SACRED HEART COLLEGE (AUTONOMOUS), THEVARA

KOCHI, KERALA, 682013

Syllabus of Courses

Under the discipline

Physics

(For Undergraduate (Honours) Degree Programmes)

Introduced from 2024-25 admissions onwards

Prepared by

Board of Studies in Physics

Sacred Heart College Thevara, Kochi.

BOARD OF STUDIES IN PHYSICS
SACRED HEART COLLEGE (AUTONOMOUS), THEVARA, KOCHI, KERALA

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FOREWARD

I am pleased to present the revised curriculum and syllabi for the B.Sc. Honours in Physics program, seeking approval from the Faculty, Board of Studies, and Academic Council of Sacred Heart College (Autonomous) Thevara.

Physics is a fundamental science and has contributed immensely to the improvement of human life by providing materials, methods, and other essentialities. Additionally, Physics is crucial for solving many future problems, including sustainable energy and food production, managing our environment, providing safe drinking water, and promoting human and environmental health. The advancements achieved in the field of physical sciences in the past few decades have been phenomenal. These developments are increasingly crossing the traditional vertical boundaries of scientific disciplines. Science is interdisciplinary. A physicist can no longer isolate themselves from other disciplines. New branches of Physics, such as nanomaterials, quantum computing, space physics, and computational physics, are emerging and gaining importance. The practice of Physics in industry is also undergoing radical changes.

Sacred Heart College (Autonomous) Thevara will offer an Honours degree under its Undergraduate Programme (UGP) starting from the 2024-25 academic year. The Board of Studies in Physics was tasked with developing new curricula and syllabi for the B.Sc. Honours program, adhering to the regulations of Mahatma Gandhi University and SHC-UGP (Honours) guidelines.

In this endeavor, the Board of Studies diligently sought expert opinions from renowned professionals in the field and consulted faculties from affiliated colleges. Additionally, the syllabi of various Central Universities, IISERs, IITs, and the UGC model curriculum were referenced.

The new syllabus is structured based on Outcome-Based Education (OBE). Program Specific Objectives (PSOs) for the MSc Physics program and Course Outcomes (COs) for each course have been meticulously crafted to ensure an effective teaching-learning process.

The BoS prepared draft proposals of revised curricula and syllabi for B.Sc Honours Programmes in Physics keeping the Credit and Semester System. The syllabus has been set with an objective of training the students in all the fundamentals of the subject along with good practical exposure. Most of the advanced topics have been incorporated in the fourth semester. The BoS feels that appreciable updating could be done considering the current developments and latest trends in Physics education. The task of preparing the Curricula and Syllabi and bringing it out in the present form was not a simple task but it was possible with the dedicated efforts, wholehearted support and involvement of all the members of the faculty and BoS. I would like to express my sincere thanks to all my fellow members of the BoS and faculty for all their help, cooperation and encouragement.

Dr. Roby Cherian
Chairman
Board of Studies in Physics
Sacred Heart College (Autonomous), Thevara.

CONTENTS

1. INTRODUCTION

The National Education Policy (NEP) 2020 envisages the revision of the Choice Based Credit System (CBCS) for instilling innovation and flexibility. It emphasizes on promoting interdisciplinary studies, introducing new subjects, and providing flexibility in courses and fresh opportunities for students. It also envisages setting up of facilitative norms for issues, such as credit transfer, equivalence etc., and a criterion-based grading system that assesses student achievement based on the learning goals for each programme.

The NEP document suggests several transformative initiatives in higher education. These include:

- Introduction of holistic and multidisciplinary undergraduate education that would help develop all capacities of human beings - intellectual, aesthetic, social, physical, emotional, ethical and moral - in an integrated manner; soft skills, such as complex problem solving, critical thinking, creative thinking, communication skills; and rigorous specialization in a chosen field (s) of learning.
- Adoption of flexible curricular structures in order to enable creative combinations of disciplinary areas for study in multidisciplinary contexts in addition to rigorous specialization in a subject
- Undergraduate degree programmes of either 3 or 4-year duration.
- The students are getting a chance to determine his/her own semester-wise academic load and will be allowed to learn at his/her pace, to the extent possible.
- Increase in the number of choices of courses available to students and the students are getting an opportunity to choose the courses of their interest from all disciplines.
- Multidisciplinary and holistic education with emphasizes on research, skill development and higher order thinking,
- Promotion of innovation and employability of the student.
- Flexibility for the students to move from one institution to another as per their choice.
- Flexibility to switch to alternative modes of learning (offline, ODL, and online learning, and hybrid modes of learning).

Outcome Based Education (OBE)

Undergraduate courses in Physics follow the Outcome-based Education (OBE) framework. OBE is a system where all the parts and aspects of education are focused on the outcomes of the course. The students take up courses with a certain goal of developing skills or gaining knowledge and they have to complete the goal by end of the course. Outcome-based education affirms teachers as facilitators, rather than lecturers. In this model, teachers guide the students and encourage them to develop their knowledge and skills. The undergraduate courses at the Department of Physics, Sacred Heart College (Autonomous), Thevara provides a learning approach in which students develop analytical ability and critical thinking and research acumen over different situations.

Programme Outcomes

The Undergraduate Programme Outcomes (POs) are as follows:

PO 1: Critical thinking and Analytical reasoning

- Critical thinking guides the assessment and judgment of information, while analytical reasoning involves specific methods for analysis and conclusion drawing. It includes the ability to assess evidence, identify assumptions, formulate coherent arguments, understand complex relationships, and evaluate practices and theories critically. Additionally, critical sensibility involves self-awareness and reflection on personal and societal experiences.

PO 2: Scientific reasoning and Problem solving

- Capacity to interpret and draw conclusions from data, critically evaluate ideas and evidence with an open-minded perspective; ability to apply learned competencies to solve unfamiliar problems and apply knowledge to real-life situations, avoiding mere replication of curriculum content.

PO 3: Effective communication and leadership skill

- Proficiency in expressing thoughts verbally and non-verbally, utilizing appropriate communication media. Confidently sharing ideas, active listening, analytical reading and writing and presenting complex information clearly to diverse groups. Effective teamwork and leadership skills, including setting direction, inspiring vision, building and motivating teams, and guiding them efficiently towards common goals.

PO 4: Social consciousness and responsible citizenship

- Social consciousness involves an empathetic and informed perspective, extending beyond personal concerns to embrace a responsibility for the collective good in nation-building. It includes reflecting on the impact of research on conventional practices and a clear understanding of societal needs for inclusive and sustainable development. Responsible citizens contribute positively through civic engagement, environmental stewardship, and a commitment to social justice, abiding by laws and working for the advancement of society.

PO 5: Equity, Inclusiveness and Sustainability

- Promoting equity, inclusiveness, sustainability, and diversity appreciation. Developing ethical and moral reasoning with values of unity, secularism, and national integration for dignified citizenship. Understanding and appreciating diversity, managing differences, and using an inclusive approach. Emphasizing creating environments where diverse individuals feel valued, addressing present needs without compromising future generations' ability to meet their own needs, considering environmental, economic, and social factors.

PO 6: Moral and Ethical Reasoning

- Possessing the capacity to embody moral and ethical values in personal conduct, articulating positions and arguments on ethical matters from diverse perspectives, and consistently applying ethical practices in all endeavours. Proficient in recognizing and addressing ethical issues pertinent to one's work, steadfastly steering clear of any unethical behaviour.

PO 7: Networking and Collaboration

- Cultivating networking skills in education entails establishing meaningful professional connections and relationships among educators, administrators, and stakeholders. It also involves fostering cooperative efforts among individuals, institutions, and research organizations within the educational realm. These practices are indispensable for nurturing a supportive, innovative, and dynamic learning environment.

PO 8: Lifelong Learning

- Cultivating the ability to continually acquire knowledge and skills, including the art of "learning how to learn," becomes paramount for lifelong learning. This self-paced and self-directed approach serves personal development, aligns with economic, social, and cultural objectives, and facilitates adaptation to evolving workplace demands through skill development and reskilling. It equips individuals with competencies and insights, allowing them to adeptly respond to society's changing landscape and enhance their overall quality of life. Lifelong learning extends beyond formal education, embracing diverse informal and non-traditional learning experiences.

2. REGULATIONS FOR UNDERGRADUATE (HONOURS) DEGREE PROGRAMMES

PREAMBLE

Sacred Heart College (Autonomous), Thevara, Kochi is a grant-in-aid private college affiliated to Mahatma Gandhi University, Kottayam, Kerala. The College was established in 1944 as a higher educational institute for men on the basis of the minority rights. It started admitting girls in 1975 and currently serves all sections of the society without any discrimination of caste or creed.

The College was granted Autonomous Status by the University Grants Commission (UGC) in 2014.

Vision and Mission of the Institution

The vision of the College aims at the formation of holistic individuals who would champion the cause of justice, love, truth and peace. To this effect, Sacred Heart College envisions the **"Fashioning of an enlightened society founded on a relentless pursuit of excellence, a secular outlook on life, a thirst for moral values as well as an unflinching faith in God."** It seeks the creation of a world, guided by divine wisdom, governed by moral principles, inclusive by secular outlook and united by the principle of equity.

The Mission of the Institution is to provide an environment that

- **facilitates the holistic development of the individual**
- **enables the students to play a vital role in the nation-building process and contribute to the progress of humanity**
- **disseminates knowledge even beyond the academia**
- **instils in the students a feel for the frontier disciplines, and**
- **cultivates a concern for the environment**

by setting lofty standards in the ever-evolving teacher-learner interface.

Framing of the Regulations

As part of the implementation of the National Education Policy 2020 (NEP 2020), the University Grants Commission (UGC) has issued the Curriculum and Credit Framework for Undergraduate Programmes 2023 (CCFUP) which would provide a flexible choice-based credit system, multidisciplinary approach, multiple entry and exit options, and establish three Broad Pathways, (a) 3-year UG Degree, (b) 4-year UG Degree (Honours), and (c) 4-year UG Degree (Honours with Research).

The Kerala Higher Education Reforms Commission has recommended a comprehensive reform in the undergraduate curriculum for the 2023-24 academic year, adopting 4-year undergraduate programs to bring Kerala's undergraduate education at par with well acclaimed universities across the globe.

The Kerala State Curriculum Committee for Higher Education has been constituted, and have proposed a model Kerala State Higher Education Curriculum Framework (KSHECF) for Undergraduate Education.

Further, an Academic Committee and various sub committees were constituted for the implementation of the Regulations. The Academic Committee submitted the draft regulations on 15-03-2024, namely**: THE SACRED HEART COLLEGE (AUTONOMOUS) UNDERGRADUATE PROGRAMMES (HONOURS) REGULATIONS, 2024 {SHC-UGP (Honours)}** under the New Curriculum and Credit Framework, 2024.

REGULATIONS

Short Title and Commencement

i. These Regulations may be called THE SACRED HEART COLLEGE (AUTONOMOUS) UNDERGRADUATE PROGRAMMES (HONOURS) REGULATIONS, 2024 {SHC-UGP (Honours)} under the New Curriculum and Credit Framework 2024.

ii. These Regulations will come into effect from the academic year 2024-2025 and will have prospective effect.

Scope and Application

iii. These Regulations shall apply to all Undergraduate programmes under various Faculties conducted by THE SACRED HEART COLLEGE (AUTONOMOUS) for the admissions commencing in the academic year 2024-2025.

iv. Every programme conducted under the SHC-UGP shall be monitored by an SHC-UGP Academic Committee comprising members nominated by the Principal.

Definitions

Unless used in a context otherwise specified,

i. College means THE SACRED HEART COLLEGE (Autonomous), a grant-in-aid private college affiliated to Mahatma Gandhi University, Kottayam, Kerala.

ii. ‘University’ means the MAHATMA GANDHI University which is the affiliating University of Sacred Heart College (Autonomous).

iii. FYUGP means Four Year Undergraduate Programme.

iv. Academic Year: Two consecutive (one odd and one even) semesters followed by a vacation in one academic year.

v. Academic Coordinator/Nodal Officer: Academic Coordinator/Nodal Officer is a faculty nominated by the college council to co-ordinate the effective conduct of the FYUGP including Continuous Comprehensive Assessment (CCA) undertaken by various departments within the college. She/ he/ they shall be the convenor for the College level Academic Committee.

vi. Academic Week: A unit of five working days in which the distribution of work is organized, with at least five contact hours of one-hour duration on each day.

vii. Academic Credit: A unit by which the course work is measured. It determines the number of hours of instructions required per week in a semester. It is defined both in terms of student efforts and teacher's efforts. A course which includes one hour of lecture or tutorial or minimum 2 hours of lab work/ practical work/ field work per week is given one credit hour. Accordingly, one credit is equivalent to one hour of lecture or tutorial or two hours of lab work/ practical work/ field work/ practicum and learner engagement in terms of course related activities (such as seminars preparation, submitting assignments, group discussion, recognized club-related activities etc.) per week. Generally, a one credit course in a semester should be designed for 15 hours Lecture/ tutorials or 30 hours of practical/ field work/ practicum and 30 hours learner engagement.

viii. Academic Bank of Credits (ABC): An academic service mechanism as a digital/ virtual entity established and managed by Government of India to facilitate the learner to become its academic account holder and facilitating seamless learner mobility, between or within degree-granting Higher Education Institutions (HEIs) through a formal system of credit recognition, credit accumulation, credit transfers and credit redemption to promote distributed and flexible process of teaching and learning. This will facilitate the learner to choose their own learning path to attain a Degree/ Diploma/ Certificate, working on the principle of multiple entry and exit, keeping to the doctrine of anytime, anywhere, and any level of learning.

ix. Credit Accumulation: The facility created by ABC in the Academic Credit Bank Account (ABA) opened by the learner across the country in order to transfer and consolidate the credits earned by them by undergoing courses in any of the eligible HEIs.

x. Credit Recognition: The credits earned through eligible/ partnering HEIs and transferred directly to the ABC by the HEIs concerned.

xi. Credit Redemption: The process of commuting the accrued credits in the ABC of the learner for the purpose of fulfilling the credits requirements for the award of various degrees. Total credits necessary to fulfil the criteria to get a degree shall be debited and deleted from the account concerned upon collecting a degree by the learner.

xii. Credit Transfer: The mechanism by which the eligible HEIs registered with ABC are able to receive or provide prescribed credits to individual's registered with ABA in adherence to the UGC credit norms for the course(s) registered by the learner in any HEIs within India.

xiii. Credit Cap: Maximum number of credits that a student can take per semester, which is restricted to 30.

xiv. Continuous Comprehensive Assessment (CCA): The mechanism of evaluating the learner by the course faculty at the institutional level.

xv. End Semester Evaluation (ESE): The mechanism of evaluating the learner at the end of each semester.

xvi. Audit Course: a course that the learner can register without earning credits, and is not mandatory for completing the SHC-UGP. The student has the option not to take part in the CCA and ESE of the Audit Course. If the student has 75% attendance in an Audit Course, he/she/they is eligible for a pass in that course, without any credit (zero-credit).

xvii. Courses: refer to the papers which are taught and evaluated within a programme, which include lectures, tutorials, laboratory work, studio activity, field work, project work, vocational training, viva, seminars, term papers, presentations, assignments, self-study, group discussion, internship, etc., or a combination of some of these elements.

xviii. Choice Based Credit System (CBCS) means the system wherein students have the option to select courses from the prescribed list of courses.

xix. College-level Academic Committee: Is a committee constituted for the FYUGP at the college level comprising the Principal as the Chairperson, the Academic Co-ordinator/ Nodal Officer as its convenor.

xx. Academic Co-ordinator/ Nodal Officer: A senior faculty member nominated by the college council.

xxi. Course Faculty: A faculty member nominated by the Head of the Department shall be in charge of offering a particular course in a particular semester of FYUGP.

xxii. Department means any teaching department in a college offering a course of study approved by the College as per the regulations of the college and it includes a Department, Centre, or School of Teaching and Research conducted directly by the College.

xxiii. Board of Studies (BoS) means the academic body duly constituted to frame the syllabus of each department.

xxiv. Senior Faculty Advisor (SFA) is a faculty nominated by a Department Council to co-ordinate all the necessary work related to FYUGP undertaken in that department, including the continuous comprehensive assessment.

xxv. Department Council means the body of all teachers of a department in a college.

xxvi. Faculty Adviser (FA) means a teacher from the parent department nominated by the Department Council to advise students in academic matters.

xxvii. Graduate Attributes means the qualities and characteristics to be obtained by the graduates of a programme of study at the College, which include the learning outcomes related to the disciplinary areas in the chosen field of learning and generic learning outcomes. The College will specify graduate attributes for its programmes.

xxviii. Programme means the entire duration of the educational process including the evaluation leading to the award of a degree.

xxix. Programme Pathway: Combination of courses that can be chosen by a student that give options to pursue interesting and unconventional combinations of courses drawn from different disciplinary areas, like the sciences and the social sciences/ humanities. The pathways could be in terms of major- minor options with different complementary/ allied disciplines.

xxx. Regulatory Body means University Grants Commission (UGC), All India Council for Technical Education (AICTE), National Assessment and

Accreditation Council (NAAC) and National Board of Accreditation (NBA) etc.

xxxi. Signature Courses: Signature courses are the specialized Discipline Specific Elective courses or skill-based courses designed and offered by the regular/ ad hoc/ visiting/ emeritus/ adjunct faculty member of a particular college with the prior recommendation of the BoS and the approval of Academic Council of the College.

xxxii. Letter Grade or simply ‘Grade’ in a course is a letter symbol (O, A+, A, B+, B, C, P, F, and Ab). Grade shall mean the prescribed alphabetical grade awarded to a student based on their performance in various examinations. The Letter grade that corresponds to a range of CGPA.

xxxiii. Grade Point: Each letter grade is assigned a ‘Grade point’ (G) which is an integer indicating the numerical equivalent of the broad level of performance of a student in each course. Grade Point means point given to a letter grade on 10-point scale.

xxxiv. Semester Grade Point Average (SGPA) is the value obtained by dividing the sum of credit points obtained by a student in the various courses taken in a semester by the total number of credits in that semester. SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.

xxxv. Credit Point (P) of a course is the value obtained by multiplying the grade point (G) by the credit (C) of the course: P = G x C

xxxvi. Cumulative Grade Point Average (CGPA) is the value obtained by dividing the sum of credit points in all the semesters earned by the student for the entire programme by the total number of credits in the entire programme and shall be rounded off to two decimal places.

xxxvii. Grade Card means the printed record of students’ performance, awarded to them.

xxxviii. Words and expressions used and not defined in this regulation, but defined in the Mahatma Gandhi University Act and Statutes, being the Act and Statues of Sacred Heart College (Autonomous)’s affiliating University shall have the meaning assigned to them in the Act and Statutes.

Features and Objectives of SHC-UGP

The features and objectives of the SHC-UGP shall be:

v. The features, meaning, and purpose of FYUGP shall be as stipulated by the UGC and as adapted by the Kerala State Higher Education Curriculum Framework (KSHECF) for undergraduate education.

vi. The practice of lateral entry of students to various semesters exists, but an exit with a Degree shall be awarded only upon successful completion of 133 credits as per the conditions stipulated in this regulation.

vii. FYUGP shall have three Broad Pathways, (a) 3-year UG Degree, (b) 4-year UG Degree (Honours), and (c) 4-year UG Degree (Honours with Research).

viii. Students who choose to exit after 3 years shall be awarded UG Degree in their respective Discipline/ Disciplines after the successful completion of the required minimum Courses with 133 credits.

ix. A 4-year UG Degree (Honours) in the Discipline/ Disciplines shall be awarded to those who complete the FYUGP with a specific number of Courses with 177 credits including 8 credits from a graduate project/ dissertation in their major discipline.

x. Students who acquire minimum 75% in their graduation (upto 6th semester) are eligible for Honours with Research Programme. However if necessary, College may conduct screening test for the honours with research programme in accordance with College Regulations from time to time.

xi. 4-year UG Degree (Honours with Research): Students who aspire to pursue research as a career may opt for 4-year UG Degree Honours with Research stream under FYUGP with a specific number of Courses with 177 credits including 12 credits from a research project in their major discipline.

xii. -The recognized research departments or departments with at least two faculty members having PhD shall offer the Honours with Research programme. Minimum 2 students (mentees) should be allotted to a faculty member (Mentor).

xiii. Students who have chosen the honours with research stream shall do their entire fourth year under the mentorship of a mentor.

xiv. The mentor shall prescribe suitable advanced level/capstone level courses for a minimum of 20 credits to be taken within the institutions along with the courses on research methodology, research ethics, and research topic-specific courses for a minimum of 12 credits which may be obtained either within the institution or from other recognized institutions, including online and blended modes.

xv. Students who have opted for the honours with research should successfully complete a research project under the guidance of the mentor and should submit a research report for evaluation. They need to defend successfully the research project to obtain 12 credits under a faculty member of the College. The research shall be in the Major/ allied discipline.

xvi. The research outcomes of their project work may be published in peer-reviewed journals or presented at conferences or seminars or patented.

xvii. The proposed FYUGP curriculum comprises Three Broad Parts: a) Foundation Components, b) Discipline Specific Pathway components (Major/ Minor), and c) Discipline Specific Capstone Components.

xviii. The Foundation component of the FYUGP shall consist of a Set of General Foundation Courses and a Set of Discipline Specific Foundation Courses.

xix. General Foundation Courses shall be grouped into 4 major baskets as Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC), Value Addition Courses (VAC), and Multi-Disciplinary Courses (MDC).

xx. Ability Enhancement Courses shall be designed specifically to achieve competency in English, other languages as per the student’s choice with special emphasis on language and communication skills.

xxi. English or other language courses shall be designed to enable the students to acquire and demonstrate the core linguistic skills, including critical reading, academic and expository writing skills as well as the cultural and intellectual heritage of the language chosen. Separate courses will be designed for Science, Humanities and Commerce streams.

xxii. Multi-Disciplinary Courses (MDC) shall be so designed as to enable the students to broaden their intellectual experience by understanding the conceptual foundations of Science, Social Sciences, Humanities, and Liberal Arts. Students shall not be eligible to take the MDC in the same discipline that they have studied during their +2. Third semester MDC can be Kerala specific content.

xxiii. Skill Enhancement Courses (SEC) shall be designed to enhance 21st century workplace skills such as creativity, critical thinking, communication, and collaboration.

xxiv. Discipline Specific Courses shall include Discipline Specific Pathway Courses, both Major and Minor streams, enabling students to gain basic knowledge in the chosen discipline.

xxv. Discipline Specific Foundation Courses shall focus on foundational theories, concepts, perspectives, principles, methods, and critical thinking essential for taking up advanced/ Capstone Courses. Practical courses shall be included in discipline specific foundation courses.

xxvi. The curriculum of the SEC should be designed in a manner that at the end of year- 1, year-2, year-3, and year-4 students are able to meet the level descriptors for levels 5, 6, 7, and 8 of the UGC Guidelines on National Skills Qualifications Framework (NSQF). The detailed descriptors of the NSQF levels is provided as **Appendix I** below.

xxvii. Value Addition Courses (VAC) shall be so designed as to empower the students with personality development, perspective building, and self-awareness.

xxviii. Discipline Specific Pathway Components (Major/ Minor) shall provide the students with an opportunity to pursue in-depth study of a particular subject or discipline and develop competency in that chosen area, which includes Discipline Specific Core (DSC) courses and Discipline Specific Elective (DSE) courses as Major and Minor courses.

xxix. Major components consist of three types: Discipline Specific Core or the Discipline Specific Elective Courses, and the research /laboratory/ fieldwork.

xxx. Minor Courses can be selected from any discipline that may supplement or complement the Major Courses.

xxxi. Students who complete a sufficient number of Courses in a discipline or an interdisciplinary area of study other than their chosen Major shall qualify for a Minor in that discipline or in a chosen interdisciplinary area of study.

xxxii. Major Components shall be the main focus of study. By selecting a Major, the student shall be provided with an opportunity to pursue an in-depth study of a particular discipline.

xxxiii. Each Board of Studies (BoS) shall identify specific Courses or baskets of Courses towards Minor Course credits. Students shall have the option to choose Courses from disciplinary/ interdisciplinary minors and skill-based courses related to a chosen programme.

xxxiv. Students can opt for a change of Major at the end of the second semester to any Minor discipline studied among the foundation level courses. Students also can opt for a change of Major at the end of the second semester to any MDC.

xxxv. Students should opt their 5th and 6th semester VAC and SEC from their Major disciplines only.

xxxvi. Course cum Credits Certificate: After the successful completion of a semester as proof for re-entry to another institution this certificate is essential. This will help the learner for preserving the credits in the Academic Bank of Credits.

xxxvii. The Advanced Level/ Capstone Level Courses shall be designed in such a manner as to enable students to demonstrate their cumulative knowledge in their main field of study, which shall include advanced thematic specialization or internships or community engagement or services, vocational or professional training, or other kinds of work experience.

xxxviii. Advanced/ Capstone level Major Specialization shall include Courses focused on a specific area of study attached to a specific Major, which could be an Elective Course. They shall include research methodology as well.

xxxix. The student has the option to register for and attend a course without taking part in the CCA and ESE of that course. Such a course is called the Audit Course. If the student has 75% attendance in an Audit Course, he/she/they is/are eligible for a pass in that course, without any credit (zero-credit). The Audit Course will be recorded in the final grade card of the student.

xl. All students shall undergo Summer Internship or Apprenticeship in a Firm, Industry or Organization; or Training in labs with faculty and researchers or other Higher Education Institutions (HEIs) or Research Institutions. The College will adhere to the guidelines on internship published by the University.

xli. Students will be provided the opportunities for internships with local industries, business organizations, agriculture, health and allied sectors, Local Government institutions (such as panchayats, municipalities), State Planning Board, State Councils/ Boards, Research Institutions, Research Labs, Library, elected representatives to the parliament/ state assembly/ panchayat, media organizations, artists, crafts persons etc. These opportunities will enable the students to actively engage with the practical aspects of their learning and to improve their employability.

xlii. The College will provide opportunities for field-based learning/minor projects enabling them to understand the different socio-economic and development-related issues in rural and urban settings. The College will provide the students with opportunities for Community engagement and services, exposing them to socio-economic issues to facilitate theoretical learning in real-life contexts.

xliii. Additional Credits will be awarded for those who actively participating in Social Activities, which may include participation in National Service Scheme (NSS), Sports and Games, Arts, participation in College union related activities (for respective elected/ nominated members), National Cadet Corps (NCC), adult education/ literacy initiatives, mentoring school students, and engaging in similar social service organizations that deemed appropriate to the College.

xliv. Grace marks shall be awarded to a student for meritorious achievements in co-curricular activities (in Sports/ Arts/ NSS/ NCC etc.). Such a benefit is applicable in the same academic year spreading over two semesters, in which the said meritorious achievements are earned. The Academic Council will decide from time to time the eligibility and other rules of awarding the grace marks.

xlv. Options will be made available for students to earn credit by completing quality- assured remote learning modes, including Online programmes offered on the Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM) or other Online Educational Platforms approved by the competent body/university from time to time.

xlvi. Students shall be entitled to gain credits from courses offered by other recognized institutions directly as well as through distance learning.

xlvii. For the effective operation of the FYUGP, a system of flexible academic transaction timings shall be implemented for the students and teachers.

Eligibility for Admission and Reservation of Seats

i. The eligibility for admissions and reservation of seats for various FYUG Degree Programmes shall be in accordance with the norms/ rules made by the Government/ University from time to time.

ii. No student shall be eligible for admission to FYUG Degree Programmes in any of the disciplines unless he/she/they has successfully completed the examination conducted by a Board/University at the +2 level of schooling or its equivalent.

iii. Students shall be admitted and enrolled in the respective programmes solely based on the availability of the academic and physical facilities within the institution. The College shall provide all students with a brochure detailing the Courses offered by the various departments under the various Programmes and the number of seats sanctioned by the University for each Programme.

iv. During the time of admission each student may be provided with a unique higher education student ID which may be linked with the Aadhar number of the student so that this ID can be transferred if required to other higher education institutions as well.

v. The students at the end of second semester may be permitted to change their major programme of study to any course/ institution/ university across the state. Based on the availability of seats and other facilities, the students may be permitted to opt any discipline which he/she/they had studied during the first two semesters as Discipline Specific Foundation courses/ Multidisciplinary Foundation courses. If ranking is required it will be in the order of the highest-grade points secured in the discipline to which the switching of Major is sought.

vi. Students shall be allowed to change their major programmes, if required, to a maximum of 10% of the sanctioned strength of that particular programmes depending upon the academic and infrastructural facilities available in the Institution.

vii. Depending upon the availability of academic and infrastructural facilities, the College may also admit a certain number of students who are registered for particular programmes in each semester by transfer method, if required, from other Institutions subject to conditions as may be issued by the University.

viii. A student who has already successfully completed a First-Degree Programme and is desirous of and academically capable of pursuing another First-Degree Programme may also be admitted with the prior approval of the University as per the conditions regarding programme requirements specified by the University.

ix. A Student can also be admitted for an additional major/ second major/ additional minor and on completion of the required credits he/she/they can be awarded a second major/ additional major/ minor. He/she/they may be exempted from minor pathway and general foundation course requirement.

x. The College can also enroll students in certain courses as per their choice depending upon the availability of infrastructure and other academic facilities from other recognized HEIs who are already registered for a particular programme there either through regular/ online/ distance mode irrespective of the nature of programme (Govt./ Aided/ Self- finance/ Autonomous). On successful completion of the course the credits may be transferred through the Academic Bank of Credit.

Academic Monitoring and Student Support

The academic monitoring and student support shall be in the following manner, namely

i. The College shall appoint a Senior Faculty member as Academic Co-ordinator/ Nodal officer for the smooth conduct of FYUGP.

ii. Advisory System: There shall be one Senior Faculty Advisor (SFA) for each department and one Faculty Advisor (FA) for 20 to 30 students of the class to provide advice in all relevant matters. The Head of the Department, in consultation with the SFA, shall assign FA for each student.

iii. The documents regarding all academic activities of students in a class shall be kept under the custody of the FA/ SFA.

iv. All requests/ applications from a student or parent to higher offices are to be forwarded/ recommended by FA/ SFA.

v. Students shall first approach their FA/ SFA for all kinds of advice, clarifications, and permissions on academic matters.

vi. It is the official responsibility of the institution to provide the required guidance, clarifications, and advice to the students and parents strictly based on the prevailing academic regulations.

vii. The SFA shall arrange separate or combined meetings with FA, faculty members, parents, and students as and when required and discuss the academic progress of students.

viii. The FA/ SFA shall also offer guidance and help to solve the issues on academic and non-academic matters, including personal issues of the students.

ix. Regular advisory meetings shall be convened immediately after the commencement of the semester and immediately after announcing the marks of the Continuous Comprehensive Assessment (CCA).

x. The CCA related results shall be displayed on the department notice board/ other official digital platforms of the college at least for two working days.

a. Any concern raised by the students regarding CCA shall be looked into in the combined meetings of advisors, HOD, course faculty, and the students concerned.
b. If the concerns are not resolved at the advisor's level, the same can be referred to the properly constituted college-level grievance redressal committees as per the existing UGC/ University/ Government norms.
c. The Principal/ HOD shall ensure the proper redressal of the concerns raised by the students regarding CCA.
d. If the students raise further concerns about the issue, the principal shall refer the issue to the appropriate authorities with proper documents and minutes of all the committees.

xi. The FA/ SFA shall be the custodian of the minutes and action taken reports of the advisory meetings. The SFA shall get the minutes and action taken reports of advisory meetings approved by the Head of Department and the Principal.
xii. The Principal shall inform/forward all regulations, guidelines, communications, announcements, etc. regarding student academic and other matters to the HODs/ SFA for information and timely action.
xiii. It shall be the official responsibility of the Principal to extend the required administrative and financial support to the HODs, SFAs and FAs to arrange necessary orientation programmes for students regarding student counselling, the prevailing norms, regulations, guidelines and procedures on all academic and other related matters.
xiv. An integrated educational planning and administration software will be made available by the College to manage the academic information of all students including student admissions and registration, managing students' personal and academic information, course registrations, attendance management, all process related to assessments including regular & online examinations, grading, publishing of results, supplementary examinations, LMS, stakeholders' feedback, etc.
xv. Faculty, staff, students, and parents shall be allowed to access this software system over a highly secure authenticated mechanism from within the campus.

Course Registration

i. Each department shall publish well in advance the relevant details of courses offered, such as the name, academic level, expected outcomes, time slot, and course faculty members.
ii. Students shall be allowed to visit and interact with respective faculty members during the first week of each semester, to gather more information about the courses and the availability of seats.
iii. Based on consultations and advice from the faculty adviser, each student shall complete course registration within one week from the commencement of each semester.
iv. The number of credits that a student can take in a semester is governed by the provisions in these Regulations, subject to a minimum of 16 and a maximum of 30 Credits.
v. A student can opt out of a Course or Courses registered, subject to the minimum Credit/ Course requirement, if he/she/they feels that he/she/they has

registered for more Courses than he/she/they can handle, within 30 days from the commencement of the semester.

vi. The college shall publish a list of the students registered for each course including audit course, if any, along with the chosen Programmes, repeat/ reappearance courses, if any.

vii. The higher education institutions shall admit candidates not only for programmes, but also for courses.

Re-admission and Scheme Migration

i. Students who opt out before the completion of the third year shall be provided with a 'Course cum Credits Certificate' after the successful completion of a semester as proof for re-entry to another institution.

ii. Students who have successfully completed a particular programme pathway may be permitted to take an additional minor or second major.

iii. Those students who are opting for a second major are eligible for getting certain credit transfer/ credit exemption from their previous minor programs of study, subject to the prior recommendation of the BoS that, those credits are relevant for the present major programme of study.

Duration of Programme, Credits, Requirements and Options

i. Students will be offered the opportunity to take breaks during the programme and resume after the break, but the total duration for completing the FYUG programme shall not exceed 7 years.

ii. Students who wish to complete the undergraduate programmes faster may do so by completing different courses equivalent to the required number of credits and fulfilling all other requirements in N-1 semesters, where N is the number of semesters in the FYUGP.

iii. Provided further that the students may complete the undergraduate programme in slower pace, they may pursue the three years or six semester programme in 4 to 5 years (8 to 10 semesters), and four years, or eight semester programme in 5 to 6 years (10 to 12 semesters) without obtaining readmission.

iv. For students who crossed 6 semesters at a slower space, the requirement of 16 credits per semester from the institutions where they enrolled may be relaxed.

