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 (Honours/ Honours with Research) in Physics

Programme Code: 209

FOUR YEAR UNDERGRADUATE PROGRAMME

As per National Education Policy 2020
(Multiple Entry and Exit in Academic Programmes)
(with effect from 2025-26 session)

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

Table of Contents

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 Sciences (Honours/ Honours with Research) Physics according to the New Education Policy-2020. We have designed a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options for the duration of 2025-2029.

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

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

All the courses are having defined objectives and Learning Outcomes, which will help prospective students in choosing the elective courses to broaden their skills in the field of Physics 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 physics. The K. R. Mangalam University hopes the NEP-2020 approach of this four-year undergraduate programme B.Sc. (Hons. / Hons. with Research) Physics 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/Honours with Research)** 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/Honours with Research)**.

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

Table 1: Minimum Credit Requirement for Four Year UG Program

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

2.1 Categories of Courses

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

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

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

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

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

A diverse array of Open Elective Courses, distributed across different semesters and aligned with the aforementioned categories, is offered to the students. These courses enable students to expand their perspectives and gain a holistic understanding of various disciplines. Students can choose courses based on their areas of interest.

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

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

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

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

Research Project / Dissertation: Students choosing a 4-Year Bachelor's degree (Honours/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 Science (Honours / Honours with Research) in Physics

The B.Sc. (Hons. / Hons. with Research) Physics is an undergraduate academic program designed to provide students with a comprehensive foundation in the fascinating world of physics. This program offers a rigorous and engaging curriculum that covers diverse areas such as classical mechanics, electromagnetism, quantum mechanics, thermodynamics, and more. Students in this program will study fundamental principles of the universe, engage in complex problem-solving, and enhance their analytical and critical thinking skills. Combining hands-on lab work with theoretical learning, they'll gain practical experience and a solid grasp of scientific research methods. The B.Sc. (Hons. / Hons. with Research) Physics program prepares students for exciting career opportunities in scientific research, technology, education, and various other fields that require a strong grasp of physics principles and applications.

6.1. Nature of B.Sc. (Hons. / Hons. with Research) Physics 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. / Hons. with Research) Physics 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. Aim of B.Sc. (Hons. / Hons. with Research) Physics Programme

The aims of the B.Sc. (Hons. / Hons. with Research) Physics program, in accordance with the National Education Policy (NEP), are multifaceted and comprehensive. The program aims to cultivate a strong foundation in physics 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. / Hons. with Research) Physics 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 physics with other scientific disciplines and societal issues. Overall, the B.Sc. (Hons. / Hons. with Research) Physics program aspires to produce well-rounded graduates with a passion for learning and a strong foundation in physics, 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 they will 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 (PEOs*)*

These are deferred outcomes measured a few years after completion of the programme, where:

PEO1: Graduates will become globally competent professionals, suitable for careers in government, corporate, and research sectors, while also possessing skills for entrepreneurial ventures in multidisciplinary fields.

PEO2: Graduates will demonstrate strong technical knowledge in physics and will be able to think critically and creatively to develop practical solutions to scientific and technological challenges.

PEO3: Graduates will be ethical professionals who can lead and collaborate effectively in teams, contributing to both their own growth and the success of their organizations.

PEO4: Graduates will engage in lifelong learning and professional development, applying their expertise to benefit society and make meaningful contributions.

PEO5: Graduates will be well-equipped to pursue higher education and advanced research in physics and related disciplines.

6.5 Programme Outcomes (POs)

At the time of graduation, students of undergraduate degree program will be able:

PO1: To apply physics principles and mathematical techniques to effectively solve complex real-world problems.

PO2: To develop strong critical thinking skills, enabling them to analyze and evaluate evidence, arguments, and methodologies in physics research and applications.

PO3: To promote teamwork and collaborative learning, enabling students to contribute to and lead interdisciplinary research.

PO4: To build strong interpersonal skills to navigate diverse professional environments, collaborate effectively, and take on leadership roles.

PO5: To communicate complex scientific ideas and research findings clearly in both writing and presentations to scientific and non-scientific audiences.

PO6: To learn independently and stay updated with scientific advancements throughout their careers.

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

PO8: To understand the impact of physics research on the environment and society and show a commitment to using sustainable and ethical practices in work.

6.6 Programme Specific Outcomes (PSOs)

At the time of graduation, students of undergraduate degree program will be:

PSO1: Understanding fundamental concepts, laws, theories, tools and techniques in the field of physics.

PSO2: Applying mathematical techniques, theoretical models, and physical laws to solve complex scientific problems.

PSO3: Analyzing various real-life situations, problems, and challenges related to physics.

PSO4: Evaluating the validity of scientific arguments, theories, and experimental results, making reasoned judgments about the quality and reliability of research findings in physics.

PSO5: Operating laboratory instruments and experimental setups with accuracy, demonstrating skill in measuring, observing, and manipulating equipment to gather precise data.

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

6.7 Career Avenues

Graduates can pursue careers in research and development (R&D) in industries, work as research scientists or assistants in academic and research institutions, or continue with higher education (M.Sc., PhD) leading to academic or specialized roles in physics. Opportunities also exist in sectors like govt. jobs, defence services, data science, finance, and competitive examinations.

6.8 Duration

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

6.9 Criteria for award of certificates and degree

Name of Degree	Credits requirement	Completion Year
UG Certificate Physics	47	First Year
UG Diploma Physics	96	Second Year
B.Sc. Physics	143	Third Year
B.Sc. (Hons. / Hons. With Research) Physics	173	Fourth Year

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

7.1 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.

7.2 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.

7.3 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 the 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 Scilab, LaTeX, and digital simulations are integrated to enhance practical understanding. Peer reviews and discussions further solidify theoretical knowledge through collaborative learning.
- **Outside the 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.

7.4 Educational Planning and Execution: What, when and how learning will happen

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

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

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

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

7.5 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.

7.6 Academic Support Services

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.

7.7 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.

8. Assessment and Evaluation

8.1 Evaluation scheme for theory courses

Evaluation Component	Weightage
Internal Marks (Theory): - **I) Continuous Assessment** **(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) **II) Mid Term Exam**	40 Marks 20 Marks
External Marks (Theory): – End Term Examination	40 Marks

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

8.2 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 to secure minimum passing grade).**

8.3 Evaluation scheme for 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

8.4 Evaluation scheme for Internship

Particular	**Weightage**

Internal Marks: - Internship completion certificate obtained from supervisor from host institute.	30 Marks
External Marks (Practical): - Presentation Report Writing Viva Voce	70 Marks 25 25 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.)**

8.5 Grading System

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

Marks Range (%)	**Letter Grade**	**Grade Points**	**Description of the Grade**
% marks > 90%	O	10.0	Outstanding
80 < %marks ≤ 90	A+	9.0	Excellent
70 < %marks ≤ 80	A	8.0	Very Good
60 < %marks ≤ 70	B+	7.0	Good
55 < %marks ≤ 60	B	6.0	Above Average
50 < %marks ≤ 55	C	5.5	Average
40 ≤ %marks ≤ 50	P	5.0	Pass
%marks < 40	F	0	Fail
-	AB	0	Absent
%marks ≥ 50	S	-	Satisfactory
%marks < 50	U	-	Unsatisfactory
-	W	0	Withdrawal

9. 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.

10. 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.

11. PROGRAMME STRUCTURE

SEMESTER - I								
S. No.	**TYPE OF COURSE**	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**
1	**Major 1**	BSPHMP101	Mathematical Physics I	4	0	0	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].
2	**Major 2**	BSPHEM102	Electricity and Magnetism	4	0	0	4	
3	**Major 2 Lab**	BSPHEM152	Electricity and Magnetism Lab	0	0	2	1	
4	**VAC-I**		Environmental Studies	2	0	0	2	
5	**SEC-I**		Data Exploration & Analysis using Excel	0	0	6	3	
6	**SEC-II**		Instrumentation and Physics Workshop Skills	0	0	4	2	
7	**Major 3**	BSPHMC103	Mechanics	4	0	0	4	
TOTAL							**20**	

***The School of Basic and Applied Sciences (SBAS) offers four Minor Courses, each of 32 credits, to students enrolled in 4-year undergraduate degree programmes. Each student is required to select one Minor Course in the first semester and will pursue the same Minor Course continuously until the eighth semester.**

SEMESTER-II							
S. No.	**TYPE OF COURSE**	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
1	**Major 4**	BSPHMP201	Mathematical Physics II	4	0	0	4
2	**Major 5**	BSPHWO202	Waves and Oscillations	4	0	0	4
3	**Major 5 Lab**	BSPHWO253	Waves and Oscillations Lab	0	0	2	1
4	**Minor-I**		Minor	4	0	0	4
5	**VAC-II (MOOC)**		Cyber Security	2	0	0	2
6	**OE-I**		Open Elective	3	0	0	3

7	**SEC-III**		Documentation using Latex	2	0	0	2
8	**Minor-II**		Minor	4	0	0	4
9	**Project**	BSCCPR205	Project-I				2
10			CLUB/SOCIETY	0	0	0	1
			TOTAL				**27**

Summer Internship I will be of 4-6 weeks duration at the end of Semester II during summer break and the evaluation will be done during Semester III

SEMESTER-III

S. No.	TYPE OF COURSE	COURSE CODE	COURSE TITLE	L	T	P	C	Multiple Entry and Exit
1	**Major 6**	BSPHMP301	Mathematical Physics III	4	0	0	4	**Award: UG Diploma** [after completing 2 years of study (4 semesters with credits as prescribed), and an additional vocational course/internship of 4 credits to be covered within 6-8 weeks during the summer vacation of the second year].
2	**Major 7**	BSPHSS302	Solid State Physics	4	0	0	4	
3	**Major 7 (Lab)**	BSPHSS352	Solid State Physics Lab	0	0	2	1	
4	**Minor-III**		Minor	4	0	0	4	
5	**OE-II**		Open Elective	3	0	0	3	
6	**VAC-III**		Artificial Intelligence	2	0	0	2	
7	**AEC-I**		Self-Awareness	2	0	0	2	
8			Community Services	0	0	0	1	
9	**Project**	BSCCPR305	Project-II				2	
10	**Summer Internship I**	BSPHIN306	Evaluation of Summer Internship I	2	0	0	2	
			TOTAL				**25**	

SEMESTER -IV

S. No.	TYPE OF COURSE	COURSE CODE	COURSE TITLE	L	T	P	C	
1	**Major 8**	BSPHOP401	Optics	4	0	0	4	**Entry:** The student who took exit after completion of the first year (UG Certificate) is allowed to enter the diploma programme within five years from the first
2	**Major 8 Lab**	BSPHOP451	Optics Lab	0	0	2	1	
3	**Major 9**	BSPHET402	Electromagnetic Theory	4	0	0	4	
4	**Major 10**	BSPHMO403	Modern Physics	4	0	0	4	
5	**Minor IV**		Minor	4	0	0	4	

6	**OE-III**		Open Elective	3	0	0	3	entry in the programme, four years in case of degree program and three years in case of Hons. degree to complete the programme within the stipulated period of seven years.
7	**AEC-II**		Communication & Personality Development	2	0	0	2	
8	**Project**	BSCCPR405	Project-III				2	
TOTAL (Minor NS/EVS/DS/AI&ML)							**24**	

Summer Internship II will be of 4-6 weeks duration at the end of Semester IV during summer break and the evaluation will be done during Semester V

SEMESTER- V

S. No.	TYPE OF COURSE	COURSE CODE	COURSE TITLE	L	T	P	C	Multiple Entry and Exit
1	**Major 11**	BSPHTS501	Thermodynamics and Statistical Mechanics	4	0	0	4	**Award: Bachelor's Degree** [after completing 3-year of study (6 semesters with credits as prescribed)]
2	**Major 12 (DSE)**	BSPHAS502/ BSPHPE503	Analog Systems and Applications/ Applied Optics	4	0	0	4	
3	**Major 13**	BSPHCD504	Classical dynamics	4	0	0	4	
4	**Major 14**	BSPHNP505	Nuclear Physics	4	0	0	4	
5	**Minor V**		Minor	4	0	0	4	
6	**AEC-III**		Arithmetic Reasoning and Skill-III	2	0	0	2	
7	**Summer Internship II**	BSPHIN506	Evaluation of Summer Internship II	2	0	0	2	
TOTAL (Minor NS/EVS/DS/AI&ML)							**24**	**Entry:** The student who took exit after completion of two years of

SEMESTER - VI

S.No	TYPE OF COURSE	COURSE CODE	COURSE TITLE	L	T	P	C

1	**Major 15 (DSE)**	BSPHDS601/ BSPHPE602	Digital Systems and Applications /Physics of Earth	4/4	0/1	0	4/5	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 15 (DSE-Lab)**	BSPHDS651/ BSPHPE652	Analog & Digital Systems Lab	0	0	2	1	
3	**Major 16**	BSPHQM603	Quantum Mechanics and Applications	4	0	0	4	
4	**Major 17**	BSCCRM606	Research Methodology	3	0	0	3	
5	**Minor VI**		Minor	4	0	0	4	
6	**Project**	BSCCPR605	Project-IV				2	
7	**AEC-IV**		Managing people and organization	2	0	0	2	
8	**SEC-IV**		Hands on in Robotics with Arduino	1	0	4	3	
TOTAL (Minor NS/EVS/DS/AI&ML)							**23**	
SEMESTER – VII [*bachelor's degree (Honours with Research)]								
S.No.	**TYPE OF COURSE**	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**	**Multiple Entry and Exit**
1	**Major 18**	BSPHAM701	Atomic and Molecular Physics-I	3	0	0	3	
2	**Major 19**	BSPHAQ702	Advanced Quantum Mechanics	3	0	0	3	
3	**Major 20**	BSCCRW706	Research Report writing	3	0	0	3	
4	**Minor**		Minor	4	0	0	4	
TOTAL CREDITS							**13**	**Entry:** The student who took exit after completion of three years of study (UG degree) is allowed to re-enter the degree programme
Semester-VIII [*Bachelor's degree (Honours with Research)]								
S.No	**TYPE OF COURSE**	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**	
1	**Major 21**	BSPHAM801	Atomic and Molecular Physics-II	3	0	0	3	
2	**Major 22**	BSPHDR805	Dissertation	0	0	0	10	
3	**Minor**		Minor	4	0	0	4	
TOTAL (Minor NS/EVS/DS/AI&ML)							**17**	
SEMESTER – VII [*Bachelor's degree (Honours)]								

S.No.	TYPE OF COURSE	COURSE CODE	COURSE TITLE	L	T	P	C	
1	**Major 18**	BSPHAM701	Atomic and Molecular Physics-I	3	0	0	3	maximum within three years and complete the degree programme within the stipulated maximum period of seven years.
2	**Major 19**	BSPHAQ702	Advanced Quantum Mechanics	3	0	0	3	
3	**Minor**		Minor	4	0	0	4	
4	**Major 20 (DSE)**	BSPHNT703/BSPHEC704	Nanotechnology/ Fabrication of Electronic Devices	3	0	0	**3**	
TOTAL							**13**	
Semester-VIII *[Bachelor's degree (Honours)]								
S.No	**TYPE OF COURSE**	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**	
1.	**Major 22**	BSPHAM801	Atomic and Molecular Physics-II	4	0	0	4	
2.	**Major 23**	BSPHPR802	Research Project	6	0	0	6	
3.	**Major 24**	BSPHAS803	Advanced Solid-State Physics	3	0	0	3	
4.	**Minor**		Minor	4	0	0	4	
TOTAL							**17**	

TOTAL CREDITS: 173

DETAILS OF MINOR COURSES

Minor- Nano Sciences				
S. No.	**Minor**	**Name**	**Code**	**Semester**
I	Minor1	Study Of Materials	UNMINS201	II
II	Minor2	Elements Of Nanoscience and Nanomaterials	UNMINS202	II
III	Minor 3	Nanostructured Materials	UNMINS301	III
IV	Minor 4	Crystallography	UNMINS401	IV
V	Minor 4 (Lab)	Crystallography Lab	UNMINS451	IV
VI	Minor 5	Synthesis of Nanomaterials-I	UNMINS501	V

VII	Minor 5 Lab	Synthesis of Nanomaterials-I Lab	UNMINS551	V
VIII	Minor 6	Characterisation Techniques of Nanomaterials	UNMINS601	VI
IX	Minor 6 Lab	Characterisation Techniques of Nanomaterials Lab	UNMI651	VI
X	Minor 7	Synthesis Of Nanomaterials-II	UNMINS701	VII
XI	Minor 7 (Lab)	Synthesis Of Nanomaterials- II Lab	UNMINS751	VII

Minor- Environmental Science				
S. No.	**Minor**	**Name**	**Code**	**Semester**
I	Minor1	Earth And Earth Surface Processes	UNMIES201	II
II	Minor2	Hydrology And Hydrogeology	UNMIES202	II
III	Minor 3	Natural Resources Management and Sustainability	UNMIES301	III
IV	Minor 4	Natural And Anthropogenic Hazards	UNMIES401	IV
V	Minor5	Environment Legislation Policies and ESG's	UNMIES501	V
VI	Minor6	Waste Management	UNMIES601	VI
VII	Minor7	Environmental Impact Assessment and Risk Assessment	UNMIES701	VII
VIII	Minor8	SDG's And Climate Change	UNMIES801	VIII

Minor- Data Science				
S. No.	**Minor**	**Name**	**Code**	**Semester**
I	Minor1	Data Analytics Using SQL	UNMIDS201	II
II	Minor2	Data Analytics using R	UNMIDS202	II

III	Minor 3	Python for Data Science	UNMIDS301	III
IV	Minor 4	Data Preprocessing and Visualization Using Python	UNMIDS401	IV
V	Minor5	Time Series Analysis & Forecasting Using Python	UNMIDS501	V
VI	Minor6	Fundamental Of Machine Learning	UNMIDS601	VI
VII	Minor7	Data Driven Applications	UNMIDS701	VII
VIII	Minor8	Project and Case Study	UNMIDS801	VIII

Minor- Artificial Intelligence & Machine Learning				
S. No.	**Minor**	**Name**	**Code**	**Semester**
I	Minor 1	Data Analytics using SQL	UNMIDS201	II
II	Minor 2	Data Analytics using R	UNMIDS202	II
III	Minor 3	Python for Data Science	UNMIDS301	III
IV	Minor 4	Data Structures and Algorithms	UNMIDS402	IV
V	Minor 5	Fundamentals of Artificial Intelligence	UNMIDS502	V
VI	Minor 6	Fundamental of Machine Learning	UNMIDS601	VI
VII	Minor 7	Neural Network and Deep Learning	UNMIDS702	VII
VII	Minor 8	Natural Language Processing	UNMIDS802	VIII

12. Syllabi

SEMESTER I					
BSPHMP101	**Mathematical Physics-I**	**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 aims to demonstrate the use of mathematical techniques in solving problems in Physics and to provide a deeper understanding of the mathematics underpinning theoretical physics. The course is intended to develop the concepts of vector calculus and its applications. Emphasis will be on illustrative examples from Physics and Engineering.

Course Outcomes

On completion of the course, the learner will be:

CO1: Understanding key calculus concepts like limits, differentiation, and series.

CO2: Applying vector operations and theorems such as Gauss's and Stokes' and concepts in curvilinear coordinates and probability distributions.

CO3: Analyzing vector calculus concepts, including vector fields and products.

CO4: Evaluating the applications of vector integration theorems, and probability distribution functions in solving real-world problems.

Course Content

UNIT-I Calculus 15 Lecture Hours

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Intuitive ideas of continuous, differentiable, etc. Approximation: Taylor and binomial series (statements only).

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Integral.

UNIT-II Vector Calculus 15 Lecture Hours

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

UNIT-III Vector Differentiation & Integration 15 Lecture Hours

Vector Differentiation: Directional derivatives and normal derivatives. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

UNIT-IV Orthogonal curvilinear coordinates & probability 15 Lecture Hours

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance

Learning experience

The learning experience in this course will be interactive and applied. Students will engage in problem-solving exercises and practical applications of calculus and vector analysis. They will work on assignments and projects that involve real-world scenarios, using mathematical tools and techniques to solve complex problems. Hands-on activities, group discussions, and demonstrations will help reinforce theoretical concepts, making the learning process dynamic and relevant to their future studies and careers.

Textbooks:

1. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.
2. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

Suggested Readings

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.

Open Educational Resources (OER)

1. https://www.youtube.com/playlist?list=PLZHQObOWTQDNPOjrT6KVlfJuKtYTftqH6
   https://www.youtube.com/watch?v=GLs0nXZBUYk
2. https://archive.nptel.ac.in/courses/111/105/111105122/
3. https://www.youtube.com/watch?v=KZzAFX54DWs
4. https://archive.nptel.ac.in/courses/111/102/111102111/

Evaluation Scheme:

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

SEMESTER I					
BSPHEM102	**Electricity and Magnetism**	**L**	**T**	**P**	**C**

Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Mathematical Physics**				

Course Perspective The course on Electricity and Magnetism provides a foundational understanding of the behaviour of electric and magnetic fields, which are essential to many areas of physics and engineering. It introduces students to fundamental concepts, laws, and mathematical techniques used to describe and analyse these fields. The course emphasizes the application of theoretical principles to solve real-world problems, preparing students for advanced studies and practical applications in fields such as electromagnetism, electronics, and materials science. Through this course, students will develop critical thinking and problem-solving skills, enabling them to approach complex physical phenomena with confidence.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding key concepts like electric fields, potentials, Gauss's Law, and Maxwell's equations.

CO 2: Applying Gauss's Law, the Method of Images, and Ampere's Law to solve field-related problems.

CO 3: Analysing relationships between electric and magnetic properties to predict system behaviour.

CO 4: Evaluating different problem-solving approaches in electrostatics and magnetostatics.

Course Content

Unit I: Electrostatics: 15 Lecture hours

Electric field & Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential.

Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor.

Unit II: Electric Potential and Field 15 Lecture hours

Special techniques for the calculation of Potential and Field: The Method of Images is applied to a system of a point charge and finite continuous charge distribution (line charge and surface charge) in the presence of (i) a Plane infinite sheet maintained at constant potential, and (ii) a Sphere maintained at constant potential.

Electric Field in Matter: Polarization in matter, Bound charges and their physical interpretation. Field inside a dielectric, Displacement vector D, Gauss' Law in the presence of dielectrics, Boundary conditions for D, Linear dielectrics, Electric Susceptibility and Dielectric Constant, idea of complex dielectric constant due to varying electric field.

Unit III: Magnetostatics 15 Lecture hours

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid.

Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

Unit IV: Magnetic Properties & Electrodynamics 15 Lecture hours

Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

Electrodynamics

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Learning Experience

The learning experience in this course is designed to be interactive and hands-on, blending theoretical knowledge with practical applications. Students will engage with complex concepts through a combination of lectures, problem-solving sessions, and laboratory experiments. The course encourages active participation, critical thinking, and collaboration, providing opportunities for students to apply what they learn in real-world contexts. Through assignments, group discussions, and projects, students will not only deepen their understanding of electrostatics and magnetostatics but also develop skills in analytical reasoning and scientific inquiry, preparing them for future academic and professional challenges.

Textbooks

1. Physics for Scientists and Engineers (6th Ed.), Raymond A. Serway and John W. Jewett, Thomson Brooks (2004).

2. Engineering Physics Theory and Practical, A. K. Katiyar and C. K. Pandey, Wiley (2015)

Suggested Readings

1. Introduction to Electrodynamics (3rd Indian reprint), D.J. Griffiths, Pearson Education (2003).

2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.

Open Educational Resources (OER)

- https://www.youtube.com/watch?v=dGYCwt2Nqas
- https://www.youtube.com/watch?v=qjsZTBZd1Ms
- https://www.youtube.com/watch?v=KGTZPTnZBFE
- https://www.youtube.com/watch?v=hJD8ywGrXks&vl=en

Evaluation Scheme

Evaluation components	**Weightage**

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

SEMESTER I					
BSPHEM152	**Electricity and Magnetism Lab**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**2**	**1**
Category of Course	**Major Lab**				
Total Contact Hours	**15**				
Pre-Requisites/ Co-Requisites	**Basics of Electricity and Magnetism**				

Course Perspective

This course offers hands-on experiments designed to deepen understanding of fundamental principles in physics and electronics. Students will explore a variety of topics, such as determining the frequency of AC mains with a sonometer, measuring unknown capacitance using De-Sauty's bridge, and investigating magnetic fields with Stewart and Gee's apparatus. Additionally, the course covers advanced concepts like calculating the band gap of semiconductors using the four-probe method, determining the Hall coefficient, and measuring high resistance by substitution. Experiments on hysteresis loss using a CRO, resistance in series and parallel circuits, and verification of Ohm's Law further reinforce key theoretical concepts, providing students with a comprehensive and practical learning experience.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Observing and identifying the experimental procedures and identify key variables, equipment, and phenomena relevant to the scientific principles being studied.

CO2: Imitating replicate established experimental techniques and protocols accurately to achieve reliable and reproducible results in laboratory settings.

CO3: Practicing the theoretical knowledge by performing hands-on experiments, honing their technical skills, and demonstrating proficiency in using laboratory instruments and equipment.

Course Contents

1. To find the frequency of A. C. mains by using a sonometer.
2. To find the capacitance of unknown condensers by De – Sauty's bridge
3. To study the variation of magnetic field with distance and to find the radius of coil by Stewart and Gee's Apparatus.
4. To find the band gap of intrinsic semi-conductors using four-probe method.
5. To find the value of Hall coefficient.
6. To measure high resistance by substitution method.
7. To determine hysteresis loss by CRO.
8. Resistance In Series and Parallel Apparatus
9. To Verify the Ohm's Law for the given circuit

Learning Experience

The learning experience in this course is designed to be both engaging and transformative, offering students a blend of theoretical knowledge and practical application. Through hands-on experiments and interactive demonstrations, students gain valuable insights into fundamental scientific principles and develop essential technical skills. The course encourages active participation, critical thinking, and problem-solving, fostering a deeper understanding of complex concepts. By observing, replicating, and adapting experimental techniques, students not only grasp the core content but also enhance their ability to apply knowledge in real-world scenarios, ultimately preparing them for future academic and professional endeavours.

Textbooks

1. Laboratory Manual Physics for class XII - Published by NCERT
2. B. Sc Practical Physics by Geeta Sanon
3. B. Sc Practical Physics by CL Arora

Suggested Readings

1. Solid State Physics: An Introduction" by Philip Hofmann
2. Semiconductor Physics and Devices: Basic Principles" by Donald A. Neamen
3. Practical Electronics for Inventors" by Paul Scherz and Simon Monk
4. Electricity and Magnetism" by Edward M. Purcell and David J. Morin

Open Educational Resources (OER)

1. https://en.wikipedia.org/wiki/Sonometer
2. http://www.indiastudychannel.com/resources/141412-How-to-measure-the-AC-source-frequency-using-sonometer-and-electromagnet.aspx
3. http://www.schoolphysics.co.uk/age16-19/Sound/text/Sonometer_/index.html
4. https://www.youtube.com/watch?v=F6SlpU0XkPo
5. https://www.youtube.com/watch?v=F0LosOk3a1g

Evaluation Scheme

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

SEMESTER I					
	Environmental Studies	**L**	**T**	**P**	**C**

Version 2.0		2	0	0	2
Category of Course	**Value Added Course**				
Total Contact Hours	**30**				
Pre-Requisites/ Co-Requisites	**Basics of Environment**				

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

Course Outcomes

Upon completion of the course, the learner will be:

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

CO2: Applying knowledge of environmental laws and policies and utilize the concepts of disaster preparedness,

CO3: Analysing the effects of human activities on the environment

CO4: Evaluating the effectiveness of existing environmental laws, governance frameworks, and disaster management practices in India

CO5: Creating innovative solutions for sustainable development and disaster management plans.

Course Content

- **Unit A: Environment and Natural Resources** **8 Lecture Hours**

Multidisciplinary nature of environmental sciences; Scope and importance; Need for public awareness.
Land resources; land use change; Land degradation, soil erosion and desertification.
Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.
Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).
Energy resources: Renewable and non- renewable energy sources, use of alternate energy sources, growing energy needs, case studies. Carbon Footprints.

- **Unit B: Environmental Pollution and Environmental Policies** **7 Lecture Hours**

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

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

- **Unit C: Introduction to Disasters** **8 Lecture Hours**

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

- **Unit D: Disaster Management** **7 Lecture Hours**

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

Learning Experience

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

Instruction Methods:

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

Activities:

- **Case Studies & Group Work:** Students will analyse real-world problems related to environmental and disaster issues, working collaboratively on projects.
- **Field Visits:** Real-world observation of environmental and disaster management practices.

Assessments:

- **Formative:** Ongoing feedback through quizzes and online discussions.
- **Summative:** Exams, presentations, and case study reports to evaluate overall understanding and application of course content.

Support:

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

Textbooks

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

Suggested Readings

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

Open Educational Resources (OER)

1. OpenStax
2. Khan Academy
3. MIT OpenCourseWare
4. Coursera and edX

5. YouTube
6. Wikibooks
7. OER Commons
8. NOAA Education
9. UNEP Education
10. TED Talks

Evaluation Scheme:

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

SEMESTER I					
	Data Exploration and Analysis Using Excel	**L**	**T**	**P**	**C**
Version 2.0		**1**	**0**	**4**	**3**
Category of Course	**Skill Enhancement Course**				
Total Contact Hours	**45**				
Pre-Requisites/ Co-Requisites	**Basics of Computers**				

COURSE OBJECTIVES

The course will enable the student-teacher to:

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

COURSE OUTCOMES (CO)

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

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

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

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

COURSE CONTENT

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

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

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

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

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

- Creating Charts: Column, Bar, Pie, Line
- Customizing Charts: Titles, Labels, Legends, Colors
- Insert Sparklines and Data Bars
- Understanding and Creating Pivot Tables (Basic Level)
- Using Slicers for Interactivity in Pivot Tables
- Creating Simple Dashboards with Charts

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

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

Textbook

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

Suggested Reading

1. Robert de Levie (2004). *Advanced Excel for Scientific Data Analysis*

Open Educational Resources (OER)

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

Evaluation Scheme

Evaluation components	**Weightage**
Internal marks (Theory & Practical) **I. Continuous assessment** All the components to be evenly spaced Project/quizzes/assignment/Practical/class-participation	**40 Marks**
Mid Term	**20 Marks**
III. External Marks (Practical): End Term Examination	**40 Marks**

SEMESTER I					
	Instrumentation and Workshop Skills	**L**	**T**	**P**	**C**
Version 2.0		**0**	**0**	**4**	**2**
Category of Course	**Skill Enhancement Course**				
Total Contact Hours	**30**				
Pre-Requisites/ Co-Requisites	**Basics of Physics**				

Course Perspective

1. To develop proficiency in using basic measurement instruments and unit conversions.
2. To familiarize students with electronic components, circuit symbols, and soldering techniques.
3. To provide hands-on experience with electrical measurements using multimeters and oscilloscopes.
4. To enhance skills in designing and testing simple circuits including regulated power supplies.
5. To introduce foundational knowledge of PCB design and workshop tools.
6. To instill awareness of safety practices and interpretation of technical specifications.

Course Outcomes

CO1: Observing standard procedures and demonstrations related to measurement instruments, electronic components, and workshop tools.
CO2: Imitating the demonstrated techniques for measuring physical and electrical quantities, soldering components, and using CROs and multimeters.
CO3: Practicing essential laboratory skills such as assembling circuits, designing PCB layouts, testing power supplies, and safely handling tools and instruments to gain functional proficiency.

Course Content: List of Experiments

Exp. No	Experiment Title
1	Measure physical dimensions and convert between CGS and SI units.
2	Measure length, diameter, and depth of objects; calculate precision and least count.
3	Measure thickness of metal sheet and diameter of thin wire.
4	Determine volume of a cylindrical beaker
5	Solder R, L, C, Diode, and basic IC components on PCB board.
6	Measure resistance, voltage, current (AC/DC), and continuity testing.
7	Identify and color-code resistors, capacitors, and interpret simple circuit diagrams.
8	Interpret key specifications (range, accuracy, sensitivity).
9	Compare input impedance and sensitivity with analog voltmeter.
10	Identify parts and understand signal flow (theoretical with demo).

11	Measure small AC voltages and observe readings under various loads.
12	Design and test a 5V/12V regulated power supply using transformer, diode, capacitor, and regulator IC.
13	Design a simple PCB layout for a small circuit (e.g., power supply or LED flasher) using drawing or software like Fritzing.
14	Identify parts and functions of CRO (front panel controls, CRT).
15	Measure peak-to-peak voltage, frequency, and time period of waveforms.
16	Observe waveform capture, storage, and comparison with CRO.
17	Identify types of welding joints, materials used, and observe defects.
18	Introduction to machine shop tools and operations (demo-based).

Textbooks:

1. Textbook in Electrical Technology - B L Theraja - S Chand and Co.
2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.

Suggested Readings:

1. Logic circuit design, Shimon P. Vingron, 2012, Springer.
2. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
3. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.

Open Educational Resources (OER)

1. https://www.youtube.com/watch?v=kxKOU3hmNug
2. https://www.youtube.com/watch?app=desktop&v=dGtwItnYYqk

Evaluation Scheme

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

SEMESTER I					
SCPH104	**Mechanics**	**L** **4**	**T** **0**	**P** **0**	**C** **4**
Version1.0					
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Basic Physics and Mathematics**				

Course Perspective This course offers a comprehensive exploration of classical mechanics and relativity, covering fundamental dynamics, rotational motion, and harmonic oscillations. Students will gain a deep understanding of concepts such as energy conservation, rotational dynamics, and relativistic effects, and will apply these principles to solve complex physical problems. Emphasis is placed on analytical skills and practical applications, preparing students to tackle advanced topics in physics and engineering.

Course Outcomes

Upon completion of the course the learner will be able:

CO1: Understanding the concepts of inertial reference frames, Newton's Laws of Motion, different types of forces, energy interactions, collisions, principles of conservation of momentum and relativity.

CO2: Applying principles of translation and rotational dynamics to solve problems involving force, energy, momentum, torque, angular momentum, moment of inertia, elasticity and relativity.

CO3: Analyzing the motion of projectiles, rockets, systems of particles, centre of mass, relativistic effects, including time dilation, Lorentz contraction, and mass-energy equivalence.

CO4: Evaluating gravitational interactions, gravitational potential energy and central force motions, kinetic energy, potential energy, and total energy of an oscillating system to explain the concepts related to GPS and weightlessness, damping and resonance in real-world scenarios.

Course Content

UNIT-I Fundamentals of Dynamics 15 Lecture Hours

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by nonconservative forces. Law of Conservation of Energy.

Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

UNIT-II Rotational Dynamics and Gravitational motion 15 Lecture Hours

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involves both translation and rotation.

Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws.

Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

UNIT-III Oscillatory motion and Non-Inertial Systems 15 Lecture Hours

Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damp oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

UNIT-IV Special Theory of Relativity 15 Lecture Hours

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

Learning Experience

The course will be delivered through a combination of lectures, interactive demonstrations, and multimedia presentations to facilitate a comprehensive understanding of mechanics. Group discussions, and problem-solving workshops will provide practical applications of theoretical concepts. Regular quizzes, assignments, and project-based assessments will evaluate their grasp of the material. Additionally, support will be available through office hours, peer collaborations, and online forums, promoting a collaborative and resourceful learning environment.

Textbooks

1. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

Suggested Readings

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.

Open Educational Resources (OER)

1. https://www.fisica.net/mecanicaclassica/introduction_to_statics_and_dynamics_by_rudra_pratap.pdfhttps://www.fisica.net/mecanicaclassica/introduction_to_statics_and_dynamics_by_rudra_pratap.pdf
2. https://www.youtube.com/watch?v=W8_Vr7zzA84

Evaluation Scheme

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

SEMESTER II					
BSPHMP201	**Mathematical Physics-II**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Mathematical Physics-I**				

Course Perspective This course aims to demonstrate the use of mathematical techniques in solving problems in Physics and to provide a deeper understanding of the mathematics underpinning theoretical physics. The course is intended to develop the theory of errors, Fourier series, special functions and partial differential equations. Emphasis will be on illustrative examples from Physics and Engineering

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding Fourier series theory, including expansions and Parseval Identity.
CO2: Applying the Frobenius method and special functions (Legendre, Bessel, etc.) and separation of variables method to solve partial differential equations for various applications.

CO3: Analyzing special integrals like Beta and Gamma functions and their applications.

CO4: Evaluating errors, including systematic and random errors, and use least-squares fitting.

Course Content

UNIT-I Fourier Series 15 Lecture Hours

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

UNIT-I Frobenius Method and Special Functions 15 Lecture Hours

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality.

UNIT-III Integrals & Errors 15 Lecture Hours

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope andintercept of a fitted line.

UNIT-IV Partial Differential Equations **15 Lecture Hours**

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Learning experience

The learning experience in this course will involve a combination of theoretical understanding and practical application. Students will engage with mathematical techniques through lectures, problem-solving sessions, and hands-on exercises. They will apply Fourier series, special functions, and special integrals to real-world problems, and use software tools for error analysis and fitting. Practical exercises and assignments will help them understand and apply partial differential equations to physical scenarios, enhancing their problem-solving skills and mathematical proficiency.

Textbooks:

1. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.
2. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

Suggested Readings:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

Open Educational Resources (OER)

1. https://math.mit.edu/~gs/cse/websections/cse41.pdf
2. https://www.researchgate.net/publication/250156802_Notes_on_Special_Functions
3. https://ocw.mit.edu/courses/18-152-introduction-to-partial-differential-equations-fall-2011/resources/mit18_152f11_lec_01/

Evaluation Scheme

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

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

SEMESTER II					
BSPHWO202	**Waves and Oscillations**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Basic Physics**				

Course Perspective

This course offers a comprehensive foundation in oscillatory and wave phenomena, essential to understanding diverse physical systems in classical and modern physics. Beginning with simple harmonic motion and progressing through damped and forced oscillations, coupled systems, and wave propagation in various media, the course bridges theoretical concepts with real-world applications such as acoustics, molecular vibrations, resonance, and wave transmission. Emphasis is placed on mathematical modeling and physical interpretation to equip students with both conceptual clarity and problem-solving skills.

Course Outcomes

CO1: Understanding the principles of simple harmonic, damp, and forced oscillations, including resonance and energy dissipation.

CO2: Applying mathematical tools to solve problems involving coupled oscillators and wave propagation in different media.

CO3: Analyzing complex waveforms such as beats, Lissajous figures, and standing waves using the principle of superposition.

CO4: Evaluating the physical characteristics of waves (like impedance, dispersion, and group velocity) in solids, strings, and gases, and assessing their implications in real-world systems.

Course content

Unit 1: Simple Harmonic Motion **20 Lecture Hours**

Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle, rotating vector representation of simple harmonic oscillation, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring. Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2) equal frequency differences, Beats Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies, effect of variation of phase

Unit 2: Damped & Forced Oscillations **12 Lecture Hours**

Damped Oscillations: Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor

Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor

Unit 3: Coupled Oscillations **10 Lecture Hours**

Coupled oscillators, normal coordinates and normal modes, energy relation and energy transfer, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators.

Unit 4: Wave Motion **18 Lecture Hours**

The wave equation, transverse waves on a string, the string as a forced oscillator, characteristic impedance of a string, reflection and transmission of transverse waves at a boundary, impedance matching, insertion of quarter wave element, standing waves on a string of fixed length, normal modes and eigen frequencies. Energy in a normal mode of oscillation, wave groups, group velocity, dispersion, wave group of many components, bandwidth theorem, transverse waves in a periodic structure (crystal). Doppler effect, sound waves in gases, energy distribution in sound waves, intensity, specific acoustic impedance, longitudinal waves in a solid, Young's modulus, Poisson's ratio, longitudinal waves in a periodic structure, reflection and transmission of sound waves.

Textbooks

1. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
2. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

Suggested Readings

1. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

Evaluation Scheme

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

SEMESTER II					
BSPHWO252	**Waves and Oscillations Lab**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**2**	**1**
Category of Course	**Major**				
Total Contact Hours	**15**				
Pre-Requisites/ Co-Requisites	**Basic Physics**				

Course Perspective

This laboratory course is designed to introduce students to fundamental experiments in mechanics and oscillations, focusing on the practical determination of physical quantities like moments of inertia, acceleration due to gravity, and frequency. Through guided observation, imitation, and hands-on practice, students will develop core experimental skills, enhance their understanding of physical laws, and learn to operate standard laboratory apparatus such as the bar pendulum, flywheel, Melde's apparatus, tuning fork, and sonometer. The course aims to build a strong foundation in data collection, analysis, graph interpretation, and experimental reporting.

Course Outcomes

CO1: Observing and understanding the working principles of pendulums, oscillators, tuning forks, and coupled systems through demonstration and guided instruction.
CO2: Accurately setting up and performing standard mechanics and wave experiments by following procedural steps demonstrated by the instructor.
CO3: Independently conducting experiments, record observations, plot graphs, and calculate physical quantities such as moment of inertia, acceleration due to gravity, and frequency with precision and analytical reasoning.

Course Content

1. To plot a graph between the distance of the knife edge from the center of gravity and the time period of the bar pendulum. From the graph, find the acceleration due to gravity, the radius of gyration and the moment of inertia of the bar about an axis.
2. To determine the moment of inertia of a flywheel about its own axis of motion.
3. To plot a graph between the distance of the knife edge from the center of gravity and the time period of the bar pendulum. From the graph, find the acceleration due to gravity, the radius of gyration and the moment of inertia of the bar about an axis.
4. To determine the moment of inertia of a flywheel about its own axis of motion.
5. To determine the value of acceleration due to gravity using Simple pendulum
6. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ2 –T law.
7. To investigate the motion of coupled oscillators.
8. To study Lissajous Figures.
9. To study the relation between the length of a given wire and tension for constant frequency using a sonometer.

Learning Experience

The course will combine theoretical instruction with hands-on laboratory work to ensure an experiential and participatory learning experience. Lectures will introduce concepts such as wave interference and diffraction, while lab sessions will involve direct experimentation, including Melde's experiment, Lissajous figures, and various optical measurements. Students will actively set up experiments, collect and analyse data, and interpret results. Group discussions and collaborative projects will enhance engagement and problem-solving skills. Real-time troubleshooting and feedback will support practical understanding, making learning interactive and directly applicable to real-world scenarios in optics and materials science.

Textbooks
1. B. Sc. Practical Physics by Geeta Sanon
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

Suggested Readings
1. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

Open Educational Resources (OERs)

1. https://youtu.be/hwWPDqHFxOg
2. https://youtu.be/tnQn994Eqm8
3. https://youtu.be/e4poHiwoTH8
4. https://youtu.be/S3PiJ0PQghc
5. https://youtu.be/JvVOaqej1II
6. https://youtu.be/tQj5v74Q8p0
7. https://youtu.be/1Qc-HIml-U4

Evaluation Scheme

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

	Cyber Security	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Total Contact Hours	**60**				
Category of Course	**Value Added Course (MOOC)**				
Pre-requisites/Exposure	**Basic computer literacy**				
Co-requisites	**Mathematical Physics**				

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

considerations, social engineering, and national cyber initiatives, preparing learners to navigate the digital world responsibly and safely.

Course Outcome:

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

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

Course Content:

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

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

Unit 2: Device and Social Media Security

- Social Media Safety Guidelines and Best Practices
- Basic Windows Security and User Account Protection
- Smartphone Security (Android & iOS)
- Security of Micro ATMs, e-wallets, and POS Systems
- Online and Mobile Banking Security
- UPI and Credit/Debit Card Security

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

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

Unit 4: Cyber Security Infrastructure and Data Management

- National Cyber Security Initiatives
- Incident Handling and Assurance Practices
- Cyber Security Exercises

- Data Destruction and Recovery Tools
- Use of Tools like CCleaner for Secure Information Management

Books and references

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

Evaluation Scheme:

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

	Documentation using Latex	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**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

Unit-1 **8 Lecture Hours**

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

Unit 2 **7 Lecture Hours**

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

Unit-3 **8 Lecture Hours**

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

Unit-4 **7 Lecture Hours**

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

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.

Open Educational Resources (OER)

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

Evaluation Scheme

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

SEMESTER II					
BSCCPR205	**Project-I**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**0**	**2**
Category of Course	**Project**				
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Basic Scientific Knowledge**				

Course Perspective:

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

Course Outcomes:

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

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

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

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

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

Course Content:

Students may choose one of the following categories:

A. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.

B. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.

C. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.

D. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.

E. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.

F. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).

G. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

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

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

SEMESTER III					
BSPHMP301	Mathematical Physics-III	L 4	T 0	P 0	C 4
Version 1.0					
Category of Course	Major				
Total Contact Hours	60				
Pre-Requisites/ Co-Requisites	Mathematical Physics-I, II				

Course Perspective This course is crucial for developing advanced mathematical skills needed in engineering and science, focusing on complex analysis, Fourier, and Laplace transforms. It enhances problem-solving abilities essential for designing and analyzing systems in real-world applications like signal processing and control systems. Mastery of these techniques prepares students for technical careers and advanced studies, making them adept at addressing complex challenges in their fields.

Course Outcomes

Upon completion of the course the learner will be:

CO1: Understanding key concepts and formulas related to complex analysis, Fourier transforms, and Laplace transforms.

CO2: Applying Complex Algebra, Fourier and Laplace transforms to solve interdisciplinary problems in engineering and science.

CO3: Analysing the fundamental properties of complex functions, Fourier and Laplace transforms and explain their importance in solving problems.

CO4: Evaluating which transform is best suited for solving integrals and differential equations associated with a specific physical system.

Course Content

UNIT-I Complex Analysis 15 Lecture Hours

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts.

UNIT-II Functions of a Complex variable and Integrals Transforms 20 Lecture Hours

Integration of a function of a complex variable. Cauchy's Inequality. Cauchy’s Integral formula. Simply and multiply connected region. Laurent and Taylor’s expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Integrals Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral.

UNIT-III Fourier transform 10 Lecture Hours

Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

UNIT-IV Laplace Transform 15 Lecture Hours

Laplace Transform (LT) of Elementary functions. Properties ofLTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Learning Experience

The course will be conducted through a blend of lectures, PowerPoint presentations, and interactive discussions to ensure an engaging and practical experience. Students will use mathematical software and online resources to explore complex analysis, Fourier transforms, and Laplace transforms. They will participate in group projects, case studies, and problem-solving sessions to apply theoretical concepts to real-world problems. Regular assignments and exams will assess their understanding and application skills. Support will be provided through office hours, peer reviews, and collaborative activities, fostering a supportive learning environment where students are encouraged to seek help and collaborate.

Textbooks

1. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.

Suggested Readings

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence,3rd ed., 2006, Cambridge University Press.
2. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications.

Open Educational Resources (OER)

1. https://youtu.be/ysVcAYo7UPI
2. https://youtu.be/QiwfF83NWNA
3.https://www.coursera.org/lecture/complex-analysis/complex-functions koxdh?utm_source=link&utm_medium=page_share&utm_content=vlp&utm_campaign=top_button
4. https://youtu.be/OiNh2DswFt4
5. https://youtu.be/33TYoybjqPg

Evaluation Scheme

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

SEMESTER III					
BSPHSS302	**Solid State Physics**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**

Category of Course	**Major**
Total Contact Hours	**60**
Pre-Requisites/ Co Requisites	**Crystallography and Mathematical Physics**

Course Perspective

This course is intended to cover most of the basic topics of solid-state including Crystal Structure, Space groups, Packing fraction, Miller indices, defects in crystal, X-Ray Diffraction, Diamagnetism and Para-magnetism, Superconductivity. This course gives crystallographic knowledge and enables students to analyse the solid structures, which will also be beneficial for students in research field. The Solid-State Physics course is crucial for understanding the behavior of materials at the atomic level, a key aspect of both fundamental physics. It equips students with essential knowledge about crystal structures, electronic properties, and material design, which is directly applicable to careers in electronics, materials science, and nanotechnology. Mastery of these concepts enables students to innovate in fields like semiconductor technology and renewable energy, driving advancements in modern technology and research.

Course Outcomes

Upon completion of the solid-state physics course, the learner will be:

CO1: Understanding key concepts and principles of solid-state physics.

CO2: Applying theoretical models and principles to solve problems related to materials and their properties.

CO3: Analyzing experimental data and theoretical predictions to draw conclusions about material behaviours.

CO4: Evaluating different approaches and theories to understand their strengths and limitations in explaining solid state phenomena.

Course Content

Unit No I: Crystal Structure **15 Lecture Hours**

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: Magnetic Properties of Matter **15 Lecture Hours**

Classification of Magnetic materials - Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia magnetic materials, Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic domains. Discussion of B-H Curve, Hysteresis & Energy Loss, anti-ferromagnetism, ferrimagnetism.

Unit No III: Dielectrics Properties of Materials **15 Lecture Hours**

Types of Polarization, Local Electric Field at an Atom, static, Dielectric Constant, Electric Susceptibility, Polarizability, Classical Theory of Electric Polarizability, three vectors, Clausius-Mosotti Equation. Variation of dielectric polarization with temperature and frequency, pizo-pyro and ferroelectricity properties, domain theory of ferroelectricity, Complex Dielectric Constant, dielectrics in alternating fields, relaxation in dielectrics, absorption and losses, dielectric breakdowns.

Unit No IV: Superconductivity **15 Lecture Hours**

Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Learning Experience

The Solid-State Physics course will be delivered through lectures with multimedia tools, hands-on lab sessions, and virtual simulations. Students will engage in group projects, case studies, and problem-solving assignments to apply their knowledge. Technology such as simulation software will enhance learning, and regular quizzes, exams, and lab reports will assess progress. Support will be provided through office hours, peer reviews, and online discussion forums, promoting collaboration and active learning.

Textbooks

1. S O Pillai, Solid State Physics (New Age International Limited).

2. B.D. Cullity and C. D. Graham, Introduction to Magnetic Materials (John Wiley and Sons, Inc.)

Suggested Readings

1. B.D. Cullity, Elements of X-Ray Diffraction (Addison-Wesley Metallurgy Series).
2. Charles Kittel, Introduction to Solid State Physics (John Wiley and Sons, Inc.).
3. N. W. Ascroft and N. D. Mermin, Solid State Physics (Harcourt Asia, Singapore).
4. M. Ali Omar, Elementary solid-state physics: principles and applications (Pearson Education)

Open Educational Resources (OERs)

1. **https://youtu.be/5h5gXoFyo64**
2. **https://youtu.be/ax_rNTSI7ac**
3. **https://youtu.be/63cwdYXNlYE**
4. **https://youtu.be/sEGLcpmIIBY**
5. **https://youtu.be/XrTJUAyolvE**
6. **https://youtu.be/rkntp3_cZl4**
7. **https://youtu.be/WV2AexANG34**

Evaluation Scheme

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

SEMESTER III					
BSPHSS352	**Solid State Physics Lab**	**L**	**T**	**P**	**C**

Version 1.0		0	0	2	1
Category of Course	Major				
Total Contact Hours	15				
Pre-Requisites/ Co Requisites	Solid State Physics				

Course Perspective

This course imparts the basic knowledge of construction of materials, microscopically. The course deals with the factors and conditions which are required to determine various properties like dielectric constant, magnetic susceptibility, semiconductor properties. The course further delivers keen understanding of magnetism and its application in technology. The Solid-State Physics Laboratory course is crucial for B.Sc. (H) Physics students as it connects theoretical concepts with hands-on experience. It equips students with practical skills in experimental techniques, data analysis, and the application of solid-state physics principles. This knowledge is vital for careers in research, materials science, and engineering. The course also prepares students for real-world applications, such as developing new materials and improving electronic devices, making it a foundational component of their academic and professional development.

Course Outcomes

Upon completion of the solid-state physics course, the learner will be able:

CO1: Observing and describing experimental phenomena in solid state physics, demonstrating an ability to accurately record and interpret data.

CO2: Imitating standard experimental procedures and techniques, replicating established methods with attention to accuracy and detail (Applying).

CO3: Practising using laboratory instruments and techniques, refining their skills through repeated use and procedural application.

Course Content

List of experiments

1. To find the band gap of intrinsic semiconductor using four probe method.

2. To determine hysteresis loss using CRO.
3. To measure the dielectric constant of a dielectric material.
4. To study the variation of magnetic field with distance and to find the radius of coil.
5. To study V-I characteristics of PN diode.
6. To find the energy band gap of PN junction diode.
7. To determine the value of Planck's constant by photocell.
8. To find the value of Hall coefficient and carrier concentration of a semiconductor.
9. To measure the Magnetic field strength in solenoid.

Learning Experience

The Solid-State Physics Laboratory course will be conducted through hands-on experiments, utilizing advanced technology and simulation software to enhance learning. Students will engage in group work, case studies, and real-world applications to apply theoretical concepts. Assessments will include lab reports, presentations, and practical exams. Support and feedback will be provided by the course instructor, with opportunities for additional help and peer collaboration throughout the course. This approach ensures an experiential and participatory learning experience.

Textbooks

1. Solid State Physics, S.O.PIllai, New Age Publication.
2. Elements of X-Ray Diffraction, B.D. Cullity. Addison-Wesley Publishing Company.
3. Introduction to Magnetic Materials (2nd Edition), B.D. Cullity and C.D. Graham, Wiley (2009).

Suggested Readings

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
2. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer. Reference Books/Materials

Open Educational Resources (OER)

1. https://youtu.be/KU3c5WaEwkI
2. https://youtu.be/sSzpb6rOXx8
3. https://youtu.be/N9wyxXo-c30
4. https://youtu.be/_vKeaPHXF9U

5. https://youtu.be/NKYBc7u6hO4
6. https://youtu.be/gDFGj0Iodug
7. https://youtu.be/RA_wGkUBetU
8. https://youtu.be/2VkUMnl3dPk

Evaluation Scheme

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

SEMESTER III					
	Artificial Intelligence	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Valu Added Course**				
Total Contact Hours	**30**				
Pre-Requisites/ Co Requisites					

Course Perspective

AI for Sciences is a foundation-level course aimed at demystifying Artificial Intelligence for science students from non-computing backgrounds. The course presents AI not as a technical subject requiring programming, but as a powerful interdisciplinary tool with applications in everyday science and society. It emphasizes conceptual understanding, societal implications, and hands-on activities using graphical tools and simulations. The course empowers students to critically understand how AI works, how it is used in their domains, and how to ethically engage with AI systems in research and real life.

Real-World Applications:
- AI in weather prediction (Physics)
- AI in drug discovery and spectroscopy (Chemistry)
- AI in mathematical pattern recognition and graphing (Mathematics)

Course Outcomes

Upon completion of the course, students will be able to:
CO1: Understanding the fundamental concepts, evolution, and real-world applications of AI across disciplines.
CO2: Applying key AI techniques like machine learning, reasoning, and neural networks through graphical tools and examples.
CO3: Analyzing case studies in science where AI contributes to discovery and innovation.
CO4: Evaluating ethical, social, and environmental impacts of AI technologies and make informed decisions regarding their usage.

Course Content

Unit 1: Foundations of Artificial Intelligence **7 Lecture Hours**

- History and evolution of AI
- What is AI? Types: Narrow AI vs General AI
- AI applications in science: physics, chemistry, mathematics
- Intelligent agents, environments, and behavior

Unit 2: Machine Learning and Low-Code Tools **8 Lecture Hours**

- Concepts of data, patterns, and learning
- Supervised vs unsupervised learning
- Introduction to decision trees and clustering using GUI-based and low-code tools (e.g., Orange, Teachable Machine, AppSheet, Power Apps)
- Applications in science: classification of elements, predicting patterns, simulations

Unit 3: Intelligent Systems **7 Lecture Hours**

- Basics of neural networks: neurons, weights, activation
- Visualization tools to build and train simple networks
- Use-cases: image recognition, audio signals, object detection in science experiments
- Limitations and challenges of intelligent systems

Unit 4: Projects and Ethical Reflections **8 Lecture Hours**

- Student-led mini projects using low-code/graphical tools
- Interdisciplinary applications: physics, chemistry, mathematics
- Ethical reflections: bias, privacy, automation, sustainability
- Final presentations and group discussions on responsible AI

Textbooks:
1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education, 2021
2. Vinod Chandra S.S. & Anand Hareendran S., Artificial Intelligence: Foundations and Applications, PHI, 2014

Suggested Readings:
1. Melanie Mitchell, Artificial Intelligence: A Guide for Thinking Humans, Penguin, 2019
2. Nils J. Nilsson, The Quest for Artificial Intelligence, Cambridge University Press, 2010
3. John Haugeland, Artificial Intelligence: The Very Idea, MIT Press, 1985

Open Educational Resources (OER):
1. Elements of AI (https://www.elementsofai.com/)
2. Google Teachable Machine (https://teachablemachine.withgoogle.com/)
3. AI for Everyone – Andrew Ng (Coursera)

Evaluation Scheme

Evaluation Component	Weightage
I. Continuous Assessment (Quizzes, Assignments, Class participation, Project progress, Project Presentations – at least 5 components)	40 Marks
II. Midterm Test	20 Marks
End Term Examination (Written conceptual + application-based)	40 Marks

SEMESTER III					
	Self-Awareness	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Ability Enhancement Course**				
Total Contact Hours	**30**				
Pre-Requisites/ Co-Requisites					

Course Objectives (COs)

- **CO1:** understanding of the concept of self -Awareness and its psychological constructs (identity, values, beliefs etc.).
  CO2: Cultivate emotional intelligence, recognize cognitive patterns and improve emotional self-regulation.
  CO3: Explore personality frameworks and assess behavioral patterns for self-growth.

CO4: Analyze perception, motivation, and mindset for building resilience and purpose.

CO5: Embrace mindfulness and compassion practices and create a personal self-development plan.

Course Content:

Session	**Topic**	**Expanded Content Focus**	**Activities**
1	Introduction to Self-Awareness	Orientation to course structure, importance of self-awareness in personal and professional growth, stages of self-discovery.	Icebreaker + "Who Am I?" Exercise
2	Self-concept & Identity	Exploration of self-image vs ideal self, developing self-efficacy, understanding self-esteem levels, influence of locus of control on motivation and behavior.	"My Story" Reflection
3	Values and Beliefs	Identifying core personal values, understanding belief formation, how values influence decision-making and interpersonal relations.	Values Card Sort Activity
4	Johari Window & Self-Disclosure	Understanding open, blind, hidden, and unknown selves; significance of feedback, authenticity, and vulnerability in relationships.	Johari Peer Exercise
5	Emotions and Triggers	Identifying emotional states, recognizing emotional triggers, differentiating between emotions and ego responses, impact on self-regulation.	Emotional Trigger Diary

6	Cognitive Biases	Understanding cognitive distortions (confirmation bias, overgeneralization, etc.), ABCDE model of rational thinking, re-framing thoughts for clarity.	Bias Analysis Role-play
7	Emotional Intelligence	Goleman's EI domains: self-awareness, self-regulation, motivation, empathy, and social skills; application in real-life contexts.	EQ Test & Reflection
8	Personality Frameworks	Overview of Big Five, MBTI, and DISC models; understanding personality types and preferences; how personality shapes workplace and social behavior.	Personality Assessment
9	Habit Loops & Derailers	Anatomy of a habit: cue, routine, reward; analyzing habits that support/undermine goals; derailers and behavioral patterns.	Habit Tracker Activity
10	Coping & Defense Mechanisms	Common psychological coping strategies (avoidance, confrontation, reappraisal); understanding stress triggers and burnout symptoms; Freudian defense mechanisms.	Coping Style Inventory
11	Perception, Attitude and Attribution	How we perceive others, forming attitudes, attribution theory, and perceptual biases (halo effect, stereotyping); implications for communication and fairness.	Case Scenarios

12	Growth vs Fixed Mindset	Exploring Carol Dweck's mindset theory; neuroplasticity and learning; techniques to cultivate a growth mindset in academics and life.	Growth Mindset Workshop
13	Motivation Drives & Purpose	Understanding intrinsic vs extrinsic motivation, fatalistic vs Utopian perspective, aligning values and purpose to create a meaningful path. Resilience & Adaptability	Purpose Statement Writing
14	MSC Model & Mindfulness	Components of the MSC (Mindfulness, Selflessness, Compassion) model; benefits of mindfulness on focus and well-being; loving-kindness and gratitude practice.	Guided Meditation, Journaling
15	Goal Setting & Visioning	Setting SMART goals, using habit trackers, building a personal vision board, time and priority management strategies.	Vision Board Creation

Assessment Plan

Component	**Weightage**

Reflective Journal (Weekly)	20%
Personality & EQ Assessments	20%
Class Participation / Peer Feedback	10%
Self-Development Plan Presentation	30%
Final Quiz / Viva	20%

SEMESTER III					
BSCCPR305	**Project-II**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**0**	**2**
Category of Course					
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Basic Scientific Knowledge**				

Course Perspective:

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

Course Outcomes:

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

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

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

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

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

Course Content:

Students may choose one of the following categories:

H. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.

I. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.

J. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.

K. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.

L. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.

M. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).

N. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

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

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

SEMESTER III

BSPHIN306	**Evaluation of Summer Internship I**	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Internship**				
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Practical Exposure**				

Course Perspective:

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

Course Outcomes:

Upon completion of the course, the learner will be:

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

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

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

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

CO 5: Writing and presenting technical reports/articles.

Learning Experience:

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

Evaluation Scheme:

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

SEMESTER IV					
BSPHOP401	**Optics**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Basic Physics**				

Course Perspective:
This course introduces students to the fundamental principles of optics, focusing on the wave nature of light. It covers key topics such as interference, diffraction, polarization, and laser fundamentals. Classical experiments and applications like Newton's rings, Michelson interferometer, and diffraction gratings are discussed. The course also explores the production and analysis of polarized light and the working of optical instruments. Students will gain a strong conceptual understanding and practical insight into optical phenomena.

Course Outcomes:

Upon completion of the course, the learner will be:

1. Understanding the wave nature of light and explain phenomena such as interference, diffraction, and polarization using relevant physical principles.

2. Applying the concepts of wave optics to analyze experimental setups like Young's double-slit, Newton's rings, and diffraction through slits and gratings.

3. Analyzing the behavior of polarized light through optical elements like Nicol prisms and retarders and interpret their use in optical systems.

4. Evaluating the principles and working of different laser systems and their applications in scientific and technological contexts.

Course Content:

UNIT-I Interference of Light **15 Lecture Hours**

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.
Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.
Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

UNIT-II Diffraction of Light **12 Lecture Hours**
Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.
Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

UNIT-III Polarization
20 Lecture Hours

Introduction: polarised wave, Polarisation by reflection, Polarization by refraction, Polarization by scattering, Polarization by double refraction, Birefringent materials, Calcite crystals, Concept of optic axis, principal section, Nicol Prism, Polarizer and Analyser, Positive and Negative Crystals, types of polarised wave, Retarders, Production and detection of polarised light.

Unit-IV Laser **10**
Lecture Hours

Introduction to lasers and its properties, Interaction of light with matter, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Ruby Laser, He-Ne laser, Semiconductor lasers, Applications of Laser.

Textbooks

a) Ajoy Ghatak, Optics.
b) Dr. N. Subrahmanyam Brij Lal, A Textbook of Optics

Reference Books/Materials

a) Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
b) LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill

Open Educational Resources for Optics

1. Optics by Benjamin Crowell (Light and Matter series)
   A full, freely downloadable textbook covering geometric optics, wave optics, polarization, and lasers.
   🔗 https://www.lightandmatter.com/optics/

2. MIT OpenCourseWare – Physics III: Vibrations and Waves (includes optics modules)
   Offers lecture notes, assignments, and exams covering interference, diffraction, and polarization.
   https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/

3. OpenStax – College Physics
   Includes chapters on reflection, refraction, interference, diffraction, and polarization of light.
   🔗 https://openstax.org/books/college-physics/pages/27-introduction-to-geometric-optics

4. LibreTexts – University Physics Volume 3: Optics and Modern Physics
   Offers detailed chapters on wave optics, interference, diffraction, lasers, and polarization.
   https://phys.libretexts.org/Bookshelves/University_Physics/Book%3A_University_Physics_(OpenStax)/Volume_3%3A_Waves_Optics_and_Modern_Physics

5. PhET Interactive Simulations – University of Colorado Boulder Free simulations on wave interference, diffraction, and polarization – great for visual learning.
   🔗 https://phet.colorado.edu/en/simulations/category/physics/light-and-radiation

Evaluation Scheme:

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

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

SEMESTER IV					
BSPHOP451	**Optics Lab**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**2**	**1**
Category of Course	**Major**				
Total Contact Hours	**15**				
Pre-Requisites/ Co-Requisites	**Basic Physics**				

Course Perspective

This course provides hands-on experience with fundamental optical experiments involving interference, diffraction, and the use of precision instruments like the Michelson interferometer, diffraction grating, and Newton's Rings setup. Students will explore and understand the wave nature of light through experimental determination of wavelength, refractive index, angle of prism, dispersive and resolving power, and the thickness of thin films. The course aims to enhance analytical thinking, data interpretation, and the ability to conduct error analysis.

Course Content

1. To determine angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the wavelength of He-Ne Laser.
4. To determine dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine the wavelength of sodium source using Michelson's interferometer.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
8. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
9. To determine dispersive power and resolving power of a plane diffraction grating.

Textbooks

1. B. Sc. Practical Physics by Geeta Sanon

2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

Suggested Readings

1. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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**

SEMESTER IV					
BSPHET402	**Electromagnetic Theory**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Basic Electrodynamics, Calculus**				

Course Perspective This course provides a comprehensive introduction to the fundamental principles of electromagnetism, crucial for any physics student. Understanding electromagnetic theory is essential for pursuing advanced studies in physics, engineering, and related fields. This course will help students develop problem-solving skills and a deep understanding of physical laws governing electric and magnetic fields. It is applicable in various real-world contexts, including electrical engineering, telecommunications, and material science. Students will learn to apply theoretical concepts to practical situations, such as designing electrical circuits and understanding electromagnetic waves.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding and listing Maxwell's equations and fundamental concepts of electromagnetism.
CO2: Solving practical problems related to electromagnetic wave propagation in different media using appropriate mathematical techniques.
CO5: Analyzing the laws of electromagnetic induction, including Faraday’s and Lenz’s laws, and the role of Maxwell’s equations in the description of electromagnetic waves and energy flow.
CO4: Evaluating and dissecting complex boundary value problems involving electric and magnetic fields to identify underlying principles and patterns.

Course Content

Unit 1: Electrostatics **12 Lecture Hours**
Electric Field and Potential: Definition of electric field and electric potential. Calculation of electric field due to point charges, dipoles, and continuous charge distributions. Electric field lines, equipotential surfaces. Work done by electric forces, electric potential energy. **Gauss's Law**: Statement of Gauss's law, its application to various symmetrical charge distributions (plane, spherical, and cylindrical symmetries). Differential and integral forms of Gauss’s law. Electric flux, Gauss's law in dielectric media. **Capacitance and Dielectrics**: Capacitors and capacitance, calculation of capacitance for simple geometries (parallel plate, spherical, cylindrical). Energy stored in a capacitor. Dielectrics and their properties, electric susceptibility, dielectric constant, energy in the presence of dielectrics.

