bisection, Newton-Raphson, Secant, Regula-Falsi), matrix decomposition (LU), iterative methods (Gauss-Jacobi, SOR/Gauss-Seidel), and interpolation techniques (Lagrange, Newton). Additionally, students explore numerical integration (Simpson's Rule) and the solution of ordinary differential equations (ODEs). This hands-on experience equips students with the skills to implement and understand key computational methods, enhancing their problem-solving abilities and preparing them for real-world applications in science, engineering, and data analysis.

Course Outcomes

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

CO1: Observing and understanding the principles behind summation of series, absolute value computation, and basic array operations, including sorting algorithms.

CO2: Imitating and applying iterative methods such as the Bisection Method, Newton-Raphson Method, Secant Method, and Regula-Falsi Method for solving nonlinear equations.

CO3: Practicing matrix factorization and system solving techniques through LU Decomposition, as well as iterative solution methods including Gauss-Jacobi and SOR/Gauss-Seidel Methods.

Course Content

List of practical

1. Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N.
2. To find the absolute value of an integer.
3. Enter 100 integers into an array and sort them in an ascending order.
4. Bisection Method.
5. Newton Raphson Method.
6. Secant Method.
7. Regula-Falsi Method.
8. LU decomposition Method.
9. Gauss-Jacobi Method.
10. SOR Method or Gauss-Siedal Method.
11. Lagrange Interpolation or Newton Interpolation.
12. Simpson's rule
13. Solution of Ordinary Differential Equation

Learning Experience

Engage in hands-on practical exercises to apply fundamental numerical methods and algorithms. Develop problem-solving skills through implementing and analyzing various computational techniques.

Instruction Methods:

Utilize a combination of lectures, demonstrations, and interactive labs to explain concepts and methods. Encourage active participation through guided problem-solving and real-world examples.

Technology Use:

Employ computational software and programming tools to perform numerical calculations, simulations, and data analysis. Tools may include MATLAB, Python, or other relevant software.

Assessments:

Evaluate understanding through practical assignments, coding exercises, and lab reports. Assess comprehension of methods and their applications through quizzes, practical tests, and project work.

Support: Provide additional resources such as tutorials, online forums, and office hours for personalized guidance. Offer supplementary materials and peer support to reinforce learning and address challenges.

Textbooks

1. B. S. Grewal, *Numerical Methods in Engineering and Science*, Khanna Publishers.

2. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson

3. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.

Suggested Readings

1. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). *Numerical Methods for Scientific and Engineering Computation* (6th edition). New Age International Publishers

2. Robert J. Schilling & Sandra L. Harris (1999). *Applied Numerical Methods for Engineers Using* MATLAB *and C*. Thomson-Brooks/Cole.

Open Educational Resources (OER)

https://www.coursera.org/learn/numerical-methods-engineers
https://www.wolframalpha.com/

Evaluation Scheme

Evaluation components	**Weighage**
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 separately to secure minimum passing grade

SEMESTER V					
SCMA303	**Metric Spaces**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Major				
Total Contact Hours	60 Hours				
Pre-Requisites/	--				

Co-Requisites	

Course Perspective

The undergraduate course "Metric Spaces" explores the foundational concepts of set theory and metric space topology. It begins with the theory of sets, cardinality, countability, and key theorems such as Cantor's and Schröder-Bernstein. The course then introduces metric spaces, focusing on concepts like open and closed spheres, neighborhoods, and bounded sets. Students will study complete metric spaces and continuous functions, including Cauchy sequences, the Banach contraction principle, and the concepts of uniform continuity and homeomorphism. The course also explores compactness and connectedness, examining compact spaces, sequential compactness, and connected subsets, alongside related theorems and properties.

Course Outcomes

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

CO1: Explaining the key properties and principles of metric spaces, including Cauchy sequences, Cantor's intersection theorem, and the relationship between compactness and sequential compactness.

CO2: Utilizing the concepts of metric spaces to solve problems involving distance, convergence, continuity, the Heine-Borel theorem, and the Banach contraction principle.

CO3: Analyzing the properties of metric spaces by evaluating different types of sets, including dense sets, nowhere dense sets, and totally bounded sets.

CO4: Critically evaluating and comparing various metrics and topological properties to determine their implications for continuity, compactness, and connectedness.

Course Content

Unit I: **lecture hours 15**

Theory of Sets: Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, Schröder Bernstein theorem, Cantor's theorem, Order relation in cardinal numbers, Arithmetic of cardinal numbers, Partially ordered set, Zorn's lemma and Axiom of choice, Various set theoretic paradoxes

Unit II: **lecture hours 15**

Concepts in Metric Spaces: Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space

Unit III: **lecture hours 18**

Complete Metric Spaces and Continuous Functions: Cauchy and Convergent sequences, Completeness of metric spaces, Cantor's intersection theorem, Dense sets and separable spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, Homeomorphism, Banach contraction principle.

Unit IV: **lecture hours 12**

Compactness: Compact spaces, Sequential compactness, Bolzano Weierstrass property, Compactness and finite intersection property, Heine Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces. Connectedness: Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets.

Learning Experience

The Metric Spaces course will be conducted through a mix of interactive lectures, multimedia presentations, and activities. Students will engage in case studies, problem-solving sessions, and group projects to apply theoretical principles in practical contexts. Assignments will include both individual tasks and collaborative group work, with opportunities for peer review and mutual support. Outside the classroom, students will work on research projects and practice problems. The course in charge will provide additional support during office hours, and students are encouraged to seek help and collaborate to enhance their understanding and performance.

Textbooks

1. E. T. Copson (1988). Metric Spaces. Cambridge University Press.
2. P. R. Halmos (1974). Naive Set Theory. Springer.
3. P. K. Jain & Khalil Ahmad (2019). Metric Spaces. Narosa.
4. S. Kumaresan (2011). Topology of Metric Spaces (2nd edition). Narosa.

Suggested Readings

1. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag.
2. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag.

Open Educational Resources (OER)

1. https://www.youtube.com/watch?v=0ktJWbr84zA
2. https://www.youtube.com/watch?v=yvaFeNLZ9s8
3. https://www.geneseo.edu/~aguilar/public/notes/Real-Analysis-HTML/ch9-metric-spaces.html
4. https://math.libretexts.org/Bookshelves/Analysis/Introduction_to_Real_Analysis_(Lebl)/08%3A_Metric_Spaces/8.01%3A_Metric_Spaces
5. https://testbook.com/maths/metric-space

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessment (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/attendance/case studies/reflective journals(minimum of five components to be evaluated)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER V					
SCMA305	**ADVANCED ALGEBRA**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Minor				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course provides a comprehensive introduction to key concepts in abstract algebra, focusing on group theory, ring theory, and field theory. Students will explore the structure and properties of groups through group actions, class equations, and Sylow's theorems, gaining insight into symmetry and classification of finite groups. The course also covers fundamental aspects of rings and fields, including ring homomorphisms, ideals, polynomial rings, and their properties, alongside key theorems like Gauss' lemma and Eisenstein's criterion. Additionally, it introduces field extensions and the structure of finite fields, which are essential for understanding algebraic equations and applications in areas such as cryptography and coding theory. Overall, this course lays the groundwork for more advanced studies in algebra and its applications.

Course Outcomes

Upon completion of the course, the learner will be able to:
CO1: Recalling the fundamental definitions of group actions, orbits, stabilizers, and automorphisms in abstract algebra.

CO2: Applying polynomial properties and Euclidean division to factor polynomials over various fields, including rational fields and finite fields.

CO3: Analyzing the decomposition of a group into its conjugacy classes and using the class equation to extract information about its structure.

CO4: Evaluating the significance of the orbit-stabilizer theorem in understanding the sizes of orbits and stabilizers in group actions.

Course Content

Unit I: 15 Contact Hours

Group Actions: Group actions, Orbits and stabilizers, Conjugacy classes, Orbit-stabilizer theorem, Normalizer of an element of a group, Center of a group, Class equation of a group, Inner and outer automorphisms of a group

Sylow's Theorems: Cauchy's theorem for finite abelian groups, Finite simple groups, Sylow theorems and applications including non-simplicity tests.

Unit II: 15 Contact Hours

Rings and Fields: Definition, examples and elementary properties of rings, Commutative rings, Integral domain, Division rings and fields, Characteristic of a ring, Ring homomorphisms and isomorphisms, Ideals and quotient rings. Prime, principal and maximal ideals, Relation between Polynomial Rings: Polynomial rings over commutative ring and their basic properties, The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, principal ideal domain, and unique factorization domain. domain and field, Euclidean rings and their properties, Wilson and Fermat's theorems.

Unit III: 15 Contact Hours

Polynomial Rings: Polynomial rings over commutative ring and their basic properties,The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, principal ideal domain, and unique factorization domain

Unit IV: 15 Contact Hours

Field Extensions and Finite Fields: Extension of a field, Algebraic element of a field, Algebraic and transcendental numbers, Perfect field, Classification of finite fields.

Learning Experience

Students will engage in a rigorous study of abstract algebra, gaining a deep understanding of algebraic structures such as groups, rings, and fields. Through this course, they will develop critical thinking and problem-solving skills as they explore theoretical concepts and their applications. The course is designed to challenge students and enhance their ability to reason abstractly and mathematically.

Instruction Methods:

Instruction will primarily consist of lectures that introduce key concepts, supported by interactive discussions to clarify complex topics. Problem-solving sessions and tutorials will be integral, providing hands-on experience with algebraic problems and theorems. Collaborative group work may be used to encourage peer learning and to explore different perspectives on the material.

Technology Use:

Technology will play a role in enhancing the learning experience, with the use of mathematical software tools (such as Mathematica or MATLAB) to visualize algebraic structures and solve complex problems. Online resources, including lecture notes, problem sets, and supplementary materials, will be accessible through a learning management system (LMS). Virtual whiteboards and presentation tools may also be used for interactive teaching.