Credit Structure

The proposed number of credits per course and the credit distribution of them for the FYUG Programmes are given below:

i. An academic year shall consist of 200 working days; one semester consists of 90 working days; and an academic year consists of two semesters.

ii. Ten working days in a semester shall be used for extracurricular activities. One semester consists of 18 weeks with 5 working days per week. In each semester, 15 days (3 weeks) should be kept aside for End Semester Evaluation (ESE) and CCA.

iii. The maximum number of available weeks for curriculum transactions should be fixed at 15 in each semester. A minimum of 5 teaching or tutorial hours could be made available for a day in a 5-day week.

iv. A course that includes one hour of lecture/ tutorial or two hours of lab work/ practical work/ field work/ practicum per week is given one credit hour.

v. One credit in a semester should be designed for 15 hours of lectures/ tutorials or 30 hours of lab work/ practical work/ field work/ practicum and 30 hours of learner engagement in terms of course-related activities such as seminar preparation, submitting assignments, etc.

vi. A one-credit seminar or internship or studio activities or field work/ projects or community engagement and service will have two-hour engagements per week (30 hours of engagement per semester).

vii. A course can have a combination of lecture credits, tutorial credits, and practicum credits.

viii. Minimum credit for one Course should be 2 (Two), and the maximum credit should be 4 (Four).

ix. All Discipline Specific Major/ Minor Courses shall be of 4 (Four) credits.

x. For all Discipline Specific Major/ Minor Courses, there may be practical/ practicum of two or four hours per week.

xi. All Courses under the Multi-Disciplinary, Ability Enhancement, Value Addition and Skill Enhancement categories are of 3 credits.

xii. Summer Internship, Apprenticeship, Community outreach activities, etc. may require sixty hours (or as appropriate) of engagement for acquiring one credit.

xiii. A student shall be able to opt for a certain number of extra credits over and above the requirements for the award of a degree.

xiv. Maximum number of credits that a student can earn per semester shall be restricted to 30. Hence, a student shall have the option of acquiring credits to a maximum of 180 credits for a 6-semester UG programmes and 240 credits for a 4-year (8-semester) programmes.

xv. Each faculty member shall offer a maximum of 16 credits per semester. However those who are offering both practical and theory courses shall offer a maximum of 12-16 credits per semester.

xvi. For a four-credit theory course, 60 hours of lecture/ tutorial class shall be assured as a mandatory requirement for the completion of that course.

Course Structure of the SHC-UGP Programme

The SHC-UGP consists of the following categories of courses and the minimum credit requirements for pathway option-one shall be as follows;

Sl. No.	**Categorization of Courses for all Programme**	**Minimum Number of Credit Required**	
1.	Major	68	88
2.	Minor	24	24+12 *
3.	Multi-Disciplinary Courses (MDC)	9	9
4.	Skill Enhancement Courses (SEC)	9	9
5.	Ability Enhancement Courses (AEC)	12	12
6.	Value Addition Courses (VAC)	9	9

7.	Summer Internship, field based learning etc.	2	2
8.	Research Project / Dissertation		12/8**

* The students can acquire advanced/ capstone level courses with 12 credits from their DSC/ DSE/ Minor courses depending up on their pathway choice. The Minor courses can be of level 300 or above.
** The students perusing the 4-year honours with research have to complete a project with 12 credits and for the 4-year honours degree students have to complete a project with 8 credits and DSC/ DSE capstone/ advanced level course in the 8th semester.

i. 20% syllabus of each course will be prepared by the teacher as ‘Teacher Specific Content’ and will be evaluated under CCA.
ii. In case of MDC, SEC, VAC courses coming under 3rd & 4th semester, college should make necessary arrangements to give adequate preference to courses designed by language departments. MDC in the 3rd semester can be Kerala Specific Content.

Academic Levels of Pathway Courses

Semester	Difficulty level	Nature of Course
1 & 2	100-199	Foundation-level or introductory courses
3 & 4	200-299	Intermediate level courses
5 & 6	300-399	Higher level courses
7 & 8	400-499	Advanced/Capstone level courses

Signature Courses

i. With a prior recommendation of BoS and the approval of academic council, each faculty member can design and offer at least one signature course in every semester, which may be offered as DSE /SEC/ VAC.
ii. The College will publish a list of signature courses in DSE/ SEC/ VAC offered by the faculty members with a prior recommendation of BoS and the approval of academic council.
iii. The College may empanel distinguished individuals who have excelled in their field of specialization like science and technology, industry, commerce, social research, media, literature, fine arts, civil services etc. as adjunct faculty as per

the UGC guidelines with the approval of the College. With a prior recommendation of BoS and the approval of academic council, the adjunct faculty can offer SEC/VAC as signature course.

iv. Ad hoc/ Guest faculty/ Visiting faculty/ Visiting Scholars can also offer DSE/ SEC/ VAC as signature courses with a prior recommendation of BoS and the approval of academic council.

v. The faculty concerned may design the particular course and it should be forwarded to the concerned BoS after the approval of the Academic Committees formed as part of this regulations.

vi. The examinations and evaluation of the signature courses designed by the faculty shall be conducted by the faculty themselves and an external expert faculty chosen by the college from a panel of experts submitted by the faculty and recommend by the BoS concerned.

Programme Pathways and Curriculum Structure

Students who have joined for any programme under these regulations shall have the option to choose the following pathways for their UG degree and Honours programme.

i. Degree with single Major: A student pursuing the FYUG programme in a specific discipline shall be awarded a Major degree if he secures at least 50% of the total credits in the specific discipline required for the award of the Degree in that Discipline. Example: Physics Major/ Economics Major/ Commerce Major

ii. Degree Major with Minor: If a student pursuing the FYUG Programme is awarded a Major Degree in a particular discipline, he/she/they are eligible to be awarded a Minor in another discipline of his choice, if he earns a minimum of 32 credits (approximately 25% of credit required for the three-year programme) from 8 pathway courses in that discipline. Example: Physics Major with Chemistry Minor/ Chemistry Major with English Minor/ Commerce Major with Economics Minor/ English Major with Functional English Minor/ Hindi Major with Malayalam Minor etc.

iii. Major with Multiple Disciplines of Study: This pathway is recommended for students who wish to develop core competencies in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/ subjects. If a student pursuing FYUG Degree Programme is awarded a major Degree in a particular discipline, he/she/they are eligible to get mentioned his core competencies in other disciplines of his choice if he has earned 12 credits from the pathway courses of that discipline. Example: Physics Major with Minors in Chemistry and Physics, Economics Major with Minors in History and English, Commerce Major with Minors in Economics and Statistics.

iv. Interdisciplinary Major: For these programme pathways, the credits for the major and minor pathways shall be distributed among the constituent disciplines/subjects to attain core competence in the interdisciplinary programme. Example: Econometrics Major, Global Studies Major, Biostatistics Major.

v. Multi-Disciplinary Major: For multidisciplinary major pathways, the credits for the major and minor pathways will be distributed among the broad disciplines such as Life Sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc. Example: Life Science, Data Science, Nano Science.

vi. Degree with Double Major: A student who secures a minimum of 50% credits from the first major will be awarded a second major in another discipline if he could secure 40% of credit from that discipline for the 3-year/ 4-year UG degree to be awarded a double major degree. Example: Physics and Chemistry Major, Economics and History Major, Economics and History Major, Commerce and Management Major.

Pathway Option 1 - Degree Major or Major with Multiple Disciplines of Study

Course Components	**No. of Courses**											
	Semester 1	**Semester 2**	**Semester 3**	**Semester 4**		**Semester 5#**	**Semester 6#**	**Total**	**Remarks**	**Semester 7**	**Semester 8**	**Total**
DSC A (4 Credit /Course)	1(P)	1(P)	3 (2P)	3 (2P)		5	4	17	7 Out of 17 can be opted as DSE	3	2	22
DSC B & C (4 Credit /Course)	2(P)	2(P)	1(P) (B or C)	1(P) (C or B)				6		3		9
Multidisciplinary Courses (MDC) (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1**	1**	3	*Recommended that the course may be offered by the English Department ** From DSC A only			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1**	3	*Recommended that one VAC be offered by the English Department and one by Other Languages			3

									Department ** From DSC A only			
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC / DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2 + 1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Pathway Option 2 - Major with Minor

Course Components	**No. of Courses**											
	Semester 1	**Semester 2**	**Semester 3**	**Semester 4**		**Semester 5#**	**Semester 6#**	**Total**	**Remarks**	**Semester 7**	**Semester 8**	**Total**
DSC A (4 Credit /Course)	1(P)	1(P)	3 (2P)	3 (2P)		4	3	15	7 Out of 15 can be opted as DSE	3	2	22
DSC B (4 Credit /Course)	2(P)	2(P)	1(P)	1(P)		1	1	8	1 Out of 8 can be	3		11

									opted as DSE			
Multidisciplinary Courses (MDC)/ (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1**	1**	3	*Recommended that the course may be offered by the English Department ** From DSC A only			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1**	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department ** From DSC A only			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC/ DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Pathway Option 3 - Double Major

Course Components	No. of Courses											
	Semester 1	Semester 2	Semester 3	Semester 4		Semester 5#	Semester 6#	Total	Remarks	Semester 7	Semester 8	Total
DSC A (4 Credit /Course)	1(P)	1 (P)	2(2P)	2(1P)		4	3	13	7 Out of 13 can be opted as DSE	3	2	18
DSC B (4 Credit /Course)	2(P)	2(P)	2(1P)	2(2P)		1	1	10	2 Out of 10 can be opted as DSE	3		13
Multidisciplinary Courses (MDC) (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1	1	3	*Recommended that the course may be offered by the English Department			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department			3
Project/ Dissertation 12 credits for Honours with Research & 8 for											**12/8 (1 DSC/ DSE for**	

Honours											**Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Note: In all the above 3 tables "(P)" means courses with practical

Course Structure of Various Pathways based on Credit Requirements
The FYUG Programmes consist of the following categories of courses and the minimum credit requirements for each of them shall be as follows:

Table 1: FYUGP Course Structure – Major with Minors

Sl. No.	Categorization of courses for all Programmes	Minimum number of credits required	
		3-year UG	4-year UG
1	Major	68	88
2	Minor/ Minors	24	24+12*
3	Multi-disciplinary Courses (MDC)	9	9
4	Skill Enhancement Courses (SEC)	9	9
5	Ability Enhancement Course (AEC)	12	12
6	Value Addition Courses (VAC)	9	9
7	Summer Internship, field-based learning etc.	2	2
8	Project / Dissertation		12**
	Total Credits	133	177

* Students can acquire advanced level courses for 12 credits from their DSC/ DSE/ Minor depending up on their pathway choice.
** Students pursuing the four-year Honours degree shall do an 8 credit project and one capstone course from their DSC/ DSE depending up on their pathway choice.

Table 2: FYUGP Course Structure – Double Major

Sl. No.	Categorization of courses for all Programmes	Minimum number of credits required	
		3-year UG	4-year UG
1	First Major	52	72
2	Second Major	40	52
3	Multi-disciplinary Courses (MDC)	9	9
4	Skill Enhancement Courses (SEC)	9	9
5	Ability Enhancement Course (AEC)	12	12
6	Value Addition Courses (VAC)	9	9
7	Summer Internship, field-based learning etc.	2	2
8	Project/(8 Credit project + 1 capstone course)		12
	Total Credits	133	177

Table 3: FYUGP Course Structure – Multidisciplinary

Sl. No.	Categorization of courses for all Programmes	Minimum number of credits required	
		3-year UG	4-year UG
1	Multidisciplinary Major	52	72
2	Multidisciplinary Minors	40	52
3	Multi-disciplinary Courses (MDC)	9	9
4	Skill Enhancement Courses (SEC)	9	9
5	Ability Enhancement Course (AEC)	12	12
6	Value Addition Courses (VAC)	9	9
7	Summer Internship, field-based learning etc.	2	2
8	Project / (8 Credit project + 1 capstone course)		12
	Total Credits	133	177

Guidelines for Acquiring Credit from Other Institutions/Online/Distance Mode

i. A student shall register to a minimum of 16 credit per semester from the college/ department where he/she/they officially admitted for a particular programme. However, students enrolled for a particular programme in one institution can simultaneously enroll for additional credits from other HEIs within the University or outside University subject to a maximum of 30 credits per semester including the 16 institutional credits.
ii. The College shall publish a list of courses that are open for admission for students from other institutions well in advance before the commencement of each semester.
iii. Each BoS shall prepare and publish a list of online courses at different levels before the commencement of each semester offered in various online educational platforms recognized by the Academic Council of the college, which can be opted by the students for acquiring additional credits.
iv. BoS shall prepare and publish a list of allied/ relevant pathway courses before the commencement of each semester offered by other Board of Studies that can be considered as pathway course for major/ minor for their disciplines at different levels.
v. At the end of each semester the college will include the credit acquired by the student through online courses in their semester grade card subject to a maximum of 30 credits.

Attendance

i. A student shall be permitted to register for the end-semester evaluation of a specific course to acquire the credits only if he has completed 75% of the prescribed classroom activities in physical, online, or blended modes, including any makeup activities as specified by the course faculty of that particular course.
ii. A student is eligible for attendance as per the existing university and government orders which includes participation in a meeting, or events organized by the college or the university, a regularly scheduled curricular or extracurricular activity prescribed by the college or the university. Due to unavoidable or other legitimate circumstances such as illness, injury, family emergency, care-related responsibilities, bad or severe weather conditions, academic or career-related interviews students are eligible for authorized absence. Apart from this, all other eligible leaves such as maternity leave, and menstrual leave shall also be treated as authorized absences.
iii. The condonation facility can be availed as per the university norms.

Workload

i. The workload of a faculty who offers only lecture courses during an academic year shall be 32 credits.
ii. The workload of a faculty offering both practical courses and theory courses may be between 24-32 credits per academic year.
iii. An academic year shall consist of two semesters.
iv. To protect the existing language workload, college should make necessary arrangements to give adequate preference to those courses designed by language departments coming under MDC, SEC and VAC of 3rd & 4th semester. It is recommended that the MDC offered in the third semester shall be based on Indian

Knowledge Systems or Nation-specific topics and may be offered by the Other Languages department or any other department as may be seen fit. Additionally, the SEC in the fourth semester may be offered by the English Department and of the VACs in the third and fourth semesters, one may be offered by the Other Languages Department and the other may be offered by the English Department. These recommendations may be modified as per the recommendations of the SHC-UGP Academic Monitoring Committee.

v. Programme wise workload calculation will be as per the FYUGP workload ordinance 2024.

vi. The teachers given the administrative responsibilities in the department and college level may give a relaxation in their work load as specified in the UGC regulations 2018.

Credit Transfer and Credit Accumulation

i. The college will establish a digital storage (DIGILOCKER) of academic credits for the credit accumulation and transfer in line with ABC.

ii. The validity of credits earned shall be for a maximum period of seven (7) years or as specified in the university/ UGC regulations.

iii. The students shall be required to earn at least 50% of the credits from the College.

iv. Students shall be required to earn the required number of credits as per any of the pathway structure specified in this regulation for the award of the degree.

Outcome Based Approach

The curriculum will be designed based on Outcome Based Education (OBE) practices. The Graduate Attributes (GA) and Programme Outcomes (PO) will be defined and specified in the syllabus of each programme.

Assessment and Evaluation

i. The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE).

ii. 30% weightage shall be given for CCA. The remaining 70% weight shall be for the ESE.

iii. Teacher Specific Content will be evaluated under CCA.

iv. CCA will have two subcomponents Formative Assessment (FA) and Summative Assessment (SA). Each of these components will have equal weightage and to be conducted by the course faculty/ course coordinator offering the course.

v. FA refers to a wide variety of methods that teachers use to conduct in-process evaluations of student comprehension, learning needs, and academic progress during a lesson, unit, module or course. FA is to encourage students to build on their strengths rather than fixate or dwell on their deficits. FA can help to clarify and calibrate learning expectations for both students. FA will help students become more aware of their learning needs, strengths, and interests so they can take greater responsibility over their own educational growth. FA will be prerogative of the course faculty/ course coordinator based on specific requirement of the student.

vi. Suggestive methods of FA are as follows: (anyone or in combinations as decided by the course faculty/ course coordinator)

a. Practical assignment
b. Observation of practical skills
c. Viva voce
d. Quiz
e. Interview
f. Oral presentations
g. Computerized adaptive testing
h. In-class discussions
i. Group tutorial work
j. Reflection writing assignments
k. Home assignments
l. Self and peer Assessments
m. Any other method as may be required for specific course/ student by the course faculty/ course coordinator.

vii. Summative Assessments (SA) are used to evaluate student learning, skill acquisition, and academic achievement at the conclusion of a defined instructional period- typically at the end of a project, unit, module, course or semester. SA may be a class tests, assignments, or project, used to determine whether students have learned what they were expected to learn. It will be based on evidence, collected using single or multiple ways of assessment. The systematically collected evidences should be kept in record by course faculty/ course coordinator and the marks should be displayed on the college notice board/ other official digital platforms of the college before the end semester examinations.

viii. The method of SA will be as follows: (any one as decided by the course faculty/ course coordinator)

a. Written test
b. Open book test
c. Laboratory report
d. Problem based assignments
e. Individual project report
f. Case study report
g. Team project report
h. Literature survey
i. Standardized test
j. Any other pedagogic approach specifically designed for a particular course by the course faculty/ course coordinator.

viii. A student may repeat SA only if for any compulsive reason due to which the student could not attend the assessment.

ix. The prerogative of arranging a CCA lies with the course faculty/ course coordinator with the approval of SHC-UGP Academic Committee based on justified reasons.

x. The course faculty/ course coordinator shall be responsible for evaluating all the components of CCA. However, the college may involve any other person (External or Internal) for evaluation of any or all the components as decided by the Principal/Controller of Examinations from time to time in case any grievances are raised.

xi. Written tests shall be precisely designed using a variety of tools and processes (e.g., constructed responses, open-ended items, multiple-choice), and the students should be informed about the evaluation modalities before the commencement of the course.

xii. The course faculty may provide options for students to improve their performance through continuous assessment mechanism.

xiii. There shall be theory and practical examinations at the end of each semester.

xiv. Regarding evaluation, one credit may be evaluated for 25 marks in a semester; thus, a 4-credit course will be evaluated for 100 marks; 3-credit courses for 75 marks and 2-credit courses for 50 marks.

xv. All examinations will be conducted by the College and will be evaluated at the College itself.

xvi. Individual Learning Plans (ILPs) and/ or specific assessment arrangements may be put in place for differently abled students. Suitable evaluation strategies including technology assisted examinations/ alternate examination strategies will be designed and implemented for differently abled students.

Practical Examination

i. The end semester practical examination will be conducted and evaluated by the institution.

ii. There shall be a CCA for practical courses conducted by the course faculty/ course coordinator.

iii. The scheme of evaluation of practical courses will be as given below:

Components for the Evaluation of Practical Courses	Weightage
CCA of practical/practicum.	30%
ESE of practical/practicum.	70%

iv. Those who have completed the CCA alone will be permitted to appear for the ESE.

v. For grievance redressal purpose, the university shall have the right to call for all the records of CCA.

vi. Duration of Examination: Questions shall be set as per the defined Outcome .The duration of the examinations shall be as follows.

Mode	Time (in Hours)
Written Examination	2
Multiple Choice	1.5
Open Book	2
Any Other Mode	2

Evaluation of Project/Dissertation

The evaluation of project work shall be CCA with 30% and ESE 70%. The scheme of evaluation of the Project is given below:

Project type	Maximum Marks	CCA	ESE
Research Project of Honours with Research (12 credits)	200	60	140
Project of Honours (8 credits)	100	30	70

Evaluation of Internship
The evaluation of internship shall be done by a committee constituted by the Department Council. The scheme of CCA and ESE is given below:

Components of Evaluation of Internship	Weightage	Marks for Internship 2 Credits/ 50 Marks
CCA	30%	15
ESE	70%	35

The department council may decide any mode for the completion of the Internship. If in case evaluation is not specified in any of the selected internship programme, institution can adopt a proper evaluation method as per the weightage specified in the table above.

Letter Grades and Grade Points
Mark system is followed for evaluating each question. For each course in the semester, letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below,

i. The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester. The SGPA is based on the grades of the current term, while the Cumulative Grade Point Average (CGPA) is based on the grades in all courses taken after joining the programme of study.
ii. Based on the marks obtained, the weighted grade point will be mentioned in the student's grade cards.

Letter Grade	Grade Point	Percentage of Marks (Both Internal & External Marks put together)	Class
O (Outstanding)	10	95% and above	First Class with Distinction
A+ (Excellent)	9	85% and above but below 95%	
A (Very good)	8	75% and above but below 85%	
B+ (Good)	7	65% and above but below 75%	

B (Above average)	6	55% and above but below 65%	First Class
C (Average)	5	45% and above but below 55%	Second Class
P (Pass)	4	35% and above below 45% Aggregate (external and internal put together) with a minimum of 30% in external	Third Class
F (Fail)	0	Below an aggregate of 35%or below 30% in external evaluation	Fail
Ab (Absent)	0		Fail

iii. When students take audit courses, they may be given pass (P) or fail (F) grade without any credits.

Computation of SGPA and CGPA

The following method is recommended to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

iv. The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student in the semester, i.e.

SGPA (Si) = Σ(Ci x Gi) / ΣCi

Where Si is the SGPA in the i^{th} semester, Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

$$SGPA = \frac{Sum\ of\ the\ credit\ points\ of\ all\ courses\ in\ a\ semester}{Total\ Credits\ in\ that\ Semester}$$

Illustration – Computation of SGPA

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	DSC A	4	A	8	4 x 8 = 32
I	DSC B	4	B+	7	4 x 7 = 28
I	DSC C	4	B	6	4 x 6 = 24
I	MD C	3	B	6	3 x 6 = 18
I	AEC 1	3	O	10	3 x 10 = 30
I	AEC 2	3	C	5	3 x 5 = 15

	Total	21			147
	SG PA				147/21 = 7

The CGPA is also calculated in the same manner considering all the courses undergone by a student over all the semesters of a programme, i.e.

$$CGPA = \frac{Sum\ of\ the\ credit\ points\ of\ all\ courses\ in\ six\ or\ eight\ semesters}{Total\ Credits\ in\ Six\ (133)\ or\ Eight\ (177)\ semesters}$$

v. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Implementation and Monitoring of SHC-UGP

i. The implementation and monitoring of SHC-UGP will be carried out by duly appointed bodies/committees of the college such as the Academic Council, the various Boards of Studies and the Academic Monitoring Committee.

ii. Academic Council

Among its other functions, the Academic Council of the College shall:

i. Scrutinize and approve all the proposals submitted by the Board of Studies of each Department with regard to the SHC-UGP details such as, academic pathways, allowed syllabi enrichment/ updating, details of elective courses, Online courses, blended teaching, courses offering to the students of other HEIs, panel of examiners, summative and formative evaluation tools proposed by the course faculty concerned, new courses and syllabus proposed by the faculty members as signature courses etc.
ii. The Academic Council can differ on any proposal and it shall have the right to return the matter for reconsideration to the Board of Studies concerned or reject it, after giving sufficient reasons to do so.
iii. Undertake the scrutiny of all documents related to Teacher Specific Content.
iv. Recommend to the College Governing Council for starting innovative programmes using the flexibility and holistic nature of the SHC-UGP curriculum frame work.

iii. Board of Studies

Among its other functions, the Board of Studies of each Department shall:

i. Prepare teacher specific content of syllabi for various courses keeping in view the objectives of the SHC-UGP and submit the same for the approval of the Academic Council.
ii. Scrutinize the signature course content and its evaluation techniques.
iii. Suggest methodologies for innovative teaching and evaluation techniques.
iv. Suggest panel of examiners to the Office of the Controller of Examinations.
v. Coordinate research, teaching, extension and other academic activities in the department.

iv. **SHC-UGP Academic Monitoring Committee**

The SHC-UGP Academic Monitoring Committee shall be constituted under the Chairmanship of the Principal, with the Academic Coordinator as the Convenor, shall be entrusted to oversee the implementation and monitoring of the SHC-UG programme.

i. The Academic Monitoring Committee will collect and whet the proposals submitted by the Board of Studies of each Department with regard to the SHC-UGP and duly forward them to the Academic Council.

ii. It will oversee and coordinate the activities undertaken for the successful implementation of SHC-UGP in the College and will function as an advisory body in such matters.

Power to Remove Difficulties

If any difficulty arises in giving effect to the provisions of these Regulations, the Principal may by order make such provisions which appears to him/her to be necessary or expedient for removing the difficulty. Every order made under this rule shall be subject to ratification by the appropriate authorities.

Modifications to the Regulations

Notwithstanding anything contained in these Regulations, any amendments or modifications issued or notified by the University Grants Commission or the State Government or the Mahatma Gandhi University from time to time, shall be incorporated into these Regulations by the appropriate regulatory bodies of the College and shall constitute an integral part thereof.

3. SYLLABUS INDEX

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
DISCIPLINE SPECIFIC COURSES (DSC)						
I	24UPHYDSC101	Foundations of Physics	100-199	4	3	2
II	24UPHYDSC102	Modern Physics	100-199	4	3	2
III	24UPHYDSC201	Principles of Mechanics	200-299	4	3	2
	24UPHYDSC202	Essentials of Mathematical Physics	200-299	4	4	0
IV	24UPHYDSC203	Wave Optics	200-299	4	3	2
	24UPHYDSC204	Basic Electrodynamics	200-299	4	4	0
V	24UPHYDSC301	Classical Mechanics - I	300-399	4	4	0
	24UPHYDSC302	Introduction to Quantum mechanics	300-399	4	4	0
VI	24UPHYDSC303	Science of Energy (Thermal and Introduction to Statistical Physics)	300-399	4	3	2
	24UPHYDSC304	Solid State Physics	300-399	4	4	0
VII	24UPHYDSC401	Statistical Physics	400-499	4	4	0
	24UPHYDSC402	Classical Mechanics-II	400-499	4	4	0
	24UPHYDSC403	Advanced Electrodynamics	400-499	4	4	0
VIII	24UPHYDSC404	Quantum Mechanics	400-499	4	4	0
	24UPHYDSC405	Condensed Matter Physics	400-499	4	4	0
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) - (Note: Basket items clubbed together)						
III (DSE-01)	24UPHYDSE201	Basic Electronics	200-299	4	3	2
	24UPHYDSE202	Properties of Matter	200-299	4	3	2
	24UPHYDSE203	Science of Sound	200-299	4	3	2
IV (DSE-02)	24UPHYDSE204	Current Electricity and Wiring	200-299	4	3	2
	24UPHYDSE205	Computational Physics using C++	200-299	4	3	2
	24UPHYDSE206	Laser, Non-linear Optics and Fiber Optics	200-299	4	3	2
V (DSE-03)	24UPHYDSE301	Atomic and Molecular Physics	300-399	4	4	0
V (DSE-04)	24UPHYDSE302	Crystallography	300-399	4	4	0
	24UPHYDSE303	Physics of Atmosphere	300-399	4	4	0
	24UPHYDSE304	Introduction to Space Physics	300-399	4	4	0
	24UPHYDSE305	Operational Amplifiers	300-399	4	4	0
V (DSE-05)	24UPHYDSE306	Essential Radio Astronomy	300-399	4	3	2
	24UPHYDSE307	Computational Physics using Python	300-399	4	3	2
	24UPHYDSE308	Optoelectronics	300-399	4	3	2
	24UPHYDSE309	Basics of Astronomy and	300-399	4	3	2

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
		Cosmology				
VI (DSE-06)	24UPHYDSE310	Nuclear and Particle Physics	300-399	4	4	0
	24UPHYDSE311	Nanomaterials	300-399	4	4	0
	24UPHYDSE312	Nanoscience and Nanotechnology	300-399	4	4	0
	24UPHYDSE313	Introduction to quantum computing	300-399	4	4	0
VI (DSE-07)	24UPHYDSE314	Digital Electronics	300-399	4	3	2
	24UPHYDSE315	Synthesis and Characterization techniques for Functional Materials	300-399	4	3	2
VII (DSE-08)	24UPHYDSE401	Theory of Relativity	400-499	4	4	0
	24UPHYDSE402	Nanophotonics	400-499	4	4	0
	24UPHYDSE403	Quantum computing and quantum algorithm	400-499	4	4	0
VII (DSE-09)	24UPHYDSE404	Research Methodology	400-499	4	4	0
VII (DSE-10)	24UPHYDSE405	Nonlinear Dynamics and Chaos Theory	400-499	4	3	2
	24UPHYDSE406	Electroceramics (Research Based)	400-499	4	3	2
	24UPHYDSE407	Digital Signal Processing	400-499	4	3	2
VIII (DSE-11)	24UPHYDSE408	Mathematical Physics	400-499	4	4	0
	24UPHYDSE409	Radiation Physics	400-499	4	4	0
DISCIPLINE SPECIFIC COURSES (DSC) - *Minor Pathway*						
I	24UPHYDSC101	Foundations of Physics	100-199	4	3	2
II	24UPHYDSC102	Modern Physics	100-199	4	3	2
III/IV	24UPHYDSC205	Introduction to Spectroscopy	200-299	4	3	2
	24UPHYDSC206	Basic Electronics and Electricity	200-299	4	3	2
MULTIDISCIPLINARY COURSES (MDC)						
I	24UPHYMDC101	Physics in Daily Life	100-199	3	2	2
II	24UPHYMDC102	Observational Astronomy	100-199	3	2	2
III	24UPHYMDC201	Renewable Energy Sources	200-299	3	3	0
SKILL ENHANCEMENT COURSES (SEC)						
IV	24UPHYSEC201	Electrical Circuits and network skills	200-299	3	3	0
V	24UPHYSEC301	Numerical Methods for Computational Physics	300-399	3	2	2
VI	24UPHYSEC302	Essential Electrical Measurements	300-399	3	2	2
VALUE ADDITION COURSES (VAC)						
III	24UPHYVAC201	Science and Society	200-299	3	3	0

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
IV	24UPHYVAC202	Environmental physics	200-299	3	3	0
VI	24UPHYVAC301	Disaster Management	300-399	3	3	0
SIGNATURE COURSES (SIG)						
VII	24UPHYSIG301	Applied Physics -1	300-399	4	4	0
VIII	24UPHYSIG302	Applied Physics -2	300-399	4	4	0
VIII	24UPHYSIG401	General Relativity and Applications	400-499	4	4	0

PROPOSED PROGRAMME STRUCTURE FOR B.Sc. (HONS.) PHYSICS

(*with Physics as Major and Minors B and C*)

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
I	24UPHYDSC101	Foundations of Physics	100-199	4	3	2
	-	DSC – Minor (B)	100-199	4	3	2
	-	DSC – Minor (C)	100-199	4	3	2
	-	AEC - English	100-199	3	3	0
	-	AEC – Other Languages	100-199	3	3	0
	-	MDC	100-199	3	2	2
				21	**17**	**8**
II	24UPHYDSC102	Modern Physics	100-199	4	3	2
	-	DSC – Minor (B)	100-199	4	3	2
	-	DSC – Minor (C)	100-199	4	3	2
	-	AEC - English	100-199	3	3	0
	-	AEC – Other Languages	100-199	3	3	0
	-	MDC	100-199	3	2	2
				21	**17**	**8**
III	24UPHYDSC201	Principles of Mechanics	200-299	4	3	2
	24UPHYDSC202	Essentials of Mathematical Physics	200-299	4	4	0
		DSE-01	200-299	4	3	2
	-	DSC – Minor (B) / (C)	200-299	4	3	2
	-	MDC	200-299	3	3	0
	-	VAC	200-299	3	3	0
				22	**19**	**6**
IV	24UPHYDSC203	Wave Optics	200-299	4	3	2
	24UPHYDSC204	Basic Electrodynamics	200-299	4	4	0
		DSE-02	200-299	4	3	2
	-	DSC – Minor (C) / (B)	200-299	4	3	2
	-	SEC	200-299	3	3	0
	-	VAC	200-299	3	3	0
				22	**19**	**6**
		Summer Internship		**2**	**-**	**60**
V	24UPHYDSC301	Classical Mechanics - I	300-399	4	4	0
	24UPHYDSC302	Introduction to Quantum mechanics	300-399	4	4	0
		DSE-03	300-399	4	4	0

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
	-	DSE-04	300-399	4	4	0
	-	DSE 05	300-399	4	3	2
	24UPHYSEC301	SEC - Numerical Methods for Computational Physics	300-399	3	2	2
				23	**21**	**4**
VI	24UPHYDSC303	Science of Energy (Thermal and Introduction to Statistical Physics)	300-399	4	3	2
	24UPHYDSC304	Solid State Physics	300-399	4	4	0
		DSE-06	300-399	4	4	
	-	DSE-07	300-399	4	3	2
	24UPHYVAC301	VAC - Disaster Management	300-399	3	3	0
	24UPHYSEC302	SEC - Essential Electrical Measurements	300-399	3	2	2
				22	**19**	**6**
Exit at 3rd Year with 133 Credits – BSc Degree						
VII*	24UPHYDSC401	Statistical Physics	400-499	4	4	0
	24UPHYDSC402	Classical Mechanics-II	400-499	4	4	0
	24UPHYDSC403	Advanced Electrodynamics	400-499	4	4	0
	-	DSE-08	400-499	4	4	0
	-	DSE-09	400-499	4	4	0
	-	DSE-10	400-499	4	3	2
** 3 Courses in Sem 7 can be taken from minor pathway at 300-399 level (for single minor pathway)*				**24**	**23**	**2**
VIII	24UPHYDSC404	Quantum Mechanics	400-499	4	4	0
	24UPHYDSC405	Condensed Matter Physics	400-499	4	4	0
	-	12 Credit Project or 8 Credit Project + DSE11	-	12	-	-
				20	-	-
Completion of the Programme at 4th Year with 177 Credits – BSc Honours Degree						

SYLLABUS FOR DISCIPLINE SPECIFIC ELECTIVE COURSES IN PHYSICS

List of Courses in the Physics DSE Basket

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)- Baskets							
SEM	**DSE-**	**COURSE CODE**	**COURSE TITLE**	**COURSE LEVEL**	**Cr.**	**Th.Hr.**	**Pr.Hr.**
3	01	24UPHYDSE201	Basic Electronics	200-299	4	3	2
		24UPHYDSE202	Properties of Matter	200-299	4	3	2
		24UPHYDSE203	Science of Sound	200-299	4	3	2
4	**02**	24UPHYDSE204	Current Electricity and Wiring	200-299	4	3	2
		24UPHYDSE205	Computational Physics using C++	200-299	4	3	2
		24UPHYDSE206	Laser, Non-linear Optics and Fiber Optics	200-299	4	3	2
5	03	24UPHYDSE301	Atomic and Molecular Physics	300-399	4	4	0
5	04	24UPHYDSE302	Crystallography	300-399	4	4	0
		24UPHYDSE303	Physics of Atmosphere	300-399	4	4	0
		24UPHYDSE304	Introduction to Space Physics	300-399	4	4	0
		24UPHYDSE305	Operational Amplifiers	300-399	4	4	0
5	05	24UPHYDSE306	Essential Radio Astronomy	300-399	4	3	2
		24UPHYDSE307	Computational Physics using Python	300-399	4	3	2
		24UPHYDSE308	Optoelectronics	300-399	4	3	2
		24UPHYDSE309	Basics of Astronomy and Cosmology	300-399	4	3	2
6	06	24UPHYDSE310	Nuclear and Particle Physics	300-399	4	4	0
		24UPHYDSE311	Nanomaterials	300-399	4	4	0
		24UPHYDSE312	Nanoscience and Nanotechnology	300-399	4	4	0
		24UPHYDSE313	Introduction to quantum computing	300-399	4	4	0
6	07	24UPHYDSE314	Digital Electronics	300-399	4	3	2
		24UPHYDSE315	Synthesis and Characterization techniques for Functional Materials	300-399	4	3	2
7	08	24UPHYDSE401	Theory of Relativity	400-499	4	4	0
		24UPHYDSE402	Nanophotonics	400-499	4	4	0
		24UPHYDSE403	Quantum computing and quantum algorithm	400-499	4	4	0

7	09	24UPHYDSE404	Research Methodology	400-499	4	4	0
7	10	24UPHYDSE405	Nonlinear Dynamics and Chaos Theory	400-499	4	3	2
		24UPHYDSE406	Electroceramics (Research Based)	400-499	4	3	2
		24UPHYDSE407	Digital Signal Processing	400-499	4	3	2
8	11	24UPHYDSE408	Mathematical Physics	400-499	4	4	0
		24UPHYDSE409	Radiation Physics	400-499	4	4	0

4. SYLLABUS FOR DISCIPLINE SPECIFIC COURSES IN PHYSICS

DSC - 01

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Foundations of Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC101</td></tr>
<tr><td>Course Level</td><td colspan="5">100-199</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course aims to provide a strong foundation of Physics and equip the students to be familiar with the methodology of Physics. It also throws light to basic laws of mechanics and its application. This course also provides hands on experience in programming using Python.</td></tr>
<tr><td>Semester</td><td>1</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture / Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Explain the importance of vector analysis in Physics, learn to apply vector algebra in physical problems.	U, A	1, 2
2	Analyze the concepts of mechanics and learn to apply in various practical situations like accelerated motion. .	A	1, 2
3	Illustrate the ideas of Newtonian Mechanics to apply in practical situations.	U, A, An	1, 2
3	Apply the concepts of mechanical work, energy and power and analyze various their utility by solving basic problems.	U, An	1, 2

4	Demonstrate the concept of programing using Python	U, A, S	1, 2
5	Apply the basic knowledge of error analysis and to get hands on expertise in using basic components and equipments in Physics lab	U, A, An, S	1, 2
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Introduction to dynamical variables and Kinematics**		**14**	
	1.1	The Nature of Physics, Solving Physics Problems, Standards and Units, Consistency and Conversions, Uncertainty and Significant Figures, Estimates and Orders of Magnitude.	2	1
	1.2	Vectors and Vector Addition, Components of Vectors, Unit Vectors, Products of Vectors	2	2
	1.3	Displacement, Time, Average and Instantaneous Velocity, Average and Instantaneous Acceleration	2	3
	1.4	Motion with constant acceleration, Freely Falling Bodies, Velocity and Position by Integration	3	3
	1.5	Position and velocity vectors, The acceleration vector	2	3
	1.6	Projectile motion, Motion in a Circle, Relative Velocity	3	3
2	**2.1 Newton's Laws of Motion and Its applications**		**13**	
	2.1.1	Force and Interactions, Newton's First Law, Newton's Second Law	2	3
	2.1.2	Mass and Weight, Newton's Third Law, Free-Body Diagrams	2	3
	2.1.3	Newton's Laws- Applications- free body diagrams and problems.	7	3

	2.1.4	Frictional force-static and dynamics friction and simple problems.	2	3
	2.2 Mechanical energy and Energy conservation		**10**	
	2.2.1	Work, Kinetic Energy and the Work–Energy theorem	3	4
	2.2.2	Work and Energy with Varying Forces, Power	2	4
	2.2.3	Gravitational Potential Energy, Elastic Potential Energy	2	4
	2.2.4	Conservative and Nonconservative Forces, Force and Potential Energy, Energy Diagrams	3	4
3	**Python as Calculator**		**8**	
	3.1	Introduction to Python, Writing and executing simple Python scripts, Declaring and using variables,	2	5
	3.2	Basic mathematical operations in Python (+, -, *, /, %), Using parentheses for precedence, String Operations, User Input, Conditional Statements	3	5
	3.3	Introduction to for and while loops, Loop control statements (break, continue), Basic list operations (appending, indexing, slicing), Parameters and return statements.	3	5
4	**Practical (Error analysis should be done for experiments 1 to 8) - Minimum 6**		**30**	6
	1	Conceptualization of random error and propagation of error by measuring the dimensions of a thin metallic rod (using Screw gauge and Vernier calliper) and hence calculating its volume and surface area.		
	2	Comparison of Screw gauge and Vernier calliper readings by measuring the dimensions of a small object and comparison of Vernier calliper and meter scale readings by measuring the dimensions of a larger object.		
	3	Comparison of microscope and Screw gauge readings by measuring the thickness of a wire.		
	4	Parallelogram law of vector addition and determination of unknown mass/density of a liquid using loss of weight concept.		