Unit 2: Magnetostatics **15 Lecture Hours**

Magnetic Field and Magnetic Forces: Biot-Savart law, calculation of magnetic field due to currents (straight wire, circular loop, solenoid). Lorentz force law, force on a moving charge in a magnetic field. Magnetic dipole moment, torque on a magnetic dipole. **Ampere's Law**: Ampere's circuital law and its applications to various geometries (infinite wire, solenoid, toroid). Differential and integral forms of Ampere's law. Magnetic vector potential. **Magnetic Materials**: Magnetization, magnetic susceptibility, and permeability. Diamagnetic, paramagnetic, and ferromagnetic materials. Hysteresis and magnetic domains.

Unit 3: Electrodynamics **15 Lecture Hours**

Faraday's Law of Induction: Faraday's law and Lenz's law. Induced EMF and electric fields. Self-inductance and mutual inductance. Energy stored in magnetic fields, inductors in circuits. **Maxwell's Equations**: Derivation and physical interpretation of Maxwell's equations in free space and in matter. Displacement current, continuity equation, and the modification of Ampere's law. Poynting vector and the flow of electromagnetic energy. **Electromagnetic Waves**: Wave equation in free space, plane electromagnetic waves. Propagation of electromagnetic waves in vacuum and in dielectrics. Energy and momentum of electromagnetic waves, radiation pressure.

Unit 4: Applications of Electromagnetic Theory **15 Lecture Hours**

Radiation from Accelerated Charges: Larmor formula for power radiated by an accelerated charge. Radiation from a dipole antenna, Hertzian dipole. Electromagnetic radiation and its spectrum. **Relativistic Electrodynamics**: Introduction to special relativity, Lorentz transformations. Relativistic transformation of electric and magnetic fields. Covariant formulation of Maxwell's equations. Applications of relativistic electrodynamics, relativistic motion in electromagnetic fields.

Learning Experience

The course will be conducted through a mix of lectures, interactive sessions, and problem-solving workshops. Technology such as online resources will be used to enhance learning. Students will engage in group work, case studies, and practical assignments. The course will also include laboratory sessions to provide hands-on experience with electromagnetic measurements. Regular feedback and support will be available through office hours, and peer reviews will foster collaborative learning.

Textbooks

1. "Introduction to Electrodynamics" by David J. Griffiths, 4th Edition, Pearson (2017)
2. "Classical Electrodynamics" by John David Jackson, 3rd Edition, Wiley (1998)

Suggested Readings

1. "Electricity and Magnetism" by Edward Purcell and David Morin, 3rd Edition, Cambridge University Press (2013)
2. "Principles of Electrodynamics" by Melvin Schwartz, Dover Publications (2013)

Open Educational Resources (OER)

1. MIT Open Course Ware - Electromagnetic Theory: https://ocw.mit.edu/courses/physics/8-02-electromagnetism-spring-2016/Khan Academy - Electricity and Magnetism:
2. https://www.khanacademy.org/science/physics/electricity-and-magnetism

Evaluation Scheme:

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

SEMESTER IV					
BSPHMO403	**MODERN PHYSICS**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				

Total Contact Hours	60
Pre-Requisites/ Co-Requisites	Electromagnetism

Course Perspective – This course offers students a deep understanding of the principles governing atomic and subatomic particles. It builds a strong foundation in key concepts such as atomic structure, wave-particle duality, and nuclear transformations, which are essential for advanced studies and research in physics. The course enhances students' critical thinking and problem-solving skills through the exploration of historical experiments and theoretical models. It also provides practical knowledge applicable in industries like nuclear energy, healthcare, and technology. This course is a stepping stone for those pursuing advanced studies or careers in physics, engineering, and related fields.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding key concepts in atomic and nuclear physics, including atomic structure, wave-particle duality, and nuclear reactions.

CO2: Analyzing experimental evidence supporting atomic models and theories, like Rutherford's experiment and the Bohr model.

CO3: Applying quantum mechanics and nuclear principles to solve problems related to atomic spectra, nuclear transformations, and energy production.

CO4: Evaluating the impact of atomic and nuclear phenomena on real-world applications, such as energy production and medical imaging.

Course Content

UNIT-I Structure of the Atom 15 Lecture Hours

Rutherford's Experiments on Scattering of α-particles; Theory of α-particle Scattering; Bohr Atom Model; Effect of Nuclear Motion on Atomic Spectra; Evidences in Favour of Bohr's Theory; Correspondence Principle; Critical Potentials; Sommerfeld's Relativistic Atom Model; The Vector Atom Model; Quantum Numbers Associated with the Vector Atom Model; The Pauli Exclusion Principle; The Periodic Classification of Elements; Magnetic Dipole Moment due to Orbital Motion of the Electron; Magnetic Dipole Moment due to Spin; Zeeman Effect; Larmor's Theorem; Stark Effect.

UNIT-II Particle and Wave properties of Waves 15 Lecture Hours

Particle properties of Waves: Electromagnetic waves, Blackbody Radiation, Photo-electric effect, Einstein's Photoelectric Equation, Compton scattering, pair production, photons and gravity.

Wave properties of the Particles: De Broglie waves, description of wave, Probability. Wave amplitude and wave functions, Group and Phase velocities and relation between them, Davisson-Germer experiment, Heisenberg uncertainty principle.

UNIT-III Nuclear Transformations 15 Lecture Hours

stability of the nucleus; Law of radioactive decay; Mean life and half-life; types of radioactive decays, Alpha decay; Beta decay, Gamma ray emission, positron emission and electron capture, radioactive series, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus, nuclear reactions and Q values.

Nuclear Fission: Energy Released in Fission; Chain Reaction; Atom Bomb; Nuclear Reactors; Nuclear Fusion, Source of Stellar Energy; Thermonuclear reactions

UNIT IV Artificial Transmutation of Elements 15 Lecture Hours

The Discovery of Artificial Transmutation; Bohr's Theory of Nuclear Disintegration, nuclear reactions; The Q-Value Equation for a Nuclear Reaction; Nuclear Reactions; Energy Balance in Nuclear Reactions and the Q-value; Threshold Energy of an Endoergic Reaction; Nuclear Transmutations; The Scattering Cross-Section; Discovery; Preparation of Radioelements; Applications of Radioisotopes; The Discovery of the Neutron; Basic Properties of the Neutron. Classification of Neutrons; Neutron Sources; Neutron Detection; Neutron Collimator.

Learning Experience

The course content will be made experiential and participatory through a blend of interactive lectures, hands-on experiments, and collaborative projects. Students will engage in simulations and lab experiments that replicate key historical experiments, such as Rutherford's scattering experiment and the Davisson-Germer experiment, allowing them to directly observe the principles they learn. Group discussions and problem-solving sessions will encourage collaborative learning, where students can apply theoretical knowledge to real-world scenarios. Additionally, students will participate in peer-led seminars and presentations, fostering a deeper understanding of complex concepts like quantum mechanics and nuclear transformations. By incorporating these experiential activities, the course will not only reinforce theoretical understanding but also develop critical thinking, problem-solving skills, and teamwork, ensuring a well-rounded and engaging learning experience.

Textbooks

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Modern Physics (17^{th} Ed.), 2013, S. Chand & Company Pvt. Ltd.

Suggested Readings

1. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
2. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
3. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
4. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan 2002.

Open Educational Resources (OERs)

1. https://www.youtube.com/live/uFF_ptEDN0o?feature=share
2. https://youtu.be/3It49x562b0
3. https://youtu.be/UyWXOIK0uSg
4. https://youtu.be/QpXIPPln3Ig
5. https://youtu.be/Hpn5G1FiuCs
6. https://youtu.be/Lhxx2jQmLH4
7. https://youtu.be/PNBk5LjweEk

Evaluation Scheme

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

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

SEMESTER IV					
	Communication & Personality Development	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Ability Enhancement Course**				
Total Contact Hours	**30**				
Pre-Requisites/ Co-Requisites					

Course Perspective:

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

Course Outcomes:

Upon completion of the course, the learner will be:

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

CO 2: Understand the framework of Communication to augment oratory skills and written English

CO 3: Cultivate essential soft skills required at different workplaces.

Course Content

Unit 1: Developing self and others **8 Lecture Hours**

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

Unit 2: Enhancing Reading and Writing Skills **6 Lecture Hours**

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

Unit 3: Effective Communication and Public Speaking **7 Lecture Hours**

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

Unit 4: Career Guide and readiness **15 Lecture Hours**

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

Learning Experience:

The course will be conducted using experiential and participatory methods such as interactive workshops, group discussions, and practical exercises. Students will engage in self-assessment tools, collaborative writing, and public speaking drills to develop critical skills. Hands-on activities like mock interviews, resume writing, and capstone projects will provide real-world career preparation. Continuous peer feedback and role-playing will enhance communication, teamwork, and problem-solving abilities.

Textbooks:

1. Talking to Strangers – Malcom Gladwell
2. Fierce Conversation - Scot Susan
3. Public Speaking - William S. Pfeiffer, Pearson

4. Soft Skills for Everyone – Jeff Butterfield
5. Business Communication – Rajendra Pal, J S Korlahalli
6. The power of Positive Attitude -Roger Fritz
7. Believe in Yourself – Dr. Joseph Murphy

Suggested Readings:

1. Websites & MOOCs
   i. www.16personalities.com
   ii. www.tonyrobbins.com
2. Specific Research Papers
   i. GALLUP PRESS RESEARCH
   ii. FRANKLIN COVEY LEADERSHIP CENTRE
3. Videos
   i. The 7 Habits of Highly Effective People, Dr. Stephen R. Covey
   ii. I Am Not Your Guru, Tony Robbins
4. Podcast
   i. The Tim Ferriss Show
5. Magazines
   i. SUCCESS Magazine
6. Journals
   i. The IUP Journal of Soft Skills

Evaluation Scheme:

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

SEMESTER IV

BSCCPR405	Project-III	L	T	P	C
Version1.0		**0**	**0**	**0**	**2**
Category of Course					
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Basic Scientific Knowledge**				

Course Perspective:

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

Course Outcomes:

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

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

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

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

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

Course Content:

Students may choose one of the following categories:

O. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.

P. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.

Q. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.

R. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.

S. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.

T. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).

U. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

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

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

SEMESTER V					
BSPHTS501	**Thermodynamics and Statistical Mechanics**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Classical Mechanics**				

Course Perspective This course offers a comprehensive understanding of both thermodynamics and statistical mechanics, bridging classical and quantum perspectives. It equips students with the skills to apply thermodynamic and statistical principles to solve real-world problems, including those involving energy conversion, radiation, and quantum gases. Through this course, students will gain critical thinking skills, enabling them to analyze complex physical systems and apply theoretical concepts to practical scenarios, which are crucial for careers in physics and engineering.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding laws of thermodynamics and Bose-Einstein and Fermi-Dirac statistics to understand quantum gases and related phenomena like Bose-Einstein condensation and electron behaviour in metals.

CO2: Applying laws of thermodynamics and Statistical mechanics to solve problems related to involving entropy, energy conversion, heat engines, macrostate, microstate, and partition functions.

CO3: Analyzing the limitations of classical physics and the necessity for quantum statistical approaches in describing physical systems

CO4: Evaluating the behavior of complex physical systems, such as photon gases and electron gases, using Bose-Einstein and Fermi-Dirac statistics, and **assess** their real-world applications.

Course Content

UNIT-I Zeroth and First Law of Thermodynamics 15 Lecture Hours

Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

UNIT-II Second Law of Thermodynamics 15 Lecture Hours

Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work, Heat Engines, Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin- Planck and Clausius Statements and their Equivalence. Carnot's Theorem, Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy, Entropy of a perfect gas, Entropy Changes in Reversible and Irreversible processes with examples, Entropy of the Universe, Temperature–Entropy diagrams for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.

UNIT-III Classical Statistics 15 Lecture Hours

Macrostate & Microstate, Elementary Concept of Ensemble, PhaseSpace, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System.

UNIT-IV Bose-Einstein & Fermi-Dirac Statistics 15 Lecture Hours

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas.

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas.

Learning Experience This course will employ lectures, problem-solving sessions, and interactive group activities. Students will engage in hands-on learning through problem sets and group projects. The course will be supported by online resources and active discussions. Assessments will include midterms, a final exam, and graded problem sets.

Textbook:

1. Thermal Physics, Agarwal and Prakash, Pragati Prakashan Educational Publishers.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall

4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and
5. Gerhard L. Salinger, 1986, Narosa.
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

Open Educational Resources (OER)

1. https://byjus.com/physics/thermodynamics/
2. https://www.youtube.com/watch?v=8N1BxHgsoOw
3. https://www.youtube.com/watch?v=NyOYW07-L5g
4. https://www.youtube.com/watch?v=8xRFqrNyJCg&list=PLyqSpQzTE6M9iXvWVCopr67kKt61ntzIl
5. https://www.youtube.com/watch?v=Qz5D2bUQk4c&list=PLQCYtYck4nKwkiEyJ_mzuzz9aQla1Kvdh
6. https://www.youtube.com/watch?v=o1EinUCgFsw&list=PL74Pz7AXMAnOSPWBIzmZOpSs2KgchH3dP

Evaluation Scheme:

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

SEMESTER V					
BSPHAS502	**Analog Systems and Applications**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				

Pre-Requisites/ Co-Requisites	Basics of Electronics

Course Perspective

This course provides a focused study of semiconductor devices and their applications in electronic circuits. Starting with the fundamentals of PN junction diodes, students will explore their characteristics and applications in rectification and voltage regulation. The course then moves to bipolar junction transistors, covering their configurations, amplifier design, and analysis techniques. Emphasis is placed on feedback mechanisms and oscillator design, essential for understanding stability and signal generation in circuits. Finally, students will study operational amplifiers, learning their characteristics and diverse applications, including amplification and analog-to-digital conversion, equipping them with the skills to analyze and design basic electronic circuits.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding the experimental procedures and theoretical concepts by studying the key variables, equipment, and principals involved in each experiment.

CO2: Applying their theoretical knowledge by performing experiments, using laboratory equipment, and executing procedures accurately to obtain and interpret experimental results.

CO3: Analyzing experimental data and observations to identify trends, correlations, and anomalies, applying critical thinking to interpret results and derive meaningful conclusions.

CO4: Evaluating the effectiveness and accuracy of experimental methods and results, making informed decisions to refine techniques and improve overall experimental outcomes.

Course Contents

UNIT I Semiconductor Diodes 15 Lecture Hours

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift Velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

UNIT II Transistors & Amplifiers 15 Lecture Hours

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

UNIT III Feedback In Amplifier 15 Lecture Hours

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

UNIT IV Operational Amplifiers 15 Lecture Hours

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical OpAmp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

Applications for Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).

Learning Experience

The learning experience in this course will be both theoretical and hands-on, providing students with a robust understanding of semiconductor devices and their applications. Through detailed lectures and practical labs, students will explore the operation of diodes and transistors, analyze amplifier circuits, and design feedback systems and oscillators. Interactive exercises and real-world problem-solving will enhance their ability to apply theoretical concepts to practical circuit design and analysis. By working with operational amplifiers and various electronic components, students will develop the skills needed to tackle complex electronic challenges and gain a solid foundation for advanced studies in electronics.

Textbooks

1. Robert Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 8Th Edition, Pearson Education, India.
2. Albert P. Malvino, David J. Bates. Electronic Principles, Eighth Edition, McGraw-Hill Education, United States.

Suggested Readings

1. Electronic Communication, Rudy and Cohlen (Prentice Hall).
2. Semiconductor Devices Physics & Technology by S. M. Sze (John Wiley).

Open Educational Resources (OER)

1. https://www.electronics-tutorials.ws/
2. https://nptel.ac.in/courses/108102112
3. https://nptel.ac.in/courses/108105158
4. https://www.learningelectronics.net/
5. https://www.youtube.com/watch?v=XG3cVoUh7wc&list=PLs5_Rtf2P2r674CTMNJ3odeHk9Wtb-WWl
6. https://www.youtube.com/watch?v=EdUAecpYVWQ&list=PLwjK_iyK4LLBVM18VZ7JKW-q88FAtnr8_

Evaluation Scheme

Evaluation components	Weightage
Internal marks (Theory) **I. Continuous assessment**	**40 Marks**

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

SEMESTER V					
BSPHPE503	**Applied Optics**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Category of Course	**Major**				
Pre-requisites/ Co-requisites	**Waves and Optics**				

Course Perspective:

This course aims to provide students with a foundational and applied understanding of modern optical techniques and technologies. It integrates theoretical concepts and practical applications of fiber optics, holography, Fourier optics, and optical instruments, enabling students to explore contemporary advancements in imaging, communication, and spectroscopy. The course develops both conceptual clarity and analytical ability for applying optical methods in scientific and industrial settings.

Course Outcomes

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

CO1: Understanding the principles of optical fiber propagation, holography, Fourier optics, and optical instruments.

CO2: Applying optical concepts to describe the working of fiber communication systems, holograms, 4F systems, and advanced microscopes.

CO3: Analyzing light behavior through lenses, filters, and optical fibers to interpret spatial filtering, image formation, and aberration effects.

CO4: Evaluating the performance and limitations of optical devices and systems (like FTIR, electron microscopes, and eyepieces) based on their principles and applications.

Course Content

Unit 1 Fibre Optics **15 Lectures**

Introduction to Optical fibres and their properties, Principal of light propagation through a fibre, Modes of Propagation, Acceptance Angle, Acceptance Cone, Fractional Refractive Index Change, Numerical aperture, Types of Optical Fibres, Attenuation in Optical Fibres, Applications, Fibre Optics Communication System.

Unit-2 Holography **15 Lectures**

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection

hologram, application of holography in microscopy, interferometry, and character recognition

Unit-3: Fourier Optics **15 Lectures**

Concept of Fourier Transform, Spatial frequency filtering and Introduction to Fourier Optics. Fourier transforming property of a thin lens, 4F OPTICAL System, Application- Lens as a fourier transformer, 4f optical System, Understanding Spatial Filtering in a 4f System, Image Processing in a 4f Optical System, Applications of Spatial Filtering in a 4f System

Fourier Transform Infrared Spectroscopy: Introduction to Infrared Spectroscopy, Construction and working of FTIR Spectrophotometer, Role of Fourier Transform in FTIR, Spectral Analysis and Applications of FTIR Spectroscopy

Unit-4 Optical Instruments and Aberration in Images **15 Lectures**

Optical Instruments: Introduction, Human eye, Field of view, need of multiple lens eyepieces, Ramsden's Eyepiece, Huygen's Eyepiece, Gaussian's Eyepiece, Comparisons of Pieces, Spectrometer, Electron Microscope.

Aberration in Images: Introduction, Aberration in images, Chromatic Aberration of Lens, Achromatic Aberration of lens, Monochromatic Aberration, Spherical Mirrors, Other Monochromatic Aberration and their Elimination, Schmidt Correction Plate, Oil Immersion Lens

Textbooks:

a) Ajoy Ghatak, Optics.
b) Dr. N. Subrahmanyam Brij Lal, A Textbook of Optics

Reference Books:

Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.

Nonlinear Optics, Robert W. Boyd, 2008, Elsevier.

Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press

Evaluation Scheme

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

SEMESTER V					
BSPHCD504	**Classical Dynamics**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Basic Mathematical Physics**				

Course Perspective

This course offers essential insights into advanced mechanics, including classical mechanics, Hamiltonian dynamics, special relativity, and fluid dynamics. By mastering these topics, students will gain critical skills in solving complex problems, from particle motion in electromagnetic fields to relativistic effects and fluid behaviour. These concepts are foundational for further studies in physics and engineering, as well as for careers in research, technology, and applied sciences. Understanding these principles is crucial for designing systems and technologies across various industries, making this course vital for academic and professional development.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Understanding and articulating fundamental principles and theories of advanced mechanics, explaining their applications and relevance to real-world phenomena.

CO2: Applying theoretical models and equations to solve practical problems, demonstrating proficiency in using physics principles in various contexts.

CO3: Analyzing experimental data and physical systems, interpreting results to identify patterns, relationships, and anomalies, and making informed conclusions based on their analysis.

CO4: Evaluating different methodologies and approaches, assessing their effectiveness and accuracy in solving complex problems, and making necessary adjustments to enhance problem-solving strategies.

Course Contents

UNIT I Classical Mechanics of Point Particles 20 Lecture Hours

Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyro radius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler- Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators

UNIT II Hamiltonian formulation 10 Lecture Hours

Canonical momenta & Hamiltonian. Hamilton's equations of motion. Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N-identical masses connected in a linear fashion to (N -1) - identical springs.

UNIT III Special Theory of Relativity **20 Lecture Hours**

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Spacetime diagrams. Time -dilation, length contraction and twin paradox. Four vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four momentum and energy-momentum relations. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

UNIT IV Fluid Dynamics **10 Lecture Hours**

Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

Learning Experience

This course will be conducted through a dynamic blend of lectures, discussions, and integrating technology to enhance learning. Assignments and presentations will challenge students to apply and communicate their understanding creatively. Regular quizzes, exams, and timely feedback will assess and guide their progress. Support will be readily available from the course instructor, and peer collaboration will be encouraged to enrich the learning experience, ensuring students receive comprehensive support and opportunities for growth.

Textbooks

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.

2. Classical Mechanics, J.C. Upadhyaya, 2nd Edn. 2005, Himalaya Publishing House

Suggested Readings

1. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.

2. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.

3. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.

4. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.

Open Educational Resources (OER)

1. https://en.wikipedia.org/wiki/Spacetime_diagram
2. https://en.wikipedia.org/wiki/Four-force
3. https://www.researchgate.net/profile/Mohamed_Mourad_Lafifi/post/In_a_robust_control_system_design_using_mixed-sensitivity_approach_the_sensitivity_is_constant_at_0_db_isnt_is_supposed_to_be_high-pass_filter/attachment/59d63ab079197b8077997c75/AS:407064284286977@1474063096225/download/NotesCh12+Coupled+Oscillators+and+Normal+Modes.pdf
4. https://mathsci.kaist.ac.kr/~nipl/am621/lecturenotes/Euler-Lagrange_equation.pdf

Evaluation Scheme

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

SEMESTER V					
BSPHNP505	**Nuclear Physics**	**L** **4**	**T** **0**	**P** **0**	**C** **4**
Version1.0					

Category of Course	**Major**
Total Contact Hours	**60**
Pre-Requisites/ Co-Requisites	**Basic Physics**

Course Perspective This course offers a comprehensive study of nuclear physics, focusing on the fundamental properties and behaviours of atomic nuclei, radioactivity, and nuclear reactions. Students will delve into the intrinsic properties of nuclei, including mass, charge density, and binding energy, and explore various nuclear models to understand nuclear stability. The course also covers the principles of radioactive decay processes—alpha, beta, and gamma decay—providing students with theoretical and practical insights into nuclear transformations. Additionally, students will examine the interaction of nuclear radiation with matter, including ionization and radiation detection methods. Emphasis is placed on both theoretical concepts and practical applications, equipping students with the knowledge and skills to analyze and measure nuclear phenomena effectively and prepare them for advanced studies and careers in nuclear science and related fields.