Assessments:

Assessment will be a mix of formative and summative approaches, including regular homework assignments, quizzes, and problem sets to reinforce learning and provide continuous feedback. Mid-term and final exams will evaluate students' understanding of key concepts and their ability to apply algebraic principles to solve problems. Participation in discussions and problem-solving sessions may also contribute to the overall grade.

Support: Students will have access to a variety of support resources, including office hours with the instructor for one-on-one guidance and clarification of concepts. Teaching assistants may offer additional tutoring sessions. Online forums and study groups will be encouraged for peer support. Access to library resources and academic counseling will also be available to support students throughout the course.

Textbooks

1. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
2. I.S. Luthar & I.B.S. Passi (2013). Algebra: Volume 1: Groups. Narosa.
3. Michael Artin (2014). Algebra (2nd edition). Pearson.
4. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press.

Suggested Readings

1. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
5. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
6. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley.

Open Educational Resources (OER)

1. https://www.academia.edu/7141249/Abstract_Algebra_Manual_Problems_and_solution_only_the_section_on_GROUPS_
2. https://www.researchgate.net/publication/280733004_Abstract_Algebra_Solutions

3. https://users.metu.edu.tr/matmah/Graduate-Algebra-Solutions/Undergraduate-Algebra-Problems%20and%20Solutions.pdf
4. http://staffnew.uny.ac.id/upload/132319832/pendidikan/REFERENSI+ABSTRACT+ALGEBRA+SCHAUM.pdf

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER V					
SCMA307	**LINEAR PROGRAMMING**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Minor				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course offers a comprehensive introduction to linear programming, focusing on optimization techniques and mathematical problem-solving methods. Beginning with foundational concepts such as convexity, basic feasible solutions, and graphical methods, the course moves into more advanced topics, including the Simplex Method, with a focus on optimality criteria and handling cases of unboundedness and multiple solutions. The curriculum then explores duality in linear programming, delving into dual problems, duality theorems, and the Dual-simplex method. Finally, practical applications are examined, including the Transportation and Assignment Problems, utilizing methods like the Northwest-corner rule, Vogel approximation, and the Hungarian method. The course concludes with an introduction to Game Theory, emphasizing the solution of two-person zero-sum games using linear programming techniques.

Course Outcomes

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

CO1: Understanding the origin and development of operations research and linear programming.

CO2: Analyzing real-life systems with constraints, identifying and formulating the underlying problems.

CO3: Applying the theory of the simplex method and its various cases to solve optimization problems.

CO4: Evaluating solutions through the duality of the simplex method and the two-phase method.

Course Content

UNIT – I **14 lecture hours**

Linear Programming Problem, Convexity and Basic Feasible Solutions,Formulation, Canonical and standard forms, Graphical method; Convex and polyhedral sets,Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points.

Unit II **14 lecture hours**

Simplex Method

Optimality criterion, improving a basic feasible solution, Unboundedness, Unique and alternate optimal solutions; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method**.**

Unit III **14 lecture hours**

Formulation of the dual problem, Duality theorems, Complimentary slackness theorem, Economic interpretation of the dual, Dual-simplex method.

Unit IV: **16 lecture hours**

Transportation Problem: Definition and formulation, Methods of finding initial basic feasible solutions: Northwest-corner rule, Least- cost method, Vogel approximation method; Algorithm for obtaining optimal solution. Assignment Problem: Mathematical formulation and Hungarian method.
Game Theory: Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method for solving a game.

Learning Experience

Students will engage in problem-solving exercises that emphasize real-world applications of linear programming and optimization techniques. The course will foster analytical thinking and provide opportunities to apply mathematical concepts to practical scenarios.

Instruction Methods:

The course will be delivered through a combination of lectures, where theoretical concepts will be explained, and hands-on problem-solving sessions to reinforce learning. Interactive discussions and group activities will be encouraged to facilitate a deeper understanding of the material.

Technology Use:

Software tools such as MATLAB, Excel Solver, or other optimization software will be utilized to solve linear programming problems, simulate scenarios, and visualize solutions. Online resources and interactive platforms will also be used for supplementary learning.

Assessments:

Students will be evaluated through a mix of assignments, quizzes, and exams. Practical assignments will involve solving optimization problems using both manual methods and software tools. A final project or exam will assess students' overall understanding and application of course concepts.

Support:

Students will have access to additional resources such as office hours, tutoring sessions, and online forums for discussion. Instructors will provide guidance and feedback throughout the course to help students master the material.

Textbooks

Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sonsv

Suggested Readings

1. H.A. Taha, Operation Research-An introducton, Printice Hall of India.
2. P.K. Gupta and D.S. Hira, Operations Research, S. Chand & Co.
3. S.D. Sharma, Operation Research, Kedar Nath Ram Nath Publications

Open Educational Resources (OER)

Linear Programming Lecture Notes

Open Textbook Library

MIT Open CourseWare - Applied Linear Programming

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER-VI

SEMESTER VI

SCMA302	**Probability and Statistics**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Minor				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course provides a comprehensive understanding of probability theory and its applications through a structured approach across four key units. In Unit I, students delve into fundamental probability concepts, including random variables and moment-generating functions, laying the groundwork for more complex topics. Unit II expands on this foundation by exploring both univariate discrete and continuous distributions, such as Binomial and Normal distributions, essential for statistical analysis. Unit III introduces bivariate distributions, focusing on joint and marginal distributions, and the mathematical expectations of two random variables, enriching students' understanding of multivariate scenarios. Finally, Unit IV integrates concepts like correlation, regression, and the central limit theorem, bridging the gap between theory and practical statistical modeling. The course concludes with advanced topics on modeling uncertainty, including entropy and random graph models, providing students with the tools to analyze and interpret complex probabilistic systems.

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

CO1: Understanding and applying key concepts of probability, including discrete and continuous random variables, probability distributions, conditioning, independence, expectations, and variances.

CO2: Defining and explaining the different statistical distributions and the typical phenomena that each distribution often describes.

CO3: Analyzing and calculating probabilities, as well as deriving the marginal and conditional distributions of bivariate random variables.

CO4: Evaluating the covariance and correlation between jointly distributed variables to assess their relationship.

Course Content

UNIT-I **15**
Lectures

Probability Functions and Moment Generating Function Basic notions of probability, Conditional probability and independence, Baye's theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

UNIT-II **15**
Lectures

Univariate Discrete and Continuous Distributions, Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

UNIT-III
15Lectures

Bivariate Distribution Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

UNIT-IV **15**
Lectures

Correlation, Regression and Central Limit Theorem,The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

Modeling Uncertainty Uncertainty, Information and entropy, Uniform Priors, Polya's urn model and random graphs.

Learning Experience

The course is designed to offer a robust learning experience by progressively building students' understanding of probability and statistical concepts, from fundamental principles to advanced applications. Students engage with theoretical material through lectures, problem-solving sessions, and real-world examples that illustrate the practical implications of probability theory and statistical methods.

Instruction Methods: Technology Use

Instructional methods include traditional lectures complemented by technology-enhanced learning tools. Presentations, statistical software, and online simulations may be used to

demonstrate complex concepts like distributions, regression analysis, and the central limit theorem. This integration of technology aids in visualizing abstract concepts and provides hands-on experience with statistical modeling and analysis.

Assessments

Assessments are designed to evaluate both theoretical understanding and practical application of course content. These may include regular quizzes, problem sets, mid-term and final exams, and potentially project-based assessments where students apply statistical methods to real data. These varied assessment methods ensure a comprehensive evaluation of students' grasp of the material.

Support

Support mechanisms include office hours, discussion forums, and access to additional learning resources such as online tutorials and peer study groups. Instructors may also provide guidance on using statistical software, ensuring that students have the necessary skills to succeed in both the coursework and assessments.

Textbooks

1. Probability and Statistics for Engineers and Scientists" **by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying Ye**
2. Introduction to Probability" **by Dimitri P. Bertsekas and John N. Tsitsiklis**
3. A First Course in Probability" **by Sheldon Ross**

Suggested Readings

1.Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.

2. Irwin Miller &Marylees Miller (2014). John E. Freund’s Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India.

Open Educational Resources (OER)

MIT OCW - Probability and Statistics

OpenStax - Introductory Statistics

LibreTexts - Statistics and Probability

Evaluation Scheme

Evaluation components	**Weighage**

Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VI					
SCMA304	**Applied Mechanics**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Minor				
Total Contact Hours	65 Hours				
Pre-Requisites/ Co-Requisites	Nil				

Course Perspective

This course on Mechanics of Rigid Bodies focuses on understanding the behavior of bodies under various force systems, emphasizing equilibrium, friction, and motion. It begins with the study of forces in equilibrium, including the analysis of moments and couples in two and three dimensions. Students then explore friction, the center of gravity, and moments of inertia, applying these concepts to both simple and composite bodies. The course also covers the principles of energy conservation and the application of work-energy equations. Finally, the motion of rigid bodies is examined, with an emphasis on translation, rotation, and the relationships between different reference frames. This course provides a comprehensive foundation in mechanics, essential for analyzing and solving complex physical problems.

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

CO1: Understanding the significance of mathematics in describing physical quantities and their practical applications.

CO2: Analyzing cause-effect relationships in physical phenomena to predict outcomes based on these relationships.

CO3: Applying mathematical and physical principles to observe, interpret, and relate real-world situations and structures.

CO4: Evaluating the motion of multiple particles in constrained motion using appropriate models and theories.

Course Content

Unit 1: Forces in Equilibrium (Lectures: 15)

Coplanar force systems; Three-dimensional force systems; Moment of a force about a point and an axis, Principle of moments, Couple and couple moment, Moment of a couple about a line, Resultant of a force system, Distributed force system, Rigid-body equilibrium, Equilibrium of forces in two and three dimensions, Free-body diagrams, General equations of equilibrium, Constraints and statical determinacy.

Unit 2: Friction, Center of Gravity and Moments of Inertia (Lectures: 20)

Equations of equilibrium and friction, Frictional forces on screws and flat belts; Center of gravity,Center of mass and Centroid of a body and composite bodies; Theorems of Pappus and Guldinus; Moments and products of inertia for areas, composite areas and rigid body, Parallelaxis theorem, Moment of inertia of a rigid body about an arbitrary axis, Principal moments and principal axes of inertia.