	5	Verification of vector addition using force table.		
	6	Laser triangulation- determination of the height of an object using a laser.		
	7	Conceptualization of significant digits and rounding of numbers by measuring the time period of a simple harmonic motion using analogue and digital time keeping devices.		
	8	Identify resistances using colour code and verify using a multimeter. Compare the given tolerance with the measured value. Study the series and parallel resistance of two resistors.		
	9	Building a basic calculator program using Python.		
	10	Simple Programs using Python.		
5	Teacher Specific Content		To be evaluated internally	

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Lecture, Demonstrations, Animations, Presentations, Discussion, Programming sessions, Buddy discussion.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Young, Hugh D., Freedman, Roger A. *University Physics With Modern Physics*. Ed. 14 London: Pearson Education, Inc.2016
2. Olenick, Richard P., et al. *The Mechanical Universe: Introduction to Mechanics and Heat and Beyond the Mechanical Universe: From Electricity to Modern Physics and The Mechanical Universe: Mechanics and Heat* (Advanced Edition) (1987): 98-100.
3. H. C. Verma, Concepts of Physics Vol 1 and 2
4. Downey, Allen B. *How to think like a computer scientist: Learning with Python,* Green Tea Press 2003.
5. Chithranjan Das Gupta, Asok Kumar Das, A Handbook of Degree Physics Volume - 1 (Mechanics).

References

1. Shankar R. *Fundamentals of Physics I – Mechanics, Relativity, and Thermodynamics* (Open Yale Courses) Yale University Press, 2019.
2. Beiser, Arthur, Mahajan. Shobhit, Choudhury, S. Rai. *Concepts of Modern* Physics. McGraw Hill Education, 2017 7th Edition
3. Krane, Kenneth S. *Modern* Physics. John Wiley & Sons, 2019
4. Frautschi, Steven C. *The mechanical universe: Mechanics and heat*. Cambridge University Press, 1986.
5. Mahendra K Verma *Practical numerical computing using Python* 2021
6. CR Das Gupta, Handbook of Degree Physics Vol-1 and 2.

DSC - 02

Discipline	**PHYSICS**				
Course Name	**Modern Physics**				
Type of Course	DSC				
Course Code	**24UPHYDSC102**				
Course Level	**100-199**				
Course Summary	This course is an overview of the developments in Physics in the 20^{th} century. The discussion of Einstein's theory of Relativity, Quantum theory of light, the Dual nature of matter, Light matter interaction will help the student to develop a broad knowledge in Modern physics.				
Semester	2	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/ Tutorial	Practical		
		45	30		75
Pre-requisites, if any	NA				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Demonstrate in depth knowledge on Special theory of relativity and its applications	U, A	1, 2
2	Interpret the dual nature of matter and radiation and importance of de-Broglie hypothesis in development of quantum mechanics	U, A	1, 2
3	Illustrates different atomic models and the atomic structure	U	1, 2
4	Appreciate the effects of structure of matter.	U, Ap	1, 2
5	Describes basic concepts leading to quantum physics.	U	1, 2
6	Demonstrate expertise in experiments related to modern physics	S, A, An	1, 2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Theory of Relativity**		**10**	
	1.1	Frames of Reference, Postulates of Special Relativity	1	1
	1.2	Length Contraction, Time Dilation and Twin Paradox	3	1
	1.3	Doppler Effect and the Expanding Universe	3	1
	1.4	Mass Energy Relation, General Theory of Relativity.	3	1
2	**2.1 Particle properties of waves**		**8**	
	2.1.1	Electromagnetic waves, Blackbody Radiation, Planck's quantum theory of radiation	**3**	2
	2.1.2	Photoelectric effect, Quantum Theory of Light	**2**	2
	2.1.3	X-rays, Compton Effect, Pair Production	**3**	2
	2.2 Wave Properties of Particles		**7**	
	2.2.1	De Broglie's Waves, Wave function, Describing a wave using general wave formula.	**3**	2
	2.2.2	Davisson–Germer experiment	**2**	2
	2.2.3	Heisenberg Uncertainty Principle: mathematical form.	**2**	2
3	**3.1 Atomic Structure and Applications of Quantum Mechanics**		**10**	

	3.1.1	Bohr atom model, Electron Orbits, Atomic Spectra, Orbital Radii in Bohr Atom, Vector Atom Model	**3**	3
	3.1.2	Energy Level and Spectra of Atoms, Origin of line spectra, Hydrogen spectrum.	**2**	3
	3.1.3	LASER: basic properties, stimulated absorption, spontaneous and stimulated emissions, population inversion, Practical Lasers. Band Theory of Solids, Superconductivity.	**5**	4
	3.2 Introduction to Quantum Mechanics		**10**	
	3.2.1	Wave functions and wave equation.	**2**	5
	3.2.2	Schrodinger Equation – Time dependent form	**1**	5
	3.2.3	Expectation values and Operators	**2**	5
	3.2.4	Schrodinger equation - Steady state form	**1**	5
	3.2.5	Particle in a box, Nanostructures	**4**	5
4	**Practical (Minimum 6 experiments to be done)**		**30**	**6**
	1	Refractive index of water using laser (by forming circular ring).	2	6
	2	Plotting of waveforms using GeoGebra (Sine wave, Cosine Wave etc) and understanding of phase relationships.	2	6
	3	Determine the angle of the given prism using a spectrometer.	2	6
	4	Measure the thickness of a thin wire using a travelling microscope.	2	6
	5	Solar cell- understanding of power generation- measure the output current and voltage for a fixed load for two different intensities and plot the V-I graph	2	6
	6	Study the climate parameters (temperature, pressure, humidity) at a location from satellite data (MOSDAC)	2	6

		and graphically represent the same over a period of time.		
	7	Verification of Stefan's law using low power (dc) incandescent lamp.	2	6
	8	Determination of least count of a ruler using laser – Reflection grating.	2	6
	9	Plot the black body spectrum using a Python program for different temperatures.		
	10	Plot superposition of two sine waves of different frequencies using Python.		
5	Teacher specific content		To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture , Demonstration, Field Trip, Observation , Group discussion.

Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbook

1. Beiser, Arthur, Mahajan. Shobhit, Choudhury, S. Rai. Concepts of modern physics. McGraw Hill Education, 2017 7th Edition

References

1. Tipler, Paul A., and Llewellyn, Ralph A., Modern Physics, W. H. Freeman and Company, 2008. https://web.pdx.edu/~pmoeck/books/Tipler_Llewellyn.pdf
2. Young, Hugh D., Roger A. Freedman, and Ragbir Bhathal. University physics: Australian edition. Pearson Higher Education AU, 2010.Krane,
3. Kenneth S. Modern physics. John Wiley & Sons, 2019.
4. Shankar R. Fundamentals of Physics II – Electromagnetism, Optics, and Quantum Mechanics: The Open Yale Courses Series) Yale University Press 2019.

DSC - 03

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Principles of Mechanics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course</td><td colspan="5">24UPHYDSC201</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course covers fundamental principles in Classical Mechanics, beginning with Newton's Laws of Motion. It explores the concepts of inertia, Newton's second law, and the equal and opposite action-reaction principle. The study extends to analyzing motion under various force scenarios, including constant force, time-dependent force, velocity-dependent force, and position-dependent force, with a focus on simple harmonic motion. Additionally, the course delves into rotational dynamics, covering angular momentum conservation, rigid body rotation, and central force motion, including the application of Kepler's laws to describe planetary motion within a gravitational field.</td></tr>
<tr><td>Semester</td><td>2</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Demonstrate significance of equations of motion and different types of forces in real life applications.	U, A, E	1, 2
2	Describe Newton's law of Gravitation and its implications	U	1, 2
3	Demonstrate the simple harmonic motion and its mathematical basis.	A, E	1, 2

4	Illustrates different types of damping in harmonic oscillations.	U, A	1, 2
5	Illustrate forced harmonic oscillation and its deviations from free oscillations.	U, An	1, 2
6	Illustrate the dynamics of rotation.	A, An, E	1,2
7	Describes the motion under central force.	U, An	1, 2
8	Demonstrate the skill in applying laws of mechanics in various experiments.	U, A, An	1, 2
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Newton's Laws: Determining the Motion**		**15**	
	1.1	Review of Newton's laws of motion.	**2**	1
	1.2	Determining the motion for different types of forces- constant force, force as a function of time, force as a function of velocity, force as a function of position-simple harmonic motion.	**6**	1
	1.3	Newton's law of universal gravitation, the gravitational field, gravitational field of an extended body, gravitational potential, field lines and equipotential surfaces.	**7**	2
2	**Harmonic Motion**		**12**	
	2.1	Springs and pendulum, solving the differential equations, example-mass on a spring,	**4**	3
	2.2	The damped harmonic oscillator, underdamped oscillator, the overdamped oscillator, the critically damped oscillator.	**4**	4

	2.3	Forced harmonic oscillator-obtaining solution	**4**	5
3	**Rotational Dynamics and Central Force Motion**		**18**	
	3.1	Definition of angular momentum, conservation of angular momentum, angular momentum of a system of particles, angular momentum relative to the center of mass, rotation of a rigid body about a fixed axis.	**6**	6
	3.2	A linearly accelerating reference frame, a rotating coordinate frame, fictitious forces, centrifugal forces and the Plumb bob, the Coriolis force	**6**	6
	3.3	Kepler's laws, central forces, the equation of motion, energy and the effective potential, Solving the equations of motion, equation of orbit.	**6**	7
4	**Practical - Minimum 6**		**30**	**8**
	1	Length of simple pendulum equivalent to a symmetric compound pendulum.		
	2	Determination of moment of inertia of a bar		
	3	Determination of moment of inertia of a flywheel.		
	4	Determination of the length of simple pendulum equivalent to a Kater's pendulum		
	5	Determination of moment of inertia of a disc using torsion pendulum.		
	6	Study the motion of a string and calculate i) spring constant and ii) acceleration due to gravity.		
	7	Length of simple pendulum equivalent to an asymmetric compound pendulum.		
	8	Compute and plot the motion of a particle under the action of the central force F=-K/r^3 (1-α/r)r, where α and K are constants.Show that this orbit precesses. Show how your choice of α and K affect the motion.		

	9	Develop a Python program for solving and visualizing the dynamics of a harmonic oscillator.		
	10	Develop a Python program for solving and visualizing the dynamics of a damped harmonic oscillator under different damping condition.		
5		Teacher specific content		To be evaluated internally

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Tutorial ,Simulations , Practical
Assessment Types	**A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbook

1. Patrick Hamill, Intermediate Dynamics, Jones and Bartlett India Private Limited 2009.

References

1. Shankar R. Fundamentals of Physics I – Mechanics, Relativity, and Thermodynamics (Open Yale Courses) Yale University Press, 2019.
2. Mathur, D. S. Mechanics. S. Chand Publishing, 2000.
3. Kleppner, Daniel, and Robert Kolenkow. An introduction to mechanics. Cambridge University Press, 2014.
4. Young, Hugh D., Roger A. Freedman, and Ragbir Bhathal. University physics: Australian edition. Pearson Higher Education AU, 2010. https://link.springer.com/book/10.1007/978-3-030-15195-9 (open access textbook by Springer)

DSC - 04

<table>
<tr><td>Discipline</td><td colspan="5">PHYSICS</td></tr>
<tr><td>Course Name</td><td colspan="5">Essential Mathematics for Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC202</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course in “Essential Mathematics for Physicists” offers an exploration of fundamental mathematical concepts, emphasizing vectors, matrices, and vector algebra, providing students with essential tools for advanced studies in physics. Through rigorous instruction, students develop proficiency in mathematical techniques crucial for solving complex problems encountered in various branches of physics.</td></tr>
<tr><td>Semester</td><td>3</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites if any</td><td colspan="5">Higher Secondary School level knowledge in Mathematics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Demonstrate skill in using advanced concepts of vector algebra.	U	1, 2
2	Demonstrate skill in analyzing and manipulating matrices with a focus on special types.	A, An	1, 2
3	Describe and apply the concept of eigenvectors and eigenvalues	U	1, 2
4	Describe vector calculus in real-world physical scenarios.	A,	1, 2
5	Demonstrate skill in solving problems related to curvilinear coordinates and coordinate transformations.	A, An	1, 2
6	Illustrates the significance of line, surface, and volume integrals, and utility of divergence and Stokes' theorems.	An, E	1, 2

7	Illustrates mathematical methods to solve physical problems, enhancing problem-solving skills in physics.	A	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Concepts of Vector Algebra**		**14**	
	1.1	Review of Basic Vector Algebra, Physical significance of Scalar and Vector product. Physical significance of Scalar and Vector triple product	**5**	1, 7
	1.2	Equations of lines, planes and spheres, Using vectors to find distances, Reciprocal vectors	**3**	1, 7
	1.3	Physical Concepts of Vector spaces, Basis vectors, Inner product	**3**	1, 7
	1.4	Inequalities in vector space (no need of derivations), Linear operators, Orthogonality, Orthonormality of base vectors, Orthogonalization of vectors	**3**	1, 7
2	**Matrices**		**16**	
	2..1	Basic matrix algebra - Direct Sum and direct product of matrices, The transpose and conjugates of a matrix, The trace of a matrix, The determinant of a matrix	**3**	2, 7
	2.2	The inverse of a matrix, The rank of a matrix, Simultaneous linear equations	**3**	2, 7
	2.3	Special types of square matrix- Diagonal matrices, Lower and upper triangular matrices, Symmetric and antisymmetric matrices,	**3**	2, 7

		Orthogonal matrices, Hermitian and anti-Hermitian matrices, Unitary matrices-Normal matrices		
	2.4	Eigenvectors and eigenvalues, Eigenvectors and eigenvalues of a normal matrix, Hermitian and Anti-Hermition, unitary matrices and general square matrix, Simultaneous eigenvectors	**4**	3, 7
	2.5	Determination of eigenvalues and eigenvectors, Change of basis and similarity transformations, Diagonalisation of matrices,	**3**	3, 7
3	**Vector calculus**		**15**	
	3.1	Differentiation of vectors, Differentiation of composite vector expressions, Differential of a vector, Integration of vectors, Vector functions of several arguments, Surfaces, Scalar and vector fields	**3**	4, 7
	3.2	Vector operators and its geometrical interpretation. Physical concept of Gradient, Divergence and Curl. Gradient of a scalar field, Divergence of a vector field, Curl of a vector field.	**4**	4, 7
	3.3	Vector operator formulae, Vector operators acting on sums and products, Combinations of grad, div and curl	**4**	4, 7
	3.4	General curvilinear coordinates, Curvilinear coordinate system- Cartesian, Cylindrical and Spherical polar coordinate system. Gradient, divergence, curl and Laplacian in spherical system.(expressions only)	**4**	4, 5, 7
4		**Line, surface and volume integrals**	**15**	
	4.1	Line integrals, Evaluating line integrals, Physical examples of line integrals, Line integrals with respect to a scalar, Connectivity of regions.	**5**	6, 7

	4.2	Green's theorem in a plane, Conservative fields and potentials, Surface integrals, Evaluating surface integrals, Vector areas of surfaces, Physical examples of surface integrals.	**5**	6, 7
	4.3	Volume integrals, Integral forms for grad, div and curl, Divergence and Green's theorems. Physical applications of the divergence theorem, Stokes' theorem and its Physical applications	**5**	6, 7
5		Teacher specific content	**To be evaluated internally**	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Tutorial ,Simulations , Practical
Assessment Types	**A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Riley, Kenneth Franklin, and Hobson, Michael Paul "Foundation mathematics for the physical sciences". Cambridge University Press, 2011.

References

1. Kreyszig, Erwin. Advanced Engineering Mathematics 9th Edition with Wiley Plus Set. John Wiley & Sons, (2007).
2. Arfken, George B., Hans J. Weber, and Frank E. Harris. Mathematical methods for physicists: a comprehensive guide. Academic press, (2011).
3. Bence S. J., K. F. Riley, and M. P. Hobson. "Mathematical methods for physics and engineering." (2006).
4. Apostol Tom M Calculus Vol I and Vol II John Wiley & Sons, (1991)
5. Thomas, George B., Hass, Joel. Davis. Heil, Christopher and Weir Maurice D. Thomas' Calculus, Pearson Education; Fourteenth edition (2018)

DSC - 05

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Wave Optics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC203</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">The main objective of the course is to understand the wave nature of light. The key points related to wave nature of light discussed in this course are interference , Huygens principle, Fresnel and Fraunhofer diffraction , basic ideas and application of polarisation.</td></tr>
<tr><td>Semester</td><td>4</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the concept of waves, characteristics and its mathematical representations	U	1
2	Illustrates the phenomenon of polarisation of light	U	1
3	Illustrates different types of polarisation using the concepts of polarisation	U, A, An	1, 2
4	Relate superposition principle and interference of light	U, A	1, 2
5	Describes interference patterns in specific cases	U, A, An	1, 2
6	Distinguishes the Fresnel and Fraunhofer Diffraction using wave theory	U, A	1, 2
7	Relate the ideas of Fraunhofer diffraction in different conditions	U, A, An	1, 2
8	Demonstrate the concepts of optical phenomena in experiments.	U, A, S	1, 2
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C),**			

Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	**Units**	**Course description**	**Hrs**	**CO No.**
1	**Polarization of electromagnetic Waves**		**15**	
	1.1	One dimensional waves, Harmonic Waves, Phase and Phase Velocity, Plane Waves, The Three-Dimensional Differential Wave Equation, Spherical Waves and Cylindrical waves	3	1
	1.2	The Nature of Polarized Light - Linear Polarization, Circular Polarization, Elliptical Polarization	3	2, 3
	1.3	Polarizers, Malu's Law, Dichroism, Birefringence, Birefringent Crystals - Wavefronts and Rays in Uniaxial Crystals, Birefringent Polarizers	4	2, 3
	1.4	Polarisation - Polarisation by scattering, Polarisation by absorption	2	2, 3
	1.5	Retarders - Wave plates ,Half wave and Quarter wave plate, Optical Activity	3	2, 3
2	Interference		**15**	
	2.1	The superposition principle, Phasors and the addition of waves, Conditions for Interference	3	4
	2.2	Wavefront-Splitting Interferometers, Young's Experiment, Fresnel's biprism,	4	

4, 5

	2.3	Amplitude-Splitting Interferometers- Inference by a plane parallel thin film, Newtons Rings, Michelsons Interferometer	8	
3	Diffraction		**15**	
	3.1	The Huygens–Fresnel Principle , Fraunhofer and Fresnel Diffraction, Several Coherent Oscillators	3	6, 7
	3.2	Fraunhofer Diffraction-Diffraction by Single Slit, Diffraction by Double Slit, Diffraction by Many Slits, The Diffraction Grating	7	6, 7
	3.3	Fresnel Diffraction- The Free Propagation of a Spherical Wave –Fresnel half period zone, The Fresnel Zone Plate, Fresnel Diffraction by a Slit	5	6, 7
4	Practical - Minimum 6 experiments		**30**	
	1	Determination of optical constants of a convex lens using Liquid Lens arrangement (water and mercury given)		8
	2	Determination of refractive index of liquid filled in a hollow prism using spectrometer.		8
	3	Determination of refractive index of material of a small angled prism using spectrometer.		8
	4	Determination of wavelength of monochromatic light source using Newton’s rings apparatus.		8
	5	Determination of the diameter of a thin wire by forming an air wedge.		8
	6	Resolving power of grating using a spectrometer.		8

	7	Study the polarisation of the given laser beam using an analyser and verify Malus law		8
	8	To determine particle size using laser beam diffraction		8
	9	To study the diffraction pattern using single slit and calculate slit width		8
	10	To measure the wavelength of laser light using a millimeter scale as grating		8
5		Teacher Specific Content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture,Tutorial,Practical, Demonstration.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbook

1. Hecht, Eugene. Ganesan A. R. Optics. Pearson Education India, 2019.

References

1. Shankar R. Fundamentals of Physics II – Electromagnetism, Optics, and Quantum Mechanics: (The Open Yale Courses Series) Yale University Press 2019.
2. Ghatak, A. K. Optics 7th Edition McGraw Hill 2020.

DSC - 06

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Basic Electrodynamics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC204</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a comprehensive understanding of the principles governing electromagnetic fields and their applications. It explores the fundamental laws and equations that describe the behaviour of electric and magnetic fields, as well as their interactions. This introductory course gives a solid basic working understanding of electrostatics, magnetstatics and electrodynamics.</td></tr>
<tr><td>Semester</td><td>4</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
</table>

Course Outcomes

CO No.	CO Description	Domain	PO
1	Demonstrates essentials of vector analysis, divergence and curl of electrostatic fields Gauss's law, Work and energy in electrostatics, characteristics of conductors and linear dielectrics, the field of a polarized object, Gauss’s law in the presence of dielectrics and boundary conditions of fields.	U,A,An	1,2
2	Illustrates working understanding of Lorentz force law and Biot-Savart laws, the divergence and curl of B, magnetic vector potential, magnetization of matter, bound currents, magnetic field inside matter and boundary conditions of fields in matter.	U,A,An	1,2
3	Display understanding on motional emf, electromagnetic induction, Maxwell's equations, the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter and reflection and transmission at normal incidence.	U,A,An	1,2
			Understand (U), Apply (A), Analyse (An)

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
		Electrostatics (25 hours)		
1	1.1	Basics of vector analysis	3	1
	1.2	Electric field, divergence and curl of electrostatic fields	2	1
	1.3	Gauss's law	2	1
	1.4	Electric potential	2	1
	1.5	Work and energy in electrostatics	2	1
	1.6	Conductors	2	1
	1.7	Dielectrics: induced dipoles; alignment of polar molecules, polarization,	2	1
	1.8	Field of a polarized object: bound charge, physical interpretation of bound charges.	2	1
	1.9	Electric displacement, Gauss's law in the presence of dielectrics,	2	1
	1.10	Boundary conditions, linear dielectrics,	3	1
	1.11	Susceptibility, permittivity, dielectric constant.	3	1
		Magnetostatics (15 hours)		
2	2.1	The Lorentz force Law	1	2
	2.2	The Biot-Savart law	2	2
	2.3	The divergence and curl of B	1	2
	2.4	Magnetic vector potential	2	2
	2.5	Magnetization: diamagnets, paramagnets and ferromagnets.	2	2
	2.6	Bound currents, magnetic field inside matter	2	2
	2.7	The auxiliary field H	2	2
	2.8	Boundary conditions	3	2
		Electrodynamics (20 Hours)		
3	3.1	Motional emf	2	3
	3.2	Electromagnetic induction	2	3
	3.3	Maxwell's equations	2	3
	3.4	Waves in one dimension	2	3
	3.5	The wave equation for E and B	2	3
	3.6	Monochromatic plane waves	1	3
	3.7	Energy and momentum in electromagnetic waves	3	3
	3.8	Electromagnetic waves in matter	3	3
	3.9	Reflection and transmission at normal incidence	3	3

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

Text Book:

David J Griffiths, Introduction to Electrodynamics, PHI 3rd ed.

References:

1. R Murugeshan, Electricity and Magnetism, S. Chand & Company Ltd.
2. Dr E.D Dias, Santhosh P Jose, Electrodynamics made simple, Clare Publishers.
3. A S Mahajan and AA Rangwala, Electricity and Magnetism, TMH 4thEdn.
4. Matthew N Sadiku, Electromagnetics, Oxford 4th Edn.
5. Kraus/Fleish, Electromagnetics with applications,TMH, 5th Edn.
6. J A Edminister, Electromagnetics 2nd Edn, TMH
7. TVS Arunmurthi, Electromagnetic Fields, S. Chand

DSC - 07

Discipline	**Physics**				
Course Name	**Classical Mechanics.**				
Type of Course	**DSC**				
Course Code	**24UPHYDSC301**				
Course Level	**300-399**				
Course Summary	This course provides an overview of the fundamental concepts of Lagrangian and Hamiltonian formalisms, equipping students with the skills to analyze dynamic systems. Emphasis is placed on applying Lagrangian and Hamiltonian approaches to address various dynamical scenarios. The course also delves into the foundational principles of Special theory of relativity				
Semester	5	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		60	**0**		**60**
Pre-requisites, if any	Basic ideas of Newtonian Mechanics				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrates the dynamics of mechanical systems using Lagrangian formalism	A, An	1, 2
2	Describes dynamics of simple mechanical systems using Lagrangian formalism	U, A	1, 2
3	Describes central force problem in different dynamical system	U, An, A	1, 2
4	Illustrate the dynamics of mechanical systems using Hamiltonian formalism	U, A, An	1, 2
5	Describe dynamics of simple mechanical systems using Hamiltonian formalism	U, A	1, 2
6	Interpret the concepts of Special theory of relativity	U, An	1, 2

7	Illustrates different physical phenomena using Special theory of relativity	U, A	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Lagrangian Formalism**		**15**	
	1.1	Constraints, and its classification -Degrees of Freedom, Generalized coordinates, Configuration space	3	1
	1.2	Virtual displacement, Principle of virtual work, D' Alembert's principle, Lagrange's equations of motion for conservative systems.	4	1
	1.3	Conjugate momenta and Cyclic coordinates. Conservation laws and Symmetry Properties, Noether's Theorem	4	1
	1.4	Application of Lagrange's equations of motion to mechanical systems Linear Harmonic oscillator, Simple Pendulum Comparison of Newtonian and Lagrangian formulation.	4	2
2	**Two body central force problem**		**13**	
	2.1	Reduction of two Body central force problem to equivalent one body problem	3	3
	2.2	Equation of motion under central force, differential equation for an orbit	3	3
	2.3	Stability and closure of orbit under central force(Classification of orbits)	4	3
	2.4	Deduction of Kepler's law, Law of gravitation from Kepler's law	3	3

3	**Hamiltonian Formalism**		**15**	
	3.1	Hamilton's Variational principle - principle of least action - examples (Shortest distance between two points 2d, Brachistochrone problem)	4	4
	3.2	Lagrange's equation from variational principle, Hamilton's Canonical equations of motion,	3	4
	3.3	Hamilton's equations from Variational principle, Comparison of Newtonian and Lagrangian and Hamiltonian formulation.	4	4
	3.4	Application of Hamiltonian method to mechanical systems, Linear Harmonic oscillator, Simple Pendulum Planetary motion.	4	5
4	**Relativity**		**17**	
	4.1	Classical Relativity(Galilean Relativity) Galilean transformation, Galilean Invariance, Limitations	3	6
	4.2	Michelson-Morley experiment, Postulates of Special Theory of Relativity, Lorentz transformation	4	6
	4.3	Implications of Lorentz transformations, Spatial contraction- reciprocity, Time dilation, twin paradox, the composition of velocities,mass of moving particles.	5	6
	4.4	Equivalence of mass and energy. Reference to binding energy, Nuclear Fission and Fusion and pair production, Energy momentum Relation.	5	7
5		Teacher Specific Content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecturing, Problem Solving, Simulations
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Goldstein, Herbert, Poole Charles P., Safko John, Classical Mechanics, 3rd Edition, 2011.
2. Beiser, Arthur, Mahajan. Shobhit, Choudhury, S. Rai. Concepts of modern physics. McGraw Hill Education, 2017 7th Edition

References

1. Scheck Florian, Mechanics: From Newton's Laws to Deterministic Chaos, 4th Edition 2010.
2. Aruldhas G., Classical Mechanics, PHI 2008.
3. Morin David, Introduction to Classical Mechanics, Cambridge University Press, 2009.
4. Krane, Kenneth S. Modern physics. John Wiley & Sons, 2019.

DSC - 08

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Introduction to Quantum Mechanics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC302</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">At the introductory level, this course in quantum mechanics invites the student to experience the thrill of learning the counter intuitive ways of the quantum world. Basic machinery of quantum mechanics is introduced with one dimensional examples. Hilbert space formalism and interpretations are discussed in a way that enables the student to study further ahead. The approach in the course is to learn the subject through solving problems and, therefore, requires the evaluation to be problem based.</td></tr>
<tr><td>Semester</td><td>6</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Basic knowledge of Quantum Mechanics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe basic techniques of quantum mechanics	U, A	1, 2
2	Illustrates the implications of quantum physics	A, An	1, 2
3	Builds a quantum mechanical intuition	U, A, S	1, 2
4	Demonstrate the pursuit of both foundational and advanced aspects of quantum physics	U	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	Quantum Behavior		15	
	1.1	Young’s double slit experiment - with bullets, waves and electrons. Interference of electron waves and watching electrons. First principles of quantum mechanics (Reference 1, chapter 1)	6	1
	1.2	The Schrodinger Equation	2	1
	1.3	The Statistical Interpretation, Probability, Normalization	3	1,2
	1.4	Momentum, Uncertainty principle	4	1,2
2	The Time-Independent Schrodinger Equation		15	
	2.1	The Stationary States - Time evaluation of Quantum Mechanics	3	2,3
	2.2	Infinite Square Well	3	2,3
	2.3	Harmonic Oscillator - Algebraic method.	3	2,3
	2.4	Free Particle	3	2,3
	2.5	Step potential (Problem)	3	2,3
3	Vector spaces		15	
	3.1	Vectors, Inner Products	4	4
	3.2	Functions as Vectors	2	4
	3.3	Linear Transformations	3	4
	3.4	Eigenvectors and Eigenvalues	3	4
	3.5	Hermitian Transformations	3	4
4	Hilbert spaces and Interpretation		15	

	4.1	Operators as Linear Transformations	4	4
	4.2	Hilbert Space	4	4
	4.3	Generalized Statistical Interpretation	3	4
	4.4	Generalized uncertainty principle: Proof, Minimum uncertainty wave packet.	4	4
5		Teacher Specific Content	To be evaluated internally	

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Lectures, Tutorials, Seminars/ Presentations Activities, Practical sessions
Assessment Types	MODE OF ASSESSMENT A. **Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. **Semester End examination** **For Theory part**: Written examination
Activities	Problem 1.17, 2.11,2.37,3.13,3.14 and 3.30 of textbook 2

Textbooks

1. Richard P. Feynman, Feynman Lectures on Physics Vol. III, Pearson (2012).
2. D. J. Griffiths, ``Introduction to Quantum Mechanics”, Second Edition, Prentice Hall (1995)

References

1. Shankar R. Fundamentals of Physics II – Electromagnetism, Optics, and Quantum Mechanics: (The Open Yale Courses Series)Yale University Press 2019.