Course Outcomes

Upon completion of the course the learner will be:

CO1: Understanding general properties of nuclei, including constituents, mass, radii, charge density, binding energy, and the main features of nuclear models like the liquid drop model and semi-empirical mass formula.

CO2: Applying their understanding of radioactivity to analyze α-decay, β-decay, and γ-decay processes, including using decay theories and kinematics to solve related problems.

CO3: Analyzing nuclear reactions by applying conservation laws, calculating Q-values, and evaluating reaction rates and cross sections, distinguishing between compound and direct reactions as well as resonance reactions.

CO4: Evaluating the performance and efficiency of different nuclear radiation detectors, such as ionization chambers, GM counters, and scintillation detectors, based on their principles of operation and practical applications.

Course Content

Unit I: Nuclei Properties & Nuclear Model **15 Lecture Hours**

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability.

Unit II: Radioactivity decay **15 Lecture Hours**

Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β- decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

Unit III: Interaction of Nuclear Radiation with matter **15 Lecture Hours**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction,

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

Unit IV: Detector for Nuclear Radiations **15 Lecture Hours**

Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particles and photon detection (concept of charge carrier and mobility), neutron detector

Learning Experience

The course will be delivered through a combination of lectures, and interactive demonstration sessions to ensure a comprehensive understanding of nuclear physics concepts and techniques. Group discussions, problem-solving exercises, and project-based assessments will facilitate collaborative learning and the application of concepts to real-world scenarios. Regular quizzes, class test and assignments will assess students' grasp of the material and their ability to apply theoretical principles. Additional support will be available through office hours, study groups, and online resources, promoting an interactive and supportive learning environment.

Textbooks:

1. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.

Suggested Readings:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

Open Educational Resources (OER)

1. https://www.youtube.com/watch?v=MnPJgXyXHW8
2. https://www.youtube.com/watch?v=RTlThUySwUE
3. https://www.youtube.com/watch?v=Rd0CJje59bE
4. https://www2.lbl.gov/abc/wallchart/chapters/03/2.html

Evaluation Scheme

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

SEMESTER V					
	Arithmetic Reasoning and Skills-III	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Ability Enhancement Course**				

Total Contact Hours	30
Pre-Requisites/ Co-Requisites	

Course Perspective:

The course aims to improve basic arithmetic skills, speed, and accuracy in mental calculations, and logical reasoning. These abilities are essential for a strong math foundation, helping students succeed in academics and various practical fields.

Course Outcomes:

Upon completion of the course, the learner will be:

CO1: Understanding arithmetic algorithms required for solving mathematical problems**.**

CO2: Applying arithmetic algorithms to improve proficiency in calculations.

CO3: Analyzing cases, scenarios, contexts and variables, and understanding their inter-connections in each problem.

CO4: Evaluating & deciding approaches and algorithms to solve mathematical & reasoning problems.

Course Content

Unit I: Mathematical Essentials 12 Lecture Hours

Traditional Indian Calculation methods, Number types and divisibility principles, Practical uses of Percentage in calculating changes and discount, understanding Ratio and Proportion in everyday context.

Unit II: Fundamentals of Logical Reasoning 9 Lecture Hours

Blood Relations, Direction Sense, Coding Decoding

Unit III: Elementary Quantitative 15 Lecture Hours

Simple and Compound Interest in everyday situations like loans, investment, Practical problems involving Averages, Real life examples and scenarios involving Partnership

Unit IV: Reasoning Skills **11 Lecture Hours**

Introduction to reasoning, logical reasoning, Analytical reasoning, deductive reasoning, Inductive reasoning, Abductive reasoning, Reasoning in Communication, reasoning in decision making, Reasoning in Research and analysis

Learning Experience:

The course will be conducted using experiential and participatory methods such as practical problem-solving sessions, group discussions, and real-life applications. Students will practice traditional Indian calculation techniques and apply mathematical concepts like percentages, ratios, and interest to everyday situations. Logical and analytical reasoning skills will be developed through exercises in blood relations, direction sense, and reasoning techniques. Case studies and scenarios will help students apply reasoning to communication, decision-making, and research contexts, ensuring hands-on learning and active participation.

Textbooks:

i. Guha Abhijit: Quantitative Aptitude for Competitive Examinations, Tata McGraw Hill Publication
ii. Quantitative Aptitude by R.S. Aggarwal
iii. Verbal & Non-Verbal Reasoning by R.S. Aggarwal

Suggested Readings:

i. **https://www.indiabix.com/online-test/aptitude-test/**
ii. **https://www.geeksforgeeks.org/aptitude-questions-and-answers/**
iii. **https://www.hitbullseye.com/**

Evaluation Scheme:

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

SEMESTER V					
BSPHIN506	**Evaluation of Summer Internship II**	**L**	**T**	**P**	**C**
Version 1.0		**2**	**0**	**0**	**2**
Category of Course	**Internship**				
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Practical Exposure**				

Course Perspective:

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

Course Outcomes:

Upon completion of the course, the learner will be:

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

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

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

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

CO 5: Writing and presenting technical reports/articles.

Learning Experience:

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

Evaluation Scheme:

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

SEMESTER VI					
BSPHDS601	**Digital Systems and Applications**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Major (Discipline Specific Elective)**				
Total Contact Hours	**60**				
Pre-Requisites/ Co Requisites	**Digital Electronics**				

Course Perspective

This course is intended to cover most of the basic topics of digital electronics including Number systems, Logic gates and logic families,Boolean Algebra and Simplification, Arithmetic circuits, Data Processing Circuits, various Flip - flops , Clocks And Timers and Shift registers & counters. This course gives the circuit knowledge to students and students will be even able to start their start-ups. Course will also be beneficial for students in day-to-day life. The Digital Systems and Applications Theory course is crucial for B.Sc (H) Physics students as it integrates digital logic and circuit design with physics concepts, preparing them for careers in technology. Students will gain skills in designing and analyzing digital systems, which are essential for developing advanced technologies and solving real-world problems. This course provides a strong foundation for careers in electronics, computing, and research, applying theoretical knowledge to practical applications like embedded systems and signal processing.

Course Outcomes

Upon completion of the solid-state physics course, the learner will be:

CO1: Understanding the basic concepts of digital systems and logic design.

CO2: Applying digital logic principles to solve practical problems and design digital systems.

CO3: Analyzing and break down digital circuits and systems to understand their operation and performance.

CO4: Evaluating different digital design methods to choose the most effective solutions.

Course Content

Unit No I: Number Systems **15 Lecture Hours**

Decimal, binary, octal and hexadecimal systems - conversion from one number system to another. Codes - BCD code - Excess 3 code, Gray code ,Binary arithmetic - Binary addition - subtraction , 1's and 2's complement - Binary multiplication and division.

Unit No II: Boolean Algebra Simplification of Logic circuits **15 Lecture Hours**

Laws and theorems of Boolean algebra - De Morgan's theorems and their circuit implications - Duality theorem, simplification of Boolean equations – sum of products method (SOP), product of sums methods (POS) Karnaugh map(K Map) - pairs, quads, octets - 2,3 and 4 variables ,Reduction of POS using K Map.

Unit No III: Combinational Logic Circuits **15 Lecture Hours**

Arithmetic building blocks - Half adder - Full adder - parallel binary adder - Half subtractor - Full subtractor - The adder-subtractor - digital comparator - parity checker / generator , Multiplexers – Demultiplexers, Decoders.

Unit No IV: Sequential Logic Circuits **15 Lecture Hours**

Flip - flops - RS Flip Flop - Clocked RS Flip-flop - D flip-flop - JK flip-flop - JK master slave flip-flop - T type flip-flop registers and counters: Types of registers - serial in serial out - serial in parallel out - parallel in serial out - parallel in parallel out - ring counter.

Learning Experience

The Digital Systems and Applications Theory course will be conducted through interactive lectures, hands-on circuit design activities, and simulations using digital design software. Students will engage in group projects, real-world case studies, and assignments to apply and reinforce their knowledge. Assessments will include quizzes, projects, and exams, with regular feedback provided by the instructor. Students will have opportunities for additional support and collaboration through peer reviews and group work, enhancing their learning experience.

Textbooks

1. Malvino and Leech, Digital Principles and Application, 4th edition, Tata McGraw Hill, New Delhi.

Suggested Readings

1. Millman and Halkias, Integrated Electronics, International edition, McGraw Hill, New Delhi.
2. Thomas L. Floyd, Digital Fundamentals (Universal Book Stall, India).

Open Educational Resources (OER)

1. https://cnx.org/contents/85c4b2c4-2b3b-4b73-b36a-3e76a9b8c506@1
2. https://www.mathsisfun.com/binary-decimal-hexadecimal.html
3. https://www.geeksforgeeks.org/digital-electronics-binary-coded-decimal/
4. https://www.khanacademy.org/computing/computer-science/algorithms/boolean-algebra
5. https://www.youtube.com/playlist?list=PLBlnK6fEyqRhX6r2uhhlubuF5QextdCSM
6. https://www.allaboutcircuits.com/textbook/digital/chpt-9/combinational-logic-functions/
7. https://www.youtube.com/playlist?list=PLBlnK6fEyqRjMH3mWf6kwqiTbT798eAOm
8. https://www.youtube.com/playlist?list=PLBlnK6fEyqRhFUZX8d6GwI5H5frkZT2lk

Evaluation Scheme

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

SEMESTER VI					
BSPHDS651	**Analog & Digital Systems Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**2**	**1**
Category of Course	**Major (Discipline Specific Elective) Lab**				
Total Contact Hours	**15**				
Pre-Requisites/ Co Requisites	**Basic of Analog & Digital Electronics**				

Course Perspective

This course is intended to cover most of the basic topics of digital electronics including Number systems, Logic gates and logic families, Boolean Algebra and Simplification, Arithmetic circuits, Data Processing Circuits, various Flip - flops, Clocks and Timers and Shift registers & counters. This course gives the experimental and circuit knowledge to students which will be beneficial for students in day-to-day life.

Course Outcomes

Upon completion of the course, the learner will be:

CO1: Observing and describing phenomena related to digital systems, demonstrating the ability to accurately record and interpret data from various experiments and applications.

CO2: Imitating standard procedures and techniques used in digital systems and applications, replicating established methods with attention to accuracy and detail.

CO3: Practicing utilizing digital tools and techniques, refining their skills through hands-on experience with digital circuits, systems, and applications.

Course Content

List of experiments

1. Verification of the truth tables of TTL gates.
2. Verify the NAND and NOR gates as universal logic gates.
3. Design and verification of the truth tables of Half and Full adder circuits.
4. Design and verification of the truth tables of Half and Full subtractor circuits.
5. Verification of the truth table of the Multiplexer 74150.
6. Verification of the truth table of the De-Multiplexer 74154.
7. Design and test of an S-R flip-flop using NOR/NAND gates.
8. Verify the truth table of a J-K flip-flop (7476).
9. Verify the truth table of a D flip-flop (7474).
10. Operate the counters 7490, 7493.
11. Design of 4-bit shift register (shift right).
12. Design of modulo-4 counter using J K flip flop.

Learning Experience

The Digital Systems and Applications Laboratory course will be delivered through a hands-on approach, incorporating the use of advanced digital tools, simulation software, and hardware components to enhance practical learning. Students will actively participate in group projects, case studies, and real-world scenarios to apply theoretical concepts to practical problems. Assessments will include lab reports, technical presentations, and practical examinations. The course will provide continuous support and feedback from the instructor, along with opportunities for additional assistance and collaboration with peers. This approach ensures an engaging and interactive learning environment, fostering both individual and collaborative skills in digital systems and applications.

Textbooks:

1. Malvino and Leech, Digital Principles and Application, 4th edition, Tata McGraw Hill, New Delhi.

Suggested Readings:

1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI

Open Educational Resources (OER):

1. https://www.youtube.com/watch?v=47u7b2yh7s8&pp=ygUsdmVyaWZpY2F0aW9uIG9mIHRydXRoIHRhYmxlcyBvZiBsb2dpYyBnYXRlcyA%3D
2. https://www.youtube.com/watch?v=lqN8xLTtdaA&pp=ygVeMy4JRGVzaWduIGFuZCB2ZXJpZmljYXRpb24gb2YgdGhlIHRydXRoIHRhYmxlcyBvZiBIYWxmIGFuZCBGdWxsIGFkZGVyIGFuZCBzdWJ0cmFjdG9yIGNpcmN1aXRzLg%3D%3D
3. https://www.youtube.com/watch?v=SYTDxdACf2E&pp=ygVeMy4JRGVzaWduIGFuZCB2ZXJpZmljYXRpb24gb2YgdGhlIHRydXRoIHRhYmxlcyBvZiBIYWxmIGFuZCBGdWxsIGFkZGVyIGFuZCBzdWJ0cmFjdG9yIGNpcmN1aXRzLg%3D%3D
4. https://www.youtube.com/watch?v=ap0RMkqHWHQ&pp=ygU1My4JMTIuCURlc2lnbiBvZiBtb2R1bG8tNCBjb3VudGVyIHVzaW5nIEogSyBmbGlwIGZsb3A%3D
5. https://www.youtube.com/watch?v=Ub1VixA-uSE&pp=ygU1My4JMTIuCURlc2lnbiBvZiBtb2R1bG8tNCBjb3VudGVyIHVzaW5nIEogSyBmbGlwIGZsb3A%3D
6. https://www.youtube.com/watch?v=q_W_qBnOZvw&pp=ygUxMTEuCURlc2lnbiBvZiA0LWJpdCBzaGlmdCByZWdpc3RlciAoc2hpZnQgcmlnaHQpLg%3D%3D
7. https://www.youtube.com/watch?v=GJ8xxaIoIJ0&pp=ygUfT3BlcmF0ZSB0aGUgY291bnRlcnMgNzQ5MCwgNzQ5Mw%3D%3D
8. https://www.youtube.com/watch?v=p6yPvw88BJk&pp=ygUhSW50cm9kdWN0aW9uIHRvIE11bHRpcGxleGVyIDc0MTUw
9. https://www.youtube.com/watch?v=QKLWSs3z0C4&pp=ygUiUy1SIGZsaXAtZmxvcCB1c2luZyBOT1IvTkFORCBnYXRlcw%3D%3D

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**

SEMESTER VI					
BSPHPE602	**Physics of Earth**	**L**	**T**	**P**	**C**
Version1.0		**4**	**1**	**0**	**5**
Category of Course	Major (Discipline Specific Elective)				
Total Contact Hours	75				
Pre-Requisites/ Co-Requisites	Basic knowledge of origin of life and universe				

Course Perspective

This course imparts an understanding of the main aspects of the origin of earth, components of universe-galaxies and solar system. It assesses the dynamical processes –cyclones, earthquake, Tsunami, weather and climatic changes as well as the different cycles of Biosphere. It coherently introduces the geology and geomorphology of Indian subcontinent, timeline of major geological and biological events and future of evolution of the Earth and solar system: death of the Earth. The course also discusses the effect of population growth and other human activities degrading the planet for future existence.

Course Outcomes

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

CO1: Understanding the origin and structure of the Earth, universe, and the interconnected spheres—geosphere, hydrosphere, atmosphere, cryosphere, and biosphere.

CO2: Applying fundamental concepts from astronomy, geology, oceanography, and meteorology to describe Earth's dynamic systems and their interactions.

CO3: Analyzing the causes and effects of Earth's internal and surface dynamical processes such as plate tectonics, volcanic activity, earthquakes, ocean currents, and atmospheric circulation.

CO4: Evaluating geological and climate-related data to interpret evolutionary changes, geochronological timelines, and the impact of natural and anthropogenic changes on Earth's systems.

Course Content

Unit I

The Earth and the Universe: **30 Lecture Hours**

Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. (b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. (c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background.

Structure:

The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior? (b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems. (c) The Atmosphere: variation of temperature, density and composition with altitude, clouds. (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers. (e) The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

Unit II **30 Lecture Hours**

Dynamical Processes: (a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; seafloor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types. (b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of air-sea interaction; wave erosion and beach processes-Tides. Tsunamis. (c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones. Climate: i. Earth's temperature and greenhouse effect. ii. Paleoclimate and recent climate changes. iii. The Indian monsoon system. (d) Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

Unit III Evolution: **20 Lecture Hours**

Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent. 1. Timeline of major geological and biological events. 2. Origin of life on Earth. 3. Role of the biosphere in shaping the environment. 4. Future of evolution of the Earth and solar system: Death of the Earth. (18 Lectures)

Unit IV **10 Lecture Hours**

Disturbing the Earth – Contemporary dilemmas

(a) Human population growth. (b) Atmosphere: Greenhouse gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion. (d) Geosphere: Chemical effluents, nuclear waste. (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

Reference Books

Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.

Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books

Holme's Principles of Physical Geology. 1992. Chapman & Hall.

Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Learning Experience

The course will be conducted through a mix of interactive lectures, hands-on laboratory experiments, and collaborative problem-solving sessions. Lectures will introduce theoretical concepts, while lab sessions will allow students to explore quantum phenomena through practical experiments, such as measuring energy levels and analyzing atomic spectra. Group discussions and workshops will encourage students to apply their knowledge to real-world scenarios and complex quantum systems. Interactive simulations and visualizations will help in understanding abstract concepts like wave functions and potential wells. This approach ensures that learning is experiential and participatory, bridging theoretical knowledge with practical applications.

Evaluation Scheme

Evaluation components	**Weightage**

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

SEMESTER VI					
BSPHQM603	**Quantum mechanics and Applications**	**L**	**T**	**P**	**C**
Version1.0		**4**	**0**	**0**	**4**
Category of Course	**Major**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Mathematical Physics**				

Course Perspective: This course is crucial for students as it builds a solid foundation in quantum mechanics, a cornerstone of modern physics. Students will develop analytical and problem-solving skills by understanding wave functions, Schrödinger equations, and quantum systems like atoms in magnetic fields. This knowledge is essential for careers in research, technology, and applied physics, with real-world applications in quantum computing, nanotechnology, and spectroscopy. By mastering these concepts, students will be well-prepared for advanced studies and professional roles in cutting-edge scientific and technological fields.

Course Outcomes

Upon completion of the course the learner will be:

CO1: Understanding key quantum mechanics principles, including the Schrödinger equation, wave functions, and probability densities.

CO2: Applying the knowledge and solve problems involving particle behaviour in potential wells, harmonic oscillators, and hydrogen-like atoms using quantum mechanics.

CO3: Analysing quantum systems, interpreting wave functions, energy levels, and quantum numbers, and predicting outcomes like the Zeeman effect.

CO4: Evaluating quantum principles in scenarios like atoms in magnetic fields, assessing spin, angular momentum, and the Pauli exclusion principle.

Course Content

Unit 1: Wave Function and Schrodinger equation 20 Lecture Hours

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension: wave packets, momentum space wavefunction (qualitative discussion); Position-momentum uncertainty principle.

Unit 2: General discussion of bound states in an arbitrary potential 13 Lecture Hours

continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions; Hermite polynomials; ground state, zero-point energy & uncertainty principle.

Unit 3: Quantum theory of hydrogen-like atoms 12 Lecture Hours

time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells.

Unit 4: Atoms in Electric & Magnetic Fields 15 Lecture Hours

Space quantization- Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment, Stern- Gerlach Experiment. Zeeman Effect, Gyromagnetic Ratio and Bohr Magneton. (8 Lectures)

Atoms in External Magnetic Fields: - Normal Zeeman Effect. Paschen Back (Qualitative Discussion only).

Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions, Fine structure. Spin orbit coupling-LS and JJ coupling. Spectral Notations for Atomic State- Term symbols, Total angular momentum, Vector Model, Hund's Rule.

Learning Experience

The course will be conducted through a mix of interactive lectures, hands-on laboratory experiments, and collaborative problem-solving sessions. Lectures will introduce theoretical concepts, while lab sessions will allow students to explore quantum phenomena through practical experiments, such as measuring energy levels and analyzing atomic spectra. Group discussions and workshops will encourage students to apply their knowledge to real-world scenarios and complex quantum systems. Interactive simulations and visualizations will help in understanding abstract concepts like wave functions and potential wells. This approach ensures that learning is experiential and participatory, bridging theoretical knowledge with practical applications.

Textbooks

1. Introduction to Quantum Mechanics, D.J Griffith, Prentice Hall (1994).

2. Advanced Quantum Mechanics, Satya Prakesh, Kedarnaath Ramnaath (2016)

Suggested Readings

1. Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.

2. Advanced Quantum Mechanics, B,S, Rajput, Pragati Prakashan (2004)

3. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.

4. Quantum Mechanics, Eugene Merzbacher, 2004, John Wiley and Sons, Inc.

Open Educational Resources (OER)

1. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/
2. https://online.stanford.edu/courses/soe-ycphysics0002-quantum-mechanics
3. https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics
4. https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/
5. https://ocw.uci.edu/courses/chem_131a_quantum_principles.html
6. https://openstax.org/details/books/university-physics-volume-3

Evaluation Scheme

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

SEMESTER VI					
BSCCRM606	**Research Methodology**	**L**	**T**	**P**	**C**
Version1.0		**3**	**0**	**0**	**3**
Category of Course	**Major**				
Total Contact Hours	**45**				

Pre-Requisites/ Co-Requisites	None

Course Perspective: This course equips undergraduate science students with core research skills, including literature review, experimental design, data collection and analysis, and understanding of research ethics. It introduces learners to qualitative and quantitative methods and supports the development of critical thinking and problem-solving abilities for academic and applied research.

Course Outcomes

By the end of the course, students will be able to:

CO1: Understanding fundamental research concepts, including theory, hypothesis, variable, sampling, and ethics.
CO2: Applying appropriate research design methods and sampling techniques to structure basic research inquiries.
CO3: Analysing, organizing, comparing, and interpreting data using descriptive and inferential statistical methods.
CO4: Evaluating the credibility and ethical considerations in literature and research practices.
CO5: Creating structured research proposals, design experiments, and present data and conclusions effectively.