Unit 3: Conservation of Energy and Applications (Lectures: 15)

Conservative force fields, Conservation of mechanical energy, Work-energy equations, Kinetic energy and work-kinetic energy expressions based on center of mass, Moment of momentum equation for a single particle and a system of particles.

Unit 4: Rigid Body Motion (Lectures: 15)

Translation and rotation of rigid bodies, Chasles' Theorem, General relationship between time derivatives of a vector for different references, Relationship between velocities of a particle for different references, Acceleration of particle for different references.

Learning Experience

Students will engage in a variety of hands-on and theoretical activities to deepen their understanding of mechanics. The course will emphasize active learning through problem-solving sessions, collaborative group work, and the use of simulations to visualize complex

concepts. Real-world examples and case studies will be incorporated to bridge theory with practical applications, allowing students to connect abstract principles with tangible outcomes.

Instruction Methods

Instruction will include a mix of lectures, interactive discussions, and problem-solving workshops. Lectures will provide foundational knowledge, while discussions will encourage critical thinking and deeper exploration of topics. Problem-solving workshops will be used to reinforce concepts through practical applications, with students working individually or in groups. Additionally, lab sessions or virtual simulations may be utilized to provide hands-on experience with the principles being taught.

Technology Use

Technology will play a significant role in enhancing the learning experience. Students will have access to simulation software for visualizing force systems, equilibrium, and rigid body motion. Online resources such as video tutorials, interactive models, and problem-solving platforms will be integrated to support independent learning. Learning management systems (LMS) will be used to distribute course materials, manage assignments, and facilitate communication between students and instructors.

Assessments

Assessment will be conducted through a combination of formative and summative methods. Formative assessments, such as quizzes, homework assignments, and in-class problem-solving exercises, will provide ongoing feedback to students and help instructors gauge their understanding. Summative assessments will include midterm and final exams, as well as project-based evaluations where students apply course concepts to real-world scenarios. Additionally, participation in discussions and workshops may contribute to the overall assessment.

Support

Support for students will be provided through a variety of channels, including office hours, online discussion forums, and peer tutoring sessions. Instructors will be available to answer questions and provide guidance on challenging topics. Additional resources, such as supplementary readings, video lectures, and practice problems, will be available through the course's online platform. Students will also be encouraged to form study groups to collaborate and support each other in mastering the course material.

Textbooks

1. Hibbeler, R. C. (2016). Engineering Mechanics: Statics & Dynamics (14th ed.). Pearson PrenticeHall (Pearson Education), New Jersey.
2. Shames, Irving H., & Rao, G. Krishna Mohan (2009). Engineering Mechanics: Statics and Dynamics(4th ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi.

Suggested Readings

1 Engineering Mechanics: Statics and Dynamics" by J.L. Meriam and L.G. Kraige

2 "Vector Mechanics for Engineers: Statics and Dynamics" by Ferdinand P. Beer, E. Russell Johnston Jr., and David Mazurek

3. "Fundamentals of Applied Dynamics" by James H. Williams Jr.

Open Educational Resources (OER)

LibreTexts - Engineering Mechanics

Walter Lewin's Lectures - Classical Mechanics

LibreTexts - Statistics and Probability

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VI					
SCMA306	**Mathematical Modelling**	**L**	**T**	**P**	**C**
Version		5	1	0	6
Category of Course					
Total Contact	64 Hours				

Hours	
Pre-Requisites/ Co-Requisites	Nil

Course Perspective

Mathematical Modeling explores the translation of real-world problems into mathematical language, enabling students to apply various mathematical tools and techniques to analyze and solve these problems. The course emphasizes the development of models that represent physical, biological, economic, and social systems. By combining theoretical knowledge with practical application, students learn to make predictions, optimize outcomes, and understand the limitations of models. This course nurtures critical thinking, problem-solving skills, and the ability to communicate complex ideas, preparing students for advanced studies or careers where mathematical modeling is integral.

Course Outcomes

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

CO1: Formulating mathematical models to represent real-world scenarios, demonstrating understanding and remembering of mathematical concepts.

CO2: Applying mathematical techniques to analyze and solve models, showcasing the application of relevant methods.

CO3: Interpreting the results of models in the context of the original problem, emphasizing analysis and understanding.

CO4: Evaluating optimal solutions for complex systems using appropriate mathematical tools, highlighting critical evaluation skills.

Course Content

Unit I **16 hours**

Need, Techniques, Classifications, Characteristic and Limitations of Mathematical Models. Mathematical Modelling through Ordinary Differential Equation of First Order: Linear Growth and Decay Models, Non-Linear Growth and Decay Models, Compartment Models, Dynamics Problems

Unit II **16 hours**

Mathematical Modelling through systems of Ordinary Differential Equation of First Order: Population Dynamics, Epidemics and Compartment Models. Modelling in Economics, Medicine, Arms Race, Battles and International Trades.

Unit III **16 hours**

Mathematical Modelling through Ordinary Differential Equation of Second Order: Planetary Motion, Circular Motion and Motion of Satellites.

Unit IV **16 hours**

Mathematical Modelling through Graphs: Directed and Signed graphs, Weighted Di-graphs.

Learning Experience

Course Integration Approach:

This course focuses on building a strong theoretical foundation in mathematical modeling, enabling students to understand and apply various modeling techniques across different disciplines. The instructional approach emphasizes lectures, interactive sessions, and problem-solving exercises to ensure that students develop a deep comprehension of mathematical concepts and their applications without involving hands-on or practical work.

Instruction Methods:

Lectures:

Core concepts of mathematical modeling will be taught using multimedia presentations, detailed explanations of theories, and in-depth explorations of mathematical frameworks. The focus will be on understanding key principles, formulating mathematical models, and solving complex problems analytically.

Interactive Sessions:

Students will actively participate in Q&A sessions, group discussions, and problem-solving exercises. These interactive components will reinforce the theoretical content by encouraging students to engage with the material, ask questions, and discuss various approaches to modeling.

Case Study Analysis:

Real-world case studies will be analyzed to illustrate the application of mathematical modeling in different fields such as economics, engineering, biology, and social sciences. Students will critically evaluate these models to understand the assumptions, limitations, and results.

Technology Use:

Online Platforms:

The course will utilize a Learning Management System (LMS) to host resources such as recorded lectures, reading materials, assignments, and discussion forums. This platform will facilitate extended learning and allow students to access course materials at their convenience.

Assessments:

1. **Formative Assessments**:
    - **Quizzes and Assignments**: Regular quizzes and assignments will assess students' understanding of the mathematical theories and their ability to apply these theories to model real-world situations.
    - **Problem-Solving Sessions**: Students will engage in problem-solving exercises that challenge their grasp of concepts and allow for continuous feedback on their progress.
2. **Summative Assessments**:
    - **Exams**: Written exams will evaluate students' mastery of mathematical modeling techniques, including their ability to formulate and solve models accurately.
    - **Analytical Essays**: Students will be required to write essays analyzing the strengths and weaknesses of different mathematical models, demonstrating their critical thinking and theoretical understanding.

Support:

- **Instructor Guidance**: The course instructor will provide additional support through office hours and review sessions, offering personalized feedback on assignments and helping students navigate complex concepts.
- **Peer Collaboration**: Group discussions and peer evaluations will be encouraged to foster collaborative learning and allow students to benefit from diverse perspectives on mathematical problems.

Textbooks

J. N. Kapur, Mathematical Modelling, New Age International Publishers.

Suggested Readings

1. Frank R. Giordano, Maurice D. Weir and William P. Fox, A First Course in Mathematical Modeling, Thomson Learning, London and New York.

2. ReinhardIllner, Mathematical Modelling: A Case Studies Approach, Indian Editions of AMS Titles.

Open Educational Resources (OER)

1. https://sysbio.mx/wp-content/uploads/2021/02/MATHEMATICAL-MODELS-IN-BIOLOGY_Allman.pdf
2. https://ncert.nic.in/textbook/pdf/kemh1a2.pdf
3. https://www.youtube.com/watch?v=zw9Y4t-Nh3E

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER-VII

SEMESTER VII					
SCMA401	**Research Methodology**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course					
Total	60				

Contact Hours	
Pre-Requisites/ Co Requisites	-

Course Perspective

Research Methodology equips students with essential tools and techniques for conducting scientific research. It covers the systematic process of identifying a problem, formulating a hypothesis, collecting data, and analyzing results. By understanding various research designs, methods of data collection, and statistical analysis, students develop the ability to critically evaluate existing research and contribute original findings. The course emphasizes ethical considerations, ensuring that research is conducted with integrity and responsibility. Ultimately, Research Methodology fosters a deeper understanding of the scientific process, enabling students to approach problems methodically and contribute to academic and professional knowledge.

Course Outcomes

Upon completion of the Research Methodology course, the learner will be able to:

CO1: Understanding and explaining fundamental concepts of research methodology, including its meaning, objectives, and utility, as well as key research terminology such as concept, construct, definition, and variable.

CO2: Differentiating between empirical and theoretical research and apply deductive and inductive reasoning to various research scenarios.

CO3: Applying various sampling techniques and implement effective data preparation methods, including univariate and bivariate analysis, in research projects.

CO4: Analyzing different research designs, such as exploratory, descriptive, and experimental, and evaluate the importance of qualitative and quantitative research, including concepts like causality, generalization, and replication.

Course Content

Unit I: Introduction Basic Fundamentals:- Meaning, objective, motivation and utility of research. Concept of theory, empiricism, deductive and inductive reasoning. Characteristics of scientific methods – Understanding the language of research-Concept, Construct, Definition, Variable.

Unit II: Research Design: Concept and Importance of research design. Features of a good research design - Exploratory Research Design - concept, types and uses, Descriptive Research Designs - concept, types and uses. Experimental Research Design: Concept of

Independent & Dependent variables. Qualitative research - Quantitative research - Concept of measurement, causality, generalization, replication. Merging the two approaches.

Unit III: Sampling and Data Preparation Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample- Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Data Preparation - Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis Cross tabulations and Chisquare test including testing hypothesis of association. Interpretation of Data.