DSC - 09

Discipline	Physics
Course Name	**Science of Energy** **(Thermodynamics and Introductory Statistical Mechanics)**
Type of Course	DSC
Course Code	**24UPHYDSC303**
Course Level	**300-399**
Course Summary	This course includes macroscopic and microscopic aspects of science of energy, the common foundational information needed in many scientific fields, such as chemistry, physics, atmospheric sciences, several biosciences, and many engineering fields and in a way, it will provide a complete conceptual understanding of one of the most fundamental topics of science. The goal of this course is to provide students a deep grasp of the role that thermodynamics plays in a variety of natural processes. It equips students to analyse the energy changes of physical/chemical systems in thermodynamic processes by teaching them to apply the rules of thermodynamics; and to describe physical processes and systems. It facilitates a foundational understanding of the idea that "increasing entropy is at the centre of every process in the universe." The non conserved quantity, the entropy, is in line with the direction of time and explains why some phenomena, like the diffusion of molecules or heat transfer from hot to cold, occur spontaneously while other phenomena, like the creation of ice at level temperature and normal pressure, are not. Also, the course will help students to develop a solid understanding of probability and distribution functions in relation to various physical systems, making connections between the behaviour of individual particles in quantum systems and macroscopic thermodynamic systems. It also enables them to

	assess both extensive and intensive variables using statistical formulations for an ideal gas.				
Semester	6	Credits		4	Total Hours
Course Details	Learning Approach	Lecture /Tutorial	Practical		
		45	30		75

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrate microscopic and macroscopic aspects of heat and explanation on the basis of kinetic theory.	U, A	1,2,3
2	Apply principles and laws of thermodynamics to understand and describe the physical processes and systems.	U, A	1,2,3
3	Compare and analyze the energy changes of physical/chemical systems to get a broader overview of the importance of entropy. Understand and analyze the heat engines and its importance.	A, An	1,2,3
4	Illustrate thermodynamic relations and its applications. Understand and apply the concept of thermodynamic functions and requirements to bring it down in various processes.	U, A, An	1,2,3
5	**(Heat Transfer)**	U, An	1,2,4
6	Apply concepts in probability and distribution functions to different physical systems and connect single particle quantum behaviour to that of macroscopic thermodynamic systems. Evaluate intensive and extensive variables using statistical formulations for an ideal gas.	U, A, S	1,2,3

7	Illustrate laws of Thermodynamics and Determine thermal properties of matter. Demonstrate skill in handling apparatus and assemble simple experimental setup, Record measurements and perform data analysis. Describe physical parameters from experimental results and their deviation from theoretical predictions and Error Analysis	U, A, An, S	1, 2, 3, 4
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
	Kinetic Theory of Gases, Ideal and real gases		**6**	
1	1.1	Kinetic theory and Transport phenomena: Equation of state of a perfect gas, Maxwell velocity distribution, Mean free path real gases (qualitative) Authentic problems and MCQ	1	1
	1.2	Andrew's experiment (only result analysis), Boyle temperature, and van der Waal's equation, critical constants, limitations of van der Waal's equation	3	1
	1.3	Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases (qualitative); mono-atomic and diatomic gases.	2	1

		Authentic problems and MCQ		
	Oth law and 1st law of thermodynamics		**12**	
	2.1	Thermodynamics in everyday life, system and surroundings, macroscopic and microscopic systems, concept of equilibrium, thermodynamic state of the system. Thermodynamic processes. (Revision of class XI and assignments)	1	2
	2.2	Macroscopic and microscopic description of state; Thermal equilibrium and the 0th law; Concept of temperature; Temperature scales. gas thermometers, equation of state, real gas and virial equation. Problem solving	3	2
2	2.3	First law and internal energy, conversion of heat into work, Thermodynamics of simple systems (hydrostatic system, stretched wire, surfaces, electrochemical cell, dielectric slab, paramagnetic rod); Intensive and extensive variables. Various Thermodynamical Processes, Problem solving (Research Based approach)	3	2
	2.4	Work, Heat and Internal energy, Indicator diagram, Thermodynamic Processes (reversible, irreversible, quasistatic, adiabatic, isothermal, etc); Work done in various processes, equivalence of heat and work, expansion/ compression work, isothermal processes, adiabatic process, Compressibility and Expansion Coefficient, reversible processes, Joule's free expansion, specific heats, Expression for (C_P – C_V), C_P/C_V	3	2

		Problem solving		
	2.5	First law of thermodynamics, Specific heat capacity and Mayer's relation (ideal and real gases); Relevant theorems in partial differential calculus Authentic Problems (MCQ - Clicker app + discussion)	2	2
	2^{nd} and 3^{rd} laws of Thermodynamics and Entropy		**5**	
3	3.1	Reversible and irreversible processes, Carnot's cycle, Carnot's engine, Efficiency (Self study/revision) Second law and Entropy, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Refrigerator, Carnot's theorem, TdS equations. Authentic problem (MCQ - Clicker app + discussion)	3	3
	3.2	Third law of thermodynamics, Unattainability of absolute zero. Concept of absolute entropy, third law of thermodynamics.	2	3
	Thermodynamical equations and potentials		**6**	
4	4.1	Maxwell's relations and simple applications, Thermodynamic functions, (Enthalpy and throttling process, Joule-Thomson effect, Helmholtz free energy, Gibbs free energy, etc.)and applications Authentic problems (MCQ - clicker app + discussion)	3	4
	4.2	Thermodynamic potentials or functions, Legendre transformation and derive Maxwell equations. Phase transfer and the	3	4

		Clausius-Clapeyron equation (phase diagrams) Authentic problems (MCQ using clicker app)		
	Heat Transfer		3	
5	5.1	Heat transfer in solids and fluids, Thermal conductivity, Thermal resistance and comparison with electrical resistance and resistivity, Wiedemann-Franz law (statement) Searle's experiment, Lee's Disc experiment Convection and simple applications – self study Authentic problems (MCQ with clicker app and discussion)	2	5
	5.2	Thermal radiation and properties, Blackbody radiation, Spectral distribution, Concept of Energy Density, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law, UV catastrophe. (No derivations)	2	5
	Statistical Mechanics		**12**	
	6.1	Concept of ensembles and Statistical postulates; Examples of probability distributions; Maxwell's distribution (Mean and variance); Canonical partition function of an ideal monoatomic gas	2	6
	6.2	Evaluate pressure, internal energy, and entropy of ideal gas; Equipartition of energy; Distribution of speeds (average speed, average square of speed)	3	6

6	6.3	Maxwell-Boltzmann law - distribution of velocity – Quantum statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics.	3	6
	6.4	Micro and Macro states, Thermodynamic Probability Phase space, Ensembles Maxwell-Boltzmann Distribution law Thermodynamics of an ideal monoatomic gas Concept of entropy and thermodynamic probability.	2	6
	6.5	Quantum Statistics: Need of quantum statistics- Indistinguishability of particles- Introduction to Spin and Statistics Bose Einstein distribution law, Application of Bose Einstein distribution law to black body radiation Fermi Dirac Statistics Application of Fermi Dirac Statistics to electron gas, Fermi Energy	2	6

Experiments (Any 6)	1. Thermistor– Resistance- Temperature characteristics and temperature co-efficient of resistance (CO -5, CO-7) 2. Specific heat capacity of a liquid Newton's law of cooling. (CO-5, CO-7) 3. Thermal conductivity of bad conductor – Lee's disc (CO – 5, CO-7) 4. Specific latent of steam (CO-2, CO-7) 5. Carey Foster's bridge- Temperature co-efficient of resistance (CO-5, CO-7) 6. Thermal conductivity of rubber (CO – 5, CO-7) 7. Specific heat capacity of solid-method of mixtures (CO-2, CO-7) 8. Joule's calorimeter-specific heat capacity of liquid (CO-2, CO-7)

	9. Thermal conductivity - Lee's disc method (CO-5, CO-7) 10. Potentiometer and thermo emf (CO-2, CO-7) 11. Using Probability Based Method, estimate the value of pi (CO-6, CO-7) 12. Using Monte Carlo Method, generate a set of particles with speeds distributed according to the Maxwell-Boltzman distribution using Rejection sampling.
Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Problems solving and buddy discussions, Quiz using clicker app and discussion , Presentations, Programming
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. M. W. Zeemansky and R. H. Dittman, Heat and thermodynamics, McGraw Hill, 1997
2. Brijlal, N. Subrhmanyam and P. S. Hemne,Heat, thermodynamics and statistical physics- S. Chand, 2001
3. Daniel V. Schroder, An Introduction to Thermal Physics, First edition (2014) Pearson.
4. W. Pauli, Thermodynamics and kinetic theory of gases, Dover Publications, 2010

Reference

1. F. Reif, Statistical Physics: Berkeley Physics Course Vol. 5, Tata McGraw-Hill, 2011.
2. Daniel V. Schroeder, An introduction to thermal Physics, Addison- Wesley, 2000. 3. S. J. Blundell and K. M. Blundell, Concepts in Thermal Physics, Oxford, 2006.

3. Thermodynamics and an Introduction to Thermostatistics, H.B.Callen, Wiley student edition (2005).
4. F. W. Sears and G. L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, New Delhi, 1975.
5. F. Mandl,Statistical Physics, John Wiley, 1978.
6. W. Greiner, L. Neise and H. Stocker, Thermodynamics and Statistical Mechanics, Springer, 1995.
7. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
8. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
9. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
10. Kerson Huang, Statistical Mechanics, John Wiley and Sons (2003).
11. F. Rief, Fundamentals of Statistical and Thermal Physics, McGraw Hill(1986).
12. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa.

DSC - 10

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Solid state Physics</td></tr>
<tr><td>Type of Course</td><td colspan="4">DSC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYDSC304</td></tr>
<tr><td>Course Level</td><td colspan="4">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="4">The course aims to deliver basic concepts in Solid State Physics and enable students to understand the properties of metals, insulators and semiconductors. After the completion of this course, students should be able to apply the different models to analyse the behaviours of materials and their relevance in scientific research and technological advancements.</td></tr>
<tr><td>Semester</td><td>6</td><td>Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>60</td><td>0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="4">Basic concepts of Physics and Mathematics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Explain crystal structure, Bravais Lattices, different crystal systems and Miller indices	U	1
2	Describe the principle of X -ray diffraction using Bragg's law	U	1
3	Illustrate free electron theory and band theory and its role in governing the material properties	U, An	1, 2
4	Investigate the behaviour of solids using the Free Electron theory and band theory	U, A, An	1, 2
5	Distinguish metals, semiconductors and insulators based on E-k Diagram	U, A, An	1, 2
6	Discuss the basic physical properties of semiconductors	U	1
7	Explain the different electrical properties of solids	U	1
8	Investigate magnetic properties in solids and understand the role of magnetism in various materials.	A, An	1, 2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Crystal Structure**		15	
	1.1	The crystalline state. Basic definition of lattice, basis, and unit cell.	2	1
		The fourteen Bravais lattices and the seven crystal systems.	2	1
		Elements of symmetry, Nomenclature of crystal directions and crystal planes, Miller indices	3	1
		Examples of simple crystal structures, Amorphous solids and liquids, Interatomic forces, Types of bonding.	3	1
		Basic ideas on Reciprocal lattice	2	2
	1.2	The diffraction condition and Bragg's law, Expression using reciprocal lattice, Applications of XRD.	3	2
2	**Free electron theory and Band Theory**		13	
	2.1	Conduction electrons, The free-electron gas, Fermi distribution function, Fermi energy,	5	3,4
	2.2	Electrical conductivity, Collision Time, Electrical resistivity versus temperature	4	3
	2.3	Motion in a magnetic field: cyclotron resonance and Hall effect, Estimation of Hall Coefficients	4	3
3		**Band theory and semiconductors**	**15**	
	3.1	Failure of the free-electron model, Energy bands in solids, Bloch theorem- Bloch function, energy band diagram (E-k diagram), Distinction	7	5

		between Metals, insulators, and semiconductors. Direct and Indirect Band Gap.		
	3.2	Semiconductors, Band structure, Carrier concentration, intrinsic and extrinsic semiconductors, mobility, drift velocity and conductivity	8	6
4	**Electrical and Magnetic Properties of Materials**		**17**	
	4.1	The dielectric constant and polarizability, local field, Clausius-Mossotti relation, Sources of polarizability	4	4, 5
	4.2	Piezoelectricity, Ferroelectricity, Curie -Weiss law, Ferroelectric domains.	4	7
	4.3	Magnetic susceptibility, Classification of magnetic materials, Diamagnetism, Paramagnetism.	4	8
	4.4	Ferromagnetism in metals, Ferromagnetic domain, Magnetization process, Hysteresis, Antiferromagnetism and Ferrimagnetism	5	8
5		Teacher Specific Content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Lecture, Presentations, Discussions**
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Ali Omar, M. Elementary Solid State Physics Principles and Applications, Pearson India, 1st Edition 2001

2. Wahab, M. A. (2008). Solid State Physics. Narosa Publishing House

3. Puri, R. K., Babbar, V. K. Solid State Physics, S. Chand Publishing 2010.

References

1. Pillai, S.O., Solid state Physics, New Age International Private Limited 10yh Edition 2022.
2. Kittel, C., Introduction to Solid State Physics, Wiley India Pvt. Ltd. 8th Edition, 2004.
3. Ashcroft, N. W. and Mermin, N. D. Solid State Physics, Cengage Learning 1st Edition, 2003.

DSC - 11

<table>
<tr><td>Discipline</td><td colspan="4">PHYSICS</td></tr>
<tr><td>Course Name</td><td colspan="4">Statistical Mechanics</td></tr>
<tr><td>Type of Course</td><td colspan="4">DSC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYDSC401</td></tr>
<tr><td>Course Level</td><td colspan="4">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course provides a comprehensive exploration of Statistical Mechanics, covering foundational concepts, ensemble methods, and their application to various physical systems. It begins with an introduction to classical and statistical probability theories, laying the groundwork for understanding the probabilistic nature of microscopic systems.

The canonical ensemble is then introduced, providing a framework for analyzing systems in thermal equilibrium with a heat bath. Students learn to calculate thermodynamic quantities using the partition function and apply these concepts to simple models such as particles in boxes and diatomic molecules.

The study of identical particles follows, exploring the statistical behavior of bosons and fermions and their implications for quantum systems. Distribution functions, including Maxwell and Planck distributions, are examined to understand the statistical properties of particles in classical and quantum regimes.

Further topics include the grand canonical ensemble, which describes systems with variable particle numbers, and the statistical mechanics of Fermi and Bose particles. The course concludes with an analysis of phase transitions, elucidating the equilibrium conditions and behavior of systems undergoing phase changes.

Throughout the course, students engage with theoretical concepts and mathematical techniques to develop a deep understanding of Statistical Mechanics and its applications in describing the behavior of complex physical systems.</td></tr>
<tr><td>Semester</td><td>7</td><td>Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>60</td><td>0</td><td>60</td></tr>
</table>

Pre-requisites, if any	Nil			

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Foundational Understanding: Develop a strong understanding of classical probability, statistical probability, and the axioms of probability theory. Interpret basic concepts of statistical mechanics, including the quantum state of a system and equations of state, laying the groundwork for further study.	U	1, 2,6
2	Application of Ensemble Methods: Apply the canonical ensemble to analyze systems in thermal equilibrium with a heat bath, calculating thermodynamic quantities using the partition function. Utilize the grand canonical ensemble to describe systems with variable particle numbers, gaining insight into chemical equilibrium and adsorption phenomena.	U,Ap	1, 2,6
3	Analysis of Identical Particles: Analyze the statistical behavior of identical particles, distinguishing between bosons and fermions and calculating partition functions for systems containing them.	U,Ap	1, 2,6
4	Understanding Distribution Functions: Interpret Maxwell and Planck distributions, understanding the probability and density of states in classical and quantum systems. Derive and apply Planck's distribution to describe blackbody radiation and vibrational modes in solids.	U,Ap	1, 2, 6
5	Exploration of Phase Transitions: Analyze phase equilibrium and classify phase transitions, understanding the conditions and behavior associated with first	U	1, 2, 6

	and second-order phase changes. Interpret phase diagrams and apply the Clausius-Clapeyron equation to understand the thermodynamic properties of phase transitions.		
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**Foundations of statistical mechanics**	**10**	
	1.1	Ideas of probability, classical probability, statistical probability, axioms of probability theory	**2**	1
	1.2	independent events, counting the number of events, statistics and distributions, basic ideas of statistical mechanics	**3**	1
	1.3	definition of the quantum state of the system, simple model of spins on lattice sites	**3**	1
	1.4	equations of state, the second law of thermodynamics.	**2**	1
2		**Canonical ensemble**	**10**	
	2.1	System in contact with a heat bath, partition function, definition of the entropy in the canonical ensemble. the bridge to thermodynamics through partition function, condition for thermal equilibrium, thermodynamic quantities from partition function, case of a two level system, single particle in a one dimensional box, single particle in a three dimensional box	**4**	2

	2.2	expression for heat and work, rotational energy levels for diatomic molecules, vibrational energy levels for diatomic molecules, factorizing the partition function, equipartition theorem, minimizing the free energy	**8**	2
3	**Identical particles, Maxwell distribution and Planck's distribution**		**20**	
	3.1	Identical particles, symmetric and antisymmetric wavefunctions, bosons, fermions, calculating the partition function for identical particles, spin, identical particles localized on lattice sites, identical particles in a molecule.	**6**	3
	3.2	The probability that a particle is in a quantum state, density of states in k space, single particle density of states in energy, distribution of speeds of particles in a classical gas.	**6**	3
	3.3	Blackbody radiation, Rayleigh-Jeans theory, Planck's distribution, derivation of the Planck's distribution, the free energy, Einstein's model vibrations in a solid, Debye's model of vibrations in a solid.	**8**	4
4	**Grand canonical ensemble, Fermi and Bose Particles, Phase transitions**		**20**	
	4.1	Systems with variable number of particles, condition for chemical equilibrium, approach to chemical equilibrium, chemical potential, reactions, external chemical potential, grandcanonical ensemble, partition function, adsorption of atoms on surface sites, grand potential.	**8**	3
	4.2	Statistical mechanics of identical particles, thermodynamic properties of a Fermi gas, examples	**6**	3

		of Fermi systems, non-interacting Bose gas		
	4.3	Phase equilibrium, equilibrium conditions, classification of phase transitions, first order phase transitions, phase diagram, Clausius-Clapeyron equation, second order phase transition.	**6**	5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Hands on training, Presentations, Discussions
Assessment Types	MODE OF ASSESSMENT Continuous Comprehensive Assessment (CCA) Assignment,Quiz,Seminar,Activity
	Semester End examination Written examination

Textbook

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2P nd Edn. 2007, Oxford University Press, Indian Edition.
2. Fundamental of Statistical Mechanics: B.B. Laud, New Age Pub (2000)

DSC - 12

Discipline	**Physics**			
Course Name	**Classical Mechanics II**			
Type of Course	DSC			
Course Code	**24UPHYDSC402**			
Course Level	**400-499**			
Course Summary	Along with the Classical Mechanics I, this course introduce most essential techniques to describe classical dynamics of particles and rigid bodies.			
Semester	7	Credits	4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		60	**0**	**60**
Pre-requisites, if any	Classical Mechanics I			

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Describe mathematical basics of rotations	U	1,2
2	Equip with the techniques of tensor algebra	A, An	1,2
3	Describe rotational motion of rigid bodies	A, S	1,2
4	Equip with the techniques to describe oscillations	A, An	1,2
5	Illustrates method of canonical transformations	U, A	1,2
6	Describe mechanics with Poisson bracket techniques	A, S	1,2

7	Describe Hamilton - Jacobi formalism	U	1,2
8	Describe adiabatic motion with action-angle variables	A, S	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Course description	Hrs	CO No.
1	**Kinematics of Rigid Bodies**	**15**	
	Co-ordinates of a rigid body, Orthogonal transformation, Properties of Transformation matrix	**5**	**CO1**
	Euler angles, Euler theorem of motion of a rigid body, Infinitesimal rotation, Rate of change of a vector, Coriolis effect	**5**	**CO1**
	Angular momentum and kinetic energy of motion about a point, Inertia tensor and moment of inertia, Eigenvalues of inertia tensor and principal axis transformation.	**5**	**CO1, CO2, CO3**
2	**Rigid Body motion and Oscillations**	**15**	
	Rigid body problems and Euler's equation of motion, Torque-free motion of a rigid body, Heavy symmetrical top with one point fixed	**6**	**CO1**
	Formulation of the problem, Eigenvalue equation Principal axis transformation,	**5**	**CO1**

	Frequencies of free vibrations and Normal coordinates, Free vibrations of a linear triatomic molecule	**4**	**CO4**
3	**Canonical transformations**	**15**	
	Canonical transformations, Examples, Harmonic Oscillator, Symplectic approach to canonical transformations,	**5**	**CO5**
	Poisson brackets and canonical invariants, Equations of motion - Infinitesimal canonical transformations - Conservation theorems in terms of Poisson brackets,	**5**	**CO5, CO6**
	Angular momentum Poisson brackets, Liouville's theorem	**5**	**CO6**
4	**Hamilton Jacobi theory**	**15**	
	Hamilton - Jacobi equation and Hamilton's principal function, H-J equation for harmonic oscillator	**4**	**CO7**
	H-J equation for Characteristic function, Separation of variables in H-J equation, Kepler problem	**7**	**CO7**
	Action-angle variables for one degree freedom - harmonic oscillator, Adiabatic invariants - harmonic oscillator.	**4**	**CO7, CO8**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations, discussions
Assessment Types	**MODE OF ASSESSMENT** **A.Continuous Comprehensive Assessment (CCA)** **Formative assessment** Quiz:5 marks Two Assignments:10 marks Seminar:5 marks **Summative assessment** Two written tests:10 marks (5 each)
	B.Semester End examination (Theory based Examination) **Total:70 marks** 1. Short answer type questions:Answer any 10 questions out of 12(10*3=30) 2. Short essay type questions:Answer any 4 questions out of 6(4*7=28) 3. Essay type questions:Answer any 1 questions out of 2(1*12=12)

References:

1. Herbert Goldstein, Charles P.Poole and John Safko : "Classical Mechanics" (Third Edition, Pearson Education, 2011)

Books for Reference :

1. L. D. Landau, E. M. Lifshitz: "Mechanics" (Third edition, Butterworth-Heinemanne, 2005)

2. N.C.Rana and P.S.Joag : "Classical Mechanics" (Tata McGraw Hill, 2011)

DSC - 13

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Advanced Electrodynamics</td></tr>
<tr><td>Type of Course</td><td colspan="5">Major</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC403</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course gives a comprehensive understanding of the advanced topics in electrodynamics, namely conservation laws, electromagnetic waves, relativistic electrodynamics, radiation as well as antenna theory. The student attending this course is expected to gain a working knowledge in the topics.</td></tr>
<tr><td>Semester</td><td>7</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisite, if any</td><td colspan="5">Should have studied basic electrodynamics course or equivalent.</td></tr>
</table>

Course Outcomes

CO No.	CO Description	Domain	PO
1	Describe applications of Maxwell's equations and conservation theorems and behavior of electromagnetic waves in different media	U,A,An	1,2
2	Apply the four-vector formalism to describe electromagnetic phenomena in relativistic scenarios.	U,A,An	1,2
3	Analyse the physical basis of radiation reactions and comprehend electromagnetic phenomena associated with retarded potentials.	U,A,An	1,2
4	Describe principles of electromagnetic radiation and derive basic equations of electromagnetic radiation.	U,A,An	1,2
5	Comprehend different antenna parameters and propagation characteristics of waves in waveguides and transmission lines and apply them to solve numerical problems.	U,A,An	1,2
	Understand (U), Apply (A), Analyse (An)		

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
1		**Conservation Laws and Electromagnetic Waves** (15 Hours)		
	1.1	Charge and energy: The continuity equation, Poynting's theorem	2	1
	1.2	Conservation of momentum	1	1
	1.3	Newton's third law in electrodynamics,	1	1
	1.4	Maxwell's stress tensor, conservation of momentum	1	1
	1.5	Electromagnetic waves: review of basic concepts	1	1
	1.6	Reflection and transmission at oblique incidence	2	1
	1.7	Absorption and dispersion: electromagnetic waves in conductors	2	1
	1.8	Reflection at a conducting surface	1	1
	1.9	The frequency dependence of permittivity	2	1
	1.10	The potential formulation: gauge transformations,	1	1
	1.11	Coulomb gauge and Lorentz gauge	1	1
2		**Electrodynamics and Relativity** (15 Hours)		
	2.1	The special theory of relativity: review of basic concepts	2	2
	2.2	The structure of spacetime	1	2
	2.3	Proper time and proper velocity	0.5	2
	2.4	Relativistic energy and momentum	0.5	2
	2.5	Relativistic kinematics	1	2
	2.6	Relativistic dynamics	1	2
	2.7	Magnetism as a relativistic phenomenon	1	2
	2.8	How the fields transform	2	2
	2.9	The field tensor	2	2
	2.10	Electrodynamics in tensor notation	2	2
	2.11	Relativistic potentials	2	2
3		**Electromagnetic Radiation** (15 Hours)		
	3.1	Retarded potentials	1	3
	3.2	Electric dipole radiation,	2	4
	3.3	Magnetic dipole radiation	2	4
	3.4	Jefimenkos equations,	1	4
	3.5	Point charges, Lienard- Wiechert potential,	2	4
	3.6	Fields of a moving point charge	2	3
	3.7	Power radiated by point charge-Larmour formula.	2	4
	3.8	Bremsstrahlung. Radiation reaction and its physical basis	1	3
	3.9	The Abraham-Lorentz formula	2	4
4		**Antenna, Wave Guides and Transmission Lines** (15 Hours)		
	4.1	Antenna, radiation resistance of a short dipole	1	5
	4.2	Current distribution in a longer antenna	1	5
	4.3	Radiation from a half wave dipole and a quarter wave monopole	2	5
	4.4	Antenna parameters - radiation pattern, beam width, power density, directivity	1	5

	4.5	Waves between parallel conducting planes	2	5
	4.6	TE waves in parallel plane wave guide, cut off frequency	1	5
	4.7	TM and TEM Waves in parallel plane wave guide, cut off frequency	1	5
	4.8	Waves in rectangular waveguides	2	5
	4.9	TE waves in rectangular wave guide, cut off frequency	1	5
	4.10	TM waves in rectangular Wave Guide, cut off frequency, impossibility of TEM waves in rectangular wave guide	1	5
	4.11	Transmission lines, characteristic impedance	1	5
	4.12	Standing waves and SWR	1	5

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

Text Book:

1. David J Griffiths, Introduction to Electrodynamics, PHI 3rd ed.
2. K. D Prasad, Antenna and wave guide propagation– Satyaprakashan, NewDelhi, 2009
3. Electronic Communication Systems (5th edition) – George Kendy et.al – TMH

References:

1. Antennas, J.D Kraus, Tata Mc-Graw Hill
2. Antenna and wave guide propagation - K. D Prasad – Satyaprakashan
3. Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain PHI, 1968
4. Electronic Communication Systems (5th edition) – George Kendy et.al – TMH
5. Antennas, J.D Kraus, Tata Mc-Graw Hill.
6. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.
7. Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.
8. Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.
9. Electromagnetic Waves and Fields, V.V. Sarwate, Wiley Eastern Ltd, New Age International
10. The Feymann Lectures in Physics, Vol. 2, R.P. Feymann, R.B.Leighton & M. Sands.
11. Electronic Communication Systems, G. Kennedy & B. Davis, TMH.

DSC - 14

Discipline	**Physics**			
Course Name	**Quantum Mechanics**			
Type of Course	**DSC**			
Course Code	**24UPHYDSC404**			
Course Level	**400-499**			
Course Summary	The course is designed as a sequel to the introductory course where detailed			
Semester	8	Credits	4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		60	0	60
Pre-requisites , if any	Introduction to Quantum Mechanics			

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrate stationary state problems using exact and approximate methods	A, An	1, 2
2	Describe time independent perturbation theory	U	1,2
3	Acquire in depth knowledge on the techniques in scattering	U	1, 2
4	Acquire skill to compute probabilities of time dependent processes	A,An	1, 2
5	Acquire skill to lead independent investigative study into open questions	E,C	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Quantum mechanics in three dimensions**		**15**	
	1.1	**Schrodinger Equation in spherical coordinates**	4	1,5
	1.2	**Hydrogen atom**	4	1,5
	1.3	**Angular momentum**	4	1,5
	1.4	**Spin**	3	1,5
2	**Time-independent perturbation theory**		**15**	
	2.1	**Non degenerate perturbation theory**	3	2
	2.2	**Degenerate perturbation theory**	4	2
	2.3	**Fine structure of Hydrogen: Spin-orbit coupling**	4	2
	2.4	**Zeeman effect**	4	2
3	**Variational method and scattering**		**15**	
	3.1	**Variational principle : Theory**	3	3,5
	3.2	**Scattering: introduction**	3	3,5
	3.3	**Partial wave analysis**	4	3,5
	3.4	**Phase shifts**	2	3,5
	3.5	**Born approximation**	3	3,5
4	**Time dependent perturbation theory**		**15**	
	4.1	**Two level systems**	3	2,4,5

	4.2	**Emission and absorption of radiation**	4	2,4,5
	4.3	**Spontaneous emission**	4	2,4,5
	4.4	**Adiabatic theorem**	4	2,4,5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures Tutorials Seminars/ Presentations Activities Practical sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

References

D. J. Griffiths, ``Introduction to Quantum Mechanics", Prentice Hall (1995)

DSC - 15

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Condensed Matter Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC405</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course delves into both theoretical and experimental aspects, providing a comprehensive understanding of the behavior of matter in condensed phases. This course serves as a good starting point for more advanced condensed matter physics studies.</td></tr>
<tr><td>Semester</td><td>8</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre – requisites, if any</td><td colspan="5">Proficiency in topics like quantum mechanics and statistical mechanics beyond introductory levels and thermodynamics may be beneficial.</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Acquire a comprehensive understanding of fundamental principles in Wave Diffraction, Reciprocal Lattice, Crystal Symmetry, and Free Electron Fermi Gas, demonstrating the ability to explain the underlying concepts and theories.	U, A, An	1,2
2	Critically analyze the relationship between crystal vibrations and thermal properties, examining how vibrational modes influence phenomena such as heat capacity, thermal conductivity, and temperature-dependent material behavior.	U, A, An	1,2
3	Apply their knowledge of superconductivity to analyze and solve problems related to superconducting materials, demonstrating proficiency in predicting superconducting behaviors under varying conditions.	U, A, An, E	1,2,3
4	Acquire skill to evaluate the impact of crystal structure, defects, and external factors on optical properties, demonstrating the ability to assess and predict material responses to various optical stimuli.	U, A, An, E	1,2,6

5	Critically analyze advanced concepts in the magnetic properties of solids, such as magnetic domains, magnetic anisotropy, and the influence of crystal structure on magnetic behavior.	U, A, An	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Wave Diffraction, Reciprocal Lattice, Crystal Symmetry, and Free Electron Fermi Gas**		**15**	**1,2**
	1.1	Diffraction of waves by crystals – Bragg's Law – Scattered wave amplitude – reciprocal lattice vectors – diffraction condition – Laue equations – Ewald construction	3	1,2
	1.2	Brillouin zones – reciprocal lattice to SC, BCC, and FCC lattices – properties of reciprocal lattice	2	1,2
	1.3	Diffraction intensity – structure factor and atomic form factor – physical significance	3	1,2
	1.4	Crystal symmetry – symmetry elements in crystals – point groups, space groups	2	1,2
	1.5	Free electron gas in three dimensions – Heat capacity of the electron gas – relaxation time and mean free path	2	1,2
	1.6	Electrical conductivity and Ohm's law – Wiedemann-Franz Lorenz Law – electrical resistivity of metals	3	1,2
2	**Crystal Vibrations and Thermal Properties**		15	
	2.1	Vibrations of crystals with monatomic basis – First Brillouin zone – Group and Phase Velocity – Two atoms per Primitive Basis (1D)	3	3,4
	2.2	Quantization of elastic waves – Phonon momentum – Inelastic scattering of phonons	2	3,4
	2.3	Phonon Heat Capacity – Plank distribution – Density of States in one and three dimensions– Einstein Model for Density of states – Debye model for density of states – Debye T^3 Law	5	3,4

	2.4	Anharmonic Crystal interactions – Thermal Expansion	2	3,4
	2.5	Thermal Conductivity – thermal resistivity of phonon gas – Umklapp Processes – Imperfections	3	3,4
	Superconductivity		10	
3	3.1	Occurrence of superconductivity – Experimental observations – persistent currents – effect of magnetic field – Meissner effect – Type I and type II superconductors	2	5
	3.2	Isotope effect – entropy – heat capacity and thermal conductivity – Energy gap – Microwave and infrared absorption – Theoretical explanations – penetration depth – Coherence length – London equations	3	5
	3.3	Cooper pairs and elements of BCS theory – Giaever tunneling – Josephson effects	3	3,5
	3.4	Elements of high temperature superconductors – Applications of superconductors	2	3
	Optical and Magnetic Properties of Solids		20	2,4
4	4.1	Plasmon – Polaritons, Electron-Electron Interaction – Electron-Phonon Interaction: Polarons	5	2,4
	4.2	Optical Processes and Excitions – Optical reflectance – Kramers-Kronig Relations, Excitions – Frenkel excitions – Mott-Wannier excitions	5	2,4
	4.3	Quantum theory of paramagnetism – Hunds rules – crystal field splitting – spectroscopic splitting factor, Cooling by adiabatic demagnetization – Nuclear Demagnetization	5	2,4
	4.4	Ferromagnetic order – Curie point and the exchange integral – Temperature dependence of the saturation –Magnetization – Saturation Magnetization at absolute Zero, Magnons – Quantization of spin waves – Thermal excitation of Magnons	5	2,4

<table>
<tr><td>Teaching and Learning Approach</td><td>Classroom Procedure (Mode of transaction)
Lectures
Discussion sessions
Online resources for simulations
Problem solving sessions</td></tr>
<tr><td rowspan="2">Assessment Types</td><td>MODE OF ASSESSMENT
A. Continuous Comprehensive Assessment (CCA)
Theory:Assignment,Quiz,Seminar,Activity</td></tr>
<tr><td>A. Semester End examination
For Theory part: Written examination</td></tr>
</table>

Text book

Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley India Pvt. Ltd.
Wahab, M. A. (2008). *Solid State Physics*. Narosa Publishing House.
Omar, M. A. (1999). *Elementary Solid State Physics*. Pearson India.
Puri, & Babbar. *Solid State Physics*. S. Chand.

References

Azaroff, Leonid V. *Introduction to Solids*, Tata Mc-Graw Hill, 2004.
Ashcroft, N.W., and Mermin, N.D. *Solid State Physics*, Cengage Learning, 1976.
Pillai, S.O. *Solid-state Physics*, New Age International Private Limited.
Ibach, H., and Luth, H. *Solid-state Physics*, Springer, 2009.