Course Content

Unit I: Introduction to Research and Fundamentals **6 Lecture Hours**

- Meaning, objectives, and motivation for research
- Characteristics of scientific research
- Concepts: theory, hypothesis, concept, construct, variable
- Empiricism, deductive and inductive reasoning
- Types and definitions of research: basic vs. applied; theoretical vs. empirical

Unit II: Research Design **6 Lecture Hours**

- Elements of research design
- Types: Exploratory, Descriptive, Experimental
- Variables: Independent, Dependent, Controlled
- Causality, generalization, replication
- Qualitative vs. Quantitative approaches
- Merging the two or more approaches.

Unit III: Literature Review and Sources of Information **8 Lecture Hours**

- Primary, secondary, and tertiary sources
- Abstracts, reviews, monographs, encyclopaedias, handbooks
- Chemical and scientific databases: ScienceDirect, PubMed, Scopus
- Citation metrics: impact factor, h-index, citation index
- How to identify high-quality publications and authorship standards
- Ethics in Literature Review

Unit IV: Sampling Techniques and Data Collection **10 Lecture Hours**

- Concepts: population, sample, sampling frame
- Sampling methods: simple random, stratified, systematic, multi-stage
- Sample size determination, sampling error
- Types of data: qualitative, quantitative
- Data collection tools: questionnaires, observations, interviews

Unit V: Data Analysis and Interpretation **15 Lecture Hours**

- Descriptive statistics: mean, median, mode, standard deviation, variance
- Graphical representation: bar charts, pie charts, histograms
- Inferential statistics: hypothesis testing, Chi-square test
- Analysis of variance (SPSS), regression, correlation
- Designing experiments and analyzing residuals
- Data interpretation and reporting findings

Learning Experience

The course will be conducted through a mix of interactive lectures, collaborative problem-solving sessions and following experiential learning activities:

Unit	Activities
Unit I	Concept mapping of research types and components
Unit II	Group discussions on ethical case studies
Unit III	Guided literature survey and reference evaluation
Unit IV	Sampling simulations and mock data collection
Unit V	Manual statistical analysis and interpretation of lab-generated data

Textbooks

1. Kothari, C.R. – *Research Methodology: Methods and Techniques*, New Age International
2. Panneerselvam, R. – *Research Methodology*, Prentice Hall of India

Suggested Readings

1. Kumar, R. – *Research Methodology: A Step-by-Step Guide for Beginners*
2. Hibbert, D.B. & Gooding, J.J. – *Data Analysis for Chemistry*
3. Moore, D.S. – *Introduction to the Practice of Statistics*
4. Ruxton, G.D. & Colegrave, N. – *Experimental Design for the Life Sciences*
5. Bryman, A. & Bell, E. – *Business Research Methods*

6. Heiman, G.W. – *Basic Statistics for the Behavioral Sciences*
7. Creswell, J.W. – *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*

Open Educational Resources (OER)

1. **https://www.coursera.org/learn/research-methodologies**
2. **https://www.coursera.org/learn/analysis-and-interpretation-of-data**
3. **https://www.coursera.org/learn/research-methods**
4. **https://www.coursera.org/learn/qualitative-research-methods-capturing-rich-insights**

Evaluation Scheme

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

SEMESTER VI					
BSCCPR605	**Project-IV**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**0**	**2**
Category of Course					
Total Contact Hours					
Pre-Requisites/ Co-	**Basic Scientific Knowledge**				

Requisites	

Course Perspective:

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

Course Outcomes:

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

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

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

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

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

Course Content:

Students may choose one of the following categories:

V. Working Model – A tangible prototype demonstrating a scientific or mathematical concept.

W. Research-Based Project – Experimental or theoretical investigations on current or fundamental topics.

X. Innovative Project – Development of a novel product, method, or idea addressing real-world issues.

Y. Skill-Based Project – Projects based on learned technical or laboratory skills, data analysis, or instrumentation.

Z. Entrepreneurship Project – Business or product-based idea with feasibility analysis and prototype.

AA. Interdisciplinary Project – Integration of knowledge across subjects (e.g., Physics + Forensics, Chemistry + Biology).

BB. The project output may vary in form—physical models are welcome but not mandatory. Projects may also involve codebases, data analyses, curated studies, or exploratory concept development.

Evaluation Scheme:

Each project will be evaluated on the following:

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

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

SEMESTER VI					
	Managing People and Organizations	**L**	**T**	**P**	**C**
Version1.0		**2**	**0**	**0**	**2**
Category of Course	**Ability Enhancement Course**				
Total Contact Hours	**30**				
Pre-Requisites/ Co-Requisites					

Course Objectives (COs)

CO1: Understand and apply the principles of Transactional Analysis for effective interpersonal interactions.

CO2: Develop interpersonal communication skills and enhance empathy, assertiveness, and social awareness.

CO3: Demonstrate teamwork, collaboration, and feedback processing in group settings.

CO4: Analyze and manage conflict, trust, and influence in professional relationships.

CO5: Understand organizational behavior through motivation, culture, leadership, and negotiation strategies.

Course Content

Session	Topic	Expanded Content Focus	Activities
1	Introduction to People Skills	Overview of course scope, importance of self-awareness and interpersonal effectiveness in academic and professional life. Introduction to people-centered behavior and workplace relevance.	Icebreaker + Group Values Exercise
2	Transactional Analysis (TA) Basics	Introduction to Eric Berne's model. Understanding Parent, Adult, and Child ego states; identifying types of transactions (complementary, crossed, ulterior); recognizing life positions (I'm OK – You're OK).	TA Role-play, Ego Quiz
3	Strokes & Life Positions	Concepts of recognition hunger, positive and negative strokes, impact of internal dialogue. Reaffirming life positions and fostering self-worth through conscious reinforcement.	Self-reflection sheet
4	Assertive vs Aggressive	Differentiating passive, aggressive, and assertive styles. Identifying behavioral cues and practicing verbal/non-verbal assertiveness techniques for conflict-free expression.	Assertiveness Practice Drill
5	Interpersonal Communication	Emphasis on active listening, empathetic feedback, and perspective-taking. Understanding barriers to communication and how empathy influences team behavior.	Empathy Circles
6	Relationships & Social Behavior	Exploring trust-building, establishing healthy boundaries, social contracts, and relational transparency. Recognizing signs of toxic vs supportive social behavior.	Case-based Discussion

7	Group & Team Dynamics	Exploring Tuckman's stages of team development (Forming, Storming, Norming, Performing). Role's people play in teams, synergy, and team cohesion.	Team Exercise – Marshmallow Challenge
8	Effective Teams & Feedback	Identifying feedback blind spots, Johari Window application, effective feedback loops. Emphasizing constructive critique, peer appreciation, and growth mindset.	360° Feedback Activity
9	Conflict Styles & Resolution	Thomas-Kilmann Conflict Mode Instrument (TKI): Competing, Avoiding, Accommodating, Collaborating, Compromising. Application of conflict resolution models in personal and professional settings.	Conflict Style Quiz + Scenario Roleplay
10	Influence & Trust	Examining influence mechanisms (authority, credibility, reciprocity), power dynamics, and the behavioral science behind trust-building in interpersonal and team contexts.	Trust Fall + Influence Mapping
11	Collaboration & Motivation	Dissecting intrinsic vs extrinsic motivators. Applying Maslow's and Herzberg's theories. Understanding motivational alignment in team and leadership settings.	Motivation Self-test
12	Psychological Safety	Understanding team psychological safety, signs of burnout, and emotional triggers. Encouraging vulnerability, shared goals, and inclusive culture for open communication.	Psychological Safety Diagnostic

13	Organizational Culture	Defining organizational culture and subculture. Analyzing Google vs Amazon work culture case to understand morale, inclusivity, and value systems.	Culture Case Study: Google vs Amazon
14	Leadership & Change	Exploring leadership styles (transformational, servant, transactional), managing people through change, resistance management, and emotional intelligence in leadership.	Leadership Styles Activity
15	Negotiation & Persuasion	Introduction to BATNA, ZOPA, and Harvard's principles of negotiation. Understanding influence tactics and win-win frameworks in professional settings.	Mock Negotiation Simulation

Assessment Structure

Component	Weightage
Peer Feedback & Team Activities	20%
Conflict Case Analysis	15%
Communication Skills Practical	15%
Organizational Behaviour Reflection	20%
Final Simulation (Leadership or Negotiation)	30%

Suggested Readings & Resources

- Eric Berne – *Games People Play*
- Dale Carnegie – *How to Win Friends and Influence People*
- Patrick Lencioni – *The Five Dysfunctions of a Team*

- Harvard Business Review – *On Emotional Intelligence*, *On Teams*

SEMESTER VI					
	Hands on in Robotics with Arduino	**L**	**T**	**P**	**C**
Version 1.0		**1**	**0**	**4**	**3**
Total Contact Hours	**45**				
Category of Course	**Skill Enhancement Course**				
Pre-requisites/ Co-requisites	**Basic of Electronics**				

Course Perspective:

Hands-on robotics with Arduino equips learners with foundational technical skills, practical experience, and creative problem-solving abilities, preparing them for diverse careers in technology, engineering, and innovation-driven industries.

Course Outcomes (COs):

CO1: Understanding the fundamentals of robotics and the Arduino platform.

CO2: Developing and implementing Arduino programs to control electronic components.

CO3: Interfacing and utilizing various sensors to acquire and process data.

CO4: Controlling different types of motors (DC, Servo, Stepper) for robotic motion.

CO5: Designing and building simple autonomous robots using sensor feedback.

Course Content

Unit 1: Fundamentals of Arduino and Basic Electronics 15 Lecture Hours

Introduction to Robotics: Concepts, applications, and scope, Overview of Arduino platform: Boards, IDE installation, and setup. Basic Arduino programming: Digital I/O, Analog I/O, blinking LED example, Basic electronics concepts: Voltage, current, resistance, breadboard usage

Sensor’s introduction:

IR sensor for obstacle detection, Light sensor (LDR) for light intensity measurement

Serial communication & debugging

Real-World Project:

Automatic Room Light Controller Using LDR Sensor

- Detect ambient light and automatically switch LED or relay ON/OFF
- Applies sensor reading and actuator control

Unit 2: Motor Control and Sensor-Based Robotics 15 Lecture Hours

Motors: DC motor, Servo motor, Stepper motor basics, Motor driver (L298N) for direction and speed control, PWM control for speed modulation, Ultrasonic sensor (HC-SR04): working principle and interfacing, Robot motion control concepts, Sensor integration for obstacle avoidance and line following.

Real-World Projects:

- **Line Following Robot**

  Use IR sensors to follow a path automatically

- **Obstacle Avoidance Robot**

  Navigate autonomously by detecting and avoiding obstacles

Unit 3: Wireless Communication, Integration, and Final Project 15 Lecture Hours

Wireless communication fundamentals: Bluetooth (HC-05) module, Interfacing Bluetooth with Arduino, Remote control of robots via smartphone apps, integrating sensors, actuators, and wireless modules, Debugging and project optimization, Final project planning and implementation

Real-World Projects:

- **Bluetooth Controlled Robot Car**

  Remote control robot with obstacle avoidance capability

- **Mini Smart Robot Assistant**

  Robot that reacts to environmental changes and remote commands

- **Custom Project**

  Design and build a robot solving a practical problem (e.g., delivery robot)

Recommended Textbooks / Resources

1. "Introduction to Robotics: Mechanics and Control" – by John J. Craig
2. "Arduino Robotics" – by John-David Warren, Josh Adams & Harald Molle
3. "Introduction to Autonomous Robots" – by Nikolaus Correll et al.

SEMESTER VII					
BSPHAM701	**Atomic and Molecular Physics-I**	**L**	**T**	**P**	**C**
Version1.0		**3**	**0**	**0**	**3**
Category of Course	**Major**				

Total Contact Hours	45
Pre-Requisites/ Co-Requisites	Basics of Atomic Structure

Course Perspective:

The course "Atomic and Molecular Physics" is integral to the Physics curriculum, serving as a foundational pillar in understanding the behaviour of atoms and molecules, which are essential in various fields of physics, chemistry, and material science. Students will gain a deep understanding of atomic models, quantum mechanics, and molecular structures, which are critical for careers in research, technology development, and advanced studies in physical sciences. This course enables students to apply theoretical knowledge to real-world problems such as spectroscopy, laser technology, and quantum computing. For instance, knowledge of atomic spectra is essential in fields like astrophysics and the development of new materials. By mastering the concepts taught in this course, students will be well-prepared to engage in cutting-edge research and innovation in both academic and industrial settings.

Course Outcomes

Upon completion of the course the learner will be:

CO1: Understanding the fundamental models of the atom, including Rutherford, Bohr, Sommerfeld, and quantum models, and their applications in explaining atomic spectra.
CO2: Applying quantum mechanical principles to analyze the effects of magnetic fields on atomic spectra and understand phenomena such as the Zeeman effect.
CO3: Analyzing the production, characteristics, and applications of X-rays, including Laue's experiment, Bragg's law, and X-ray absorption spectra.
CO4: Evaluating the quantum statistical approaches for understanding molecular bonding, rotational and vibrational energy levels, and their applications in spectroscopy.

Course Content

Unit I: Atom Models **15 Lecture Hours**

Rutherford scattering experiment and the nuclear model of the atom, size of the nucleus, atomic spectra and spectral series. Bohr model of the atom: energy levels and spectral series, line spectra, discovery of deuterium, correspondence principle, nuclear (reduced) mass and its effect of the atomic spectra: discovery of deuterium, positronium and muonic atom energy levels compared to hydrogen energy levels, critical potentials, atomic excitation, Franck-Hertz experiments. Sommerfeld relativistic model and fine structure of hydrogen. Quantum (Vector) model of the hydrogen atom (no derivation) and quantum numbers, principal quantum number, orbital quantum number, magnetic quantum number, probabilistic electronic orbits (radial and angular), radiative transitions, selection rules.

Unit II: Many Electron Atoms 15 Lecture Hours

Effect of Magnetic Fields and Many Electron Atoms: Normal Zeeman effect, gyro-magnetic ratio, Bohr magneton, spin of the electron, spin angular momentum, magnetic dipole moments due to orbital motion and spin of the electron, exclusion principle, Stern-Gerlach experiment. Symmetric and anti-symmetric wave functions, bosons and fermions, atomic shells, subshells and periodic table Spin-orbit coupling, anomalous Zeeman effect, Paschen-Back effect, Stark effect, total angular momentum, LS coupling, j-j coupling, singlet, doublet, triplet, term symbols. Atomic spectra of hydrogen and sodium.

Unit III: X-Rays 15 Lecture Hours

X-Ray Spectra: X-rays: production, Laue's experiment, Bragg's law, X-ray spectra: continuous and characteristic spectra, Mosley's law and X-ray series, Auger effect, X-ray absorption spectra, absorption edges.

Learning Experience This course offers a comprehensive learning experience through a combination of lectures, hands-on labs, and real-world case studies. Students will engage in practical experiments to apply theoretical concepts. Group projects and collaborative activities will enhance teamwork and problem-solving skills. Regular assessments and assignments will ensure students' understanding and application of key topics. Support and feedback will be provided throughout, encouraging independent learning and continuous improvement.

Textbooks

1. Modern Physics, R. Murugeshan and Kiruthiga Sivaprasath, 17th Ed., S. Chand & Company Pvt. Ltd.

2. Atomic and Molecular Spectra: Laser, Rajkumar, 2020, Knrn

Suggested Readings

1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987)
2. Atomic physics by J,B,Rajam& foreword by Louis De Broglie,(S,Chand& Co,, 2007),

3. Atomic Physics by J,H,Fewkes& John Yarwood, Vol, II (Oxford Univ, Press, 1991),

4. Physics of Atoms and Molecules, Bransden and Joachein,

5. Molecular Spectroscopy, Banwell,

6. Optoelectronics by Ghatak and Thyagarajan,Principles of Lasers by Svelto

Open Educational Resources (OERs)

1. https://www.geeksforgeeks.org/rutherfords-alpha-scattering-experiment/
2. http://labs.plantbio.cornell.edu/wayne/pdfs/Fine%20structure.pdf
3. https://en.wikipedia.org/wiki/Gyromagnetic_ratio#:~:text=In%20physics%2C%20the%20gyromagnetic%20ratio,by%20the%20symbol%20%CE%B3%2C%20gamma.
4. https://www.youtube.com/watch?v=_1S6KfMzOH8
5. https://www.radiologymasterclass.co.uk/tutorials/physics/x-ray_physics_production
6. https://eng.libretexts.org/Bookshelves/Electrical_Engineering/Electro-Optics/Direct_Energy_(Mitofsky)/07%3A_Lamps%2C_LEDs%2C_and_Lasers/7.01%3A_Absorption%2C_Spontaneous_Emission%2C_Stimulated_Emission
7. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Book%3A_Quantum_States_of_Atoms_and_Molecules_(Zielinksi_et_al)/07%3A_Rotational_States

Evaluation Scheme:

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

SEMESTER VII

BSPHAM701	ADVANCED QUANTUM MECHANICS	L	T	P	C
Version1.0		3	0	0	3
Category of Course	Major				
Total Contact Hours	45				
Pre-Requisites/ Co-Requisites	Basics of Atomic Structure				

Course Perspective:

This course provides an in-depth understanding of quantum mechanics beyond the foundational level. It focuses on solving the Schrödinger equation for systems with spherical symmetry, developing operator-based formulations through representation theory, and exploring advanced approximation methods such as perturbation theory. The treatment of identical particles and angular momentum in quantum systems equips students with tools necessary for dealing with multi-particle systems and atomic structure. Furthermore, the course introduces relativistic quantum mechanics and quantum scattering theory, bridging non-relativistic quantum mechanics with quantum field theoretical concepts. This comprehensive treatment builds a strong conceptual and mathematical foundation for students aiming to pursue research or careers in quantum physics, atomic and molecular physics, nuclear physics, and condensed matter theory.

Course Outcomes

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

CO1: Understanding the mathematical structure of quantum mechanics using Hilbert spaces, Dirac notation, matrix representations of operators, and the concept of identical particles.

CO2: Applying the Schrödinger equation to spherically symmetric systems like the 3D harmonic oscillator, rigid rotator, and hydrogen atom to determine energy eigenvalues and eigenfunctions.

CO3: Analyzing quantum systems subject to perturbations using time-independent and time-dependent perturbation theories; interpret results for physical effects such as the Zeeman effect, Stark effect, and isotopic shifts.

CO4: Evaluating the appropriateness and limitations of approximation methods such as the variational method, Fermi's golden rule, adiabatic and sudden approximations for specific quantum systems.

Contents

UNIT-I **12 Lectures Hours**

Spherically Symmetric Systems & Angular Momentum: Schrödinger equation for spherically symmetric potentials, 3D harmonic oscillator, rigid rotator, Hydrogen atom solutions, energy levels, degeneracy, Orbital and total angular momentum operators, Ladder operators, angular momentum matrices, Clebsch-Gordan coefficients and addition of angular momenta, Electromagnetic transition selection rules.

UNIT-II **8 Lecture Hours**

Representation Theory and Identical Particles: Hilbert space, operators as matrices, unitary transformations, Dirac Bra-Ket notation, Harmonic oscillator matrix theory, Identical particle symmetries: symmetric & antisymmetric wave functions, Pauli exclusion principle and spin angular momentum, Pauli matrices and density operators.

UNIT-III **10 Lectures Hours**

Perturbation Theory and Approximations: Time-independent perturbation theory: non-degenerate and degenerate, Applications: Zeeman effect, Stark effect, isotopic shifts, Variational method, Time-dependent perturbation theory: interaction picture, Fermi's golden rule, Adiabatic and sudden approximations

UNIT-IV **15 Lecture Hours**

Scattering Theory and Relativistic Quantum Mechanics: Wave packet description, Green's function method, Born approximation, partial wave analysis, optical theorem, Klein-Gordon and Dirac equations, Dirac matrices, plane wave solutions, Spin, magnetic moment of electron, Nonrelativistic reduction of Dirac equation, Spin-orbit coupling and Coulomb energy levels.

Textbooks

1. Introduction to Quantum Mechanics (Prentice Hall) by D. J. Griffiths

Reference Book

1. Quantum Mechanics: Concepts and Applications" by Nouredine Zettili

Evaluation components	Weightage

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

SEMESTER VI	**For B.Sc. (Honours with Research)**				
BSCCRW706	**Scientific Report Writing and Presentation skills**	**L**	**T**	**P**	**C**
Version1.0		**3**	**0**	**0**	**3**
Category of Course	**Major**				
Total Contact Hours	**45**				
Pre-Requisites/ Co-Requisites	**Research Methodology/ Basic English proficiency and foundational exposure to scientific studies**				

Course Perspective:

- To build comprehensive skills in scientific and academic writing.
- To develop the ability to critically analyze scientific literature and write research reports and review papers.
- To introduce tools and techniques for citation, referencing, and plagiarism detection.
- To enhance the students' ability to write, format, present, and defend scientific ideas in written and oral form.

Course Outcomes

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

CO1: Understanding the structure, language, and purpose of scientific reports and review papers.
CO2: Applying appropriate formatting, referencing styles, and plagiarism-checking tools in writing scientific documents.
CO3: Analyzing scientific literature to identify research trends, themes, and knowledge gaps for writing a review paper.
CO4: Evaluating scientific sources and visual data representations for accuracy, reliability, and relevance.
CO5: Creating structured scientific reports and review articles with effective graphical representation and oral presentation.