Unit IV: Paper Writing and Publishing Process Paper Writing- Layout of a Research Paper, Journals, Impact factor of Journals, Choosing Journals and Conferences to publish the work. Ethical issues related to publishing, Plagiarism and Self Plagiarism. Preparing response to reviewers and editors. Reviewing the manuscript.

Unit V: Use of various resources and software Use of encyclopaedia, handbooks, research guides and academic databases. Use of tools and techniques for Research, methods to search required information effectively. Reference Management Software like Zotero/ Mendeley. Software for paper formatting like Latex, LyX, MS Office. Software for detection of Plagiarism.

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on research projects to provide students with a comprehensive understanding of research methodology and its application across various disciplines.

Instruction Methods:

- **Lectures:** Fundamental concepts of research methodology, including research design, data collection, data analysis, and report writing, will be taught using case studies, multimedia presentations, and examples from contemporary research.
- **Interactive Sessions:** Students will engage in Q&A sessions, group discussions, and peer critiques to explore research questions, methodologies, and ethical considerations, fostering critical thinking and collaborative learning.

Technology Use:

- **Online Platforms:** A Learning Management System (LMS) will be utilized to provide access to course materials, recorded lectures, assignment submissions, and discussion forums, promoting extended learning and peer-to-peer interaction.

Assessments:

- **Formative:** Continuous assessments through quizzes, research proposals, and participation in online discussions will provide feedback and help students monitor their understanding and progress.

- **Summative:** Final assessments will include research project presentations, written reports, and peer evaluations, focusing on students' ability to apply research methodologies in practical scenarios.

Support:

- **Instructor Guidance:** The course instructor will offer additional support through scheduled office hours, and students will be encouraged to collaborate through group work and peer review sessions. Continuous feedback will be provided to ensure students' development in meeting course objectives.

Textbooks

1. Panneerselvam, R., Research Methodology, Prentice Hall of India, New Delhi, 2004.
2. Kothari CR, Research Methodology-Methods and Techniques, New Wiley Eastern Ltd., Delhi, 2009.
3. Brymam Alan and Bell, Emma, Business Research Methods

Suggested Readings

1. "Research Methodology: A Step-by-Step Guide for Beginners" by Ranjit Kumar (ISBN: 9781446269978, 2014).
2. "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" by John W. Creswell and J. David Creswell (ISBN: 9781506386706, 2017).
3. "Qualitative Inquiry and Research Design: Choosing Among Five Approaches" by John W. Creswell (ISBN: 9781506330204, 2016).
4. "Introduction to the Practice of Statistics" by David S. Moore, George P. McCabe, and Bruce A. Craig (ISBN: 9781319013387, 2017).

Open Educational Resources (OER)

https://oercommons.org/courseware/lesson/25010
https://www.oercommons.org/courses/research-methods-knowledge-base
http://www.youtube.com/watch?v=2FYm3GOonhk
http://www.youtube.com/watch?v=PtjxtG2FcaQ
http://www.youtube.com/watch?v=A1URJE7x7ec

Evaluation Scheme (Please refer to Notice Ref No: KRMU/CoE/Even/2023-24/018 dated 10 May 2025)

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessments (30 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)	**30 Marks**

II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VII					
SCMA405	**INTEGRAL TRANSFORMS AND FOURIER ANALYSIS**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Core				
Total Contact Hours	64 Hours				
Pre-Requisites/ Co-Requisites	**Basic knowledge of Trigonometry, Integration and Differentiation**				

Course Perspective

This course provides an in-depth study of mathematical transforms and series that are pivotal for solving differential and integral equations. It begins with an introduction to Laplace Transforms, including their properties, theorems, and applications to ordinary differential equations. The course progresses to advanced topics in Laplace Transforms, covering convolution, integral equations, and inverse transforms. It then explores Fourier Transforms, focusing on their properties, applications to boundary value problems, and their relationship with Laplace Transforms.

Course Outcomes

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

CO1: Understanding and recalling Laplace Transforms techniques to solve ordinary differential and integral equations.

CO2: Utilizing Fourier Transforms to solve boundary value problems and integral equations.

CO3: Analyzing advanced properties and applications of Laplace Transforms and their inverse.

CO4: Synthesizing solutions using Laplace and Fourier Transforms, and communicate mathematical findings effectively.

Course Content

Unit I: **15 lecture hours**

Laplace Transforms: Laplace transform, Linearity, Existence theorem, Laplace transforms of derivatives and integrals, Shifting theorems, Change of scale property, Laplace transforms of periodic functions, Dirac's delta function.

Unit II: **15 lecture hours**

Further Properties of Laplace Transforms and Applications: Differentiation and integration of transforms, Convolution theorem, Integral equations, Inverse Laplace transform, Lerch's theorem, Linearity property of inverse Laplace transform, Translations theorems of inverse Laplace transform, Inverse transform of derivatives, Applications of Laplace transform in obtaining solutions of ordinary differential equations and integral equations.

Unit III: **15 lecture hours**

Fourier Transforms: Fourier and inverse Fourier transforms, Fourier sine and cosine transforms, Inverse Fourier sine and cosine transforms, Linearity property, Change of scale property, Shifting property, Modulation theorem, Relation between Fourier and Laplace transforms.

Solution of Equations by Fourier Transforms: Solution of integral equation by Fourier sine and cosine transforms, Convolution theorem for Fourier transform, Parseval's identity for Fourier transform, Plancherel's theorem, Fourier transform of derivatives, Applications of infinite Fourier transforms to boundary value problems, Finite Fourier transform, Inversion formula for finite Fourier transforms.

Unit IV: **15 lecture hours**

Fourier Series: Fourier cosine and sine series, Fourier series, Differentiation and integration of Fourier series, Absolute and uniform convergence of Fourier series, Bessel's inequality, The complex form of Fourier series.

Learning Experience

Students will engage with foundational and advanced concepts of Laplace and Fourier Transforms, including practical applications and problem-solving techniques. The learning experience includes theoretical instruction, problem-solving sessions, and real-world applications.

Instruction Methods:

The course will use lectures, interactive problem-solving sessions, and discussions to convey theoretical concepts and practical applications. Hands-on exercises will be incorporated to reinforce understanding and application of the transforms.

Technology Use:

Students will utilize mathematical software and tools for solving problems involving Laplace and Fourier Transforms. Examples include MATLAB or Mathematica for computational exercises and simulations.

Assessments:

Assessment methods include quizzes, homework assignments, mid-term exams, and a final exam. These assessments will test students' understanding of concepts, ability to apply transforms, and problem-solving skills.

Support:

Students will receive support through office hours, discussion forums, and supplementary materials. Additional resources such as tutorial sessions and online help may be available to assist with understanding complex topics and solving problems.

Textbooks

1.James Ward Brown & Ruel V. Churchill (2011). Fourier Series and Boundary Value Problems. McGraw-Hill Education.

2. Charles K. Chui (1992). An Introduction to Wavelets. Academic Press.

3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10^{th} edition). Wiley.

4. Walter Rudin (2017). Fourier analysis on Groups. Dover Publications.

5. A. Zygmund (2002).Trigonometric Series (3^{rd} edition). Cambridge University Press.

Suggested Readings

1.Fourier Series and Integral Transforms" by Alan J. S. Smith

2. "Transforms and Applications" by J.L. B. Hughes

Open Educational Resources (OER)

https://math.mit.edu/~gs/cse/websections/cse41.pdf

https://reference.wolfram.com/language/guide/FourierAnalysis.html

Evaluation Scheme

Evaluation components	Weighage

Internal marks (Theory) **I. Continuous assessment (30 marks)** Include assignments, lab work, quizzes, and a final project, focusing on the practical application of data preprocessing and visualization techniques.	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

Semester VII (B.Sc. (H) Mathematics)

SCMA4017	**Number Theory**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	Familiarity with elementary number theory, abstract algebra (groups, rings, ideals, fields)				

Course Perspective

This course explores the foundational aspects of number theory, focusing on prime numbers, number theoretic functions, modular arithmetic, and their applications. It introduces students to classical problems and modern applications such as public key cryptosystems.

Course Outcomes (COs)

On completion of the course, the learner will be able to:

CO1 Understanding key properties of prime numbers, including prime counting functions, and appreciate open problems in number theory, such as the Goldbach conjecture.

CO2 Applying the concepts of number theoretic functions and modular arithmetic to solve practical problems in number theory.

CO3 Analyzing and solving linear, quadratic, and systems of linear congruence equations using theorems like Fermat's Little Theorem and the Chinese Remainder Theorem.

CO4 Evaluating the principles behind public key cryptosystems, particularly RSA encryption, and apply number theoretic methods to cryptography.

Course Content

UNIT-I: Prime Numbers and Congruences (15 Lectures)

- Linear Diophantine equations
- Prime counting function and the Prime Number Theorem (statement)
- Goldbach conjecture
- Linear congruences, complete set of residues
- Chinese Remainder Theorem
- Fermat's Little Theorem and Wilson's Theorem

UNIT-II: Number Theoretic Functions (15 Lectures)

- Number theoretic functions: sum and number of divisors
- Totally multiplicative functions
- Dirichlet product: definition and properties
- Mobius Inversion formula
- Greatest integer function
- Euler's phi-function: definition, properties, and Euler's Theorem
- Reduced set of residues and properties of Euler's phi-function

UNIT-III: Quadratic Congruences and Primitive Roots (15 Lectures)

- Order of an integer modulo n
- Primitive roots for primes and composite numbers having primitive roots
- Euler's criterion
- Legendre symbol and its properties
- Quadratic reciprocity theorem
- Quadratic congruences with composite moduli

UNIT-IV: Applications in Cryptography (15 Lectures)

- Public key encryption: RSA encryption and decryption
- The equation x2+y2=z2x^2 + y^2 = z^2x2+y2=z2 and Fermat's Last Theorem

- Application of number theory in modern cryptography

Learning Experience

Students will engage in theoretical problem-solving activities to explore classical results and apply number theoretic concepts to real-world problems, particularly in cryptography. Group discussions, assignments, and projects will reinforce understanding and foster a deeper appreciation of number theory.