5. SYLLABUS FOR DISCIPLINE SPECIFIC ELECTIVE COURSES IN PHYSICS

DSE - 01

Discipline	**Physics**				
Course Name	**Basic Electronics**				
Type of Course	MAJOR - DSE				
Course Code	**24UPHYDSE201**				
Course Level	**200-299**				
Course Summary	This course gives an overview of the various circuit parameters and components involved in electronics.This course also provides a comprehension of the fundamentals of diodes and transistors and their applications.				
Semester	**3**	Credits		**4**	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		45	**30**		**75**
Pre-requisites, if any	Basic knowledge in semiconductors.				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describes utility of biasing in diodes working and applications and distinguishes forward and reverse biasing,	K	1, 2, 3

2	Demonstrate utility of Zener diodes for voltage regulation circuits.	A	1, 2, 3
3	Illustrate the working of diode rectification and effect of filter capacitor in the output.	U,A,E	1, 2, 3
4	Describe characteristics of CB and CE configurations in transistor biasing for evaluating current and voltage gain	U, An,E	1, 2, 3
5	Illustrates design feedback circuits for amplifiers and oscillators	U,A,E	1, 2, 3
6	Demonstrate skill in oscillator circuit designing	A,E	1, 2, 3
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Semiconductor Diode**		**15**	
	1.1	PN Junction, Depletion layer, Barrier potential	3	1
	1.2	Biasing- forward and reverse, Reverse breakdown, Junction capacitance and diffusion capacitance	3	1
	1.3	PN Junction diode – V-I characteristics	3	2
	1.4	Diode current equation, Diode parameters, Ideal diode	3	2
	1.5	Zener diode and its reverse characteristics Zener diode voltage regulator.	3	2
2	**Rectification and transistor characteristics**		15	
	2.1	Rectification - Half wave, Full wave- Centre tapped, Bridge rectifier circuits - Nature of rectified output, Efficiency & Ripple factor,	3	3

	2.2	Filter circuits – Inductor Filter, Capacitor Filter.	3	3
	2.3	Bipolar junction transistors, Transistor biasing, characteristics of CB and CE configurations- active, saturation and cut-off regions.	3	4
	2.4	Current gains α and β. Relations between α and β.	3	4
	2.5	DC operating point , AC and DC Load line, Q-Point.	3	4
3	**Amplifiers and Oscillators**		15	
	3.1	Principles of feedback-positive & negative feedback, Advantages of negative feedback,	3	5
	3.2	Negative feedback circuits,Voltage series & shunt, Current series & shunt.	3	5
	3.3	Voltage Divider Bias Circuit for CE Amplifier	2	5
	3.4	Input & output Impedance. Current, Voltage and Power gains	3	5
	3.5	Oscillators -Basic ideas of oscillators. Colpitt Oscillator, Hartley Oscillator.	4	6
4	**Practical - Minimum 6 to be done**		30	
	1	Diode Characteristics - Study of dynamic and static characteristics of a Diode		1
	2	Zener Diode Characteristics- – Study of dynamic and static characteristics of a Zener diode in Reverse bias.		2
	3	Voltage regulator using zener diode – Study of line and load regulations		2
	4	Half wave rectifier – Study of ripple factor and load regulation with and without filter circuit		2
	5	Full wave rectifier – (center tap) – Study of ripple factor and load regulation with and without filter		2

		circuit		
	6	Full wave rectifier – (bridge) – Study of ripple factor and load regulation with and without filter circuit		3
	7	Clippers – positive, negative and biased – Study of output waveforms		3
	8	Clampers – positive, negative and biased – Study of output waveforms		3
	9	Voltage multipliers – doubler & tripler		2
	10	Common Emitter amplifier -study the amplification		5
	11	Oscillators – To construct Colpitts / Hartleys oscillator and study the waveform.		6
	12	Pspice simulation of any four experiments		
5		Teacher specific content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Tutorial ,Simulations , Practical
Assessment Types	**A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Theraja, B. L. Basic Electronics: Solid State. S. Chand Publishing, 2007.
2. Muhammad H. Rashid Introduction to PSpice Using OrCAD for Circuits and Electronics Pearson 3rd edition 2003.

References

1. Dennis L Eggleston Basic Electronics for Scientists and Engineers Cambridge University Press; Illustrated edition 2011.
2. Malvino, Bates, Electronic Principles McGraw Hill Education; 7th edition 2017.
3. Mehta, V. K., R. Mehta. "Principles of Electronics S. Chand & Co. Ltd., India 2005.
4. Floyd, Thomas L., David Buchla. Fundamentals of analog circuits. Pearson, 2002.
5. Boylestad, Robert L., Louis Nashelsky. Electronic devices and circuit theory. Pearson Education India, 2009.
6. Maheshwari, L.K., Anand, M.M.S. Laboratory experiments and Pspice simulations Prentice Hall India Learning Private Limited 2006.

DSE - 02

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">PROPERTIES OF MATTER</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE202</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course on Properties of Matter is designed to develop a comprehensive understanding of the behaviour of materials to external forces. In addition, the student will explore key concepts related to fluid dynamics covering surface tension, capillary rise, viscosity, and buoyancy as well as waves and their varied applications.</td></tr>
<tr><td>Semester</td><td>3</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the elasticity principles and elastic properties of materials, viz. Hooke's Law, elastic moduli	U	1
2	Describe the behaviour of materials under different stress and strain conditions	A	1, 2
3	Illustrate the dynamics of fluids, with a focus on surface tension, capillary rise, viscosity.	U, A, An	1, 2
4	Demonstrate a thorough understanding of wave motion and properties such as amplitude, wavelength, frequency, and	U	1

	wave speed		
5	Describes different characteristics of mechanical waves and electromagnetic waves.	U, An	1, 2
6	Illustrates interdisciplinary nature of waves and their significance in applications ranging from communication technologies to medical imaging.	U	1, 2
7	Display expertise in solving different physical problems by using various theoretical concepts in properties of matter	A, E	1, 2, 3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for transactions (Units)

Module	Unit	Course Description	Hrs	CO No.
1	**Elasticity**		**13**	
	1.1	Elastic behaviour of solids; Types of elasticity, Work done per unit volume in a strain, stress-strain diagram, Poisson's ratio, limiting values, Elastomers	4	1, 2
	1.2	Twisting couple, torsion pendulum, determination of moment of inertia.	2	1, 2
	1.3	Bending of beams, bending moment, Cantilever (when weight is ineffective);	2	1, 2
	1.4	Distinction between uniform and non-uniform bending, I shape girders	3	1, 2
	1.5	Piezoelectricity, piezoelectric sensors, and its applications	2	1, 2
2	**Surface tension and Viscosity**		**16**	
	2.1	Molecular force– molecular range-sphere of influence-theory of surface tension, surface film and surface energy, applications surface tension and	3	3

		capillary effect, factors affecting surface tension		
	2.2	Excess pressure over curved surface – application to spherical and cylindrical drops and bubbles, force between two plates separated by a thin layer of liquid	3	3
,	2.3	Classification of Fluid Flow , Viscosity: Coefficient of viscosity, Factors affecting viscosity, Reynold's number	3	3
	2.4	Poiseuille's formula – Correction to Poiseuille's formula	2	3
	2.5	Equation of continuity, Bernoulli's theorem, -Applications; Euler equation, Terminal velocity,	3	3
	2.6	Stoke's law	2	3
3	**Waves and Acoustics**		**16**	
	3.1	Wave Motion, Equation of a plane progressive wave, Differential equation of a one-dimensional wave, distinction between progressive and stationary wave, Types of waves, Transverse and Longitudinal waves.	5	4, 5
	3.2	Superposition of waves and Beats, Speed of sound and Mach number	5	4, 6
	3.3	Ultrasonics - properties, production by Piezoelectric effect and magnetostriction method	1	4, 6
	3.4	Ultrasonics - Detection, properties, and applications-ultrasound Imaging	2	4, 6
	3.5	Doppler Effect, SONAR	2	4, 6
4	**Practicals- Minimum 6 to be done**		30	
	1	Determination of Poisson's ratio of rubber.		7
	2	Determination of rigidity modulus- Static torsion method.		7
	3	Determination of rigidity modulus- Torsion pendulum- identical masses.		7

	4	Measurement of Young's modulus of a metallic scale- Cantilever oscillations.		7
	5	Effect of impurities on surface tension- capillary rise method.		7
	6	Variation of viscosity with temperature.		7
	7	Verification of Bernoulli's theorem		7
	8	Coefficient of viscosity by Stoke's method		7
	9	Determination of velocity of ultrasonic waves in a liquid.		7
	10	Sonometer – Determination of frequency of given tuning fork, unknown mass, and verification of laws of strings.		7
	11	Create an animation of the wave ($Asinkx - \omega t$) (using Python). Select values for amplitude(A), wave number (k), angular frequency (ω), and define ranges for both x and t. After successfully animating this wave, extend the animation to include the wave ($Asinkx - \omega t$)+ ($Asinkx + \omega t$)		7
	12	Implement a (python) program that models the deformation of the material under an applied load and generates a plot of the stress-strain relationship.		7
5	**Teacher specific content**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Field Trip,Observation and interactive Session, Group discussion.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)**

	Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Mathur D. S., Mechanics. S. Chand Publishing, 2000.
2. Mathur D. S., Elements of Properties of matter, 2014, S.Chand and Co
3. Murugeshan, R., Sivaprasath K. Properties of matter and Acoustics S Chand 2005.

References

1. Shankar R. Fundamentals of Physics I – Mechanics, Relativity, and Thermodynamics (Open Yale Courses) Yale University Press, 2019.
2. BrijLal and Subrahmanyam N., Properties of Matter, S.Chand and Co. 2003.
3. Upadhyaya J. C., Mechanics Ram Prasad Publications 2017.
4. Butcher, Ginger. *Tour of the electromagnetic spectrum*. Government Printing Office, 2016.

DSE - 03

Discipline	**Physics**				
Course Name	**Science of Sound**				
Type of Course	DSE				
Course Code	**24UPHYDSE203**				
Course Level	**200-299**				
Course Summary	This course is an introduction to sound and its interaction with humans and matter in the world around us. The physics of sound waves as well as basic sound analysis will be briefed here.The fundamental physical properties of sound This course is an introduction to sound and its interaction with humans and matter in the world around us.				
Semester	4	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		45	30		75
Pre-requisites, if any	Basic concepts of Physics and Mathematics				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describes physical nature and characteristics of waves	U	1,2
2	Demonstrate Perception and interpretation of sound by human ear	K,U	1,2
3	Illustrates characteristics of sound waves	U,A,An	1,2
4	Demonstrate the physics of acoustics and factors affecting acoustics	U	1,2
5	Describe audio measurement methods	U	1,2
6	Illustrates basic theories of sound in real life situations	A,An,S	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Waves and the characteristics**		**15**	
	1.1	Wave theory – Sine wave, Transverse and Longitudinal wave, Sound as a pressure wave, Propagation of sound wave through medium	3	1
	1.2	Waveform characteristics – Amplitude, Frequency, Wavelength, Time-period, Velocity, Phase; Sound and density	3	1,3
	1.3	Simple and complex wave, Fundamental frequency, Harmonics and Overtones, Partials, Octave, Timbre;	5	1
	1.4	Different waveform types – Sine, Square, Triangle, Saw-tooth; Sound Envelope – ADSR	4	1
2	**Human Ear,Sound and Acoustics**		**15**	
	2.1	Structure of ear – outer, middle and inner ear;	1	2
	2.2	Perception of pitch, critical bands, Dynamic Range of Hearing, Equal Loudness Contour and Flecter- Munson curve, Protective mechanism of Ear	3	2
	2.3	Sound waves and their characteristics: Loudness, how loudness is measured, Decibel, intensity of a sound. Acoustics- acoustic powers of different sources of sound, pitch, quality of sound, Noises and	6	2

		Musical sound,Doppler effect, , Sound production and perception, Physics of music and musical instruments Physical characteristics of sound – reflection, absorption, refraction diffraction, diffusion;		
	2.4	Acoustics: Architectural acoustics, reverberation, acoustical demands on an auditorium, reverberation time and absorption coefficient. Sabine's law	5	4
3	Audio Measurements		**15**	
	3.1	Peak and RMS, Linear and Logarithmic scale ,Decibel ,Sound pressure level, Sound pressure to dB scale, Decibel equations, Inverse-square law;	3	5
	3.2	SPL measurements, Threshold of hearing, Threshold of pain,	2	5
	3.3	Weighing Networks, Metering – VU & PPM, dBm, dBu, dBA, dBV, dBFS, LUFS, standard levels for interconnecting audio equipments	6	5
	3.4	Dynamic Range, S/N Ratio, Headroom, Pink and White Noise	4	5
4	**Practical- Minimum 6 to be done**			
	4.1	To find the Speed of Sound in air at room temperature using a resonance tube by two resonance Positions		6
	4.2	Simulate the phenomenon of beats using two harmonic waves		6
	4.3	Using a stop-watch, measure the period of oscillations of a mass on a spring for different values of its mass *m*, spring stiffness *k*, and the amplitude *A.*		6
	4.4	To construct a square wave from a sinusoidal wave by adding overtones		6

	4.5	Understand doppler effect in sound by Measuring Frequency in Linear Motion using a stationary audio source, and a mobile phone running the Phyphox app.		6
	4.6	To study the relationship between the vibrating frequency and the length of a given wire using a sonometer.		
	4.7	Audio spectrum analyzer using GNU radio		
5		Teacher Specific Content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Field Trip,Observation and interactive Session, Group discussion.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbook

1. Modern Recording Techniques – David Miles Huber
2. D. R. Khanna and R. S. Bedi, A Textbook of Sound, Atma Ram and Sons, 1992

References

1. Sound and Recording – Francis Rumsey
2. Acoustics and Psychoacoustics - Howard Davis M, James Angus

DSE - 04

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Current Electricity and Wiring</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE204</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a comprehensive exploration of the principles, techniques, and applications of electric current.

After the completion of the course, participants will be able to work independently on electrical wiring. A thorough understanding in various electrical components, their electrical power rating etc is expected.</td></tr>
<tr><td>Semester</td><td>4</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture
Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describes various circuit parameters including current, voltage, resistance, gain skill in electrical wiring and theory of electrical instruments.	U	1, 2
2	Demonstrate skill in electrical networking by solving the complex electrical networks using the Network Theorems.	U, A	1, 2
3	Illustrates the principles of linear and passive energy storage elements and their applications.	U	1, 2
4	Describes electrical conduction in liquids, chemical effects of electric current, and analyse the daily life situations that	U, A, An	1, 2

	involve the chemical effects.		
5	Illustrates the importance of various ac elements and explain the transient and AC response of the RL, RC series and LCR circuits.	U, A, An	1, 2
6	Describes thermoelectricity and implications.	U	1, 2
7	Describe skill in applying theoretical understanding on problem solving.	A,An	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**Electric Current and Network Theorems**	**10**	
	1.1	Modern electron theory of electricity- The idea of electric potential (Review of Class XII).	1	1
	1.2	Resistance, Resistance in series and parallel connections, Variation in resistance with temperature, Temperature coefficient of Resistance, Problems- Assignment.	2	1
	1.3	Open and Short circuits equivalent resistance- Voltage divider circuits, simple problems	2	1
	1.4	Kirchhoff's laws- sign convention, Ideal voltage source and current source. Problems (Revision).	2	1
	1.5	Superposition theorem, Thevenin's theorem - Norton's theorem - Maximum power transfer theorem (Proofs not needed)	3	1, 2

2		**Capacitors & Inductors and Chemical effect of electric current**	**10**	
	2.1.1	Capacitor- Capacitance of an isolated sphere, Earth as a spherical capacitor.	1	3
	2.1.2	Parallel plate capacitor, uniform dielectric medium, medium partly air, composite medium, multiple and variable capacitor.	2	3
	2.2.1	Inductors-Faraday's Law of E.M induction-Lenz's law, Induced emf, Self-inductance, coefficient of Self-inductance	2	3
	2.2.2	Mutual inductance, coefficient of mutual inductance	2	3
	2.3	Chemical Effect of Electric Current: Electrical conductivity of an electrolyte, Arrhenius theory of electrolytic Dissociation	3	4
3	**3.1**	**Transient Current and Alternating Current**	**18**	
	3.1.1	Growth and decay of current in an LR circuit-Charging and discharging of a capacitor through a resistor.	2	5
	3.1.2	Growth and decay of charge in an LCR circuit.	2	5
	3.1.3	EMF induced in a coil rotating in a magnetic field	2	5
	3.1.4	AC applied to resistive, inductive and capacitive circuits, AC applied to LR and RC circuits	4	5
	3.1.5	Analysis of LCR series circuits - LCR parallel circuits-resonance – comparison.	3	5

	3.1.6	Power in ac circuits - Wattless current - choke coil - transformer on no load- skin effect.	2	5
	3..2	**Thermoelectricity** Seebeck effect - thermoelectric series, Laws of thermo emf - Peltier effect- Thomson effect- Thermoelectric diagrams -Thermocouple (qualitative study) Explanation of thermoelectric effects based on electron theory	3	6
4		**Theory of electrical wiring and home appliances.**	7	
	4.1	Review electricity basics – Simple problems, electric power, power rating of appliances, household consumption of energy, kWh	2	1
	4.2	Different kinds of electrical wiring, quality of wires and switches, earth connection, socket, main switch, three phase, ac, two way switch, staircase wiring, fuse, MCB, colour coding of wires, tree and ring connections.	5	1
5		**Practical**	30	
	1	Verification of Thevnin's and Norton's Theorem		7
	2	Verification of superposition and Maximum Power transfer theorem		7
	3	Conversion Galvanometer into Voltmeter		7
	4	Conversion Galvanometer into Ammeter		7

	5	LCR Series and Parallel Resonant Circuit Analysis		7
	6	Potentiometer- Measurement of Resistance of wire.		7
	7	Potentiometer-Calibration of low range voltmeter		7
	8	Potentiometer-Calibration of Ammeter		7
	9	Potentiometer-Calibration of high range voltmeter.		7
	10	Carey Foster's Bridge – Resistivity of a given material.		7
	11	Determination of self inductance of coil using Anderson's bridge		7
	12	Characteristics of thermistor.		7
	13	Basic Electrical Wiring - 1		7
	14	Basic Electrical Wiring - 2		7
	15	Basic Electrical Wiring - 3		7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Problem Solvings, buddy discussion Laboratory experiments and simulations.

Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	B. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Theraja, B. L. A textbook of electrical technology. S. Chand Publishing, 2014
2. Murugeshan, R. Electricity and Magnetism. S. Chand Publishing, 2017

References

1. Shankar R. Fundamentals of Physics II – Electromagnetism, Optics, and Quantum Mechanics: (The Open Yale Courses Series) Yale University Press 2019.
2. Neil Storey, Electronics: A systems Approach Pearson Education Limited; 6th edition 2017.
3. Tewari K. K. Electricity and Magnetism, S. Chand. 2022

DSE - 05

Discipline	**PHYSICS**			
Course Name	**Computational Physics using C++**			
Type of Course	MAJOR-DSE			
Course Code	**24UPHYDSE205**			
Course Level	**200-299**			
Course Summary	To enable the student to master the C++ basics, understand the C++ programming tool and apply it to write moderately difficult programs and to debug for logical and syntax errors.			
Semester	4	Credits	4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		45	30	75

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrates fundamental C++ syntax, including variables, data types, and basic operators.	U	1, 3
2	Describe key control flow structures in C++ such as if statements, loops, and functions.	U	1, 3
3	Illustrates the utility of object-oriented programming and basic principles of classes and objects in C++	U	1, 3
4	Demonstrate skill in developing and implementing C++ programs to solve simple computational problems using appropriate data structures and control flow	A, An, C	1, 2, 3

5	Demonstrate skill in debugging the logical errors and syntax problems.	S, An	1, 2, 3
5	Domonstrate skill in devceloping simple to moderately complex C++ programs	S, C	1, 2, 3
6	Describe skill in implementing C++ programming basics to physical problems	A, C	1, 2, 3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Basic concepts of C++ programming**		**15**	
	1.1	Basic concepts of programming. Language classification. Steps in developing a program, Algorithm, and flowchart	**3**	1
	1.2	C++ language basics: C++ character set, keywords, Data types, constants, variables, declarations	**3**	1
	1.3	Input and output operators/functions, compound statements, arithmetic operators, unary operators, relational and logical operators, assignment operators, increment and decrement operators, conditional operators.	**3**	1, 2
	1.4	Decision making and Branching: If statement, if else statement, nested if...else, statement, Else if ladder, switch statements	**3**	1, 2
	1.5	looping - for loop, while loop, do..while, statements, nested loop structure, break, continue and go to statements, scope of	**3**	1, 2

		variables.		
2		**Arrays Classes and Objects**	**15**	
	2.1	Arrays one dimensional and two dimensional arrays, initializing, reading, writing,	**7**	1, 2
	2.2	User defined functions, Elements of functions, different arguments, Return values and their types, Function declaration, Function calls, different types/category of functions.	**8**	1, 2
3		**Classes and Objects**	**15**	
	3.1	Specifying a class- Defining member functions- nesting of member functions – private	**3**	3
	3.2	Member functions – arrays within a class – Memory allocation for object- static data	**4**	3
	3.3	Project Work and Application Development Students work on a mini-project or coding assignments applying the concepts learned throughout the course	**8**	3
4		**Practicals- A minimum of 6**	**30**	**any 6**
	1	Solving a quadratic equation		4, 5, 6
	2	Conversion of a decimal number into binary number		4, 5, 6
	3	Sorting an array of 10 numbers in ascending and descending order		4, 5, 6
	4	Adding of two matrices		4, 5, 6
	5	Generate n prime numbers		4, 5, 6

	6	Find the value of sin(x), cos(x) and exp(x) using series expansion and compare it with the value obtained using math.h, tabulate the error with the number of terms in the series expansion.		4, 5, 6
	7	Multiplication of two matrices		4, 5, 6
	8	Create a user defined data type **complex** and define the necessary functions and operators using function overloading and operator overloading		4, 5, 6
	9	Create a user defined datatype **vector** and define the necessary functions and operators using function overloading and operator overloading		4, 5, 6
	10	Find out the determinant of a given Matrix		4, 5, 6
5		Teacher specific content	**To be evaluated internally**	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Hands on training, Presentations, Discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record

	A. **Semester End examination** **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbook

1. Balagurusamy, E. "Object oriented programming with C++." McGrawhill 8th Edition 2020.

Reference

1. Lafore, Robert. Object-oriented programming in Turbo C++. Galgotia publications, 2001.

DSE - 06

Discipline	**Physics**				
Course Name	**Laser, Non-linear Optics and Fiber Optics**				
Type of Course	**DSE**				
Course Code	**24UPHYDSE206**				
Course Level	**200-299**				
Course Summary	Laser, Non-linear Optics and Fiber Optics aims to equip the students with the concepts of laser action and diverse laser systems, offering a concrete theoretical backdrop. The course unfolds the modes of laser operation, delves into the dynamics of nonlinear optics, and provides practical insights into the application of nonlinear effects and materials. This course also helps the students to explore the propagation of light through fibres and waveguides.				
Semester	4	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		45	**30**		**75**
Pre-requisites, if any	Fundamentals of Optics				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrates laser action and different laser systems with relevant theoretical background	U	1, 2, 3
2	Illustrates modes of laser operation and dynamics underlying the processes	U	1, 2, 3
3	Describes theoretical foundations and practical knowledge of nonlinear optics, nonlinear effects and its utility in nonlinear materials.	U, A	1, 2, 3
4	Demonstrates concepts and methods of non-linear optics with its applications	U, A	1, 2, 3
5	Illustrates propagation of light through fibres and	U, An	1, 2

	waveguides based on the non linear optical effects		
6	Describes performance parameters of optical fibre and laser by using different optical techniques	A, An, S	1, 2, 3
7	Demonstrates of concepts of diffraction ,polarisation ,dispersion in different optical phenomena	A, An, S	1, 2, 3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**Basic Principles of Lasers & Laser Systems**	**15**	
	1.1	Population Inversion, Laser Pumping – Two level system, Three level system, Resonators – Vibrational Modes of a resonator, Number of Modes per unit volume, Open Resonators, Confocal Resonators, Quality factor of a laser cavity, Losses inside the cavity, The Threshold Condition, Quantum Yield	8	1
	1.2	Solid state lasers- Ruby Laser, Gas Lasers- Helium-Neon laser, Semiconductor Laser-Central Features of Semiconductor Lasers ,Intrinsic Semiconductor Lasers , Doped Semiconductors , Condition for Laser Action	7	1
2		**Dynamics of Laser Processes & Nonlinear Optics**	**15**	
	2.1	Production of Giant Pulse- Q ,Methods of Q switching - Mechanical shutter, Electro optical shutters (Kerr and Pockels),Shutters using saturable dyes, Laser Amplifiers, Mode locking (Qualitative), Ultrashort light pulses	5	2
	2.2	Harmonic generation, Second Harmonic generation, Phase Matching, Third Harmonic generation, Optical Mixing,Parametric generation of light, , Self focusing of light, Multiphoton processes- Two photon and three	10	3

		photon processes (Qualitative Only)		
3		**Fiber and Waveguide Optics**	**15**	
	3.1	Guided Waves, The slab dielectric guide, Evanescent fields in fibre optics, Cylindrical Fibers and waveguides	5	4,5
	3.2	Numerical Aperture, Materials for optical fibres	3	4,5
	3.3	Dispersion in optical fibres, Dispersion Compensation, Modulation and Communication	5	4,5
	3.4	Photonic crystal fibres, Optical fibre sensors (Qualitative only), Fabrication of Optical fibres	2	4,5
4		**Practicals - Minimum 6 to be done**	30	
	4.1	Verification of Snell's law using a laser and a glass slab.		7
	4.2	Design and construct a laser beam expander and study its performance.		6
	4.3	Study the refraction of a laser beam in a glass slab and measure its refractive index using total internal reflection.		6
	4.4	Determination of wavelength of a laser using diffraction grating.		7
	4.5	Determine the diameter of a thin wire using laser.		7
	4.6	Fraunhoffer diffraction: Wavelength of a laser using a double slit.		7
	4.7	Determine the numerical aperture and acceptance angle of an optical fibre.		6
	4.8	Determine the refractive index of glass by measuring the Brewster angle using a laser beam.		7
	4.9	Measure the divergence of an edge emitting diode laser beam by measuring the dimensions of the beam projected on to a screen at different distances.		6
	4.10	To measure the diameter (beam spot size) of the laser beam		6

	5	Teacher Specific Content	To be evaluated internally

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Lecture, Use of demonstrations, activities and animations/videos
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	B. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1 Laud, B. B Lasers and Nonlinear Optics (New Age International- 3rd Edition), 2011 (For Module 1 and 2)
2 Smith F. Graham, King Terry A., Wilkins Dan Optics and Photonics: An Introduction John Wiley & Sons, 2 Edition, 2013 (For Module 3)

References

1. William T. Silfvast, Laser Fundamentals, Cambridge University Press 2nd Edition 2008.
2. Svelto Orazio, Principles of Lasers Springer 5th Edition 2016.
3. Boyd, Robert W. Nonlinear Optics, Academic Press, 3rd Edition 2008.
4. Thyagarajan, K., Ghatak Ajoy, Fiber Optic Essentials John Wiley & Sons. 1st Edition 2007.

DSE - 07

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Atomic and Molecular Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE301</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a comprehensive view of the principles, techniques, and applications of Atomic and Molecular Spectroscopy. Students will gain an in-depth knowledge of the interactions between matter and electromagnetic radiation, focusing on the electronic, vibrational, and rotational transitions within atoms and molecules.</td></tr>
<tr><td>Semester</td><td>6</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Basic understanding of Quantum Physics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Illustrates evolution of classical and modern atom models, tracing the historical development from the Bohr atom model to the quantum mechanical model.	U	1,2
2	Describes the basics of quantum numbers in describing the electron states in atoms	U, A	1,2
3	Describes the quantum mechanical principles in electronic,	U, A	1,2

	vibrational, and rotational transitions, for explaining the spectroscopic data		
4	Analyse different spectra, identify patterns, and draw meaningful conclusions from experimental data and thus cultivate critical thinking skill	An	1,2
5	Illustrates principles of various spectroscopic techniques, including UV-Visible, Infrared (IR), Raman, NMR, and ESR spectroscopy.	U	1,2
6	Appreciate the diverse practical uses of different spectroscopic methods in real-world situations.	Ap	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Atomic Spectroscopy**		**20**	
	1.1	Absorption and emission spectra, Review of Atomic Physics, Bohr atom model – energy levels and Hydrogen spectra, Limitations of Bohr Model	5	1
	1.2	Stern- Gerlach experiment, Space quantization, Electron Spin , Quantum states of an electron in an atom, , Quantum numbers, Exclusion principle, Orbital and Spin Angular momentum, Magnetic moments, Vector atom model	6	1, 2, 3
	1.3	Spectral terms and selection rules, LS and j-j coupling, Fine structure of Sodium D lines	4	1, 2, 3
	1.4	Zeeman effect, Quantum mechanical explanation for normal and anomalous Zeeman effect, Lande g-factor.	5	2, 3, 4

2		**Molecular Spectroscopy I**	**10**	
	2.1	Regions of Electromagnetic Spectrum, Microwave spectroscopy- Classification of molecules based on moment of inertia, Rigid diatomic molecules, rotational energy levels. Instrumentation and Applications	5	4, 5, 6
	2.2	Infrared spectroscopy- Vibrational energy of diatomic molecules, Harmonic oscillator, vibrational energy levels, Instrumentation and Applications	5	4, 5, 6
3		Molecular Spectroscopy II	**10**	
	3.1	Raman Scattering- Classical and Quantum theory of Raman Effect, Stokes and anti- stokes lines Mutual exclusion of IR and Raman spectra. Instrumentation and Applications.	5	4, 5, 6
	3.2	Electronic transitions- UV and Visible spectra,, Beer Lambert law, Fluorescence and Phosphorescence	5	4, 5, 6
4		**Resonance Spectroscopy and Analysis**	**20**	
	4.1	NMR Spectroscopy- Basic principles, Resonance condition, Chemical shift, Instrumentation, Applications of NMR- MRI	6	4, 5, 6
	4.2	ESR Spectroscopy- Basic principles -and Instrumentation	4	4, 5, 6
	4.3	Mossbauer Spectroscopy - Basic Principle and Experimental Techniques and applications	4	4,5,6
	4.4	1.GAMESS/ Gaussview softwares- (a) View molecular vibrations (b) Demonstration of IR, Raman, UV spectra	6	3,5,6

		2.Using simulation software (Gamess/Gaussview & Gaussian), visualise the optimized structure of H_2O & CO_2 molecules. Visualise the normal modes of vibrations. Identify the type of vibrations (symmetric stretching, asymmetric stretching, bending etc). 3.Analyse IR/Raman/UV spectra and interpret the results to extract information about the molecule/material. 4.Using a (Quantum chemical) computational software compare the IR and Raman spectra of H_2O and CO_2 molecules. 5.Using a (Quantum chemical) computational software, obtain the vibrational frequencies, bond length, bond angle, dipole moment & Total energy of H_2O and CO_2 molecules.		
5		Teacher Specific Content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Tutorials, Seminars/ Presentations Activities, Practical sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbooks

1. Beiser, Arthur, Mahajan. Shobhit, Choudhury, S. Rai. Concepts of modern physics. McGraw Hill Education, 2017 7th Edition
2. Banwell C.N., McCash E. M. Fundamentals of Molecular Spectroscopy, McGraw Hill, 4th Edition, 2017
3. Aruldhas, G. Molecular Structure and Spectroscopy. PHI Learning Pvt. Ltd., 2nd Edition, 2007.

References

1. Murugeshan, R., and Sivaprasath Kiruthiga. Modern physics. S. Chand Publishing, 2016.
2. White, Harvey Elliott. "Introduction to atomic spectra." International Series in Pure and Applied Physics (1934).
3. Straughan B. P., Walker S.(Editors), Spectroscopy: –(Vol.1) John Wiley 1976
4. Feynman, Richard Phillips. The Feynman lectures on physics. 1 1963.