Course Content

Unit I: Introduction to Scientific Writing **5 Lecture Hours**
Characteristics of scientific writing

- Types: reports, review articles, research papers
- Language, clarity, and tone
- Stages of the writing process

Unit II: Scientific Report Writing **15 Lecture Hours**
Structure of scientific reports: Title, Abstract, Introduction, Method, Results, Discussion

- Review paper writing: thematic organization, literature synthesis
- Tables, graphs, and figures
- **Graphical Tools:**
    - **ChemDraw** – for chemical diagrams
    - **Origin** – for graph plotting and data visualization
    - **PowerPoint** – for visual abstracts and slide design
- Referencing and bibliography
- Use of Mendeley/Zotero

Unit III: Plagiarism & Ethics **7 Lecture Hours**
Plagiarism and self-plagiarism: definitions and examples

- Plagiarism checks tools: Turnitin, Grammarly, URKUND
- Academic integrity and ethical writing: Informed consent, confidentiality, and privacy, Ethical considerations in qualitative vs. quantitative research, Ethical data management: collection, storage, and sharing, Authorship and intellectual property rights

Unit V: Publishing Process **10 Lecture Hours**

- Understanding journals, impact factor, and indexing
- Choosing appropriate journals and conferences
- Importance of proper citation and common citation styles (Harward, Chicago)
- Avoiding plagiarism through correct attribution

- Understanding the peer review process, writing responses to reviewers and handling editorial feedback, Techniques for self-editing and revising research reports, Preparing and presenting research findings
- Ethical issues in presenting research: avoiding bias and misrepresentation, duplicate submissions, self-plagiarism

Unit IV: Presentation Skills **8 Lecture Hours**

- Preparing and structuring oral presentations
- Creating effective slides and posters
- Non-verbal communication and Q&A handling
- Using PowerPoint and visual aids professionally

Learning Experience

The course will be conducted through a mix of interactive lectures, collaborative problem-solving sessions and following experiential learning activities:

a. Major Assignment – Review Paper Writing:
- Topic selection and approval by instructor
- Review of minimum 10 peer-reviewed articles
- Word limit: 2000–2500 words
- Mandatory plagiarism checks report (<15% similarity index) with submission
- Oral presentation (10 minutes + 5 minutes Q&A)

b. In-Class Exercises:
- Drafting abstracts, writing summaries, referencing practice, paraphrasing

c. Peer Review Workshop:
- Students review each other's drafts using rubrics

d. Mini Presentations on article analysis and referencing tools

Suggested Readings:

1. Day, R.A. & Gastel, B. – How to Write and Publish a Scientific Paper
2. Glasman-Deal, H. – Science Research Writing for Non-Native Speakers of English
3. Booth, W.C., Colomb, G.G., & Williams, J.M. – The Craft of Research
4. Eco, U. – How to Write a thesis
5. Publication Manual of the American Psychological Association (APA, Latest Edition)

Suggested Tools & Platforms:

- Reference Managers: Mendeley, Zotero, EndNote
- Plagiarism Checkers: Turnitin, Grammarly, URKUND
- Writing Tools: LaTeX, MS Word, Grammarly
- Databases for Literature: Scopus, PubMed, ScienceDirect, Google Scholar

Open Educational Resources (OER)

5. https://www.coursera.org/learn/research-methodologies
6. https://www.coursera.org/learn/analysis-and-interpretation-of-data
7. https://www.coursera.org/learn/research-methods
8. https://www.coursera.org/learn/qualitative-research-methods-capturing-rich-insights

Evaluation Scheme:

Component	Marks
Review Paper (written submission)	40
Plagiarism Check Compliance (<15% similarity)	10
Oral Presentation of Review Paper	20
In-Class Activities & Assignments	20
Quiz on Referencing & Plagiarism Awareness	10
Total	**100**

SEMESTER VII					**For B.Sc. (Honours)**
BSPHNT703	**Nanotechnology**	**L**	**T**	**P**	**C**
Version 1.0		**3**	**0**	**0**	**3**
Category of Course	**Major (Discipline Specific Elective)**				
Total Contact Hours	**45**				
Pre-Requisites/ Co-Requisites	**Basics of Physics**				

Course Perspectives

This course provides undergraduate Physics students with a foundational understanding of nanotechnology, focusing on the unique properties of nanomaterials, their synthesis methods, and basic characterization techniques. It prepares students to apply core concepts in real-world research and emerging technologies, laying the groundwork for further studies or careers in materials science, electronics, and interdisciplinary scientific fields.

On completion of the course, the learner will be:

CO1: Understanding the fundamental concepts of nanoscience, classification of nanomaterials, and their size-dependent physical and chemical properties.

CO2: Applying appropriate synthesis methods—both top-down and bottom-up—to develop nanomaterials for specific applications.

CO3: Analyzing the relationship between the synthesis method and the resulting nanomaterial properties such as shape, size, and functionality.

CO4: Evaluating the suitability of various characterization techniques (e.g., XRD, SEM, UV-Vis) for determining the structural and morphological features of nanomaterials.

Course Contents

Unit I: Introduction to Nanoscience and Nanomaterial Properties 15 Lecture hours

Definition and scope of nanoscience and nanotechnology; Classification of nanomaterials: 0D, 1D, 2D, and 3D; Surface area-to-volume ratio and quantum confinement; Physical properties: Optical (e.g., surface plasmon resonance), Electrical and magnetic, Mechanical (hardness, elasticity); Applications in electronics, medicine, environment, and energy

Unit II: Synthesis of Nanomaterials 15 Lecture hours

Top-down vs. bottom-up approaches; Physical methods: Ball milling, Laser ablation, Sputtering; Chemical methods: Sol-gel process, Hydrothermal and solvothermal synthesis; Co-precipitation; Chemical vapor deposition (CVD); Green synthesis and bio-inspired methods

Unit III: Characterization Techniques 15 Lecture hours

Structural characterization: X-Ray Diffraction (XRD); Morphological characterization: Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM); Spectroscopic techniques: UV-Vis spectroscopy; Fourier-transform infrared spectroscopy (FTIR); Raman spectroscopy; Surface area and porosity: Brunauer–Emmett–Teller (BET) analysis

Learning Outcomes

Through this course, students will gain a hands-on and conceptual learning experience in nanotechnology by exploring the fascinating behavior of materials at the nanoscale. They will engage with real-world examples, understand how nanomaterials are synthesized and characterized, and apply this knowledge to analyze their structure and properties. The course encourages curiosity, critical thinking, and a research-oriented mindset, bridging classroom learning with future scientific applications.

Learning Experience

This course will be conducted through interactive lectures, discussions, and case studies, making the learning process experiential and participatory. Students will engage in real-world scenarios to understand ethical issues, participate in group discussions to explore research dilemmas, and work on writing exercises to develop research proposals and reports. Hands-on activities like peer reviews and presentations will allow students to apply ethical principles in research design, data management, and academic writing. The course emphasizes active learning through debates, case study analysis, and collaborative projects.

Textbooks

1. Bharat Bhushan: Handbook of Nanotechnology, Springer
2. Elements of X-ray diffraction, B D Cullity- Addison-Wesley Publishing Company, Inc.
3. Encyclopedia of Materials Characterization, C. Richard Brundle and Charles A. Evans, Jr
4. Processing & properties of structural naonmaterials by Leon L. Shaw (editor)

5. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al. Wiley VCH Verlag Gmbh & Co, Weinheim
6. Nanostructure and Nanomaterials: Synthesis, Properties and Application by G. Cao, Imperial College Press, 2004

Suggested Readings

1. https://web.pdx.edu/~pmoeck/phy381/intro-nanotech.pdf
2. https://www.kth.se/social/upload/54062f97f2765416cecdfd74/HT14-IM2655_Lecture%201.pdf
3. https://www.agc.ac.in/resources/Introduction_to_Nanomaterials_and_Nanotechnology.pdf

Open Educational Resources (OER)

1. https://www.youtube.com/watch?v=ebO38bbq0_4
2. https://www.youtube.com/watch?v=0EWCqCIsFOA
3. https://www.youtube.com/watch?v=Sd3jaxue4Hc&pp=ygURI3AxbmFub3RlY2hub2xvZ3k%3

Evaluation Scheme:

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

SEMESTER VII	**For B.Sc. (Honours)**

BSPHEC704	Fabrication of electronics devices	L	T	P	C
Version1.0		3	0	0	3
Category of Course	Major (Discipline Specific Elective)				
Total Contact Hours	60				
Pre-Requisites/ Co-Requisites	Basics of Electronics				

Course Perspective

Introduction to the basic steps and processes of fabricating integrated circuit semiconductor devices: crystal growth (thin film and bulk), thermal oxidation, dopant diffusion/implantation, thin film deposition/etching, and lithography. Introduction to process simulators, such as SUPREM. Fabrication and characterization of resistors, MOS capacitors, junction diodes and MOSFET devices.

Course Outcomes

CO1: Understanding the classification of integrated circuits and describe the steps involved in crystal growth and wafer preparation for IC fabrication.
CO2: Applying knowledge of various thin film deposition techniques such as vacuum evaporation, sputtering, and chemical vapor deposition in fabrication processes.
CO3: Analyzing the effects and suitability of thermal oxidation, diffusion, and ion implantation techniques in semiconductor processing.
CO4: Evaluating the importance and performance of fabrication steps such as lithography, metallization, and CMOS processing in integrated circuit production.

Course Content

Unit-I **15 Lecture Hours**

Classification of Integrated circuits (IC), Steps of IC fabrication, Basics of structure and growth of crystals, crystal growth techniques such as Czochralski method, Bridgmann technique, zone melting method etc. Cleaning of wafers, and clean room specifications.

UNIT-II **15 Lecture Hours**

Methods of deposition of thin films such as vacuum evaporation, sputtering and chemical vapor deposition.

UNIT-III **15 Lecture Hours**

Thermal oxidation of Silicon, diffusion and ion implantation.

UNIT-IV **15 Lecture Hours**

Other fabrication steps such as lithography process, metallization, contacts, CMOS fabrication, and fabrication of passive components etc.

Learning Experience

This course will be conducted through interactive lectures, discussions, and case studies, making the learning process experiential and participatory. Students will engage in real-world scenarios to understand ethical issues, participate in group discussions to explore research dilemmas, and work on writing exercises to develop research proposals and reports. Hands-on activities like peer reviews and presentations will allow students to apply ethical principles in research design, data management, and academic writing. The course emphasizes active learning through debates, case study analysis, and collaborative projects.

TEXTBOOK

- Design of Analog CMOS Integrated Circuits, Behzad Razavi, 2nd Edition.
- IC Fabrication Technology, Goranga Bose, McGraw Hill Education.

Evaluation Scheme:

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

SEMESTER VIII					
BSPHAM801	**Atomic and molecular physics-II**	**L**	**T**	**P**	**C**
Version1.0		**3**	**0**	**0**	**3**

Category of Course	**Major**
Total Contact Hours	**45**
Pre-Requisites/ Co-Requisites	**Atomic and molecular physics-I**

<u>Course Perspective:</u>

This course introduces students to the quantum mechanical understanding of molecular structure and the origin of various types of molecular spectra. It emphasizes the interaction between electromagnetic radiation and molecules, exploring the rotational, vibrational, and electronic transitions. Students will understand the underlying principles and quantum models that govern molecular energy states and transitions. Through conceptual and analytical training, the course prepares students to interpret experimental spectral data and explore its applications in physics, chemistry, and material sciences.

<u>Course Outcomes:</u>

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

CO1: Understanding the nature of molecular bonds and explain the origin and characteristics of rotational, vibrational, and electronic spectra in molecules.

CO2: Applying quantum mechanical models like the rigid rotator and harmonic oscillator to interpret molecular energy levels and spectral features.

CO3: Analyzing molecular spectral data to distinguish between different transitions and identify fine structures in rotational and vibrational spectra.

CO4: Evaluating and comparing the mechanisms of Raman, infrared, fluorescence, and phosphorescence spectra using energy level diagrams and selection rules.

Course Content

Unit I: **15 Lecture Hours**

Molecules and molecular spectra: The Molecular bond, electron sharing, H_2^+ molecular ion, Hydrogen molecule, complex molecules, types of molecular spectra and molecular energy states.

Pure rotational spectra: features of rotational spectra, Rigid rotator model, energy levels, spectrum

(no derivation of selection rules), non-rigid rotator.

UNIT-II **15 Lecture Hours**

Vibrational–Rotational spectra: Features, Molecule as a Harmonic oscillator: energy levels, spectrum, Anharmonic oscillator: energy levels, Vibrational frequency and force constants. Molecule as vibrating rotator: fine structure of infrared bands.

Raman Effect: Quantum Theory of Raman Effect, Characteristics of Raman Lines, Stokes and Anti-Stokes Lines, Complimentary Character of Raman and infrared Spectra.

UNIT-III **15 Lecture Hours**

Electronic Spectra: Features and formation of electronic spectra, electronic energy and potential curves, Vibrational Structure of Electronic band in emission and absorption spectra, Rotational Structure of Electronic bands: General relations, branches of a band, band-head formation, Intensity distribution in a vibrational band system: Franck-Condon Principle, Explanation of intensity distribution in absorption and emission bands using Franck-Condon principle. Fluorescence and Phosphorescence: Mechanism of emission.

Learning Experience

This course will be conducted through interactive lectures, discussions, and case studies, making the learning process experiential and participatory. Students will engage in real-world scenarios to understand ethical issues, participate in group discussions to explore research dilemmas, and work on writing exercises to develop research proposals and reports. Hands-on activities like peer reviews and presentations will allow students to apply ethical principles in research design, data management, and academic writing. The course emphasizes active learning through debates, case study analysis, and collaborative projects.

Textbooks

1. Atomic & Molecular Physics, Raj Kumar.

Reference Books/Materials

1. Atomic, Molecular, Laser and Nuclear Physics, Dr. V.P. Seth, Dr. Nawal Kishore, Vijaya Publications.
2. Modern Physics, A.K. Sikri.
3. Modern Physics, Arthur Beiser.

Evaluation Scheme:

Evaluation components	**Weightage**

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

SEMESTER VIII					
BSPHAS803	**Advanced Solid-State Physics**	**L**	**T**	**P**	**C**
Version1.0		**3**	**0**	**0**	**3**
Category of Course	**Major**				
Total Contact Hours	**45**				
Pre-Requisites/ Co-Requisites	**Solid State Physics**				

Course Perspective

This course provides an in-depth understanding of the physical principles governing the structural, electronic, semiconducting, and magnetic properties of materials. It explores the analysis of crystal structures using X-ray diffraction, the behaviour of electrons in solids through band theory, and the physics of semiconductors including charge carrier dynamics and transport phenomena. The course also investigates different magnetic phenomena and models that explain magnetic ordering in materials. It equips students with theoretical and practical insights essential for careers in condensed matter physics, material science, and electronic device engineering.

Course Outcomes

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

CO1: Understanding fundamental concepts of crystal structure, diffraction, band theory, semiconductors, and magnetism relevant to solid-state physics.

CO2: Applying principles such as Bragg's Law, Bloch's theorem, and semiconductor theory to solve problems related to crystal diffraction, electronic band structure, and charge carrier behavior.

CO3: Analyzing the electrical and structural properties of materials using structure factor calculations, Brillouin zones, energy bands, and Hall effect measurements.

CO4: Evaluating the magnetic and semiconducting behavior of materials using theoretical models like Langevin's theory, Weiss theory, and band theory, and assessing their applications in real-world materials.

Course Content

UNIT-I Intensities of Diffracted Beams 10 Lecture Hours

Introduction to crystal structure, X-ray Diffraction, Bragg's Law, scattering by an electron, scattering by an atom, Scattering by a unit cell; Structure-factor calculations, Multiplicity factor, Lorentz factor, Absorption factor, temperature, Intensities of powder pattern lines

UNIT-II Electrons in Solids 10 Lecture Hours

Bloch theorem, the Kronig-Penny Model, constriction of Brillouin zones, symmetry properties of energy function, extended, reduced and periodic zones schemes, effective mass of an electron, the nearly free electron model, conductors, semiconductors and insulators.

UNIT-III Semiconducting properties of Materials 15 Lecture Hours

Semiconductors, carrier concentrations in intrinsic semiconductors, Fermi level; Statics of Extrinsic semiconductors: Fermi level, general equation for impurity semiconductor, Fermi level in an n-type semiconductor at very low temperature, Theory of n-type semiconductor, Theory of p-type semiconductor, mobility of charge carriers, effect of temperature on mobility, electrical conductivity of semiconductors, Hall Effect, junction properties

UNIT-IV Magnetism 10 Lecture Hours

Molecular Field Theory, Exchange Forces, Band Theory, Thermal Effects, Theories of Ferromagnetism: Langvin`s theory and, Wiss theory, Origin of ferrimagnetism: indirect exchange interaction and spin order, Wiss theory for ferrimagnetism.

Textbook:

1. Solid State Physics, S.O.Pillai, New Age Publication

Reference Book

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
2. Elements of X-Ray Diffraction, B.D. Cullity. Addison-Wesley Publishing Company,
3. Introduction to Magnetic Materials (2nd Edition,), B.D. Cullity and C.D. Graham, Wiley (2009)

Evaluation Scheme:

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

Learning Experience

This course will be conducted through interactive lectures, discussions, and case studies, making the learning process experiential and participatory. Students will engage in real-world scenarios to understand ethical issues, participate in group discussions to explore research dilemmas, and work on writing exercises to develop research proposals and reports. Hands-on activities like peer reviews and presentations will allow students to apply ethical principles in research design, data management, and academic writing. The course emphasizes active learning through debates, case study analysis, and collaborative projects.

SEMESTER VIII		**For B.Sc. (honours with Research)**			
SCPH404	**Dissertation**	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**0**	**10**
Category of Course	**Major**				
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Practical exposure**				

Course Perspective: Students will be divided among faculty members of the Department for the supervision of the research work. In the first week of Semester VII, each faculty member will assign a suitable research topic to the students from the selected topics in the areas of chemical sciences. The student will work on the assigned research topic during semesters VII and VIII in regular consultation with his/her assigned teacher. The student will write a dissertation based on the research work carried out during Semesters VII and VIII and prepare two copies to be submitted to the office of the Head of the Department duly signed by the student and the supervisor in the sixth week of VIII semester or a date decided by the HOD of the department. Before preparing power point presentation and submission of dissertation, each student has to deliver a seminar talk on his/ her research project work on a date fixed by HOD, necessary suggestions have to be incorporated in the final draft of dissertation. The student will make a power point presentation based on the work carried out and mentioned in the dissertation to the board of examiners appointed by the University.

Course Outcomes

On completion of this course, the students will be:

CO1. Carrying out the extensive literature survey.

C02. Applying the learning techniques to write and present technical reports/articles.

CO3. Analyzing various methods and techniques applicable to the topic to study and contribute to domain knowledge.

CO4. Evaluating the result of the experiment carried out and presenting the results using data visualization methods.

Learning Experience:

The course will be conducted through hands-on research activities, where students choose a topic, design experiments, and collect data under faculty mentorship. Regular group discussions, peer reviews, and presentations will foster a participatory learning environment. The course will emphasize experiential learning through real-world problem-solving, encouraging students to apply theoretical knowledge in practical research settings.

Evaluation Scheme

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

SEMESTER VIII		**For B.Sc. (Honours)**			
	Research Project	**L**	**T**	**P**	**C**
Version1.0		**0**	**0**	**0**	**6**
Category of Course	**Major**				
Total Contact Hours					
Pre-Requisites/ Co-Requisites	**Practical exposure**				

Course Perspective: Students will be divided among faculty members of the Department for the supervision of the research work. In the first week of Semester VII, each faculty member will assign a suitable research topic to the students from the selected topics in the areas of chemical sciences. The student will work on the assigned research topic during semesters VII and VIII in regular consultation with his/her assigned teacher. The student will write a dissertation based on the research work carried out during Semesters VII and VIII and prepare two copies to be submitted to the office of the Head of the Department duly signed by the student and the supervisor in the sixth week of VIII semester or a date decided by the HOD of the department. Before preparing power point presentation and submission of dissertation, each student has to deliver a seminar talk on his/ her research project work on a date fixed by HOD, necessary suggestions must be incorporated in the final draft of dissertation. The student will make a power point presentation based on the work carried out and mentioned in the dissertation to the board of examiners appointed by the University.

Course Outcomes

On completion of this course, the students will be:

CO1. Carrying out the extensive literature survey.

C02. Applying the learning techniques to write and present technical reports/articles.

CO3. Analyzing various methods and techniques applicable to the topic to study and contribute to domain knowledge.

CO4. Evaluating the result of the experiment carried out and presenting the results using data visualization methods.

Learning Experience:

The course will be conducted through hands-on research activities, where students choose a topic, design experiments, and collect data under faculty mentorship. Regular group discussions, peer reviews, and presentations will foster a participatory learning environment. The course will emphasize experiential learning through real-world problem-solving, encouraging students to apply theoretical knowledge in practical research settings.

Evaluation Scheme

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

Minor-Nano Science

SEMESTER II					
UNMINS201	**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 **15 Lecture Hours**

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 **15 Lecture Hours**

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 15 Lecture Hours

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 15 Lecture Hours

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

SEMESTER II					
UNMINS202	**Elements of Nano sciences and nanomaterial**	**L**	**T**	**P**	**C**
Version 1.0		**4**	**0**	**0**	**4**
Category of Course	**Minor**				
Total 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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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

SEMESTER III					
UNMINS301	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 **15 Lecture Hours**

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 **15 Lecture Hours**

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 **15 Lecture Hours**

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 **15 Lecture Hours**

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

SEMESTER IV					
UNMINS401	**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 **15 Lecture Hours**

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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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

SEMESTER IV					
UNMINS451	**Crystallography Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**2**	**1**
Category of Course	**Minor Lab**				
Total Contact Hours	**15**				
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	10 Marks
II. Lab Record	10 Marks
III. Lab Participation	10 Marks
IV. Lab Project	20 Marks
II. External Marks (practical's): End Term Examination	50 Marks

SEMESTER V					
UNMINS501	**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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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

SEMESTER V					
UNMINS551	**Synthesis of nanomaterials-I Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**2**	**1**
Category of Course	**Minor**				

Total Contact Hours	15
Pre-Requisites/ Co-Requisites	Basics of Nanomaterials

Course Perspective

This course is designed to provide hands-on experience in the synthesis, fabrication, and characterization of functional nanomaterials such as $BaTiO_3$ nanoparticles, silver wires, and magnetite composites. Students will learn techniques for preparing composite materials, core-shell structures, and evaluating their dielectric and optical properties. Emphasis is placed on understanding the influence of synthesis parameters, such as heating rates, on material performance. Through experimental learning, students will gain practical insights into material science, nanotechnology, and device-level applications

Course Outcomes:

CO1: Understanding the synthesis processes and material chemistry involved in preparing $BaTiO_3$, magnetite composites, silver wires, and core-shell nanoparticles.

CO2: Applying suitable experimental techniques to synthesize and fabricate multilayer composite and core-shell nanostructures.

CO3: Analyzing the dielectric and optical properties of synthesized nanomaterials and correlate them with structural and processing parameters.

CO4: Evaluating the influence of calcination conditions, such as heating rate, on the physical and optical characteristics of $BaTiO_3$ nanoparticles.

CO5: Designing and executing a comprehensive experimental protocol for material preparation and property characterization, including calculating X-ray density and determining optical band gaps.

Course Content

1, Stabilization of BaTiO3 particles.