Textbooks

1. David M. Burton, *Elementary Number Theory*, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
2. Neville Robbins, *Beginning Number Theory*, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

Suggested Readings

1. NPTEL/SWAYAM/MOOCs (various resources on number theory)

Open Educational Resources (OER)

1. https://archive.nptel.ac.in/courses/111/101/111101137/
2. https://www.geeksforgeeks.org/number-theory/

Evaluation Scheme

Evaluation Components	Weightage
Internal Marks (Theory)	
I. Continuous Assessment (Project/Quizzes/Assignments/Essays/Presentations)**	30 Marks
II. Mid Term Examination**	20 Marks
External Marks (Theory)	
End Term Examination**	50 Marks

It is compulsory for a student to secure at least 40% marks in both Internal and End Term Examination to pass.

Semester VII (B.Sc (H) Mathematics)

SCMA4019	**Combinatorial Mathematics**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				

Pre-Requisites/ Co-Requisites	Calculus

Course Perspective

This course introduces students to fundamental concepts of combinatorics, including counting principles, generating functions, recurrence relations, and Polya theory. It equips students with problem-solving skills and a deep understanding of both elementary and specialized combinatorial objects.

Course Outcomes (COs)

On completion of the course, the learner will be able to:

CO1 Understanding the basic counting principles, permutations, combinations, and recurrence relations.

CO2 Applying concepts such as generating functions, partitions, and combinatorial designs to solve counting problems.

CO3 Analyzing the properties of mathematical objects like Fibonacci numbers, set partitions, Stirling numbers, and integer partitions.

CO4 Evaluating the applications of Polya theory, Burnside's lemma, and combinatorial designs to solve complex combinatorial problems.

Course Content

UNIT-I: Counting Principles and Combinatorics (15 Lectures)

- Basic counting principles
- Permutations and combinations (with and without repetitions)
- Binomial and Multinomial Theorems
- Counting subsets, set partitions, and Stirling numbers
- Principle of Inclusion and Exclusion, Derangements, and Inversion formulae

UNIT-II: Generating Functions (15 Lectures)

- Algebra of formal power series
- Generating function models
- Calculating generating functions
- Exponential generating functions

UNIT-III: Recurrence Relations and Partitions (15 Lectures)

- Recurrence relation models
- Divide and conquer relations

- Solutions of recurrence relations
- Solutions by generating functions
- Integer partitions, systems of distinct representatives

UNIT-IV: Polya Theory and Combinatorial Designs (15 Lectures)

- Polya theory of counting: Necklace problem and Burnside's lemma
- Cyclic index of a permutation group
- Polya's theorems and their applications
- Latin squares, Hadamard matrices
- Combinatorial designs: t-designs, BIBDs, symmetric designs

Learning Experience

The course involves theoretical and problem-solving exercises that enable students to apply combinatorial techniques to various mathematical problems. Group work, assignments, and projects will help students explore combinatorics in both theoretical and applied contexts.

Textbooks

1. J.H. van Lint and R.M. Wilson, *A Course in Combinatorics*, 2nd Ed., Cambridge University Press, 2001.
2. V. Krishnamurthy, *Combinatorics, Theory and Application*, Affiliated East-West Press, 1985.
3. P.J. Cameron, *Combinatorics, Topics, Techniques, Algorithms*, Cambridge University Press, 1995.

Suggested Readings

1. M. Jr. Hall, *Combinatorial Theory*, 2nd Ed., John Wiley & Sons, 1986.
2. S.S. Sane, *Combinatorial Techniques*, Hindustan Book Agency, 2013.
3. R.A. Brualdi, *Introductory Combinatorics*, 5th Ed., Pearson Education Inc., 2009.

Open Educational Resources (OER)

1. https://archive.nptel.ac.in/courses/111/106/111106155/
2. https://www.khanacademy.org/math/statistics-probability/counting-permutations-and-combinations

Evaluation Scheme

Evaluation Components	Weightage
Internal Marks (Theory)	
I. Continuous Assessment (Project/Quizzes/Assignments/Presentations)**	30 Marks
II. Mid Term Examination**	20 Marks
External Marks (Theory)	

Evaluation Components	Weightage
End Term Examination**	50 Marks

It is compulsory for a student to secure at least 40% marks in both Internal and End Term Examination to pass.

SCMA408	Finite Field	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	Major				
Total Contact Hours	60				
Pre-Requisites/ Co-Requisites	Group Theory, Ring Theory				

Course Perspective

This course provides an in-depth understanding of finite fields and Galois theory, essential for modern applications such as cryptography and coding theory. It covers the fundamental properties of finite fields, their extensions, and their automorphism groups, and explores the relationship between field theory and polynomial equations.

Course Outcomes (COs)

On completion of the course, the learner will be able to:

CO1. Understanding the concepts of fields, algebraic and transcendental extensions, and explain normal extensions in terms of splitting fields. Demonstrate comprehension of the existence of the algebraic closure of a field.

CO2. Applying the concepts of separable extensions and perfect fields to construct examples of automorphism groups and Galois extensions. Utilize Artin's theorem and the Fundamental Theorem of Galois Theory to solve problems in field theory.

CO3. Analyzing the classification of finite fields using roots of unity and Galois theory. Break down the structure of finite separable extensions and show that every such extension is simple, providing an in-depth analysis of field structures.

CO4. Evaluating the solvability of polynomial equations using Galois theory. Assess and critically evaluate the conditions under which a polynomial equation over a field is solvable by radicals, and justify why the general quintic equation is not solvable by radicals.

Course Content

UNIT-I: Introduction to Fields (15 Lectures)

- Review of Groups, Rings, and Fields
- Irreducible polynomials
- Roots and construction of irreducible polynomials
- Primitive polynomials
- Introduction to Galois Theory: Key concepts, historical significance, and foundational theorems

UNIT-II: Finite Fields and Extensions (15 Lectures)

- Finite extensions of fields
- Characterization of finite fields
- Algebraic extensions and splitting fields
- Separable and normal extensions
- Existence of algebraic closure

UNIT-III: Galois Theory and Applications (15 Lectures)

- Galois extensions and automorphism groups
- Artin's Theorem and the Fundamental Theorem of Galois Theory
- Roots of unity and cyclotomic extensions
- Cyclotomic polynomials and abelian extensions over Q

UNIT-IV: Applications in Coding and Cryptography (15 Lectures)

- Error-correcting codes and the role of finite fields
- Polynomial equations solvable by radicals
- General quintic equation and its unsolvability by radicals
- Representation of elements of finite fields

Learning Experience

The course offers a blend of theoretical learning and practical problem-solving, encouraging students to explore real-world applications of finite fields in cryptography, coding theory, and beyond. Students will engage in discussions, work on assignments and case studies, and participate in group projects.

Textbooks

1. D.S. Dummit and R.M. Foote, *Abstract Algebra*, John Wiley & Sons Inc., 3rd Ed., 2004.
2. W.W. Peterson and E.J. Weldon, Jr., *Error-Correcting Codes*, M.I.T. Press, Cambridge, Massachusetts, 1972.

Suggested Readings

1. S. Lang, *Algebra*, Springer (India) Pvt. Ltd., 2010.
2. R. Lidl and H. Niederreiter, *Introduction to Finite Fields and their Applications*, Cambridge University Press, 1994.
3. G.L. Mullen and C. Mummert, *Finite Fields and Applications*, Student Mathematical Library, AMS, 2007.
4. V.K. Khanna and S.K. Bhambri, *A Course in Abstract Algebra*, 4th Edition, Vikas Publishing House Pvt. Ltd., 2013.
5. P.B. Bhattacharya, S.K. Jain, and S.R. Hagpaul, *Basic Abstract Algebra*, Cambridge University Press, Second Edition.

Open Educational Resources (OER)

1. https://archive.nptel.ac.in/courses/111/102/111102111/
2. SWAYAM: Online modules in finite field theory and its applications

Evaluation Scheme

Evaluation Components	Weightage
Internal Marks (Theory)	
I. Continuous Assessment (Project/Quizzes/Assignments/Essays/Presentations)**	30 Marks
II. Mid Term Examination**	20 Marks
External Marks (Theory)	
End Term Examination**	50 Marks

It is compulsory for a student to secure at least 40% marks in both Internal and End Term Examination to pass.

SEMESTER-VIII

SEMESTER VIII					
SCMA404	**Computer Algebra System and related Software's**	**L**	**T**	**P**	**C**
Version		2	0		2
Category of Course	Minor				

Total Contact Hours	64 Hours
Pre-Requisites/ Co-Requisites	**Nil**

Course Perspective

This course is designed to provide students with essential skills in Computer Algebra Systems (CAS) and statistical programming with R. Students will learn to perform advanced mathematical computations, visualize functions, and handle complex data operations using CAS. Additionally, the course covers the use of R for statistical analysis, data manipulation, and graphical representation. Emphasizing practical application, students will gain hands-on experience in solving mathematical problems, analyzing data, and creating meaningful visualizations. By mastering these tools, students will develop a strong foundation in mathematical and statistical analysis, equipping them to effectively address real-world challenges in various fields.

Course Outcomes

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

CO1: Understanding and remembering key concepts of Computer Algebra Systems (CAS) for advanced mathematical computations and graphical representations.

CO2: Applying CAS to perform matrix operations, including Gauss elimination, computing determinants, inverses, and solving systems of linear equations, along with eigenvalue and eigenvector analysis.

CO3: Analyzing and interpreting data structures in R, including importing and manipulating data using vectors, data frames, matrices, and lists.

CO4: Evaluating and generating summary statistics and visualizations in R, such as histograms and scatter plots, to effectively analyze and present data.