DSE - 08

<table>
<tr><td>Discipline</td><td colspan="5">PHYSICS</td></tr>
<tr><td>Course Name</td><td colspan="5">Introductory Crystallography</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE302</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides the basic knowledge of Crystal Structure, Symmetry operation and different Crystallographic methods for determining crystal structure.</td></tr>
<tr><td>Semester</td><td>5</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Basic knowledge Physics and Mathematics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describes the crystal structure and its classification	U	1
2	Relate the symmetry operations with different symmetries observed in crystals	A	1, 2
3	Illustrate the crystal systems based on the parameters	An	1, 2
4	Explain the concept of space groups and equivalent positions	U	1
5	Solve structure factors from XRD data.	A	1, 2
6	Determine the atomic positions from diffraction data	A	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**Crystals and Symmetry**	**15**	
	1.1	**Crystals and Lattices** Definition of a crystal, Lattice points, Unit cells, Fractional coordinates, Unit cell calculations, Primitive and centered cells	5	**1**
	1.2	**Symmetry** Introduction, Definition of symmetry, Symmetry operations and elements of symmetry, Rotation axes, Mirror planes, Identity, Center of symmetry, Improper rotation axes	**5**	**2**
	1.3	Point symmetry, Combinations of symmetry elements, Point groups, Group multiplication table, Point group nomenclature, Determination of point groups, Limitation on combinations of symmetry elements	**5**	**2**
2		**Crystal Systems and Space Groups**	**15**	
	2.1	**Crystal Systems** Classification of unit cells, Restrictions imposed by symmetry on unit cell dimensions, Crystal systems, Limitations on symmetry in crystals, Hermann-Mauguin notation, Bravais lattices, Crystal planes and indices, Law of rational indices, Interplanar spacings	**5**	**3**
	2.2	**Space Groups and Equivalent Positions** Translational symmetry, Screw axes, Glide planes, Space groups, Relationship between space groups, point groups, and physical properties	**5**	**4**
	2.3	Equivalent positions, Special positions, Space group tables in International Tables for X-ray Crystallography	**5**	**4**
3		**X-ray diffraction**	**15**	
	3.1	**X-Ray Diffraction** X -ray diffraction, Periodicity and structural information, The diffraction grating, Diffraction of X rays by crystals, The Laue equations, Rotating crystal method, Bragg's law, Generalization of Miller Indices	5	**5**

	3.2	Weissenberg camera, Buerger precession camera, Comparison of Weissenberg and precession techniques, Information obtained from diffraction patterns	**5**	**5**
	3.3	Electron density function, Fourier series, Fourier expansion of electron density, Intensities of diffraction spots, The phase problem, Calculation of structure factors, Effect of thermal vibration, Structure factors of centrosymmetric crystals, Friedel's law, Laue groups, Structure factors of sodium chloride	**5**	**5**
4	**Determination of Atomic Positions**		**15**	
	4.1	**Determinations of Atomic Positions** Solutions of structure factor equations, The Patterson function, Heavy-atom methods, Isomorphous replacement, Superposition methods	**7**	**6**
	4.2	Inequalities, Sayre-Cochran-Zachariasen relationship, Hauptman-Karle methods, Summary of phase-determining methods, Refinement	**8**	**6**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Presentations, Discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Text Book:

1. Sands, Donald E., Introduction to Crystallography, Dover Publications, (reprint) 2003

Suggested Readings:

1. Cullity, B. D., Stock S. R. Elements of X-Ray Diffraction, , Pearson Publications 3rd Edition 2014

2. Azaroff, Leonid V. Introduction to Solids, McGraw Hill Education 1st Edition (reprint) 2017.

DSE - 09

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Physics of Atmosphere</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE303</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a foundational understanding of the Earth's atmosphere, covering key aspects such as its composition, vertical structure, winds, precipitation, and hydrologic cycles. Students learn fundamental concepts like virtual temperature, lapse rates, and moisture parameters, enabling them to analyze atmospheric behaviors. The course encourages critical thinking by exploring radiation, energy balance, dynamics of horizontal flows, and forces affecting winds. Additionally, it facilitates synthesis of knowledge by studying planetary impact on general atmospheric circulation. Students also gain insights into climate-related concepts including variability, greenhouse gases, feedback, and methods for monitoring and predicting climate change.</td></tr>
<tr><td>Semester</td><td>6</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Mechanics, Mathematics(calculus, algebra and differential equations)</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Demonstrate a comprehensive understanding of fundamental atmospheric concepts including mass, chemical composition, vertical structure, wind-pressure relationships, smaller-scale motions, and the hydrologic cycle, enabling them to describe and explain these phenomena accurately.	K, U	1,2
2	Illustrates thermodynamic principles, such as virtual temperature, hydrostatic equation, geopotential, and moisture parameters, to analyze air parcel behavior, lapse rates, potential temperature, and moisture content in various atmospheric conditions.	U, A, An	2,3,4
3	Describes effects of radiation laws (Planck's function, Wein's displacement law, Stefan-Boltzman law, Kirchoff's law), the greenhouse effect, atmospheric scattering, and Beer's law, and apply them to predict and assess radiation balance at the top of the atmosphere.	U, A, An	2,3,4
4	Demonstrate proficiency in analyzing vorticity, divergence, horizontal flow dynamics, and forces influencing atmospheric circulation, including geostrophic, gradient, and thermal winds, thereby enabling them to interpret the impacts of planetary rotation on atmospheric motions and wave generation.	U,A,An	2,3,4
5	Describes present-day climate conditions, seasonal variations, and climate variability (internal, coupled, and external), incorporating climate feedback mechanisms, greenhouse gas accumulation, and techniques for climate monitoring and prediction into comprehensive analyses.	An, E	4,5

6	Illustrates general circulation in atmosphere, pressure as a vertical coordinate, hydrostatic balance, and inference of vertical motion fields, thereby constructing sophisticated interpretations of global weather patterns and climate systems.	An, E, C	4,5,6
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Introduction and Atmospheric Thermodynamics**		**15**	
1	1.1	A brief survey of the atmosphere-, mass, chemical composition, vertical structure, wind and pressure, observed surface wind field, motions on smaller scales, precipitation- hydrologic cycle	3	CO1
	1.2	Virtual temperature, hydrostatic equation, geopotential, scale height, hypsometric equation	3	CO1
	1.3	Concept of air parcel, dry adiabatic lapse rate, potential temperature	2	CO1
	1.4	Moisture parameters- mixing ratio, saturation vapour pressure, relative humidity and lifting condensation level	4	CO2
	1.5	Saturated adiabatic lapse rate, equivalent potential temperature, conditional and convective instability	3	CO2
2	**Radiative Transfer**		**15**	

2	2.1	Blackbody Radiation- Planck's function, Wein's displacement law, Stefan-Boltzmann law, Kirchoff's law	5	CO3
	2.2	Greenhouse effect, scattering by air molecules and particles, Beer's law, atmospheric window	5	CO3
	2.3	Radiation balance at the top of the atmosphere, Surface energy balance-radiative fluxes	5	CO3
3	**Atmospheric dynamics**		**20**	
3	3.1	Vorticity and Divergence, dynamics of horizontal flow-apparent forces, real forces, horizontal equations of motion	6	CO4
	3.2	Geostrophic wind, gradient wind, thermal wind	5	CO4
	3.3	Suppression of vertical motions by planetary rotation, potential vorticity, rossby waves, atmospheric scales of motion	5	CO4
	3.4	Pressure as a vertical coordinate, hydrostatic balance, inference of the vertical motion field	4	CO4
4	**Weather and Climate**		**10**	
4	4.1	Atmospheric general circulation, atmosphere as a heat engine	3	CO4, CO5
	4.2	Weather and Climate, Present day climate-annual mean conditions and seasonal dependence, climate of India during the four seasons	3	CO5
	4.3	Climate variability-internally generated, coupled and external variabilities, climate feedbacks, buildup of greenhouse gases, climate monitoring and prediction	4	CO5

5				

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Discussions, Online simulations, Problem solving sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Wallace, John M., and Peter V. Hobbs. 2006. *Atmospheric Science: An Introductory Survey*. 2nd ed. Elsevier Inc.

References

1. Ahrens, Donald C. 2009. *Meteorology Today*. 9th edn. Brooks/Cole, Cengage Learning.
2. Holton, James R. 2004. *An Introduction to Dynamic Meteorology*. 4th ed. USA: Elsevier Academic Press.
3. Mcilveen, Robin. 1992. *Fundamentals of Weather and Climate*. 2nd ed. Spinger-Science+Business Media.

DSE - 10

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Introduction to Space Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE304</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course in plasma physics provides a comprehensive exploration of fundamental concepts and phenomena. Students will learn the nature and definition of plasmas, understanding their occurrence in natural settings. The curriculum covers the critical Debye shielding concept, illustrating the impact of temperature on plasma behavior. By understanding plasma waves, students can analyze and evaluate the validity of the plasma approximation, gaining insights into electromagnetic and electrostatic oscillations. The course provides an in-depth study of space plasma phenomena, considering their influence on Earth's magnetic field, space weather, and the practical applications of observational methods. Students will also gain insights into theory and working of state of art measurement techniques like Ionosndae and Langmiur Probe.</td></tr>
<tr><td>Semester</td><td>5</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Students should have a strong foundation in classical physics, particularly in mechanics and electromagnetism. Proficiency in mathematical concepts such as calculus, linear algebra, and differential equations are essential for understanding the complex equations and analyses involved. Basic knowledge of quantum mechanics can be beneficial. While not mandatory, a background in astronomy and</td></tr>
</table>

	astrophysics would enhance comprehension of space plasma phenomena.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the fundamental concepts of plasmas. Explain the concept of temperature in plasmas and demonstrate an understanding of Debye shielding. Apply the knowledge of plasma fundamentals to analyze and solve problems related to Debye shielding in various plasma environments.	K, U, A	1,2,3
2	Analyze different types of large scale ionospheric plasma processes. Evaluate the ionospheric conductivity. Apply theoretical knowledge such as slab geometry to investigate the comprehensive understanding of ionospheric current	An, E,A	4,5,3
3	Apply knowledge to understand the influence of solar wind on various phenomenons.Synthesize information to propose solutions or strategies for mitigating the impact of space weather on Earth's space environment.Evaluate the consequences of space plasma phenomena on space assets and astronauts.	A,An,E	3,4,5
4	Synthesize knowledge of fluid equations, fluid drifts, and the plasma approximation to represent and analyze waves in plasmas. Design and conduct experiments using Langmuir probes, ionosondes, and radiation sensors to gather data on plasma phenomena. Apply theoretical knowledge to interpret and analyze experimental results, drawing conclusions about plasma properties.	E,C,An	4,6,3
5	Evaluate the importance of ground-based and satellite-based observations in advancing plasma physics	E, An, C	5,4,6

	research. Analyze and interpret observational data from various instruments to draw meaningful conclusions about plasma behavior. Develop critical thinking skills by proposing innovative ways to enhance observational techniques and improve the understanding of plasma physics.		
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Introduction to Plasma**		**12**	
1	1.1	Occurrence of Plasmas in Nature ; Definition of Plasma , Collisional and collisionless plasma	3	1
	1.2	Concept of Temperature; Debye Shielding.	3	1
	1.3	The Plasma Parameter; Criteria for Plasmas; Applications of Plasma Physics;	3	1
	1.4	Importance of observation; ground, Satellite based observations and modelling.	3	2
2	**Terrestrial ionosphere and Plasma Processes**		**18**	
2	2.1	Solar radiation and production of ionization, Ionization Profile, Ion composition and chemistry, The D, E and F regions	4	3

	2.2	Gyration dominated Plasma Transport, Ambipolar Electric field and diffusion, diffusive equilibrium in the F2 region, Ionospheric conductivity	4	3
	2.3	Introduction to earth's magnetism,Elements of earth's magnetic field, Difference between geographic and geomagnetic coordinates	2	3, 4
	2.4	Dynamo Electric field, Sq Current, equatorial ionospheric processes-Equatorial Electrojet and Counter Electrojet-Slab Geometry	4	4,5
	2.5	Equatorial Ionization Anomaly-Equatorial Spread-F-Rayleigh Taylor plasma Instability, E region irregularities, Type I and Type II irregularities	4	4,5
3	**Ionospheric Measurement Techniques**		**15**	
	3.1	Radio wave techniques in ionospheric physics-coherent and incoherent radars, Ionosonde	3	3
	3.2	GPS Receivers, Total Electron Content measurements using GPS	3	2
3	3.3	Current measurements-Proton Precession Magnetometers (PPM) and FluxGate Magnetometers	3	4
	3.4	Optical methods, Airglow, Fabry perot Interferometery	3	2
	3.5	In Situ measurements-Langmuir Probes, Retarding Potential Analysers, and Drift Meters	3	4
4	**Sun -Earth Interactions**		**15**	
	4.1	Sun- structure, Basic solar properties,Historical understanding, Source of Sun's energy	3	2

4

	4.2	Sunspots and solar cycle. Solar flares, solar wind and its properties.	3	2
	4.3	Plasmasphere, Earth's magnetosphere-its structure, Interplanetary Magnetic Field, the bow shock and magnetopause	3	3
	4.4	Influence of Solar Wind on the terrestrial magnetic field, Ring current and Field Aligned Currents, Magnetic reconnection	3	2
	4.5	Geomagnetic storms, sub storms, auroral phenomena and their influence on Earth's space environment, Space weather, its impacts on space assets and astronauts	3	2
5	Teacher Specific Content		To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Discussion sessions, Online resources for simulations Problem solving sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Text Book

1. Chen, Francis F. *Introduction to plasma physics*. Springer Science & Business Media, 2012.

2. Rishbeth, Henry, and Owen K. Garriott. "Introduction to ionospheric physics." *Introduction to ionospheric physics* (1969).
3. Kelley, Michael C. *The Earth's ionosphere: Plasma physics and electrodynamics*. Academic press, 2009.

Reference

1. Hargreaves, J. K. "The Solar-Terrestrial Environment: An Introduction to Geospace - the Science of the Terrestrial Upper Atmosphere, Ionosphere, and Magnetosphere Cambridge University Press, 1992
2. Kivelson, Margaret Galland, and Christopher T. Russell, eds. *Introduction to space physics*. Cambridge university press, 1995.
3. Khomich, Vladislav Yu, Anatoly I. Semenov, and Nicolay N. Shefov. *Airglow as an indicator of upper atmospheric structure and dynamics*. Springer Science & Business Media, 2008.
4. J. A. Raticliffe, Sun, Earth and Radio: An Introduction to Ionosphere and Magnetosphere, Littlehampton Books Services Ltd.1970.
5. Bhatnagar, Arvind, and William Charles Livingston. *Fundamentals of solar astronomy*. Vol. 6. World Scientific, 2005.
6. M.H. Rees, 'Physics and Chemistry of Upper Atmosphere', Cambridge University Press, 1989.
7. Arnab Rai Chowdhury, Nature's Third Cycle, Oxford University Press.
8. Schrijver, Carolus J., and Cornelis Zwaan. *Solar and stellar magnetic activity*. Vol. 34. Cambridge University Press, 2008.
9. Robert Schunk and Andrew Nagy, 'Ionospheres: Physics, Plasma physics and chemistry, Cambridge University Press, 2009.

DSE - 11

Discipline	**Physics**				
Course Name	**Operational Amplifiers**				
Type of Course	DSE				
Course Code	**24UPHYDSE305**				
Course Level	**300-399**				
Course Summary	This course gives an overview of the various circuit parameters and components involved in electronics.This course also provides a comprehension of the fundamentals of diodes and transistors and their applications.				
Semester	**5**	Credits		**4**	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		60	**0**		**60**
Pre-requisites, if any	Basic knowledge in semiconductors.				

COURSE OUTCOMES (CO)

CO No.	**Expected Course Outcome**	**Learning Domains ***	**PO No**
1	Describes theoretical aspects of operational amplifier	K	1, 2, 3
2	Demonstrate skill in designing various op-amp circuits	A	1, 2, 3
3	Describe different filter circuits and their design	U,A,E	1, 2, 3
4	Analyze and Evaluate the practical problems related to Op-amps	U, An,E	1, 2, 3
5	Apply the Op-amp circuits to various practical situations	U,A,E	1, 2, 3
6	Display skill in oscillator designing for practical circuits	A,E	1, 2, 3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Op-Amp with Negative feedback**		**16**	
1	1.1	Differential amplifier – Inverting amplifier – Non-inverting amplifier -Block diagram representations – Voltage series feedback: Negative feedback – closed loop voltage gain	4	1,2
	1.2	Difference input voltage ideally zero – Input and output resistance with feedback – Bandwidth with feedback – Total output offset voltage with feedback– Voltage follower.	4	1
	1.3	v o l t a g e shunt feedback amplifier: Closed loop voltage gain -inverting input terminal and virtual ground - input and output resistance with feedback – Bandwidth with feedback - Total output offset voltage with feedback.	4	1
	1.4	Current to Voltage Converter- Inverter. Differential amplifier with one op-amp and two op-amps.	4	1
2	**The Practical Op-amp and Applications**		**20**	
2	2.1	Input offset voltage –Input bias current – input offset current – Total output offset voltage-Thermal drift.	3	2,3
	2.2	Effect of variation in power supply voltage on offset voltage – Change in input offset voltage and input offset current with time - Noise – Common mode configuration and CMRR.	4	2,4

	2.3	DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing, Scaling, averaging amplifiers.	3	2
	2.4	Instrumentation amplifier using transducer bridge. Differential input and differential output amplifier – Low voltage DC and AC voltmeter.	4	2.5
	2.5	Voltage to current converter with grounded load – Current to voltage converter.	2	2
	2.6	Very high input impedance circuit – integrator and differentiator.	4	2,1
3	**Frequency Response of Op-amp and Filters (18 Hours)**		**18**	
3	3.1	3.1. Frequency response –Compensating networks – Frequency response of internally compensated and non-compensated op-amps – High frequency op- amp equivalent circuit.	3	2,3
	3.2	3.2. Open loop gain as a function of frequency – Closed loop frequency response – Circuit stability - slew rate.	4	2,4
	3.3	3.3. Active filters – First order and second order low pass Butterworth filter	4	2
	3.4	3.4 First order and second order high pass Butterworth filter.	3	2,3
	3.5	3.5. Wide and narrow band pass filter - wide and narrow band reject filter. All pass filter – Oscillators: Phase shift and Wien- bridge oscillators.	4	2,4,6
4	**Comparators and Converters**		**6**	
	4.1	4.1. Basic comparator- Zero crossing detector.	3	2,5

4	4.2	4.2. Schmitt Trigger – Comparator characteristics-	2	2,4
	4.3	4.3.Limitations of op-amp as comparators. Peak detector–	1	2,4,6
	4.4.	4.4. Sample and Hold circuit.		

Text Book

1. Op-Amp and linear integrated circuit Ramakanth A Gaykwad, Eastern Economy Edition, ISBN-81-203-0807-7

Reference

1. Electronic Devices (Electron Flow Version), 9/E Thomas L. Floyd, Pearson
2. Fundamentals of Electronic Devices and Circuits 5th Ed. David A. Bell, Cambridge.

DSE - 12

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Essential Radio Astronomy</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE306</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course gives a broad overview, from various physical processes to the instrumentation used in the science of radio astronomy.</td></tr>
<tr><td>Semester</td><td>5</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

Course Outcomes

CO No.	CO description	Domain	PO
1	Illustrates basics of the radio universe we are in. Also a basic understanding of brightness and flux density, radiative transfer, polarization, blackbody radiation, noise generated by a warm resistor, cosmic microwave background radiation, radiation from an accelerated charge and dust emission at radio Wavelengths can be expected from a student taking this course.	U,A,An	1,2
2	Illustrates antenna fundamentals, reflector antennas, two-dimensional aperture antennas, waveguides, radio telescopes, radiometers and interferometers.	U,A,An	1,2
3	Describes synchrotron and pulsar radiations, recombination lines, line radiative transfer, excitation temperature, masers, recombination line Sources, molecular line spectra and the HI 21-cm line.	U,A,An	1,2
Understand (U), Apply (A), Analyse (An)			

Course Contents & Classroom Transactions

Module	Unit	Description	CO
		Radiation Fundamentals (15h)	
1	1.1	History of Radio Astronomy, Radio Universe,	1
	1.2	Brightness and Flux Density, Radiative Transfer,	1
	1.3	Polarization,	1
	1.4	Blackbody Radiation,	1
	1.5	Noise Generated by a Warm Resistor,	1
	1.6	Cosmic Microwave Background Radiation,	1
	1.7	Radiation from an Accelerated Charge,	1
	1.8	Dust Emission at Radio Wavelengths	1
		Radio Telescopes and Radiometers (15h)	
2	2.1	Antenna Fundamentals	2
	2.2	Reflector Antennas,	2
	2.3	Two-Dimensional Aperture Antennas,	2
	2.4	Waveguides,	2
	2.5	Radio Telescopes,	2
	2.6	Radiometers,	2
	2.7	Interferometers	2
		Radiation And Spectral Lines (15h)	
3	3.1	Free free , synchrotron and pulsar radiations,	3
	3.2	Recombination Lines,	3
	3.3	Line Radiative Transfer,	3
	3.4	Excitation Temperature,	3
	3.5	Masers,	3
	3.6	Recombination Line Sources,	3
	3.7	Molecular Line Spectra,	3
	3.8	The HI 21-cm Line	3

	Experiments (Minimum 6 must be done)	
No.		
1	Hydrogen 21 cm line detection	1,2
2	Study of Cygnus A region	1,2
3	Estimation of antenna temperature	1,2
4	Verifying Kepler's Laws	2
5	Estimation of mass of Jupiter	1
6	Inverse Square law	1,2
7	Effect of back reflectors on directivty of radio signals	1,2
8	Effect of back corner reflectors on directivty of a radio antenna	1,2
9	Interferometry using direct and reflected rays from a radio source	1,2

10	Setting up of a VLF reciever based SID Monitor	1,2
11	Distance to the moon by parallax	1
12	Small Radio Telescope	1,2
13	Beam width of an antenna	1,2
14	Temperature of an artificial star by photometry.	1,2
15	Night sky brightness with a photometer.	1,2
16	Radiometer Equation	1,2
17	Antenna Simulation	1,2

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

Text Book:

Essential Radio Astronomy, James J. Condon and Scott M. Ransom, Princeton University Press, 2016

References:

1. Burke, B. F., and Graham-Smith, F. (2002). An Introduction to Radio Astronomy (2nd ed.). Cambridge University Press: Cambridge.

2. Christiansen, W. N., and Högbom, J. A. (1985). Radio Telescopes. Cambridge University Press: Cambridge.

3. Draine, B. T. (2011). Physics of the Interstellar and Intergalactic Medium. Princeton University Press: Princeton.

4. Griffiths, D. J. (2012). Introduction to Electrodynamics (4th ed.). Addison-Wesley.

5. Kraus, J. D. (1986). Radio Astronomy. Cygnus-Quasar Books: Powell, OH.

6. Lyne, A. G., and Graham-Smith, F. (1998). Pulsar Astronomy (2nd ed.). Cambridge University Press: Cambridge.

7. Rybicki, G. B., and Lightman, A. P. (1979). Radiative Processes in Astrophysics. Wiley: New York.

8. Stanimirovic, S., Altschuler, D. R., Goldsmith, P. F., and Salter, C. J. (eds) (2002). Single-Dish Radio Astronomy: Techniques and Applications. ASP: San Francisco.

9. Sullivan, W. T. (2009). Cosmic Noise: A History of Early Radio Astronomy. Cambridge University Press: Cambridge.

10. Taylor, G. B., Carilli, C. L., and Perley, R. A. (eds) (1999).

11. Thompson, A. R., Moran, J. M., and Swenson, G. W. (2001).

12. Wilson, T. L., Rohlfs, K., and Hüttemeister, S. (2009). Tools of Radio Astronomy (5th ed.). Springer: Berlin.

DSE - 13

Discipline	**Physics**				
Course Name	**Computational Physics using Python**				
Type of Course	DSE				
Course Code	**Computational Physics using Python**				
Course Level	**300-399**				
Course Summary	To enable the student to master the Python basics, understand the Python programming tools and apply it to physical problems. Develop Python programs and debug for logical and syntax errors.				
Semester	5	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		45	30		75

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe fundamental Python syntax, including variables, data types, and basic operators. Illustrates key control flow structures in Python, such as if statements, loops, and functions.	R	
2	Describes the concept of object-oriented programming and understand the basic principles of classes and objects in Python. Demonstrate an understanding of Python data structures, including lists, tuples, dictionaries, and sets.	U	
3	Write and implement Python programs to solve simple computational problems using appropriate data structures and control flow. Apply error handling techniques to identify and resolve common issues in Python code.	A	

4	Analyze and debug simple Python programs by identifying and correcting logical errors and syntax issues. Analyze and optimize code for performance by employing profiling tools and identifying bottlenecks in Python programs.	An	
5	Evaluate and select appropriate data visualization techniques using libraries like Matplotlib and Seaborn for presenting data in Python Evaluate the efficiency of different algorithms and make informed decisions about their implementation in Python.	E	
6	Design and develop Python programs that incorporate modular programming principles, using functions and libraries effectively.	C	
****Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)***			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Essentials & Operations**		**12**	
	1.1	Introduction to Algorithms, Flowcharts and Pseudocode.	**3**	1
	1.2	Variables, operators, expressions, Reading keyboard input print command, formatted printing, Data types, Strings, Arrays (from the array module) List, Tuples, Sets, Dictionaries	**3**	1, 2
	1.3	List operations (len, append, reverse, sort, max, min, count, sum), set operations (set, add, remove, in, not in).	**3**	1
	1.4	Tuples (max, min, sum, concatenate). Dictionaries operations (get, update, pop, keys)	**3**	1, 2
2	**Flow of Control**		**13**	

	2.1	if..else, if..elif, while, for, break, List comprehension	**4**	1
	2.2	Various control and looping statements: (if, if..else, if..elif, while, for, break, continue)	**4**	1
	2.3	User defined functions- File input and file output.	**2**	1
	2.4	Concepts of Object-oriented programming	**3**	2
3	**Packages: Math and CMath**		**7**	
	3.1.1	Fundamental Operations: Arithmetic operations (addition, subtraction, multiplication, division)	**2**	
	3.1.2	Exponents and logarithms, Trigonometric functions, Advanced Concepts: Complex numbers, Mathematical constants.	**3**	
	3.1.3	Complex Number Manipulation, Basic operations on complex numbers, Trigonometric and logarithmic functions for complex numbers	**2**	
	Packages: NumPy		**7**	
	3.2.1	Introduction to NumPy: Arrays: creation, indexing, and slicing.	**2**	
	3.2.2	Array operations: element-wise operations, Linear algebra operations with NumPy.	**2**	
	3.2..3	Advanced NumPy Techniques: Random number generation, Universal functions (ufuncs).	**3**	
	Matplotlib		**6**	
	3.3.1	Basic Plotting: Line plots, scatter plots, and bar plots, Customizing plot appearance.	**2**	
	3.3.2	Advanced Visualization: Subplots and multiple plots, 3D plotting, Plotting with external datasets,	**2**	

	3.3.3	Data Visualization Best Practices: Choosing the right plot for the data, Adding labels, titles, and legends, Enhancing clarity with colors and styles	**2**	
4	**Practicals - Any 6** **(Do not use any built-in packages for doing the problem)**		**30**	
	4.1	Determine the accuracy and processing time for different step sizes by solving algebraic equations using the Bisection and Newton-Raphson methods. Then, plot the error vs step size.		
	4.2	Solve the differential equation of a simple pendulum numerically (using the Euler and Runge-Kutta techniques), compare the result with analytical solutions, and plot the results for various initial conditions.		
	4.3	Use the Trapezoidal Rule, Simpson's 1/3-Rule, and Simpson's 3/8-Rule to fine-tune the definite integral of a given function. Then, compare the accuracy to the analytical solution. Plot the error vs. step size while repeating the experiment with various step sizes.		
	4.4	Find the maximum height of a projectile, its horizontal range, and its time of flight for varying initial velocities and projection angles.		
	4.5	Examine how the diffraction pattern varies with the slit width and wavelength of a monochromatic light source while examining diffraction patterns caused by a single slit.		
	4.6	Plot the intensity pattern for the Fresnel and Fraunhofer diffraction of monochromatic light by a single slit for different slit widths and screen distances.		

	4.7	Trace the 3-dimensional trajectory of an electron travelling in a homogeneous perpendicular electric and magnetic field		
	4.8	Examine the trajectory and phase space trajectory of a damped harmonic oscillator for various damping coefficients, (solve the differential equation numerically) and compare it with the analytical solutions.		
	4.9	Using two oscillatory functions of varying frequency and amplitude, illustrate various kinds of Lissajous figures.		
	4.10	Using the Monte Carlo method obtain the value of π(*pi*).		
	4.11	Using Monte Carlo technique, calculate the value of the given integral. Compare your result with the value obtained by analytical method.		
	4.12	Solve radioactive decay law to plot the number of nuclei remaining without disintegration(N) after a time t for a sample of known decay constant. From this evaluate the activity of the given sample. or similar codes suggested by the instructor		
5		Teacher specific content	**To be evaluated internally**	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Hands on training, Presentations, Discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record

	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Text Books:

1.Downey, Allen B. *How to think like a computer scientist*. Green Tea Press 2003.

REFERENCES

1. Mahendra Verma, Practical Numerical Computing Using Python: Scientific & Engineering Applications, Amazon Digital Services LLC.
2. Programming for Computations - Python, Svein Linge, Hans Petter Langtangen, SpringerOpen 2016. [free ebook].
3. Lambert, Kenneth A. *Fundamentals of Python: first programs*. Cengage Learning, 2018.

DSE - 14

Discipline	Physics				
Course Name	**Optoelectronics**				
Type of Course	**DSE**				
Course Code	24UPHYDSE308				
Course Level	**300-399**				
Course Summary	This course aims to develop an understanding the physics and applications of semiconductor junctions as well as that of optoelectronic semiconductor devices such as LEDs, lasers, photodetectors and solar cells				
Semester	5	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		45	30		75

Course Outcomes

CO No.	CO Description	Domain	PO
1	Describes the physics and utility of semiconductor light emitting diodes	U,A,An	1,2
2	Illustrates the working of semiconductor lasers and amplifiers	U,A,An	1,2
3	Illustrates physics of photodetectors and photovoltaics and its practical applications.	U,A,An	1,2
4	Describes different kinds of optoelectronic modulators and the physics behind its working.	U,A,An	1,2
	Understand (U), Apply (A), Analyse (An)		

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
1		**Semiconductor Science and Light Emitting Diodes** (10 hrs)		
	1.1	Semiconductor energy bands, semiconductor statistics, extrinsic semiconductors,	1	1

	1.2	compensation doping, degenerate and non degenerate semiconductors,	1	1
	1.3	energy band diagrams in applied field, direct and indirect bandgap semiconductors,	1	1
	1.4	p-n junction principles, open circuit, forward and reverse bias	1	1
	1.5	depletion layer capacitance, recombination life time,	1	1
	1.6	p-n junction band diagram, open circuit, forward and reverse bias,	1	1
	1.7	light emitting diodes, principles, device structures, LED materials,	1	1
	1.8	heterojunction high intensity LEDs, double heterostructure –	1	1
	1.9	LED characteristics and LEDs for optical fiber communications,	1	1
	1.10	surface and edge emitting LEDs.	1	1
2		**Semiconductor lasers** (7 hrs)		
	2.1	Laser oscillation conditions, diode laser principles,	2	2
	2.2	heterostructure laser diode, double heterostructure, stripe geometry, buried heterostructure,	2	2
	2.3	gain and index guiding, laser diode characteristics, laser diode equation,	1	2
	2.4	single frequency solid state lasers, distributed feedback, quantum well lasers	1	2
	2.5	vertical cavity surface emitting laser,optical laser amplifiers.	1	2
3		**Photodetectors and Photovoltaics** (18 hrs)		
	3.1	Principle of p-n junction photodiode, Ramo's theorem and external photocurrent	2	3
	3.2	absorption coefficient and photodiode materials, quantum efficiency and responsivity	2	3
	3.3	PIN-photodiode, avalanche photodiode, phototransistor	2	3
	3.4	photoconductive detectors and photoconductive gain	2	3
	3.5	noise in photo-detectors, noise in avalanche photodiode	2	3
	3.6	solar energy spectrum, photovoltaic device principles	2	3
	3.7	I-V characteristics, series resistance and equivalent circuit	2	3
	3.8	temperature effects, solar cell materials,	2	3
	3.9	device and efficiencies	2	3
4		**Optoelectronic Modulators** (10 Hrs)		
	4.1	Optical polarization,	2	4
	4.2	birefringence, retardation plates,	1	4
	4.3	electro-optic modulators, Pockels effect	1	4
	4.4	longitudinal and transverse electro-optic modulators,	2	4
	4.5	Kerr effect, Magneto-optic effect,	2	4
	4.6	acousto-optic effect	1	4
	4.7	Raman Nath and Bragg-types.	1	4

Lab Sessions

No.	**Experiments** (A minimum of 6 experiments must be done)-30 Hrs	CO
1	Power characteritics of RGB LEDs	1
2	Spectral characteristics of RGB LEDs	1
3	Study the VI characteristics of LEDs emitting different wavelengths and compare their turn-on voltages.	1
4	Determination of Plank’s constant using LED.	1
5	Design a LED driver circuit employing a constant current source using an opamp and transistor and study its performance.	1
6	Design a photoconductor (LDR) circuit using opamp in the trans impedance mode and study its performance	3
7	Study the performance of a photodiode connected in photovoltaic mode using an opamp.	3
8	Study the performance of a photodiode connected in photoconductive mode using an opamp.	3
9	Compare the performance of a phototransistor connected in common emitter and common collector configurations.	3
10	Design a pyroelectric sensor circuit in voltage mode / current mode using an opamp and study its performance.	3
11	To characterize the solar cell and find out the FF and Efficiency of a solar Cell.	3
12	Construct an optical communication system by transmitting a modulated LED light through an optical fiber and detect the transmitted light intensity using a photodetector.	4
13	Determine the current transfer ratio of an Optocoupler (PC817 / 4N35) and draw the input, output and transfer characteristics curves.	3
14	Use the optocoupler 6N137 as logic gate and verify its truth table.	3

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

Text Books:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009)
2. Fiber optics and Optoelectronics, R.P. Khare, Oxford University Press, (2004)
3. Optoelectronics: An Introduction, J. Wilson and J.F.B. Hawkes, PHI, (2000)

References:

1. Semiconductor optoelectronic devices: Pallab Bhattacharya, Pearson(2008)
2. Optoelectronics: An introduction to materials and devices, Jasprit Singh, Mc Graw Hill International Edn., (1996).
3. Optical waves in crystals: Propagation and Control of Laser Radiation, A. Yariv and P. Yeh, John Wiley and Sons Pub. (2003)

DSE - 15

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Basics of Astronomy and Cosmology</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE309</td></tr>
<tr><td>Course Level</td><td colspan="5">300</td></tr>
<tr><td>Course Summary</td><td colspan="5">The course is structured to encourage the students to explore and appreciate the starry night by understanding the celestial coordinates and using diverse tools of astronomy.The course provides the students in the vast realm of astronomy, imparting a deep understanding of the sun and the evolution of stars.The different theories of origin and evolution of Universe is also detailed in this course</td></tr>
<tr><td>Semester</td><td>5</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Knowledge of Basic Mathematics and Physics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Locate sky objects by their right ascension and declination on the celestial sphere.	U, A	1, 2
2	Explain the apparent daily and annual motions of the Sun	U, An	1, 2
3	To explain the different types of telescopes and their features	U	1, 2
4	Compare and contrast the advanced stages of evolution for stars of large and small mass:	U, An	1, 2
5	Explain the structure of sun processes happening in the sun and its influences on earth	U	1, 2
6	Compare the different theories for the origin and evolution of	U, An	1, 2

	Universe		
7	Handle different tools for observational astronomy	U, A, An	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Understanding the Starry Sky,**		**11**	
	1.1	Concept of celestial sphere, Celestial Coordinates, Local reference lines, Latitude and stargazing, apparent daily motion of the stars, apparent annual motion of the star, the ecliptic, earth's seasons, equinoxes and solstices, Sun's altitude, solar day and sidereal day	6	1, 2
	1.2	. Optical Telescopes-Refracting Telescopes, Reflecting Telescopes, Magnification and f Number. Resolving Power, Radio Astronomy, Infrared Astronomy, Ultraviolet, X-Ray and Gamma Ray Astronomy	5	3
	2	**Stellar Evolution & The Sun**	18	
	2.1	Gravitational contraction - Virial theorem, Jeans mass. Energy production inside stars. Thermonuclear fusion. Hydrogen burning. p-p chain. CNO cycle**.** Classification of stars – H-R Diagram	4	4
	2.2	Birth place of star, protostar , hydrostatic equilibrium, main sequence star, old age of star-red giant, super giant ,Death of star depending on its mass –planetary nebula, white dwarf, supernova, neutron stars, pulsars, black holes-event horizon and the Schwarzschild radius (R_S) i	6	4

	2.3	**The Sun**	8	
	2.3.1	The Sun –Luminosity, diameter, mass, density, total energy output of sun, Solar constant ,Distances and size,	4	5
	2.3.2	The sun's structure, Sunspots, Activity cycle, Magnetism, Flares and coronal mass ejections, How solar eruptions affect earth, Solar wind	4	5
	3	**Cosmology - the Origin and Evolution of the Universe**	16	
	3.1	Big Bang models of the Universe, The blue shift and redshifts observed in the spectra of galaxies, The expansion of the Universe, The steady state model of the Universe, The cosmic microwave background, Inflation, The Big Bang and the formation of the primeval elements	8	6
	3.2	The Hidden Universe: dark matter and dark energy, Evidence for dark matter and dark energy, Solar neutrino problem	8	6
		Practical	30	
	1	Night sky observations (Polar alignment of an astronomical telescope)		7
	2	Find the Orion Constellation. Name three stars in the belt and prepare a report of these stars as pointer stars		7
	3	Distance determination to Cepheid variables based on their light curves		7
	4	Hands on experience in using softwares –Stellarium ,Sky map etc		7
	5	Astrophotography-Night Sky Photography		7

	6	Observe and identify the Sunspots		7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Tutorial,
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Moché, Dinah L. Astronomy. A self-teaching guide, 8th Edition, 2014.
2. Morison, Ian. Introduction to astronomy and cosmology. John Wiley & Sons, 1st Edition 2008.
3. Narlikar, Jayant Vishnu. An introduction to cosmology. Cambridge University Press, 3rd Edition, 2002.