2. Preparation of silver wires.

3. Preparation of magnetite/PS composite,

4 Find the dielectric properties of multilayer composite material.

5. Prepare core-shell type nanoparticles.

6 Find the optical band gap of BaTiO3 nanoparticles.

7. Study the effect of heating rate during calcination on the optical properties of BaTiO3.

8. Find the X ray density of nanoparticles.

Suggested Textbooks

1 Nanostructures and Nanomaterials: Synthesis, Properties and Applications, G, Cao, Imperial College Press (2003).

Advanced 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://www.youtube.com/watch?v=DnozInAi1q0
2. https://pubs.acs.org/doi/10.1021/acs.inorgchem.8b00381
3. https://pubs.rsc.org/en/content/articlelanding/2018/nr/c8nr02242a
4. https://pubs.acs.org/doi/10.1021/acs.nanolett.0c01565
5. https://doi.org/10.1007/s13233-017-5065-1
6. https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=853840
7. https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202102221
8. https://pubs.acs.org/doi/abs/10.1021/cr100449n
9. https://pubs.rsc.org/en/content/articlelanding/2015/cs/c5cs00343a
10. https://www.mdpi.com/2073-4360/14/21/4664
11. **Evaluation Scheme:**

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

SEMESTER VI					
UNMINS601	**Characterization Techniques of Nanomaterials**	**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, 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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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 15 Lecture Hours

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 (OERs)

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

Course Perspective

This course is an introduction to the principles of instrumental techniques for characterization of nanomaterials. This course aims at teaching the students 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

CO1: Evaluate and interpret structural and morphological properties of nanomaterials using

SEMESTER VI					
UNMINS651	**Characterization Techniques of Nanomaterials Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**2**	**1**
Category of Course	**Minor**				
Total Contact Hours	**15**				
Pre-Requisites/ Co-Requisites	**Basics of Nanomaterial**				

X-Ray Diffraction and SEM/EDX/TEM techniques, demonstrating an ability to link these properties to material composition and structure.

CO2: Perform and interpret composition and thermal analysis of nanomaterials using FTIR spectroscopy and TGA/DSC, applying this understanding to infer material stability and transformations under thermal stress.

CO3: Apply UV-VIS spectrophotometry to study the optical properties of nanomaterials, focusing on determining the bandgap, and comprehend its impact on material performance in various applications.

CO4: Conduct and analyze mechanical property tests on nanomaterials through nanoindentation/hardness tests, using these outcomes to comprehend the relationship between material structure, composition, and mechanical performance.

List of Experiments

1. To analyse the structural properties such as crystallite size and lattice parameters using X-Ray Diffraction technique.

2. To study the morphological properties of nanomaterials using SEM/EDX/TEM.

3. To perform composition analysis using FTIR spectroscopy.

4. To Study thermal properties of nanomaterials using TGA/DSC.

5. To study the optical properties such as bandgap of a nanomaterial using UV-VIS spectrophotometer.

6. To study the mechanical properties of nanomaterials using nanoindentation/hardness test.

Reference Books

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977

2. Transmission Electron Microscopy: A Textbook for Materials Science

David B Williams, C Barry Carter, (1996) Plenum Press, New York

3. Impedance Spectroscopy: Theory, Experiment, and Applications,

E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.

4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC

Press

Open Education Resources

- https://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVzaW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D
- https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D
- https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D
- https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D
- https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D
- https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3D

- https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D

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**

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

SEMESTER VII					
UNMINS701	**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**				

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 **15 Lecture Hours**

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 **15 Lecture Hours**

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 15 Lecture Hours

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 15 Lecture Hours

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

SEMESTER VII					
UNMINS751	**Synthesis of Nanomaterials-II Lab**	**L**	**T**	**P**	**C**
Version 1.0		**0**	**0**	**2**	**1**
Category of Course	**Minor Lab**				
Total Contact Hours	**15**				
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: Understanding the principles and procedures involved in the synthesis of polymers, ceramic oxides, and ferrofluids using standard laboratory methods.

CO2: Applying solvent evaporation, co-precipitation, and solid-state reaction techniques to prepare thin films, magnetite particles, and calcium titanate.

CO3: Analyzing the stability of magnetite particles in different media and determine the optical band gap of the prepared samples.

CO4: Evaluating material properties such as density using Archimedes' principle and assess sintering quality and pellet formation.

CO5: Designing and implementing a complete material processing workflow from synthesis to final characterization, including pelletization, sintering, and polishing.

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 (OERs):

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**

MINOR- ENVIRONMENTAL SCIENCE

SEMESTER-II					
UNMIES201	**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	**--**				

COURSE PERSPECTIVE:

This course provides an in-depth understanding of Earth's history, processes, and materials, equipping students with essential knowledge for careers in geology, environmental science, and related fields. It covers the formation of Earth, plate tectonics, rock cycles, and surface processes, enabling students to analyze and interpret geological phenomena. The skills gained, such as mineral identification, understanding seismic activities, and assessing erosion impacts, are crucial for addressing real-world challenges like resource management, disaster preparedness, and environmental conservation. By linking theoretical concepts with practical applications, the course prepares students for professional roles that require expertise in Earth sciences and supports informed decision-making in various environmental contexts.

COURSE OUTCOMES (CO)

On completion of this course, the student will be:

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

Unit 1: History of Earth **15 Lecture Hours**

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.

Unit 2: Earth system processes **15 Lecture Hours**

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hot spots, plate boundaries; sea floor spread; 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 evidence of plate tectonics; continental collision and mountain formation with specific examples of the Himalaya.

Unit 3: Minerals and rocks **10 Lecture Hours**

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.

Unit 4: Earth surface processes **10 Lecture Hours**

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.

Unit 5: Importance of being a mountain **10 Lecture Hours**

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 Lecture Hours, interactive sessions, and practical exercises to explore Earth's history, processes, and landscapes.

Instruction Methods:

- **Lecture Hours:** 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* (5thedition). 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)	40 Marks
I. Continuous assessment All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER II					
UNMIES202	**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

On completion of this course, the student will be:

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 Lecture Hours**

- 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 Lecture Hours**

- 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 Lecture Hours**

- 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 **15 Lecture Hours**

- 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 Lecture Hours, interactive sessions, and practical exercises to cover hydrology and hydrogeology fundamentals, data analysis, and advanced topics.

Instruction Methods:

- **Lecture Hours:** 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 Lecture Hours, 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 (OERs)

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

SEMESTER III					
UNMIES301	**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 will be:

CO1: Understanding the types of natural resources, including renewable and non-renewable resources, and how they are affected by human activities.

CO2: Applying knowledge of forest, water, soil, and food resources, including their importance and how to conserve them.

CO3: Analyzing mineral resources, their extraction methods, and the environmental impacts of mining.

CO4: Evaluating non-renewable energy sources like oil, natural gas, and coal, including their formation, extraction, and environmental effects.

Course Content

Unit 1: Introduction **10 Lecture Hours**

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.

Unit 2: Natural resources and conservation **10 Lecture Hours**

Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

Unit 3: Mineral resources **10 Lecture Hours**

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

Unit 4: Non-renewable energy resources **10 Lecture Hours**

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 nonrenewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges.

Unit 5: Renewable energy resources **10 Lecture Hours**

Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, J N N solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Unit 6: Resource management **10 Lecture Hours**

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 Lecture Hours, interactive discussions, and hands-on activities on resource management and conservation.

- **Instruction Methods:** Lecture Hours 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* (2^{nd} 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* (7^{th}edition). 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

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

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

SEMESTER IV					
UNMIES401	NATURAL AND ANTHROPOGENIC HAZARDS	L	T	P	C
Version 3.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Basics of Environment				
Co-requisites	--				

COURSE PERSPECTIVE

This course explores the causes and impacts of natural and anthropogenic hazards, including earthquakes, tsunamis, volcanic eruptions, and pollution. Through case studies and scientific analysis, students will learn about disaster prediction, mitigation strategies, and the influence of human activities on environmental stability. The course aims to equip students with the knowledge to understand and reduce the risks associated with these hazards.

COURSE OUTCOMES (CO)

On completion of this course, the student will be:

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 Lecture Hours

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 Lecture Hours

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 Lecture Hours

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 Lecture Hours

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 Lecture Hours, case studies, and interactive discussions to explore natural and anthropogenic hazards.

- **Instruction Methods:** Lecture Hours on various hazards, their causes, and mitigation strategies; case studies for real-world understanding.
- **Technology Use:** LMS for resources, recorded Lecture Hours, 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 All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER V					
UNMIES501	**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 will be:

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

Unit A: Introduction **10 Lecture Hours**

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.

Unit B: History of environmental legislation and policy **20 Lecture Hours**

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.

Unit C: Environmental legislation **10 Lecture Hours**

Legal definitions (environmental pollution, natural resources, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article51 A (Fundamental duties).

Unit D: Legislative Instruments **20 Lecture Hours**

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 Biological Diversity 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 Lecture Hours, interactive sessions, and practical exercises to explore environmental legislation and policies.

Instruction Methods:

- **Lecture Hours:** 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 Textbooks

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

SEMESTER VI					
UNMIES601	**Waste Management**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-	**Basics of Environment**				
Co-requisites	**--**				

COURSE PERSPECTIVE: This course provides a detailed understanding of solid waste management and resource recovery, covering waste sources, environmental impacts, and management techniques. Students will explore methods for handling municipal, hazardous, and biomedical waste, including collection, landfilling, thermal treatment, and recycling. The course also addresses industrial waste management, resource recovery practices, waste-to-energy processes, and integrated waste management strategies, alongside lifecycle assessment and relevant policies. This knowledge equips students with essential skills for effective waste management and sustainability.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understanding the sources and types of solid waste, including municipal, hazardous, and biomedical waste, 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 **5 Lecture Hours**

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

Unit B: Effect of solid waste disposal on environment **8 Lecture Hours**

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 each ate on soil characteristics and ground water pollution.

Unit C: Solid waste Management **9 Lecture Hours**

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.

Unit D: Industrial waste management **8 Lecture Hours**

Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

Unit E: Resource Recovery **6 Lecture Hours**

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) **6 Lecture Hours**

Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, land fill gas (LFG) recovery; anaerobic digestion; gasification.

Unit G: Integrated waste management **6 Lecture Hours**

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

Unit H: Life cycle assessment (LCA) **6 Lecture Hours**

Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

Unit I: Policies for solid waste management **6 Lecture Hours**

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly or green products.

Suggested Textbooks

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
- 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** 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 VII					
UNMIES701	**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 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 will be:

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.

<u>COURSE CONTENT</u>

Unit 1: Environmental impact assessment (EIA): 15 Lecture Hours

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 Lecture Hours**

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 Lecture Hours**

EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects.

Unit 4: **15 Lecture Hours**

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 Lecture Hours, interactive sessions, and hands-on activities for understanding environmental impact and risk assessment.

Instruction Methods:

- **Lecture Hours:** 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.

Textbook

Barrow,C.J.2000.*Social Impact Assessment: An Introduction. Oxford* University Press.

Reference Books/Materials

Glasson,J.,Therivel,R.,Chadwick,A.1994. *Introduction to Environmenta lImpact Assessment*.London, Research Press, UK. Judith,P.1999. *Handbook of Environmental Impact Assessment*. Blackwell Science. Marriott, B.1997. *Environmental Impac tAssessment: A Practical Guide*. 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 assessment** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER-VIII					
UNMIES801	**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:

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 Lecture Hours

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 Lecture Hours

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 Lecture Hours

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 Lecture Hours**

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 Lecture Hours, interactive discussions, and case studies to explore climate change, sustainable development, and governance.

Instruction Methods:

- **Lecture Hours:** 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/

Evaluation:

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

Minor - Data Science

SEMESTER II					
UNMIDS201	**Data Analytics using SQL**	**L**	**T**	**P**	**C**

Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

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 15 Lecture Hours

- 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 22 Lecture Hours

- 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 15 Lecture Hours

- 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 15 Lecture Hours

- Subqueries: Importance and Types

- Nested Queries
- JOINS: Importance and Types (Inner Join, Outer Joins, Left, Right Outer Joins)

List of Practical

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

SEMESTER II					
UNMIDS202	**Data Analytics using R**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Hours	**60**				
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:

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: 15 Lecture Hours

- 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: 15 Lecture Hours

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: 15 Lecture Hours

- 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: 15 Lecture Hours

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

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER III

UNMIDS301	Python for Data Science	L	T	P	C
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	60 Lecture 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:

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   15 Lecture Hours

- 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   15 Lecture Hours

- 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 **15 Lecture Hours**

- 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 **15 Lecture Hours**

- 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 Lecture Hours to seek additional help when needed. Regular feedback will ensure that students meet the course's 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.

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 (OERs)

1. NPTEL Python for Data Science
2. Kaggle's Python for Data Science
3. Awesome Python for Data Science (GitHub)

Evaluation:

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

SEMESTER IV					
UNMIDS401	Data Pre-processing and Visualization using Python	L	T	P	C
Version		2	0	4	4
Total Contact Hours	60				
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:

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 Preprocess **15 Lecture Hours**

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

Unit 2: Data Cleaning and Transformation **15 Lecture Hours**

- Removing duplicates and dealing with data inconsistencies
- Data normalization, scaling, and encoding techniques
- Handling categorical variables

Unit 3: Exploratory Data Analysis (EDA) **15 Lecture Hours**

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 **15 Lecture Hours**

- 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 Lecture 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	Weightage
Internal marks (Theory) **I. Continuous assessment** Include assignments, lab work, quizzes, and a final project, focusing on the practical application of data preprocessing and visualization techniques.	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER V					
UNMIDS501	**Time series analysis and forecasting using Python**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

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: 15 Lecture Hours

- 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: 15 Lecture Hours

- 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: 15 Lecture Hours

- 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: 15 Lecture Hours

- 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 Practical

- **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 Lecture 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	**Weightage**
Internal marks (Theory) **I. Continuous assessment** 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)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER VI					
UNMIDS601	**Fundamental of Machine Learning**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

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 Neighbor, 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 **15 Lecture Hours**

- Application of Machine Learning
- Supervised vs Unsupervised Learning
- Python libraries suitable for Machine Learning

Unit II: Data Pre-Processing and Data **15 Lecture Hours**

- Identifying and handling the missing values
- Encoding the categorical data
- Normalization
- Standardization
- PCA

Unit III: Supervised Learning Regression and Classification **15 Lecture 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 **15 Lecture 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 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	**Weightage**
Internal marks (Theory) **I. Continuous assessment** All the components to be evenly spaced	**40 Marks**

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

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER VII					
UNMIDS701	**Data Driven Applications**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor VII (Practical)**				
Total Contact Hours	**60 Lecture 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:

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 **15 Lecture Hours**

Introduction to Power BI - Need, Importance, Power BI - Advantages and Scalable Options, History - Power View, Power Query, Power Pivot, Power BI Data Source Library and DW Files, Cloud Collaboration 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, On-premise Data Access and Microsoft On Drive, Power BI Desktop - Installation, 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 **15 Lecture Hours**

Report Design with Legacy & .DAT Files, Report Design with Database 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 15 Lecture Hours

Power BI Design: Canvas, Visualizations and Fields, 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 Colours - Static, Dynamic, Sparse, Flashy Rows, Condensed Table Reports. Focus Mode, Totals Computations, Background. Bordes Properties, Column Headers, Column Formatting, Value Properties, Conditional Formatting Options - Colour 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 15 Lecture Hours

Chart report types and properties, stacked bar chart, stacked column chart clustered 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: Colour Saturation, Filters Types, Formats: Legend, Axis, Data Labels, Plot Area, Data Labels: Visibility, Colour 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	Weightage
Internal marks (Theory) **I. Continuous assessment** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

SEMESTER VII					
UNMIDS801	**Project and Case Study**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Hours	**60**				
Pre-Requisites/ Co-Requisites	**Python Programming and ML techniques**				

Course Outcomes (COs)

Upon completion of the course, the learner will be:

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 Lecture 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 II					
UNMIDS201	**Data Analytics using SQL**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

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 **15 Lecture Hours**

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 **20 Lecture Hours**

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 **10 Lecture Hours**

- 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 **15 Lecture Hours**

- 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

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

SEMESTER II					
UNMIDS202	**Data Analytics using R**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

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: 15 Lecture Hours

- 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: 15 Lecture Hours

- 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: 15 Lecture Hours

- 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: 15 Lecture Hours

- 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

3. Cognitive Computing with IBM Watson by Rob High, Tanmay Bakshi (1st edition)
4. Nina Zumel, John Mount, Practical Data Science with R, Manning Publications, 2014

Suggested Readings

3. Mark Gardener, Beginning R: The Statistical Programming Language, John Wiley & Sons, 2012
4. 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	Weightage
Internal marks (Theory) **I. Continuous assessment** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER III					
UNMIDS301	**Python for Data Science**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

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 15 Lecture Hours

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 **15 Lecture Hours**

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 **15 Lecture Hours**

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 15 Lecture Hours

- 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 Lecture 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.

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

SEMESTER IV					
UNMIDS402	**Data Structures and Algorithms**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60**				
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:

Course Content

CO1: Understanding and remembering key data structures such as arrays, linked lists, stacks, queues, trees, and graphs for effective data management.

CO2: Applying knowledge to design, implement, and analyze algorithms for various computational tasks, assessing their efficiency in terms of time and space complexity.

CO3: Analyzing complex real-world problems and selecting appropriate data structures and algorithms to optimize performance and resource usage.

CO4: Evaluating and improving existing algorithms, enhancing their efficiency and preparing them for more advanced studies or professional challenges in computer science.

Unit I: Oops Concepts 10 Lecture 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 Lecture 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 Lecture Hours

Introduction to Linked Lists and trees, Implementing Linked lists and Binary trees in Python. Introduction to searching algorithms: Linear search, Binary search. Introduction to sorting algorithms: Bubble sort, selection sort, insertion sort. Divide and Conquer algorithms: Merge Sort and quick sort algorithms.

Problem-Solving Exercises: Longest Common Subsequence, Longest Increasing Subsequence, Word Break Problem, Subset Sum Problem, Binary Search, Merge Sort, Quick Sort.

Unit IV: Graph Algorithms and Dynamic Programming 15 Lecture 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** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

Student Activity

Create a simple sorting algorithm, such as Bubble Sort or Insertion Sort, and implement it in your preferred programming language. Write a program to sort an array of integers and analyze its time complexity. After implementation, discuss with peers how different sorting algorithms compare in terms of efficiency and practical use cases. Submit both your code and a brief report on your findings.

SEMESTER V					
UNMIDS502	**Fundamentals of Artificial Intelligence**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Lecture Hours	**60 Lecture 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:

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 Lecture 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 Lecture 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 Lecture 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 Lecture 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).

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

Student Activity

In the *Fundamentals of Artificial Intelligence* course, students will engage in activities such as implementing AI models through hands-on projects, analyzing case studies of AI applications, participating in group discussions on ethical implications, and completing coding assignments using AI frameworks. Interactive quizzes and practical exercises will reinforce learning and enhance their understanding of AI concepts.

SEMESTER VI					
UNMIDS601	**Fundamental of Machine Learning**	**L**	**T**	**P**	**C**
Version		**2**	**0**	**4**	**4**
Category of Course	**Minor**				
Total Contact Hours	**60**				
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:

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 **15 Lecture Hours**

- Application of Machine Learning
- Supervised vs Unsupervised Learning
- Python libraries suitable for Machine Learning

Unit II: Data Pre-Processing and Data **15 Lecture Hours**

- Identifying and handling the missing values
- Encoding the categorical data
- Normalization
- Standardization
- PCA

Unit III: Supervised Learning Regression and Classification **15 Lecture 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 **15 Lecture 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 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)

1. **https://www.coursera.org/learn/machine-learning**
2. **https://www.datacamp.com/tutorial/introduction-machine-learning-python**

Evaluation Scheme

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

Student Activity

Students will participate in activities such as data cleaning, summarization, and visualization tasks. They will engage in assignments, quizzes, and group discussions, focusing on applying the concepts learned to real-time data. These activities will reinforce the theoretical knowledge acquired and provide practical experience in data analytics.

SEMESTER VII					
UNMIDS702	Neural Network and Deep Learning	L	T	P	C
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	60				
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:

CO1: Understanding the fundamental principles of neural networks, including architecture, activation functions, and optimization techniques.

CO2: Applying knowledge to design, train, and evaluating 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 **15 Lecture 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 Lecture 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 **15 Lecture Hours**

Convolution neural networks for image data, CNN building blocks- convolution, pooling, LeNet, AlexNet – pioneer CNN architectures, VGGNet, ResNet, and other modern CNN architectures, Data Augmentation techniques for computer vision, Applications of CNN- image recognition, object detection.

Unit IV: Recurrent Neural Networks and Sequences **15 Lecture 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** All the components to be evenly spaced Project/quizzes/assignment and essays/presentation/ participation/case studies/reflective journals (minimum of five components to be evaluated)	**40 Marks**
II. Internal marks (Theory): Mid Term Examination	**20 Marks**
III. External Marks (Theory): End Term Examination	**40 Marks**

Student Activity

Develop a neural network model to classify images from a provided dataset using a deep learning framework like TensorFlow or PyTorch. Students will preprocess the data, design and train the model, and evaluate its performance. They will then present their results, discussing challenges faced, model accuracy, and potential improvements. This activity emphasizes hands-on experience, problem-solving skills, and effective communication of technical findings.

SEMESTER VIII

UNMIDS802	Natural Language Processing	L	T	P	C
Version		2	0	4	4
Category of Course	Minor				
Total Contact Hours	60				
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:

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 10 Lecture Hours

Natural language Processing, Applications of NLP (chatbots, machine translation, sentiment analysis, etc.), Basic Text processing: tokenization, stop word removal, stemming/lemmatization, Vector representation of text (bag-of-word, TF-IDF, word embeddings).

Unit II: Language Learning Models 20 Lecture 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 10 Lecture 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 Lecture 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 10 Lecture Hours

Introduction to generative models and their applications, Text generation with language models and beam search, Image captioning and multimodal tasks, Generative adversarial networks (GANs) for text and image generation, Limitations, ethical considerations and future of generative AI, Open ended conversational AI and chatbots, ChatGPT.

Learning Experience

The learning experience in this course is highly interactive and hands-on, blending theoretical knowledge with practical applications. Students will engage in coding exercises, real-world projects, and collaborative group work to reinforce their understanding of Natural Language Processing (NLP) and Generative AI. Through the use of contemporary tools and frameworks, they will build and deploy models, analyze language data, and explore the ethical implications of AI. This approach ensures that students gain both technical expertise and critical thinking skills.

Textbooks

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

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 stop words 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 embedding.