Unit 1: Introduction to CAS and Applications Computer Algebra System (CAS)

(No. of Hours: 16)

- Use of a CAS as a calculator
- Computing and plotting functions in 2D

- Plotting functions of two variables using Plot3D and Contour Plot
- Plotting parametric curves surfaces
- Customizing plots
- Animating plots
- Producing tables of values
- working with piecewise defined functions
- Combining graphics

Unit 2: Working with Matrices Simple programming in a CAS

(No. of Hours: 16)

- Working with matrices
- Performing Gauss elimination
- operations (transpose, determinant, inverse)
- Minors and cofactors
- Working with large matrices
- Solving system of linear equations
- Rank and nullity of a matrix
- Eigenvalue, eigenvector and diagonalization.

Unit 3: R - The Statistical Programming Language R as a calculator

(No. of Hours: 16)

- Explore data and relationships in R
- Reading and getting data into R: Combine and scan commands
- Types and structure of data items with their properties
- Manipulating vectors
- Data frames
- Matrices and lists
- Viewing objects within objects
- Constructing data objects and conversions

Unit 4 : **Summary commands: Summary statistics for vectors** (No. of Hours: 16)

- Data frames
- Matrices and lists
- Summary tables
- Stem and leaf plot
- Histograms
- Plotting in R: Box-whisker plots
- Scatter plots
- Pairs plots
- Line charts,
- Pie charts
- C level and dot charts and bar charts
- Copy and save graphics to other applications

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on projects to deepen understanding of Computer Algebra Systems (CAS), matrix operations, and statistical programming with R.

Instruction Methods:

- **Lectures:** Core concepts of Computer Algebra Systems (CAS) and R programming will be taught using multimedia presentations and practical examples.
- **Interactive Sessions:** Q&A, hands-on coding exercises, and collaborative group discussions will actively engage students in applying CAS and R techniques.
- **Group Work and Case Studies:** Collaborative projects will reinforce learning, with case studies to address real-world data science challenges.

Technology Use:

- **Computer Algebra Systems (CAS):** These tools will be used for plotting functions and working with matrices.
- **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. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.
2. Torrence, Bruce F., & Torrence, Eve A. (2009). The Student's Introduction to Mathematica: A Handbook for Precalculus, Calculus, and Linear Algebra (2nd ed.). Cambridge University Press.

Suggested Readings

1. Verzani, John (2014). Using R for Introductory Statistics (2nd ed.). CRC Press, Taylor & Francis Group.
2. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley

Open Educational Resources (OER)

https://www.coursera.org/learn/r-programming
https://www.r-project.org/other-docs.html
https://r-graphics.org/

Evaluation Scheme

Evaluation components	Weightage

Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VIII					
SCMA452	**Computer Algebra System and related Software's Lab**	**L**	**T**	**P**	**C**
Version		0	0	4	2
Category of Course	Major-Practical				
Total Contact Hours	45 Hours				
Pre-Requisites/ Co-Requisites	**Nil**				

Course Perspective

This course is designed to provide students with essential skills in Computer Algebra Systems (CAS) and statistical programming with R. Students will learn to perform advanced mathematical computations, visualize functions, and handle complex data operations using CAS. Additionally, the course covers the use of R for statistical analysis, data manipulation, and graphical representation. Emphasizing practical application, students will gain hands-on

experience in solving mathematical problems, analyzing data, and creating meaningful visualizations. By mastering these tools, students will develop a strong foundation in mathematical and statistical analysis, equipping them to effectively address real-world challenges in various fields.

Course Outcomes

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

CO1: Observing and identifying the fundamental tools and functionalities of a Computer Algebra System (CAS), including basic operations, plotting functions, and working with matrices.

CO2: Imitating best practices in mathematical computing by replicating the use of CAS and R programming for solving systems of equations, performing matrix operations, and creating visual representations of data.

CO3: Practicing the creation and management of mathematical and statistical models using CAS and R, including performing symbolic differentiation, integration, and data manipulation, while experimenting with various visualization techniques.

List of Practicals

1. Basic operations: arithmetic, algebraic manipulation, and equation solving
2. Manipulating inequalities and solving systems of equations
3. Symbolic differentiation and integration
4. Definite and indefinite integrals
5. Applications in calculus and physics problems
6. Representing vectors and matrices symbolically
7. Matrix operations: addition, multiplication, and inversion
8. Solving systems of linear equations using matrices
9. Plotting functions and data
10. Customizing plots and graphs
11. 2D and 3D visualizations of mathematical functions
12. Solving ordinary differential equations (ODEs)
13. Initial value problems and boundary value problems
14. Applications in science and engineering
15. Importing and analyzing data sets
16. Descriptive statistics

Learning Experience

This course will integrate lectures, interactive sessions, and hands-on projects to deepen understanding of Computer Algebra Systems (CAS), matrix operations, and statistical programming with R.

Instruction Methods:

- **Lectures:** Core concepts of Computer Algebra Systems (CAS) and R programming will be taught using multimedia presentations and practical examples.
- **Interactive Sessions:** Q&A, hands-on coding exercises, and collaborative group discussions will actively engage students in applying CAS and R techniques.
- **Group Work and Case Studies:** Collaborative projects will reinforce learning, with case studies to address real-world data science challenges.

Technology Use:

- **Computer Algebra Systems (CAS):** These tools will be used for plotting functions and working with matrices.
- **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. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.
2. Torrence, Bruce F., & Torrence, Eve A. (2009). The Student's Introduction to Mathematica: A Handbook for Precalculus, Calculus, and Linear Algebra (2nd ed.). Cambridge University Press.

Suggested Readings

1. Verzani, John (2014). Using R for Introductory Statistics (2nd ed.). CRC Press, Taylor & Francis Group.
2. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley

Open Educational Resources (OER)

https://www.coursera.org/learn/r-programming
https://www.r-project.org/other-docs.html
https://r-graphics.org/

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VIII					
SCMA4021	**SPECIAL FUNCTION**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Core				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites					

Course Perspective

This course offers an in-depth study of special functions in mathematical analysis, emphasizing their properties, applications, and interrelations. It covers the fundamental concepts of complex numbers and entire functions, including Gamma and Beta functions with their integral representations and special formulas. The course explores advanced

functions such as the Riemann Zeta function and Gauss Hypergeometric function, addressing their asymptotic expansions, convergence, and transformation properties. It also includes a focus on Generalized Hypergeometric Functions and Legendre polynomials, with an emphasis on their integral representations, differential equations, and generating functions. Additionally, the course covers Bessel functions and Hermite polynomials, examining their differential equations, solutions, recurrence relations, and generating functions.

Course Outcomes

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

CO1: Identifying and describing concepts of asymptotic expansions, Euler product formulas, and Riemann functional equations, properties and integral representations of special functions, including Gamma and Beta functions.

CO2: Applying transformation techniques to special functions like the Riemann Zeta and Gauss Hypergeometric functions.

CO3: Analyzing convergence conditions and interrelations among special functions.

CO4: Evaluating the effectiveness of integral representations and asymptotic expansions in solving mathematical problems.

Course Content

Unit I: 15 lecture hours

Infinite product of complex numbers, Factorization of entire functions, Gamma functions, Beta functions, Factorial function, Legendre's duplication formula, Gauss's multiplication formula, Integral representations for Gamma function and Beta functions.

Unit II: 15 lecture hours

Asymptotic expansion, Riemann Zeta functions, Euler product formula, Riemann Functional equations, Gauss Hypergeometric Function, Elementary Properties, Conditions of convergence, Contiguous function relations , Simple transformation, Quadratic transformation.

Unit III: 15 lecture hours

Generalized Hypergeometric Functions, Integral representation, Elementary Properties, Integral Representation, Legendre polynomials and functions, Solution of Legendre's differential equations, Generating Functions, Rodrigue's Formula , Recurrence relations.

Unit IV: 15 lecture hours

Bessel functions, Bessel differential equation and it's solution, Recurrence relation, Generating functions, Integral representation, Hermite Polynomials.

Learning Experience

Students will engage in a detailed exploration of special functions, integrating theoretical understanding with practical applications. They will develop a deep grasp of complex functions, differential equations, and integral representations.

Instruction Methods:

Instruction will be delivered through lectures that provide foundational knowledge and interactive sessions that encourage problem-solving and application of concepts.

Technology Use:

Online platforms will be utilized for access to course materials, interactive simulations, and additional resources to enhance learning and facilitate remote engagement.

Assessments:

Formative assessments will include quizzes and problem sets to gauge understanding throughout the course, while summative assessments will consist of exams and projects to evaluate comprehensive knowledge and application of concepts.

Support:

Additional support will be available through office hours, discussion forums, and online tutoring to assist students in grasping complex topics and solving challenging problems.

Textbooks

1. Rainville E. D., 1960, *Special Functions, The MacMillan Comp.*

2.Bell W.W., 1968, *Special Functions for Scientists and Engineers, D. Van Nostrand Comp. Ltd.*

3.Andrews G.E., Askey R. and Roy R., 1999, *Special Functions, Encyclopedia of Mathematics and Its Applications,* Cambridge University Press.

Suggested Readings

1. "Special Functions and Their Applications" by N. N. Lebedev

2. Bessel Functions for Beginners" by R. B. Paris and D. K. Anagnostopoulos

Open Educational Resources (OER)

https://math.mit.edu/~gs/cse/websections/cse41.pdf

https://reference.wolfram.com/language/guide/FourierAnalysis.html

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous assessment (30 marks)** Include assignments, lab work, quizzes, and a final project, focusing on the practical application of data preprocessing and visualization techniques.	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VIII					
SCMA4010	**q-SERIES AND FRACTIONAL CALCULUS**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Core				
Total Contact Hours	60 Hours				
Pre-Requisites/ Co-Requisites					

Course Perspective

This course provides an advanced study of specialized mathematical functions, including q-shifted, q-gamma, and q-beta functions, and their integral representations. It covers the q-binomial theorem, q-analogue formulas, and fractional calculus concepts like Mittag-Leffler functions and fractional derivatives. The course also explores Meijer's G-functions and H-functions, focusing on their definitions, properties, and transformations.

Course Outcomes

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

CO1: Understanding and defining q-shifted, q-gamma, and q-beta functions in various mathematical contexts, including their properties and applications.

CO2: Applying the q-binomial theorem and q-analogues of key transformation formulas to derive results and solve mathematical problems.