References

1. Padmanabhan, Thanu. An invitation to astrophysics. Vol. 8. World Scientific, 2006.
2. Karttunen, Hannu, et al., eds. Fundamental astronomy. Berlin, Heidelberg: Springer Berlin Heidelberg, 6th Edition 2017.

DSE - 16

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Nuclear and Particle Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE310</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course is designed to give UG students a substantial understanding of the development of Nuclear Physics as a core physics subject in the 20th century. A detailed account on various important concepts of Nuclear Physics are included under six different modules, which will uncover the biodata of nucleus like nuclear size, mass and energy distribution, stability of the nucleus, different nuclear models, the power of nucleus as a brilliant energy source and multiple applications of the nuclear processes like radioactivity, nuclear fission and fusion, and many more. An introduction to high energy physics and nuclear detectors are included along with elementary particles and their characteristics.</td></tr>
<tr><td>Semester</td><td>6</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites if any</td><td colspan="5">Basic knowledge of algebra, quantum physics and relativity</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe and appreciate the introductory experiments which lead to the discovery of	U, A	1,2,5

	nucleus and learn the structure and properties of nucleus matter.		
2	Illustrate and contrast various nuclear models, merits and demerits, nuclear energy and semiempirical mass formula to establish the stability of the nucleus.	U, An	1,2,3,4
3	Compare and contrast the techniques to be used to harness nuclear energy and various nuclear decay processes.	A, An	1,2,3,4
4	Illustrate various applications of nuclear physics and recent trends in nuclear physics.	U, A, An	1,2,3,7
5	Appreciate and describe the physics of nuclear reactions	U, An	1,2
6	Describe the interaction between elementary particles, the conservation laws. Also, understand the quarks as fundamental particles	U, A, S	1,2,3,7
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

	Units	Course description	Hrs	CO No.
Module	**Introduction to Nucleus and static properties**		**8**	
	1.1	Introduction: Origin of nuclear physics - Becquerel's discovery of radioactivity, Rutherford scattering experiment. Nuclear composition – Discovery of neutron	2	1

1	1.2	Static properties of nuclei: taking deuteron as basic model, Nuclear size and shape – mass and charge distribution, nuclear mass, Nuclear radii – nuclear angular momentum, spin and parity, magnetic moment and quadrupole moment (qualitative).	4	1
	1.3	Nuclear force and properties, Meson theory of nuclear forces – Discovery of pion– Virtual Photons.	2	1
	Nuclear models and nuclear stability		**10**	
2	2.1	Nuclear stability, Binding energy- Binding energy curve, Liquid drop model - Semi empirical binding energy formula with correction factors - Bethe–Weizacker formula, Applications of semi- empirical binding energy formula, Mass parabola (Qualitative).	5	2
	2.2	Shell model – magic number, spin parity of nucleus, collective model(Qualitative).	5	2
	Dynamic behaviour of nucleus		**16**	
3	3.1	Radioactive Decay: Alpha decay, (tunnel theory excluded), Beta decay, positron emission, electron capture, inverse beta decay, orbital electron capture, Neutrino hypothesis, Fermi theory of beta decay (qualitative analysis). Gamma Decay.	5	3
	3.2	Radioactive decay law (authentic problems), half-life, carbon dating, uranium dating, Radioactive equilibrium.	2	3
	3.3	Nuclear fission: nuclear energy, fission products, fissile materials, chain reactions,	6	3

		moderators, neutron thermalization, reactor physics, Nuclear-reactors – Breeder reactors criticality & design; energy transport and conversion in reactor systems, nuclear reactor safety.		
	3.4	Nuclear fusion: controlled fusion, nuclear fusion reactions, fusion reactor concepts, Fusion reactors – Confinement methods	3	3
	Biomedical Applications and Recent Advances		**10**	
	4.1	Biological effects of radiation; radiation therapy for cancer treatment, Medical imaging using X-rays, ultrasound, MRI (Magnetic Resonance Imaging), CT (Computed Tomography), PET. Radioiodine therapy.	4	4
4	4.2	**Recent Advances** Neutrino and dark matter search at SNOLAB, Neutrino oscillations – Indian Neutrino Observatory (INO), Matter-antimatter asymmetry, LIGO- Gravitational Wave detection, James Webb telescope, Fusion research and prospects, Tokamak – Princeton Plasma Physics Lab, ISRO missions.	6	4
	Nuclear Reactions		**6**	
5	5.1	Energetics of nuclear reaction, The concept of interaction cross section, reaction rate – Nuclear reactions, Resonance, Centre of mass coordinate system, Q-value of nuclear reaction. Direct reaction, heavy ion reactions, Compound nuclear reaction.	6	5
	Introduction to Particle Physics		**10**	

6	5.1	Interactions and Particles – Leptons – Neutrinos and Antineutrinos, other leptons – Hadrons –Elementary particle quantum numbers.	3	6
	5.2	Classification of fundamental forces and elementary particles, quantum numbers - charge, spin, parity, isospin, strangeness, flavor. Basic concepts of symmetries and conservation principles, Quarks – color, flavor, Quark confinement.	4	6
	5.3	**Experimental particle physics** Van de Graaff accelerator, LINAC, cyclotron, Synchrotron(basic ideas only), Modern Synchrotrons. Large Hadron Collider (LHC), Quark Gluon Plasma, Higgs Boson . (Qualitative discussion)	3	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Tutorial, Buddy Discussion, Seminars, Assignments.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbooks

1. Atomic and Nuclear Physics, S N Ghoshal, S.Chand.
2. Concepts of Nuclear Physics, S P, Kuila, New central book agency (P) Ltd, Kolkata

3. Concepts of Modern Physics, Arthur Beiser, 6th Edition, Tata McGraw-Hill publishing Company.
4. Modern Physics, R Murugeshan and K. Sivaprasath, 15th Edition (Revised) (2010), S.Chand
5. Basic Nuclear Physics, B. N. Srivastava, A Pragati Edition.
6. Fundamentals of Nuclear Physics, Srivatava, Rastogi Publications.

References:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1987).
2. Introduction to nuclear and particle physics, A. Das and T. Ferbel.
3. Nuclear Physics, D. C. Tayal, Himalaya Publishing House.
4. Basic Ideas and Concepts in Nuclear Physics An Introductory Approach, K Heyde, Institute of Physics publishing, Briston and Philadelphia.
5. Nuclear and particle physics: an introduction, B. R. Martin.
6. R. J. Blin-Stoyle, Nuclear and Particle Physics, Springer (1991).
7. J. K. Shultis and R. E. Faw, Fundamentals of Nuclear Science and Engineering, Marcel Dekker (2007)
8. James E. Turner, Atoms, Radiation, and Radiation Protection, Wiley-VCH (2007)
9. R. L. Murray, Nuclear Energy 6th Ed., Butterworth-Heinemann (2008).
10. James J. Duderstadt and Louis J. Hamilton, Nuclear Reactor Analysis, Wiley (1976)
11. Perkins, Donald H., Introduction to High Energy Physics, Cambridge University Press (2000).
12. John R. Lamarsh and Anthony J. Baratta, Introduction to Nuclear Engineering, Prentice Hall (2001)
13. Nuclear and Particle Physics S L Kakani and SubhraKakani -Viva Books 2008

DSE - 17

<table>
<tr><td>Discipline</td><td colspan="6">Physics</td></tr>
<tr><td>Course Name</td><td colspan="6">Nanomaterials</td></tr>
<tr><td>Type of Course</td><td colspan="6">DSE</td></tr>
<tr><td>Course Code</td><td colspan="6">24UPHYDSE311</td></tr>
<tr><td>Course Level</td><td colspan="6">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="6">This course aims to establish a solid comprehension of essential concepts pertaining to nanomaterials, covering their structural characteristics, variation in density of states and optical, electronic and magnetic properties influenced by size. Moreover, students will acquire an in-depth knowledge of various types of nanomaterials, techniques for synthesis, and methods for characterization. The course ensures that students develop insights into the wide-ranging applications of nanoparticles across fields such as electronics, optics, biomedicine, energy, and sensing technologies.</td></tr>
<tr><td>Semester</td><td>6</td><td colspan="3">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td colspan="2">Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td></td><td colspan="2">0</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="6">Basics of Solid State Physics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the significance of length scales in the context of nanomaterials.	Understand	1,2
2	Relate and distinguish nanosystems from macroscopic systems	Analyse	1.2
3	Illustrates the behavior of density of states of 2D, 1D and 0D nanomaterials	UnderstandAppreciate	1,2
4	Compare and contrast the structures and properties of different kinds of nanomaterials, nanoclusters and nanocomposites	Evaluate	1,2

5	Describe different synthesis methods and characterization of nanomaterials	Understand	1,2
6	Contrast and assess different techniques such as X-Ray Diffractometer(XRD), Scanning Probe Microscope (SPM), Scanning Tunneling Microscope (STM), and Atomic Force Microscope (AFM) to characterize nanomaterials	Understand	1,2
7	Appreciate real-world applications of nanomaterials in electronics, optics, biomedicine, energy, and sensing technologies.	Appreciate	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**1.1 Introduction to Nanomaterials**		**8**	
	1.1.1	Length scales in physics, Features of nanosystems,	1	1,2,3
	1.1.2	The density of states of materials at the nanoscale, Variation of band gap with the size of the nanocrystal.	3	**3**
	1.1.3	Properties of Nanomaterials - Mechanical properties of nanomaterials, Optical properties of nanomaterials, Electrical and Magnetic properties of nanomaterials (qualitative ideas only)	4	4
	1.2 Quantum Mechanics for Nanoscience		**9**	
	1.2.1	Size-effects in Smaller Systems, Quantum Behaviour of Nanometric World	3	2
	1.2.2	Applications of Schrödinger Equation - Infinite potential well	3	2
	1.2.3	Quantum confinement effect of carriers in 3D, 2D, 1D nanostructures and its consequences.	3	2
2	**2.1 Types of Nanomaterials**		**8**	
	2.1.1	Semiconductor nanomaterials, Metal Nanocrystals, Surface plasmon resonance	3	4

	2.1.2	Carbon nanomaterials - Fullerenes, Carbon nanotubes and Graphene, (basic idea)	3	4
	2.1.3	Nanoclusters - Metal nanoclusters, Magic number,	2	4
	2.2 Synthesis Techniques of Nanomaterials		**10**	
	2.2.1	Top down and Bottom up approach, Lithographic process,	2	5
	2.2.2	Plasma arc discharge, sputtering. Evaporation: Thermal evaporation, Electron beam evaporation.	3	5
	2.2.3	Chemical Vapour Deposition (CVD). Pulsed Laser Deposition, Molecular Beam Epitaxy	3	5
	2.2.4	Sol-Gel Technique, Electrodeposition.	2	5
3	**Characterization of Nanomaterials**		**13**	
	3.1	Atomic Structures -Grain size determination – XRD (Debye Scherrer equation)	5	6
	3.2	Microscopy – Scanning Electron Microscope (SEM), Tunneling Electron Microscope (TEM)	5	6
	3.3	Scanning Tunneling Microscope (STM), Atomic Force Microscope (AFM).	3	6
4	**Applications of Nanotechnology**		**12**	
	4.1	Nano-electronics: Quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation).	2	7
	4.2	CNT based transistors, Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS)	2	7
	4.3	Nano-optics, Biological/bio-medical applications- drug delivery.	2	7
	4.4	Photovoltaic, fuel cells, batteries and energy-related applications, High strength nanocomposites, Nanoenergetic materials, Nanoscale chemical and bio-sensing	4	7

	4.5	Thin film chemical sensors, gas sensors, biosensors	2	7
5	Teacher Specific Content		To be evaluated internally	
	Activity- Teacher Specific			
	1	Length scales in physics(ppt/report/video)		
	2	Grain size determination using Debye Scherrer formula (using given data)		
	3	Green synthesis of nanoparticles/Detailed study of procedures involved in green synthesis		
	4	Construction of a model of graphene structure		
	5	Resistance measurement of nanofilms		
	6	Estimation of Miller Indices from given data		
	7	Sketch the miller indices of all sides of a cube		
	8	Explore ‘nano in nature’ and make a Presentation		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecturing, Problem Solving, Simulations, Demonstration/ Powerpoint Presentations, buddy discussion
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity- Teacher Specific
	A. Semester End examination **For Theory part**: Written examination

Textbook

1.Chattopadhyay, Kalyan K. *Introduction To Nanoscience And Nanotechnology*. PHI Learning Pvt. Ltd., 2009.

2. Poole, Charles P., and Frank J. Owens. "Introduction to nanotechnology." (2003): 145-150.

3. Pradeep, T. *Nano: the essentials: understanding nanoscience and nanotechnology*. McGraw-Hill

Education, 2007.

4. Nanoscience and nanotechnology: Fundamentals to Frontiers, M. S. R. Rao and Shubra Singh (Wiley 2013)

References

1.Callister Jr, William D. *Materials science and engineering an introduction*. 2007.

2. Vollath, Dieter. "Nanomaterials an introduction to synthesis, properties and application." *Environmental*

Engineering and Management Journal 7.6 (2008): 865-870.

3. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, *Nanoparticle Technology Handbook (Elsevier, 2007).*

4. Bharat Bhushan, *Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004)*

5. Gabor .L et al,*Introduction to Nanoscience and Nanotechnology,*

6. Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep,*Fundamentals of Nanotechnology*, CRC Press, 2009

7. V. S. Muraleedharan and A Subramaniam, *Nano Science and Technology,,* Ane Books Pvt. Ltd, New

Delhi

8. John D, Miller, *A Handbook on Nanophysics,* Dominant Publishers and Distributors, Delhi-51

9. Charles P Poole Jr. and Frank J Owens, *Introduction to Nanotechnology*, Wiley Students Edition

10. K Ohno et. al, *Nano-and micro materials,* Springer International Edition 2009, New Delhi

11. Brundle, Evans and Wilson, Butterworth – Heinmann, E*ncyclopedia of Materials Characterization,*

Surfaces, Interfaces, Thin Films, Eds., 1992

12. Bharat Bhushan (Ed.),*Springer Handbook of nanotechnology,* Springer-Verlag, Berlin, 2004

13. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama (Eds.), *Nanoparticle Technology Handbook* – , Elsevier

DSE - 18

Discipline	**Physics**			
Course Name	**Nanoscience and Nanotechnology**			
Type of Course	DSE			
Course Code	**24UPHYDSE312**			
Course Level	**300-399**			
Course Summary	This course is mainly designed for students from various science backgrounds. Main aim of the course is to provide a broader overview of nanoscience and nanotechnology and appreciate its influence in our day-to-day life. The course will give a comprehensive understanding on nanoscience and nanotechnology with special reference to emerging developments and applications of nanotechnology multiple avenues.			
Semester	6	Credits	4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		60	0	60
Pre-requisites if any	Basic physics and Mathematics			

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describes the importance of nanoscience and nanotechnology. **Nanoscale materials and their properties**	U, A	1,2,3
2	Illustrates different methods to develop nanosystems **Synthesis of Nanomaterials**	U, An	1,2,3
3	Illustrates various techniques that can be used to characterize nanosystems analyze the merits and demerits of various techniques **Characterization Tools**	A, An	1,2

4	Demonstrate multiple applications of nanomaterials and nanotechnology, carbon based nanomaterials and their properties. **Nanotechnology and new trends**	U, A, An	1,2,3
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

	Units	Course description	Hrs	CO No.
Module	**Nanoscale materials and their properties**		**10**	
1	1.1	History of Nanoscience and Nanotechnology. Size dependant properties of nano systems, 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)	2	1
	1.2	Surface energy, melting point, crystal structure, band structure and density of states of materials in bulk and nano-systems, Effective mass.	4	1
	1.3	Fermi surfaces localized particles, Excitons, Size effects in nano systems, Quantum mechanics of low dimensional systems, Quantum wells, Quantum wires and Quantum dots and its consequences.	4	1
	Synthesis of Nanomaterials		**18**	
	2.1	Factors affecting synthesis of nanoparticles.	2	2
	2.2	Top-down techniques: optical lithography, particle-beam lithography (e-beam, focused ion beam, shadow mask evaporation), probe lithography.	4	2

2	2.3	Bottom-up techniques: Self-assembly, Self-assembled monolayers, directed assembly, layer-by-layer assembly.	4	2
	2.4	Ball milling and applications, Molecular beam epitaxy – advantages and drawbacks, Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Physical vapour deposition, Pulsed Laser deposition (PLD), Sputtering.	4	2
	2.5	Thermal evaporation, e-beam evaporation, Chemical vapor deposition (CVD), Metal Organic Chemical Vapour Deposition (MOCVD), colloidal synthesis Sol-Gel. Spray pyrolysis. Hydrothermal synthesis.	4	2
	Characterization Tools		**16**	
3	3.1	X-Ray crystallography, Debye-Scherrer method, particle size determination, Low energy electron diffraction, Peak broadening, Absorption spectra and peak shift from nanoparticles.	5	3
	3.2	Photoluminescence, Optical Microscopy, Raman spectroscopy, XPS. (Qualitative)	3	3
	3.3	Electron microscopy – Principles and instrumentation –Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy.	6	3
	3.4	Theory of linear Four-Probe method, Electrical Resistivity measurements, SQUID. (Qualitative).	2	3
	Nanotechnology and new trends		**16**	

4	4.1	Nanofabrication, Semiconductor devices, transistor fabrication, oxidation, diffusion, ion implantation, photolithography, Etching, Metallization.	6	4
	4.2	Nanotechnology in carbon materials, graphene, CNT, synthesis of CNT, structure of CNT, Properties of CNT – electrical, mechanical and thermal, Fullerenes, applications of carbon nanotubes	4	4
	4.3	Nanomedicine. Application of magnetic nanoparticles, superparamagnetism, spintronics, magnetoresistance, Nature nanotechnology and applications, thin films, photodetection and solar cells, Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. MEMS and NEMS.	6	4

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Lecture, Tutorial, buddy discussion**
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity

	A. Semester End examination **For Theory part**: Written examination

Text Books

1. Nanoscience and nanotechnology: Fundamentals to Frontiers, M. S. R. Rao and Shubra Singh (Wiley 2013)
2. Nanoscience and nanotechnology, Sundar Singh (Pragati Prakasan 2017)
3. Introduction to Nanoscience and Nanotechnology, K. K. Chatopadhyay and A. N. Banerjee (PHI, 2022)

Reference Books:

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)
2. Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya
3. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.
4. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer
5. Introduction to Nanoscience and Nanotechnology, Charles P Poole, Jr., Frank J. Owens (Wiley, First
6. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company
7. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
8. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
9. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
10. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).
11. Nano: The Essentials, T. Pradeep (Mc Graw-Hill Education, 2007)

DSE - 19

Discipline	**Physics**			
Course Name	**Introduction to Quantum Computing**			
Type of Course	DSE			
Course Code	24UPHYDSE313			
Course Level	300-399			
Course Summary	This course provides a comprehensive understanding of mathematical basis of quantum mechanics, Dirac bra ket formalism and the Heisenberg matrix formalism. It gives an understanding of Hilbert space, ultimately the student understands the Basic Quantum Gate Properties, NOT (X) Gate, XOR (CNOT) Gate.			
Semester	6	Credits		Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		60	0	60

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Describe Dirac bra ket formalism	U	1,2
2	Illustrate Matrix formalism	U	1,2
3	Describe Dirac notation and Matrix formalism in quantum mechanical systems	U,A	1,2,3
4	Illustrate 1-qubit / 2-qubit gate operators and ability to design simple quantum circuits	U,A	1,2,3,4,5

5	Describe fundamentals of Quantum computations	U,A	1,2,3,4,5
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Dirac Bra Ket Formalism**		12	
		Introduction, Vectors in Quantum Computing	1	1
		Vector Space, Inner Products of Vectors, Higher Dimensional Vector Space, Orthonormal Basis, Bra–Ket Notation,	3	1
		Quantum Mechanical State, Superposition, and Measurement, Basis and Uncertainty Principle,	4	1
		Observables and Operators, Eigenvalues and Eigenvectors, Finding and Phase Factor	4	1
2	**Matrix formalism**		16	
		Pauli Spin Matrices, Commutation and Anti-commutation,	2	2,3
		Spin Operator in Arbitrary Direction, Relationship Between Spin Direction and Real 3D Space	3	2,3
		Adjoint and Hermitian Matrices, Operator Rules in the Bra-ket Notation, Eigenvalues of Hermitian Matrix.	3	2,3
		Copenhagen Interpretation/Born Rule and Projection Operator, Eigenvalues and Matrix Diagonalization	3	2,3

		Unitary Matrix, Unitary Transformation, Construction of Unitary Transformation Matrices, Completeness of Basis, Construct Operator from Eigenvalues and Eigenvectors,	5	**2,3**
3	**Hilbert space**		**12**	
		Hilbert Space, Expansion of Hilbert Space and Tensor Product,	4	**3,4**
		Multi-Qubits, More About Tensor Product in Hilbert Space	3	**3,4**
		Tensor Product of Vectors in General Form	2	**3,4**
		Tensor Product of Operators, Partial Measurement, Matrix Representation in a Given Basis	3	**3,4**
4	**Quantum regime**		**20**	
		Quantum Register, Quantum Data Processing,	4	**4,5**
		Entanglement and Bell States	3	**4,5**
		Einstein–Podolsky–Rosen (EPR) Paradox, Concepts Review Using Entanglement	3	**4,5**
		Pure State, Mixed State, and Density Matrix	3	**4,5**
		Measurement of Entanglement	2	**4,5**
		Basic Quantum Gate Properties, NOT (X) Gate, XOR (CNOT) Gate.	5	**4,5**
5		Teacher Specific content		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations, discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Introduction to Quantum Computing: From a Layperson to a Programmer in 30 Steps. Hiu Yung Wong, Springer International Publishing, 2022.

References:

1. G.F.Knoll: "Radiation detection and measurement", (John Wiley & sons, Newyork, 2000)

2. K.Thayalan :"Basic radiological physics",(Jaypee brothers medical Publishers, New Delhi, 2003)

3. W.J. Meredith and J.B. Masse: "Fundamental Physics of radiology", (Varghese publishing house, Bombay, 1992)

4. M.A.S. Sherer, P.J.Visconti, E.R Ritenour: "Radiation Protection in medical radiography". (Mosbey Elsevier, 2006)

5. Lowenthal G.C and Airey P.L.:" Practical applications of radioactivity and nuclear radiation sources", (Cambridge University Press, 2005)

DSE - 20

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Digital Electronics</td></tr>
<tr><td>Type of Course</td><td colspan="4">DSE</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYDSE314</td></tr>
<tr><td>Course Level</td><td colspan="4">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="4">This undergraduate course delves into the fundamental principles of digital systems, exploring electronic circuits designed for the processing and control of digital signals. Throughout the curriculum, students gain a comprehensive understanding of these concepts, enabling them to confidently design and implement straightforward digital electronics circuits upon completion.</td></tr>
<tr><td>Semester</td><td>6</td><td colspan="2">Credits</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>45</td><td>30</td><td>75</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="4">Knowledge of Basic Mathematics</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	PO No
1	Describes binary number system in digital design.	U	3
2	Demonstrates in depth knowledge about logic gates.	U	1, 3
3	Relate various logic components.	An	1, 2, 3
4	Demonstrate Boolean algebra and the Karnaugh Map.	U	1, 2, 3
5	Illustrates working mechanisms and design guidelines of logic circuits and their implementations.	U	1, 2, 3

6	Create digital counters by employing flip flops and registers	U, C	1, 2, 3
7	Acquire collaboration skills through team-based laboratory activities.	U, A, An, I, S	4, 5, 7, 9
8	Design and construct Simple, combinational and sequential logic circuits	U, A, An, C	2, 3, 10
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Binary Numbers, Logic Gates and Boolean Algebra**		**15**	
1	1.1	**Binary Numbers** Decimal-to-Binary Conversion, Binary Arithmetic, Complements of Binary Numbers, Signed Numbers, Arithmetic Operations with Signed Numbers	5	1
	1.2	**Logic Gates** The Inverter, The AND Gate, The OR Gate, The NAND Gate, The NOR Gate, The Exclusive-OR and Exclusive-NOR Gates, Programmable Logic, Fixed-Function Logic Gates	6	2, 3
	1.3	**Boolean Algebra** Boolean Operations and Expressions, Laws and Rules of Boolean Algebra, DeMorgan's Theorems, Standard Forms of Boolean Expressions, Boolean Expressions and Truth Tables	4	4, 5
2	**Combinational logic**		15	
2	2.1	**The Karnaugh Map** Introduction, Karnaugh Map SOP Minimization	4	5

	2.2	**Combinational Logic Analysis** Basic Combinational Logic Circuits, The Universal Property of NAND and NOR gates, Combinational Logic Using NAND and NOR Gates	4	5
	2.3	**Functions of Combinational Logic** Half and Full Adders, Parallel Binary Adders, Decoders, Encoders, Multiplexers (Data Selectors), Demultiplexers	7	5
3	**Sequential logic**		15	
3	3.1	**Latches and Flip-Flops** Latches, Flip-Flops- RS, Clocked RS, JK, Master slave, Flip-Flop Applications	6	6
	3.2	**Shift Registers** Shift Register Operations, Types of Shift Register – SISO, SIPO. Data I/Os,	4	6
	3.3	**Counters** Asynchronous Counters, Synchronous Counters, Up/Down Synchronous Counters	5	6
4		**Lab Content- Any 6**	30	7, 8
	4.1	Realization of logic gates – AND, OR and NOT – Using diodes, transistors etc.		
	4.2	Realization of logic gates – AND, OR and NOT – Using universal gates		
	4.3	Verification of truth table of NAND, NOR, XOR and XNOR gates		
	4.4	Verification of De Morgan's theorems – Using IC 7400		
	4.5	Realization of Half adder/ Full adder using gates – Verification of truth table		

	4.6	Multiplexer using gates		
	4.7	Demultiplexer using gates		
	4.8	SR Flip Flops using IC 7400 – Verification of truth table		
	4.9	JK Flip Flops using IC 7400 & 7410 – Verification of truth table		
	4.10	Shift register – SISO/Shift register – SIPO		
	4.11	Digital counter using IC 7490 / 7495 / 74194 / 74151 – Verification of truth table		
	4.12	To study the temperature dependence of Electrical Resistance using Arduino		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Tutorial, Demonstration
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Mano, M. Morris, Digital Logic and Computer Design 2016.

References

1. William, H. Gothmann. "Digital Electronics." (1982).
2. Floyed Thomas L., Digital fundamentals, Pearson Education, 11th edition 2017.
3. Leach D. P., Malvino A. P., and Saha G., Digital principles and applications, McGraw Hill, 8th Edition 2014
4. Digital electronics, S Salivahanan & S Arivazhagan VPH (2010)

DSE - 21

Discipline	Physics				
Course Name	**Synthesis and Characterization techniques for Functional Materials**				
Type of Course	DSE				
Course Code	**24UPHYDSE315**				
Course Level	**300-399**				
Course Summary	The course will give a concrete foundation on the Synthesis and Characterization techniques for Functional Materials which will be spring board for aspiring material science researchers. It covers modern synthesis and experimental techniques related to bulk and nano synthesis and advanced characterization tools.				
Semester	6	Credits		4	Total Hours
Course Details	Learning Approach	Lecture /Tutorial	Practical		
		45	30		75
Pre-requisites if any	Basic understanding in Physics and Mathematics				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the importance of material science and analyze the reason for different properties exhibited by the material and various synthesis techniques for bulk materials. **Bulk polycrystalline materials and composites – Synthesis Methods**	U, A	1,2,3,4
2	Illustrates various kinds of techniques used the preparation of nanomaterials in 1D, 2D and 3D forms	U, An	1,2,3,4

	Nanomaterials – Synthesis Methods		
3	Describe skill in synthesising nano materials having vibrant properties. **Synthesis and Fabrication of Functional Materials (Qualitative)**	A, An	1,2,3,4
4	Demonstrate skill in analyzing the materials using prominent techniques available for characterization. **Characterization Techniques**	U, An	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

	Units	Course description	Hrs	CO No.
Module	**Synthesis Methods for bulk materials**		**6 Lectures**	
1	1.1	Polycrystalline, single-crystalline, and amorphous materials; Ceramics, metals, alloys, and intermetallics: Relationship between physical properties and crystallographic symmetry (qualitative)	2	1
	1.2	Heating methods (thermal and RF); furnaces, types of the thermocouple; Solid-state reaction; self-propagating high-temperature synthesis	2	1
	1.3	Chemical precursor methods; coprecipitation; composites, high pressure, and high temperature techniques.	2	1
	Nanomaterials – Synthesis Methods		**14 Lectures**	

2	2.1	Top-down methods for fabrication of nanocrystalline materials; Bottom-up methods for synthesis of nanostructured solids; Solid-Vapor, Solid-Liquid and Solid-Solid reactions, Sol-gel method. (Qualitative)	4	2
	2.2	Solvothermal and Hydrothermal synthesis, High-energy Milling, combustion synthesis, microwave synthesis, spray pyrolysis	4	2
	2.3	Thin film growth - Thermal evaporation, sputtering, CVD, MOCVD, PLD.	6	2
	Synthesis and Fabrication of Functional Materials (Qualitative) 10 Lectures			
3	3.1	Carbon nanotube, graphene, chalcogenide quantum dots, nanowires and nanobelts	5	3
	3.2	Multiferroics, superconducting oxides, and intermetallics, GMR oxides, nonlinear optical crystals, and other novel functional materials	5	3
		Characterization Techniques 15 Lectures		
4	4.1	Destructive Techniques: Principles of chemical analysis, DTA, TGA, DSC.	4	4
	4.2	Non-destructive Techniques: use of X-ray; density determination, electrical transport, and magnetic properties.	3	4

	4.3	Basics of electron microscopy - Microstructure analysis (SEM, TEM).	4	4
	4.4	STM, AFM, XPS, UPS, Raman spectroscopy, UV-VISible and IR spectroscopy. (Qualitative)	4	4

Experiments	**Minimum of 5 experiments need to be performed - 30 hrs** 1. Study the X Ray diffraction data of the given sample and find crystal structure (CO-1, CO-4) 2. Prepare columbite like ceramic through solid state synthesis and study the Raman and XRD data. (CO-1, CO-4) 3. Learn the Rietveld refinement of powder XRD. (Data will be given for refinement). (CO-1, CO-4) 4. Make ceramic pellets for functional characterization and study the density as function of compacting pressure/temperature. (CO-1, CO-4) 5. Study the morphology of the given ceramic pellets. (CO-1, CO-5) 6. Compare the ferroelectric response of the relaxor ferroelectric system PMN-PT(or given material system) due to compositional modification/doping. (CO-1, CO-4) 7.Compare the dielectric response of the relaxor ferroelectric system PMN-PT (or given material system) due to compositional modification/doping. (CO-1, CO-4)

	8. Compare the dielectric response of the relaxor ferroelectric system PMN-PT (or given material system) due to compositional modification/doping. (CO-1, CO-4) 9. Prepare ceramic samples via sol gel method and analyze its magnetic properties. (CO-1, CO-4). 10. Study the X ray photoelectron spectroscopic data of the given materials. (data will supplied).(CO-1, CO-4). 11. Study raman spectrum of 2D layered material. (MoS2). (CO-1, CO-4). 12. Synthesize 2D layered MoS2 via liquid exfoliation and confirm the phase formation through raman spectrum analysis. (CO-1, CO-4). Material of interests- ZnO:MgO, PMN-PT, BCZT, BFO, SRO, LSMO, LSCO, KNN, HZO, etc
Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Tutorial, Buddy Discussion, Research Paper analysis, Open book test, problem solving, Clicker app quiz..

Assessment Types	**MODE OF ASSESSMENT** CIA 1 Objective and Descriptive – 50:50 weightage (Google form test and clicker app test may be considered for 30% of the objective weightage mentioned) CIA 2 – Descriptive type test Assignments – 1 and Seminar/dissertation – 1 Test on problem solving skill ESE **A. Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory involving** Quiz, Assignments, Seminar,Problem solving skill **Practical** Lab involvement, Viva **Summative assessment** Two written tests
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

TextBooks:

(i) Materials Science and Technology: A Comprehensive Treatment, Volume 13, 15, 16, 17, R.W. Cahn, P. Haasen, E.J. Kramer (eds), Wiley, 1996.

(ii) Novel Synthesis and Characterization of Nanostructured Materials, A. K. Alves, C. P. Bergmann, and F. A. Berutti., Springer-Verlag Berlin Heidelberg, 2013.

(iii) Inorganic Materials Synthesis and Fabrication, J N. Lalena, D. A. Cleary, E. Carpenter, and N. F. Dean, John Wiley and Sons, Inc., 2008.

(iv) Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing, J. D. Wright and N. A. J. M. Sommerdijk, Academic Press, 1990.

(v) Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer.

(vi) Nanostructures & Nanomaterials: synthesis, properties, and applications, G. Cao, Imperial College Press, 2004.

(vii) The growth of crystals from the melt, J. C. Brice, North-Holland Publishing company, 1965.

(viii) Materials Science of Thin Films, Deposition and Structure, M. Ohring, Academic Press, 2002.

(ix) Pulsed Laser Deposition of Thin Films: Applications-Led Growth of Functional Materials, R. Eason, Wiley-Interscience.

(x) Elements of X-Ray Diffraction, B. D. Cullity and S. R. Stock, Pearson, 2001.

Reference Books:

(i) The Inorganic Chemistry of Materials, P. J. van der Put, Plenum Press, New York, 1998.

(ii) Basic Solid State Chemistry, A.R. West, 2nd edition, Wiley, Student Edition, 2014.

(iii) Solid state chemistry- an introduction, L. Smart and E. Moore, CRC Press, 4th ed. (2012).

(iv) Nanowires and nanobelts: materials, properties, and devices, L. Wang (eds.), Kluwer Academic Publishers (2003).

(v) Nanochemistry: A Chemical Approach to Nanomaterials, G. A. Ozin and A. C. Arsenault, Royal Society of Chemistry (2005).

(vi) Carbon nanotubes: synthesis, structure, properties, and applications, M. S. Dresselhaus, G. Dresselhaus and P. Avouris (eds.), Springer (2001).

(vii) Nanomaterials: Synthesis, Properties and Application, A. S. Edelstein and R. C. Cammarata (eds.), Institute of Physics Publishing (1996).

(viii) Fundamental Properties of Nanostructured Materials, D. Fiorani, G. Sberveglieri, World Scientific (1994).

(ix) T. Engel, Quantum Chemistry and Spectroscopy, 3rd Ed., Pearson (2006).

(x) J. M. Hollas, Modern Spectroscopy, 4th Ed., Wiley (2004).

(xi) C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw-Hill (2017).

(xii) P. Atkins, J. de Paula and J. Keeler, Atkins' Physical Chemistry, 11th Ed., Oxford University Press (2018).

(xiii) T. Engel and P. Reid, Physical Chemistry, 3rd Ed., Pearson (2013).