CO3: Analyzing and computing fractional derivatives and integrals, including understanding the applications of Mittag-Leffler functions in different contexts.

CO4: Evaluating and applying integral representations and recurrence relations of specialized functions to complex mathematical and theoretical problems, demonstrating their significance in advanced studies.

Course Content

Unit I: **15 lecture hours**

q-shifted functions ,q-gamma and q-beta functions ,definitions of basic hypergeometric function, elementary q-identities, deductions from integral representations.

Unit II: **15 lecture hours**

q-binomial theorem, q-analogue of gauss's transformation formula, q-analogue of Vandermonde's formula, q-derivative operator.

Unit III: **15 lecture hours**

Introduction to fractional calculus , mittag-Leffler functions of one and two parameters , Leibnitz's formula for fractional derivative and integral, fractional derivative and integral of an arbitrary order of elementary function.

Unit IV: **15 lecture hours**

Meijer's G-Functions: definitions, multiplication formulas, derivatives, recurrence relation, Mellin and Laplace transform. Definition of H-function of one variable, special cases, differentiation formula, recurrence relation.

Learning Experience

Students will engage in a deep exploration of advanced mathematical functions through lectures, problem-solving sessions, and practical applications.

Instruction Methods:

The course will use a mix of lectures, interactive discussions, and hands-on exercises to facilitate understanding of complex mathematical concepts.

Technology Use:

Students will utilize software tools for symbolic computation and mathematical modeling to analyze functions and perform calculations.

Assessments:

Evaluation will include quizzes, assignments, and exams focused on applying theoretical knowledge and solving problems related to q-functions, fractional calculus, and special functions.

Support:

Additional support will be provided through office hours, online resources, and collaborative study groups to assist with course materials and problem-solving strategies.

Textbooks

1. "q-Series and q-Identities" by George E. Andrews (2000)

2. "Fractional Calculus: An Introduction for Physicists" by Richard A. Ross (2010)

3. "Special Functions and Their Applications" by N. N. Lebedev (1972)

4. "Meijer's G-Functions and H-Functions" by A. A. Kilbas, H. M. Srivastava, and J. J. Trujillo (2006)

Suggested Readings

1. "Advanced Mathematical Methods for Scientists and Engineers" by C. A. J. Fletcher (2009)

2. "Fractional Calculus: Theory and Applications" by Igor Podlubny (1999)

Open Educational Resources (OER)

https://instr.iastate.libguides.com/oer/math
https://onlinelibrary.wiley.com/doi/10.1155/2010/375858

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous assessment (30 marks)** Include assignments, lab work, quizzes, and a final project, focusing on the practical application of data preprocessing and visualization techniques.	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

****

MINOR- DATA SCIENCE

SEMESTER I					
UDT101	**Data Analytics using SQL**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 Hours				
Pre-Requisites/ Co-	Nil				

Requisites	

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 **Contact Hours:** 16

- 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 **Contact Hours:** 22

- 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 **Contact Hours:** 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 **Contact Hours:** 16

- 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

Suggested Readings

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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 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					
UDT102	**Data Analytics using R**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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: (No. of Hours: 16)

- 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: (No. of Hours: 16)

- 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: (No. of Hours: 16)

- 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: (No. of Hours: 16)

- 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, Tanmay Bakshi (1st edition)
2. Nina Zumel, John Mount, Practical Data Science with R, Manning Publications, 2014

Suggested Readings

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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
UDT103	**Python for Data Science**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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 (No. of Hours: 16)

- 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 (No. of Hours: 16)

- Arrays and Vectorized Computation
- The NumPy ndarray
- 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 (No. of Hours: 16)

- 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 (No. of Hours: 16)

- 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.
3. Jake VanderPlas, “Python Data Science Handbook: Essential Tools for Working with Data,” O’Reilly, 2017.

4.

Suggested Readings

1. Wesley J. Chun, "Core Python Programming," Prentice Hall, 2006.
2. Mark Lutz, "Learning Python," O'Reilly, 4th Edition, 2009.
3. 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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER IV					
UDT104	**Data Pre-processing and Visualization using Python**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				

Total Contact Hours	64 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- 16**

- Understanding the importance of data preprocessing
- Steps involved in data preprocessing
- Handling missing data and outliers

Unit 2: Data Cleaning and Transformation **No. of Hours : 16**

- Removing duplicates and dealing with data inconsistencies

- Data normalization, scaling, and encoding techniques
- Handling categorical variables

Unit 3: Exploratory Data Analysis (EDA) **No. of Hours : 16**

- 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 **No. of Hours : 16**

- 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.

Suggested Readings

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 (30 marks)** Include assignments, lab work, quizzes, and a final project, focusing on the practical application of data preprocessing and visualization techniques.	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER V					
UDT105	**Time series analysis and forecasting using Python**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	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: No. of Hours: 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: No. of Hours: 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: No. of Hours: 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: No. of Hours: 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 Python Dr. Avishek Pal Dr. Pks Prakash (2017)

Suggested Readings

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 (30 marks)** All the components to be evenly spaced Test/Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals(minimum of five components to be evaluated)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VI					
UDT106	**Fundamental of Machine Learning**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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 No. of Hours: 16 Hours

- Application of Machine Learning
- Supervised vs Unsupervised Learning
- Python libraries suitable for Machine Learning

Unit II: Data Pre-Processing and Data No. of Hours: 16 Hours

- Identifying and handling the missing values
- Encoding the categorical data
- Normalization
- Standardization
- PCA

Unit III: Supervised Learning Regression and Classification No. of Hours: 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 No. of Hours: 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 Vahid Mirjalili

Suggested Readings

1. Understanding Machine Learning - Shai Shalev-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 (30 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)	**30 Marks**

II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
UDT107	**Data Driven Applications**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor VII (Practical)				
Total Contact Hours	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 **Contact Hours: 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 **Contact Hours: 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 **Contact Hours: 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 **Contact Hours: 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
3. "Mastering Microsoft Power BI" by Brett Powell

Reference Books for Power BI

1. The Definitive Guide to DAX by Marco Russo and Alberto Ferrari
2. Microsoft Power BI Cookbook by Greg Deckler
3. 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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VII					
UDT108	**Project and Case Study**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	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.	**30 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 I					
UDT101	**Data Analytics using SQL**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				

Total Contact Hours	64 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 **Contact Hours:** 16

- 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 **Contact Hours:** 22

- 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 **Contact Hours:** 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 **Contact Hours:** 16

- 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

2. "Learning SQL" by Alan Beaulieu
3. "SQL for Dummies" by Allen G. Taylor

Suggested Readings

2. "SQL in 10 Minutes, Sams Teach Yourself" by Ben Forta
3. "SQL Pocket Guide" by Jonathan Gennick
4. "The Practical SQL Handbook" by Judith S. Bowman, Sandra L. Emerson, and Marcy Darnovsky

Open Educational Resources (OER)

2. https://www.w3schools.com/sql/
3. https://www.khanacademy.org/computer-programming/new/sql
4. https://www.coursera.org/learn/sql-for-data-science

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 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					
UDT102	**Data Analytics using R**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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: (No. of Hours: 16)

- 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: (No. of Hours: 16)

- 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: (No. of Hours: 16)

- 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: (No. of Hours: 16)

- 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, Tanmay Bakshi (1st edition)
2. Nina Zumel, John Mount, Practical Data Science with R, Manning Publications, 2014

Suggested Readings

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)

4. "Introduction to Data Science with R" (HarvardX Data Science Series on edX)
5. "R Programming" (Coursera by Johns Hopkins University)
6. "Advanced R" by Hadley Wickham (available online at Advanced R)

Evaluation Scheme

Evaluation components	Weighage
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
UDT103	**Python for Data Science**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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 (No. of Hours: 16)

- 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:

6. Implement basic Python programs for reading input from the console.
7. Perform operations on Python built-in data types: Strings, List, Tuples, Dictionary, Set.
8. Solve problems using decision and looping statements.
9. Handle numerical operations using math and random number functions.
10. Create user-defined functions with different types of function arguments.

Unit 2: Introduction to NumPy (No. of Hours: 16)

- Arrays and Vectorized Computation
- The NumPy ndarray
- 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:

6. Create NumPy arrays from Python Data Structures and Random Functions.
7. Manipulate NumPy arrays: Indexing, Slicing, Reshaping, Joining, and Splitting.
8. Perform computations using Universal Functions and Mathematical methods.
9. Import and analyze data from CSV files using NumPy.
10. Manipulate images using NumPy.

Unit 3: Data Manipulation with Pandas (No. of Hours: 16)

- 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:

6. Create Pandas Series and DataFrames from various inputs.
7. Perform data operations on CSV files using Pandas.
8. Conduct statistical analysis and operations on DataFrames.
9. Handle categorical data using Pandas.
10. Rename columns and restructure data using Pandas.

Unit 4: Data Cleaning, Preparation, and Visualization (No. of Hours: 16)

- 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:

5. Handle missing data and perform data transformations using Pandas.
6. Detect and filter outliers in datasets.
7. Execute vectorized string operations in Pandas.
8. 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

5. Y. Daniel Liang, "Introduction to Programming using Python," Pearson, 2012.
6. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython," O'Reilly, 2nd Edition, 2018.
7. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data," O'Reilly, 2017.
8.

Suggested Readings

4. Wesley J. Chun, "Core Python Programming," Prentice Hall, 2006.
5. Mark Lutz, "Learning Python," O'Reilly, 4th Edition, 2009.
6. Joel Grus, "Data Science from Scratch: First Principles with Python," O'Reilly, 2015.

Open Educational Resources (OER)

4. NPTEL Python for Data Science
5. Kaggle's Python for Data Science
6. Awesome Python for Data Science (GitHub)

Evaluation Scheme

Evaluation components	**Weighage**
Internal marks (Theory) **I. Continuous accessment (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER IV					
UDT109	**Data Structures and Algorithms**	**L**	**T**	**P**	**C**
Version		4	0	0	4
Category of Course	Minor				
Total Contact Hours	64 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 **12 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 17 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

Suggested Readings

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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
UDT110	**Fundamentals of Artificial Intelligence**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				

Total Contact Hours	64 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 12 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 17 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) (required).

Suggested Readings

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, Yoshua Bengio & 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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
UDT106	**Fundamental of Machine Learning**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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 No. of Hours: 16 Hours

- Application of Machine Learning
- Supervised vs Unsupervised Learning
- Python libraries suitable for Machine Learning

Unit II: Data Pre-Processing and Data No. of Hours: 16 Hours

- Identifying and handling the missing values
- Encoding the categorical data
- Normalization
- Standardization
- PCA

Unit III: Supervised Learning Regression and Classification No. of Hours: 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 **No. of Hours: 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

2. Machine Learning - Tom M. Mitchell
3. Python Machine Learning – Sebastian, Raschka and Vahid Mirjalili

Suggested Readings

2. Understanding Machine Learning - Shai Shalev-Shwartz and Shai Ben-David La
3. 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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
	Neural Network and Deep Learning	**L**	**T**	**P**	**C**

UDT111					
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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 feed forward, 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 **19 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 **18 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).

Suggested Readings

1. “Pattern Recognition and Machine Learning” by Christopher Bishop.
2. “Hands-on Machine Learning with Scikit-Learn, Keras and Tensor Flow” by Aurelien Geron (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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

It is compulsory for a student to secure 40 % marks in Internal and End Term Examination separately 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					
UDT112	**Natural Language Processing**	**L**	**T**	**P**	**C**
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	64 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 10 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 7 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

"Conversational AI" by Lili Zheng and Honglak Lee (2022).

Suggested Readings

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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER I					
UNS101	**Study of Materials**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Contact Hours	**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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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.

Suggested Readings"

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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 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					
UNS102	**Elements of Nano sciences and nanomaterial**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Contact Hours	**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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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.
3. Quantum Physics – A. Ghatak

Suggested Readings:

1. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
2. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
3. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.
4. 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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER III					
UNS103	**Nanostructured materials**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Contact Hours	**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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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.

Suggested Readings:

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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER IV

UNS104	Crystallography	L	T	P	C
Version 1.0		4	0	0	4
Category of Course	Minor				
Total Contact Hours	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 **No. of Hours 15**

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 **No. of Hours 15**

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 **No. of Hours 15**

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 **No. of Hours 15**

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).

Suggested Readings

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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER V					
UNS105	**Crystallography Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**4**	**2**
Category of Course	**Minor Lab**				
Total Contact Hours	**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).

Suggested Readings

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 separately to secure minimum passing grade

SEMESTER VI					
UNS106	**SYNTHESIS OF NANOMATERIALS-I**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Contact Hours	**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 No. of Hours: 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 No. of Hours: 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 No. of Hours: 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 No. of Hours: 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

Suggested Readings

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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VI					
UNS107	**Synthesis of Nanomaterials-II**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Contact Hours	**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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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).

Suggested Readings:

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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

SEMESTER VI					
UNS108	**Synthesis of Nanomaterials Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**4**	**2**
Category of Course	**Minor Lab**				
Total Contact Hours	**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).

Suggested Readings:

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 Examination separately to secure minimum passing grade.

SEMESTER VII					
UNS109	**Characterization Techniques of Nanomaterials**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total Contact Hours	**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 **No. of Hours: 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 **No. of Hours: 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 **No. of Hours: 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 No. of Hours: 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

Suggested Readings:

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 (30 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)	**30 Marks**
II. internal marks (Theory): Mid Term Examination	**20 Marks**

III. External Marks (Theory): End Term Examination	**50 Marks**

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

MINOR (ENVIRONMENTAL SCIENCES)

COURSE PERSPECTIVE

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV101	**EARTH AND EARTH SURFACE PROCESSES**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Earth and its processes**				
Co-requisites	**--**				

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.

CO5: Evaluating the importance of mountains in India, including their role in river systems, monsoon patterns, and the development of human civilization.

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.

Unit5: Importance of being a mountain **10 lectures**

Formation of Peninsular Indian Mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; development of glaciers, perennial river systems and evolution of monsoon in Indian subcontinent; formation of Indo-Gangetic Plains, arrival of humans; evolution of Indus Valley civilization; progression of agriculture in the Indian subcontinent in Holocene; withdrawing monsoon and lessons to draw.

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.

Suggested Readings

3. 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.

4. Keller, E.A. 2011. *Introduction to Environmental Geology* (5th edition). Pearson Prentice Hall.

5. Krishnan, M. S. 1982. *Geology of India and Burma*.CBS Publishers & Distributors.

6. Leeder, M., Arlucea, M. P. 2005. *Physical Processes in Earth and Environmental Sciences.*Blackwell Publishing.

7. 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 (30 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

MINOR- ENVIRONMENTAL SCIENCE

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV102	**Hydrology and Hydrogeology**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Contact Hours	**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

3. K Subramanya, Water Resources Engineering through Objective Questions, Tata McGraw Hill.
4. G L Asawa, Irrigation Engineering, Wiley Eastern
1. L W Mays, Water Resources Engineering, Wiley.
2. J D Zimmerman, Irrigation, John Wiley & Sons
3. C S P Ojha, R Berndtsson and P Bhunya, Engineering Hydrology, Oxford.
4. 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 (30 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV103	**NATURAL RESOURCES MANAGEMENT AND SUSTAINABILITY**	**4**	**0**	**0**	**4**
Version 1.0					
Total Contact Hours	**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

Unit1: Introduction **10 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.

Unit2: Natural resources and conservation **10 lectures**

Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, fresh water shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

Unit3: Mineral resources **10 lectures**

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.

Unit4: Non-renewable energy resources **10 lectures**

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.

Unit 5: Renewable energy resources **10 lectures**

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.

Unit6: Resource management **10 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.

Suggested 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

3. Freeman, A. M. 2003. *Millennium Ecosystem Assessment: Conceptual Framework*. Island Press.

4. Ginley, D. S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*.CambridgeUniversity Press.

5. Klee, G. A. 1991.*Conservation of Natural Resources*. Prentice Hall Publication.

6. Miller, T. G. 2012. *Environmental Science*. Wadsworth Publishing Co.

7. Owen, O. S, Chiras, D. D, &Reganold, J. P. 1998. *Natural Resource Conservation–Management for Sustainable Future* (7thedition). Prentice Hall.

8. Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.

9. 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 (30 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)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV104	**NATURAL AND ANTHROPOGENIC HAZARDS**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Baics 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.

Suggested Textbooks

1. Natural Hazards and Disasters" by D. Hyndman & D. Hyndman:
2. "Introduction to Environmental Geology" by E. A. Keller

Reference Books/Materials

3. "Environmental Hazards: Assessing Risk and Reducing Disaster" by K. Smith
4. "Introduction to Environmental Engineering and Science" by G. M. Masters & W. P. Ela
5. "Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes" by E. A. Keller & D. E. DeVecchio
6. "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 (30 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)**	**30 Marks**
II. Internal marks(Theory): **Mid Term Examination**	**20 Marks**
III. External Marks (Theory): **End Term Examination**	**50 Marks**

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

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV105	**ENVIRONMENT LEGISLATION POLICIES AND ESG'S**	**L**	**T**	**P**	**C**
Version 3.0		4	0	0	4
Total Contact Hours	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.

Suggested Text Books

1. "Environmental Law in India" by Shyam Diwan and Armin Rosencranz
2. "Environmental Law" by Bimal N. Patel

Reference Books/Materials

3. "Environmental Management: Text and Cases" by Rajagopalan Raman
4. "Environmental Laws in India: An Introduction" by Gurdip Singh
5. "Environmental Legislation and Policy: Selected Statutes" by Gitanjali Nain Gill
6. "Environmental Governance in India: Problems and Perspectives" by N.C. Saxena and Kanchi Kohli
7. "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 (30 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV106	**Waste Management**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisite/Exposure	**Basics ofEnvironment**				
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, and their impact on health and the environment.

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.

CO5: Creating energy from waste through processes like combustion, pyrolysis, and anaerobic digestion.

CO6: Reviewing policies for solid waste management and their role in promoting eco-friendly practices.

COURSE CONTENT

Unit A: Introduction **5lectures**

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste**.**

UnitB:Effectofsolidwastedisposalon environment **8lectures**

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.

UnitC:SolidwasteManagement **9lectures**

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.

UnitD: Industrialwastemanagement **8lectures**

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;effluenttreatmentplantandsewagetreatmentplant.

UnitE:ResourceRecovery **6lectures**

4R-reduce, reuse, recycle and recover; biological processing-composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit F: Waste- to-energy (WTE) **6lectures**

Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfillgas (LFG) recovery; anaerobic digestion; gasification.

UnitG: Integratedwastemanagement **6lectures**

Concept of Integrated waste management; waste management hierarchy; methods and importance ofIntegratedwastemanagement**.**

UnitH: Life cycle assessment (LCA) **6lectures**

Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study onLCA of aproduct.

UnitI:Policiesforsolidwastemanagement **6lectures**

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management andHandling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly orgreenproducts.

Suggested 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

3. "Waste Management Practices: Municipal, Hazardous, and Industrial" by Pichtel.
4. "Handbook of Solid Waste Management" by Kreith and Tchobanoglous.
5. "Waste Management and Sustainable Consumption" by Cooper.
6. "Hazardous Waste Management" by LaGrega et al.
7. "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

POOL OF ENVIRONMENTAL SCIENCE AS MINOR

- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu

Evaluation components	**Weightage**
Internal marks (Theory) **I. Continuous assessment (30 marks)** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case	30 Marks
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

- 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

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

UEV107	Environmental Impact assessment and Risk assessment	L	T	P	C
Version 3.0		4	0	0	4
Total Contact Hours	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

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 (30 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)	**30 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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

POOL OF ENVIRONMENTAL SCIENCE AS MINOR					
UEV108	**SDG'S AND CLIMATE CHANGE**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Contact Hours	**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 (30 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)	**30 Marks**
II. Internal marks(Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**50 Marks**

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