(xiv) I. N. Levine, Physical Chemistry, 6th Ed., Tata McGraw-Hill (2011).

DSE - 22

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Theory of Relativity</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE401</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course delves into the fascinating world of relativity, exploring the ground breaking concepts introduced by Albert Einstein.This course will initiate the learner to gain a clear and insightful understanding of this revolutionary theory.</td></tr>
<tr><td>Semester</td><td>7</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe fundamental laws of optics that are useful in comprehending how special and general theory of relativity view light and its behaviour	U An	1, 2
2	Illustrate the fundamental laws of electrodynamics that are crucial in understanding relativity	U An	1, 2
3	Acquire skill to apply special theory of relativity in applications.	U An E	1, 2
4	Describe general theory of relativity and its applications	U An E	1, 2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**The Fundamental Laws of Optics**		**15**	
	1.1	Ether	1	1
	1.2	Corpuscular and the Undulatory Theory	1	1
	1.3	Velocity of Light, Fundamental Conceptions of the Wave Theory lnterference	3	1
	1.4	Polarisation and Transversality of Light Waves	1	1
	1.5	Ether as an Elastic Solid	2	1
	1.6	Optics of Moving Bodies, Doppler Effect	3	1
	1.7	Convection of Light by Matter	2	1
	1.8	Aberration, Retrospect and Future Prospects	2	1
2	**The Fundamental Laws of Electrodynamics**		**15**	
	2.1	Electromagnetic Theory of Light	2	2
	2.2	Electromagnetic Ether	1	2
	2.3	Hertz' Theory of Moving Bodies	2	2
	2.4	Lorentz' Theory of Electrons	3	2
	2.5	Electromagnetic Mass	2	2
	2.6	Michelson and Morley's Experiment	3	2
	2.7	The Contraction Hypothesis	2	2
3	**Einstein's Special Principle Of Relativity**		**15**	
	3.1	Conception of Simultaneity	1	3
	3.2	Einstein's Kinematics and Lorentz' Transformations	2	3

	3.3	Geometrical Representation of Einstein's Kinematics	2	3
	3.4	Moving Measuring-rods and Clocks	2	3
	3.5	Appearance and Reality	2	3
	3.6	Addition of Velocities	1	3
	3.7	Einstein's Dynamics	2	3
	3.8	Inertia of Energy	2	3
	3.9	Minkowski's Absolute World	1	3
4	**Einstein's General Theory Of Relativity**		**15**	
	4.1	Relativity of Arbitrary Motions	1	3,4
	4.2	Principle of Equivalence	2	3,4
	4.3	Failure of Euclidean Geometry	1	3,4
	4.4	Geometry on Curved Surfaces	2	3,4
	4.5	Two-dimensional Continuum	2	3,4
	4.6	Measure-determination of the Space-time Continuum	2	
	4.7	Fundamental Laws of the New Mechanics	2	
	4.8	Experimental Confirmation of the General Theory of Relativity	3	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Tutorials, Seminars/ Presentations Activities, Practical sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Einstein's Theory of Relativity, Max Born, E.P Dutton and Company
2. Relativity: The Special and General Theory, Albert Einstein(translated: Robert W. Lawson), Methuen,1916.

The first course in general relativity, B. F. Schutz; Cambridge University Press.

Reference

1. The first course in general relativity, B. F. Schutz; Cambridge University Press.
2. Classical Mechanics, J. C Upadhyaya, Himalaya Publications, 2010.
3. Gravitation and Cosmology: Principles and Applications of General Theory of Relativity, Steven Weinberg; John Wiley & Sons.
4. Lecture notes on General Relativity, Sean M. Carroll
5. Classical Mechanics, G Aruldhas, Prentice Hall, 2009
6. Classical Mechanics, Herbert Goldstein, Charles Poole & John Safko, Pearson Education

DSE - 23

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">NANOPHOTONICS</td></tr>
<tr><td>Type of Course</td><td colspan="4">DSE</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYDSE402</td></tr>
<tr><td>Course Level</td><td colspan="4">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course will provide an overview of Nanophotonics To expose students to the principle of Nanophotonics- the emerging area of Nanotechnology and Photonics that deals with light-matter interactions on the nanometer scale (1-100 nm).This course will also give an overview of the phenomena involved in such devices, types of devices in the present context of the technology andthe photonic crystal based nano-photonic systems and surface plasmon based applications</td></tr>
<tr><td>Semester</td><td>7</td><td>Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>60</td><td>0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Analyse the photon propagation through media of different dielectric constants and electron propagation under various interaction potentials.	U,A	1.2,3
2	Explain the quantum confinement effects in optical properties of material	U	1.2,3
3	Describe plasmonic effects in metal nanoparticles	U,A	1.2,3
4	Illustrate different applications of Nanophotonics	U	1.2,3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Foundations of nanophotonics**		**15**	
1	1.1	Photons and electrons: similarities and differences, Free-Space Propagation ,Confinement of Photons and Electrons ,Propagation Through a Classically Forbidden Zone :Tunneling , Localization Under a Periodic Potential: Bandgap , Cooperative Effects for Photons and Electrons	7	1
	1.2	Nanoscale optical interactions- axial and lateral nanoscopic localizations	4	1
	1.3	Nanoscale confinement of electronic interactions; Quantum Confinement Effects , Nanoscopic Interaction Dynamics , New Cooperative Transitions , Nanoscale Electronic Energy Transfer Cooperative Emission	4	1
	Quantum confined materials		**15**	
2	2.1	Quantum wells, Quantum wires, Quantum dots, Quantum rings	5	2
	2.2	Manifestations of quantum confinement- Optical properties, nonlinear optical properties;	3	2
	2.3	Quantum confined stark effect, Dielectric confinement effect.	3	2
	2.4	Superlattices; Core-Shell Quantum Dots and Quantum Dot-Quantum Wells, Quantum confined structures as lasing media,	4	2
	Plasmonics		**15**	
3	3.1	Metallic nanoparticles, nanorods and nanoshells;	3	3
	3.2	local field enhancement; subwavelength aperture plasmonics; plasmonic wave guiding;	3	3

	3.3	applications of metallic nanostructures; radiative decay engineering	3	3
	3.4	Nanostructure and excited states; up converting nanophores; photon avalanche; quantum cutting.	6	3
	Applications		**15**	
4	4.1	Photonic Crystal fibers: Basics concepts, features and theoretical modelling of photonic crystals, photonic crystal fibers	7	4
	4.2	Nanocomposites: Nanocomposites as photonic media, Nanocomposites for optoelectronics two photon lithography, plasmon printing,	4	4
	4.3	Nanoparticles for optical diagnostics and targeted therapy, Up-Converting Nanophores For Bioimaging, Biosensors, self -cleaning glasses	4	4
5	Teacher Specific content		To be evaluate internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Lecture, Presentations, Discussions**
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

Prasad, Paras N.. Nanophotonics. Wiley India, 2016

References

Gaponenko, Sergey V. Introduction to Nanophotonics. N.p., Cambridge University Press, 2010.

DSE - 24

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Quantum algorithm and Quantum computation</td></tr>
<tr><td>Type of Course</td><td colspan="4">DSE</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYDSE403</td></tr>
<tr><td>Course Level</td><td colspan="4">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course provides a comprehensive understanding of mathematical basis of quantum mechanics, Dirac bra ket formalism and the Heisenberg matrix formalism. It gives an understanding of Hilbert space, ultimately the student understands the Basic Quantum Gate Properties, NOT (X) Gate, XOR (CNOT) Gate.</td></tr>
<tr><td>Semester</td><td>7</td><td colspan="2">Credits</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>60</td><td>0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Describe matrix and properties of SWAP, Phase Shift, CCNOT gates and Walsh–Hadamard gate.	U	1,2
2	Describe quantum circuit and quantum teleportation	U	1,2
3	Describe Deutsch algorithm, Able to distinguish the two types of quantum oracles, Able to explain Grover's algorithm pictorially	U,A	1,2,3

4	Describe the differences and similarities between Discrete Fourier Transform and Quantum Fourier Transform, Will be able to describe how to map a qubit state to the surface of the Bloch sphere	U,A	1,2,3,4,5
5	Demonstrate and explain the equations in the Shor's algorithm, understand how to practise quantum programming	U,A	1,2,3,4,5
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Quantum gates and quantum teleportation**		**16**	
	1.1	SWAP Gate, Phase Shift Gate	3	**1**
	1.2	Controlled Phase Shift Gate, Toffoli (CCNOT) Gate	3	**1**
	1.3	Walsh–Hadamard Gate, Properties of the Hadamard Gate	2	**1**
	1.4	Quantum Circuit for Rotating Basis, No-Cloning Theorem	3	**2**
	1.5	Quantum Teleportation	2	**2**
	1.6	Quantum Teleportation: The Full Version, Entanglement Swapping	3	**2**
2	**Algorithm**		**22**	

	2.1	Deutsch Algorithm	2	**3**
	2.2	Quantum Oracle, Construction of Quantum Gates and Oracles	4	**3**
	2.3	Grover's Algorithm, Computational Complexity, Implementation of Grover's Algorithm	4	**3**
	2.4	Circuit for Grover's Algorithm, Numerical Example for Grover's Algorithm	4	**3**
	2.5	Construction of Quantum Oracle, Construction of the Grover Diffusion Operator	4	**3**
	2.6	Evolution of the Wavefunction, Simulation on IBM-Q, Implementation Using XOR Quantum Oracle.	4	**3**
3	**Quantum Fourier transform and circuit**		**10**	
	3.1	The N-th Root of Unity, Discrete Fourier Transform, Quantum Fourier Transform,	2	**4**
	3.2	Inverse Quantum Fourier Transform, Another Definition of QFT and IQFT	2	**4**
	3.3	Many-Qubit SWAP Gate	1	**4**
	3.4	QFT Circuit, Implementation of a 3-Qubit QFT Circuit	3	**4**
	3.5	Implementation of IQFT, General Circuit of QFT	2	**4**
4	**Quantum programming**		**12**	
	4.1	Bloch Sphere	1	**4**
	4.2	Expectation Values of Pauli Matrices	1	**4,5**

	4.3	Single-Qubit Arbitrary Unitary Rotation	2	**4,5**
	4.4	General Controlled Unitary Gate	1	**5**
	4.5	Quantum Phase Estimation	2	**5**
	4.6	Shor's Algorithm	3	**5**
	4.7	Quantum Programming	2	**5**
5		Teacher Specific content		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations, discussions
Assessment Types	MODE OF ASSESSMENT A. **Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. **Semester End examination** **For Theory part**: Written examination

Textbook

1. Introduction to Quantum Computing: From a Layperson to a Programmer in 30 Steps. Hiu Yung Wong, Springer International Publishing, 2022.

References:

1. Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge University Press

2. Quantum Information and Computation, CIT Lecture Notes by J. Preskill

3. Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers

DSE - 25

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Research Methodology</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE404</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course intends to provide the basic methodology to be followed in Scientific research. This course also provides the methods for data collection and Analysis. The importance of research ethics to be practised in the research is also highlighted here. The various helping tools in computer and internet for the research is also briefed in this course</td></tr>
<tr><td>Semester</td><td>7</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the significance of literature Survey and methodology of Research in Science	K	1
2	Apply the methodology in the data collection and Analysis of data	Re,A	1,2,3
3	Create an authentic scientific paper for Journal or Seminar from the result of analysis	An,C	1,2,3
4	Acquire skill in prepare a project proposal in the proper format	A,C	1,2,3,6
5	Describe and practice the research ethics in our area of research	A	1,2,3,6,
6	Acquire skill in using computer and internet tools in the research	A	1,2,3,9

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**INTRODUCTION TO RESEARCH METHODOLOGY**	15	
	1.1	Types of Research – Selection and formulation of Research Problem	2	1
	1.2	Need and Features of Research Design : Inductive, Deductive and Development of models	2	1
	1.3	Developing a Research Plan : Exploration, Description, Diagnosis, Experimentation, Determining Experimental and Sample Designs.	4	1
	1.4	Analysis of Literature Review : Primary and Secondary Sources, Web sources	2	1
	1.5	Different Types of hypothesis , Significance and Development of Working Hypothesis	2	1
	1.6	Research Methods: Scientific method vs Arbitrary Method Logical Scientific Methods: Deductive, Inductive, Deductive-Inductive, pattern of Deductive – Inductive logical process – Different types of inductive logical method	3	1
2		**DATA COLLECTION AND ANALYSIS**	15	
	2.1	Sources of Data – Primary, Secondary and Teritary – Types of Data – Categorical, nominal & Ordinal.	3	2
	2.2	Methods of Collecting Data : Observation, field investigations, Direct studies – Reports, Records or Experimental observations.	5	2
	2.3	Sampling methods , Data Processing and Analysis strategies-,Graphical representation , Descriptive	7	2

		Analysis ,Inferential Analysis, Correlation analysis, Least square method ,Data Analysis using statistical package ,Hypothesis ,testing ,Generalization and Interpretation ,Modelling.		
3	**Scientific Writing**		**15**	
	3.1	Structure and components of Scientific Reports , types of Report ,Technical Reports and Thesis, Significance	2	3
	3.2	Different steps in the preparation : Layout, structure and Language of typical reports ,Illustrations and tables ,Bibliography, Referencing and foot notes ,	2	3
	3.3	Oral presentation : Planning, Preparation and practice ,Making presentation ,Use of visual aids ,Importance of Effective Communication Conventions and strategies of Authentication – Citation Style - sheet	3	3
	3.4	Preparing Research papers for journals, Seminars and Conferences: Design of paper using TEMPLATE, Calculations of Impact factor of a journal, citation Index, ISBN & ISSN.	4	3
	3.5	Preparation of Project Proposal : Title, Abstract, Introduction ,Rationale, Objectives, Methodology ,Time frame and work plan, Budget and Justification ,References	4	4
4	**Research Ethics and Application of Computer in Research**		**15**	
	4.1	Ethical Issues ,Ethical Committees ,Commercialization ,copy right ,royalty	2	5
	4.2	Intellectual Property rights and patent law ,Track Related aspects of intellectual property Rights, Reproduction of published material ,Plagiarism ,Citation and Acknowledgement ,Reproducibility and accountability.	5	
	4.3	MS office and its application in Research – MS Word, MS Power point and MS Excel	5	6
	4.4	Use of Internet in Research – Websites, search Engines, E-journal and ELibrary – INFLIBNET.	3	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Lecture, Presentations, Discussions**
Assessment Types	MODE OF ASSESSMENT Continuous Comprehensive Assessment (CCA) Assignment,Quiz,Seminar,Activity
	Semester End examination Written examination

Text Books

Kothari, C. R. "Research Methodology: Methods and Techniques2004." (2004).

DSE - 26

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Nonlinear Dynamics and Chaos Theory.</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE405</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course delves into nonlinear dynamics, teaching students to model systems, understand complex behaviors, and apply computational techniques for analyzing real and synthetic data.</td></tr>
<tr><td>Semester</td><td>7</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="5">Basics of Mechanics and Calculus.</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe fundamentals of nonlinear dynamics.	U	1,2
2	Illustrate model system dynamics using differential or difference equations.	U, A	1,2
3	Comprehend periodic, aperiodic, and complex behaviors.	U, A, An, E	1,2
4	Describe dynamical stability and deviations from it.	U, A, An	1,2
5	Acquired skill in using computers and computational methods to explore the world.	U, A, An, S	1,2,8
6	Acquire skills in managing real or synthetic data.	U, A, An, S	1,2,8

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Fundamentals of Nonlinear Dynamics and Bifurcation Theory**		**15**	
	1.1	A brief history of Nonlinear dynamics, Importance of Nonlinear dynamics,World as a dynamical system.	3	1
	1.2	One dimensional flows, fixed points,Linear stability analysis	5	1,3,4
	1.3	Bifurcations, saddle-node bifurcation, Transcritical bifurcation, Pitchfork bifurcation.	7	2
2	**Exploring Dynamical Systems**		**12**	
	2.1	Phase portraits, numerical computation of phase portraits, Fixed points, Lorenz equations, Roessler system	5	1,3,4,5
	2.2	Chaos on a strange attractor, Defining Attractor and Strange attractor	3	2,3,4,5
	2.3	Lorenz map-ruling out stable limit cycles, Exploring parameter space.	4	3,4,5,6
3	**Complexity and Chaos in Dynamical Systems**		**18**	
	3.1	One dimensional maps, Fixed points and linear stability, map: numerics, Logistic map: analysis, Lyapunov exponent.	6	1,3,4,5
	3.2	Fractals,countable and uncountable sets,Cantor set, Sierpinski Carpet Dimension of self similar fractals.	6	3,4,5,6
	3.3	Box dimension,Pointwise correlation dimensions,Reconstruction of Phase space (qualitative only)	6	2,3,4,5
4	**Practicals**		**30**	**Any 5**
	4.1	Simulate the Logistic Map and demonstrate the period-doubling route to chaos.		5,6

	4.2	Compute the Lyapunov exponent of the logistic map and identify the onset of chaos.		5,6
	4.3	Obtain the Box Counting dimension of the logistic map by varying the bifurcation parameter		5,6
	4.4	Explore the parameter space of the Rössler system using a bifurcation diagram and demonstrate the period-doubling route to chaos		5,6
	4.5	Simulate the Lorenz system using the Runge-Kutta method and explore the parameter space.		5,6
	4.6	Reconstruct the phase space of a chaotic system from time series data using delay embedding and obtain the phase plot		5,6
	4.7	Obtain the Lyapunov spectra of the Lorenz attractor		5,6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures Tutorials Seminars/ Presentations Practical sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014.

Analysis of Observed Chaotic Data, Abarbanel, Henry D.I., Springer, 1995.

References

Deterministic Chaos, N. Kumar, Universities Press.

Chaos and Nonlinear Dynamics, RC. Hilborn, Oxford University Press.

Chaotic Dynamics: An Introduction, G.L. Baker, and J.P. Gollub, CUP, 1993.

Chaos in Dynamical System, E. Ott, Cambridge University Press.

5 . S. Neil Rasband, Chaotic Dynamics of Nonlinear Systems, Courier Dover Publications

DSE - 27

Discipline	**Physics**			
Course Name	**Electroceramics (Research Based)**			
Type of Course	DSE			
Course Code	**24UPHYDSE406**			
Course Level	**400-499**			
Course Summary	Electronic, optical, and magnetic ceramics, or electro-ceramics as they are more commonly known, are valuable materials for a wide range of technological applications, including data storage devices, actuators, sensors, and transducers. Substantial research is being carried out across the globe to bring out new properties and new materials to cater the need of advanced technology. Here are a few thoroughly investigated uses for electroceramics. Ferroelectrics like BaTiO3 and PMN-PT are utilized as sensors and actuators, while dielectric materials like SiO2 are used as data storage elements in random access memory, or RAMs. Magnetic oxides, like iron oxides, are utilized in magnetic heads to store data. One well-known optoelectronic material is ZnO. To engineer these materials for a specific use, a thorough understanding of their physics and chemistry is crucial, which is the aim of the course.			
Semester	7	Credits	4	Total Hours
Course Details	Learning Approach	Lecture /Tutorial	Practical	
		45	30	75
Pre-requisites if any	Suited for final year undergraduate students of Physics and Chemistry.			

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describe the importance of material science, structure and microstructure of materials and their correlation to various properties exhibited by the material.	U, A	1,2,3
2	Illustrate the principles and general attributes of ceramic materials and their utility in various applications.	U, A	1,2,3
3	Describe various processes taking place in ceramic processing and its effect on the property of the ceramic for applications.	A, An	1,2,3
4	Illustrate polar behaviour in solids and properties of dielectric and ferroelectric materials and utility in various applications.	U, A, An	1,2,7
5	Describe the property of piezoelectricity and pyroelectricity and its implications in various applications.	U, An	1,2,3,7
6	Illustrate various applications of multiferroicity and superconductivity etc.	U, A, S	1,2,3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

	Units	Course description	Hrs	CO No.
Module	**Material structure**		**8 Lectures**	
	1.1	Introduction to research with a special reference to material science and environmental issues in material science. Structure of crystalline and noncrystalline solids; imperfections in solids (Qualitative)	2	1

1	1.2	Bonding in materials, Crystal structure, Packing of atoms in different crystal structures (cubic, FCC, diamond), Perovskites, Pyrocholre, Spinel, microstructure.	5	1
	1.3	XRD, SEM (Research analysis)-Qualitative	1	
	Ceramic Materials		**6 Lectures**	
	2.1	Structure of Ceramic Materials, Defect Chemistry and Equilibria, Physical principles of electrical and electronic properties of ceramics.	4	2
	2.2	Ionic structure, defects, spontaneous polarization, phase transitions, electrical conduction and charge displacement processes.	2	2
	Fabrication of ceramics		**6 Lectures**	
3	3.1	General methods and new developments in ceramic processing. Diffusion and Conduction in Ceramics, Fick's law	2	3
	3.2	Calcination, Sintering and microstructure development: Solid state sintering, densification vs. coarsening processes, grain boundary mobility mechanisms, porosity	4	3

		evolution, viscous densification, liquid phase sintering (constrained sintering, Spark plasma sintering, microwave sintering, crucibles, furnace and filaments for different temperatures - Qualitative).		
	Dielectrics and insulators		**10 Lectures**	
	4.1	Ferroelectric Ceramics, Permanent Dipole Moment and Polarization, Principle of Ferroelectricity: Energetics, Proof of Curie-Weiss Law, Basis of Ferroelectric Phase Transitions, Case I: Second order Transition, Case – II: First Order Transition, Ferroelectric Domains, Analytical treatment of domain wall energy, Ferroelectric Switching and Domains, Measurement of Hysteresis Loop	4	4
	4.2	Dielectrics in DC electric field, Mechanisms of Polarization, Ferroelctricity and domain formation, Relaxor ferroelectrics, Capacitive and ferroelectric applications. Dielectric properties for low-, medium- and high-permittivity ceramics, Polarization mechanism and frequency range	4	4

		Dipolar Relaxation i.e. Debye Relaxation in Polar Solids dielectric loss, dielectric spectrum, Dielectric Breakdown. Structural change and ferroelectricity in Barium Titanate ($BaTiO_3$) (Ferroeectric system) and PMN-PT (Relaxor ferroelectric), Applications of Ferroelectrics (qualitative). Research based	2	4
	Piezo and pyroelectricity		**5 Lectures**	
5	5.1	Piezoelectric Ceramics- Direct Piezoelectric Effect, Reverse or Converse Piezoelectric Effect, Poling of Piezoelectric Materials, Depolarization of Piezoelectrics, Common Piezoelectric Materials, Applications of Piezoelectric Ceramics.	3	5
		Pyroelectric Ceramics- Difference between and pyroelectric and ferroelectric material, Theory of Pyroelectric Materials, Measurement of Pyroelectric coefficient, Direct and Indirect effect, Common Pyroelectric Materials.	2	5
	Electro-optic ceramics and Magnetoelectric ceramics		**10 Lectures**	

6	6.1	Basic concepts, properties and applications of model ferrites. Electrical and optical properties of the materials; ceramics, polymers and composites materials.	2	6
	6.2	Theory of magnetism, different kinds of magnetism and comparative study (qualitative), magnetic losses and frequency dependence, magnetic ferrites, Superconductivity and essential theory (qualitative), High temperature superconductors.	4	6
	6.3	Requirements of a magnetoelectric and multiferroic material, Magnetoelectric Coupling, Type I Multiferroics, Type II Multiferroics, Two Phase Materials.	4	6

Research Lab (30 Hrs)	Synthesis of ceramic material and study the structure and microstructure and hence establish structure property correlation and defend their research before a DC committee/ public. Students will be grouped and each group should prepare a set of chosen material with varying dopants or compositions to establish the hypothesis. Material of interests- ZnO:MgO, PMN-PT, BCZT, BFO, SRO, LSMO, LSCO, KNN etc.

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Lecture, Problems solving and buddy discussions, Quiz using clicker app and discussion , Presentations
Assessment Types	MODE OF ASSESSMENT-CIA 1 Objective and Descriptive – 50:50 weightage 30% of the objective weightage may be taken from regular quiz using google form or Clicker app. CIA 2 – Descriptive type test Assignments – 1 and Seminar/dissertation - 1 ESE **A.Continuous Comprehensive Assessment (CCA)** **Formative assessment** **Theory** Quiz, Two Assignments MCQ - google form/Clicker app and discussion of multiple answers by students. Open book exam. **Practical** Lab involvement , Viva **Summative assessment** Two written tests:10 marks (5 each)
	A. Semester End examination **For Theory part**: Written examination

Texts:

1. V. Raghavan, Material Science and Engineering :A First Course, 5th Ed, Prentice-Hall of India, 2004.

2. W.D. Callister (Jr.), Materials Science and Engineering : An Introduction, 6th Ed., 2003. References: 1. J. B. Watchman, Characterization of Materials, Butterworth-Heinenmann, 1992. 2. L.H. Van Valck, Elements of Materials Science and Engineering, 6th Ed., Addision-Wesley, 1998.
3. A. J. Moulson, J. M. Herbert, Electroceramics, 2nd Ed., John Wiley & Sons Ltd, 2003.
4. M.N.Rahaman, Ceramic processing and sintering, 2nd Ed., 2nd Ed., Marcel Dekker, Inc, New York, 1995.
5. C Suryanarayana, M. Grant Norton, X-Ray Diffraction: A practical approach
6. Nanoscience and Nanotechnology : Fundamentals to Frontiers by M.S. Ramachandran Rao, Shubra Singh , Wiley 2013

References:

1. S. Somiya,F. Aldinger, N. Claussen, R. M. Spriggs, K. Uchino, K. Koumoto, M. Kaneno, Handbook of Advanced Ceramics, Volume II Processing and their Applications, Elsevier Inc, 2003.
2. M. W Barsoum, Fundamentals of ceramics, IOP Publishing Ltd, 2003 3. R.C. Buchanan, Ceramic Materials for Electronics: Processing, Properties, and Applications. Electrical Engineering and Electronics, 2nd Ed., Marcel Dekker, Inc, New York, 1991.
3. Materials Science and Engineering, W.D. Callister, Jr., Wiley
4. Physical Ceramics: Principles for Ceramic Science and Engineering, Y.-M. Chiang, D. P. Birnie, and W. D. Kingery, Wiley-VCH
5. Introduction to Ceramics, W. D. Kingery, H. K. Bowen, D. R. Uhlmann, Wiley
6. Fundamentals of Ceramics, Michael Barsoum, McGraw Hill
7. Principles of Electronic Ceramics, by L. L. Hench and J. K. West, Wiley
8. Electroceramics: Materials, Properties, Applications, by A. J. Moulson and J. M. Herbert, Wiley
9. Nonstoichiometry, Diffusion and Electrical Conductivity in Binary Metal Oxides (Science & Technology of Materials), P.K. Kofstad, John Wiley and Sons Inc.
10. Introduction to Solid State Physics, C. Kittel, Wiley
11. Electrical Properties of Materials, L. Solymer and D. Walsh, Oxford University Press

12. Transition Metal Oxides: An Introduction to Their Electronic Structure and Properties, P.A. Cox, Oxford University Press
13. Basic Solid State Chemistry, A.R. West, Wiley
14. Feynman Lectures on Physics, Volume 1-3, R.P. Feynman, Addison Wesley Longman
15. Materials Science and Engineering: A first course, V. Raghavan, Prentice Hall of India
16. Materials Science And Engineering: An Introduction, W.D. Callister, Wiley

DSE - 28

Discipline	**Physics**
Course Name	**Digital Signal Processing**
Type of Course	**DSE**
Course Code	**24UPHYDSE407**
Course Level	**400-499**
Course Summary	This course introduces the basics of signal theory and transforms. DFT and FFT computations are discussed. Laboratory sessions give hands-on experience with the implementation of various filters using softwares like GNU Octave or Matlab or Wolfram Mathematica and GNU Radio.

Semester	7	Credits	4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		45	30	75
Pre-requisite, if any	A working knowledge of Fourier transforms is desirable.			

Course Outcomes

CO No.	CO Description	Domain	PO
1	Illustrate digital and discrete time signals, systems and their significance	U,A,An	1,2
2	Analyse the digital signals using various digital transforms DFT, FFT etc.	U,A,An	1,2
3	Designing of digital filters	U,A,An	1,2
4	Develop basic knowledge in DSP with GNU Octave or Matlab or Mathematica and GNU Radio	U,A,An	1,2
	Understand (U), Apply (A), Analyse (An)		

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
1		**Signals** (12 hours)		
	1.1	Discrete time signals	3	1,4
	1.2	Special sequences	3	1,4
	1.3	Shift invariance, Stability and causality	3	1,4
	1.4	Impulse response, Difference equations	3	1,4
2		**Z Transform** (18 hours)		
	2.1	Z-transforms by summation of left, right, and two-sided sequences	4	2,4
	2.2	Regions of convergence and Z-transform properties	4	2,4
	2.3	Inverse Z-transform	5	2,4
	2.4	Implementation of Z-Transform using GNU Octave / Matlab / Wolfram Mathematica	5	2,4
3		**Discrete Fourier Transform** (15 hours)		
	3.1	Definition of DFT and relation to Z-transform	2	2,4
	3.2	Properties of the DFT	2	2,4
	3.3	The fast Fourier transform-DIT and DIF	3	2,4
	3.4	Implementation of DFT & FFT, FFT for various signals and data using GNU Octave / Matlab / Wolfram Mathematica	8	2,4

Lab Sessions

No.	**Experiments** (A minimum of 6 experiments must be done)	CO
1	DFT / IDFT of given DT signal.	3,4
2	Linear convolution of two finite length sequences.	3,4
3	Computing auto correlation.	3,4
4	Frequency response of a given system.	3,4
5	DFT / FFT of given sequence.	3,4
6	Low pass FIR filter for a given sequence.	3,4
7	High pass FIR filter for a given sequence.	3,4
8	Low pass IIR filter for a given sequence.	3,4
9	High pass IIR filter for a given sequence.	3,4
10	Sinusoidal signal through filtering.	3,4
11	Power Spectrum of a given signal.	3,4
12	Power Spectrum of a given signal with GNU Radio.	3,4
13	Lissajo's figures using GNU Radio	3,4

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

Text Book:

1. S. K. Mitra,,Digital Signal Processing: A Computer-Based Approach, McGraw-Hill, Third edition, 2006.
2. A. Oppenheim and R. Schafer,Discrete-Time Signal Processing, Prentice Hall

References:

1. The Student Edition of MATLAB, Prentice-Hall, New Jersey
2. V. Ingle, J. Proakis, Digital Signal Processing Using MATLAB, Brooks/Cole, 1999.
3. B. Porat,A Course in Digital Signal Processing, J. Wiley and Sons, 1996
4. Websites / documentation of Matlab / Octave / Mathematica / GNU Radio

DSE - 29

<table>
<tr><td>Discipline</td><td colspan="5">PHYSICS</td></tr>
<tr><td>Course Name</td><td colspan="5">Mathematical Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE408</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">This Mathematical Physics course offers a comprehensive study of complex analysis, Fourier series and transforms, special functions and series solutions of ordinary differential equations, providing students with essential mathematical tools for tackling intricate problems in diverse domains of Physics.</td></tr>
<tr><td>Semester</td><td>8</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Analyse complex numbers and functions, using techniques contour integration and residue theory.	A &An	1,2
2	Acquire skill in representing periodic functions using Fourier series, including determining coefficients and applying Fourier transforms.	U	1,2
3	Apply the Fourier transforms in the Problems related to Physics	A	1,2
4	Illustrate ordinary differential equations using power series methods,	A	1,2
5	Describe differential equations arising in physics by using special Special functions	A&An	1,2
6	Acquire skill in solving differential function by applying eigenvalue methods	A	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Complex Analysis**		**15**	
	1.1	Functions of a complex variable, The Cauchy–Riemann relations, Power series in a complex variable, Some elementary functions, Multivalued functions, and branch cuts.	5	1
	1.2	Singularities and zeros of complex functions, Conformal transformations, Complex integrals	4	1
	1.3	Cauchy's theorem, Cauchy's integral formula, Taylor and Laurent series	3	1
	1.4	Residue theorem, Definite integrals using contour integration	3	1
2	**Fourier series and Fourier transforms**		**15**	
	2.1	The Dirichlet conditions, The Fourier coefficients, Symmetry considerations, Discontinuous functions, non-periodic functions	**5**	2,3
	2.2	Integration and differentiation, Complex Fourier series, Parseval's theorem	**4**	2,3
	2.3	Fourier transforms-The uncertainty principle; Fraunhofer diffraction; the Dirac δ-function; relation of the δ-function to Fourier transforms; Properties of Fourier transforms; odd and even functions;	**6**	2,3
3		**Series solutions of ordinary differential equations**	**13**	

	3.1	Second-order linear ordinary differential equations, Ordinary and singular points, Series solutions about an ordinary point, Series solutions about a regular singular point	**4**	4,5
	3.2	Distinct roots not differing by an integer; repeated root of the indicial equation; distinct roots differing by an integer, Obtaining a second solution	**5**	4,5
	3.3	The Wronskian method; the derivative method; series form of the second solution, Polynomial solutions	**4**	4,5
4	**Special Functions**		17	
	4.1	Legendre functions/Polynomial, Legendre functions for integer l, Spherical harmonics	**4**	4,5
	4.2	Bessel functions, General solution for non-integer ν; general solution for integer ν; Laguerre functions, Hermite functions	**4**	4,5
	4.3	The Beta and gamma function, and related function	**4**	4,5
	4.4	Sets of functions, Some useful inequalities, Adjoint, self-adjoint and Hermitian operators , Properties of Hermitian operators, Reality of the eigenvalues; orthogonality of the eigenfunctions; construction of real eigenfunctions	**5**	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations and Discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

Bence, S. J., K. F. Riley, and M. P. Hobson. "Mathematical methods for physics and engineering." (2006).

Books for Additional Reading:

Arfken, George B., Hans J. Weber, and Frank E. Harris. *Mathematical methods for physicists: a comprehensive guide*. Academic press, 2011.

Riley, Kenneth Franklin, and Michael Paul Hobson. Foundation mathematics for the physical sciences. Cambridge University Press, 2011.

Riley, K. F., and M. P. Hobson. Essential Mathematical Methods for the Physical Sciences. Cambridge: Cambridge UP, 2011. Print.

DSE - 30

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Radiation Physics</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSE409</td></tr>
<tr><td>Course Level</td><td colspan="5">400-499</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a comprehensive understanding of radiation sources, including types of ionizing and non-ionizing radiations, electromagnetic particles, and various sources such as radioactive materials, accelerators, cyclotrons, and nuclear reactors. Students explore the interaction of radiations with matter, covering topics like inelastic collisions, energy loss, and interaction mechanisms for electrons, heavy charged particles, gamma rays, and neutrons. The course also delves into radiation quantities, units, and dosimeters, discussing particle flux, curie, becquerel, absorbed dose, biological effectiveness, and various dosimeter types. Furthermore, it addresses biological effects of ionizing radiations at molecular, cellular, and genetic levels, emphasizing applications in cancer therapy, food preservation, and sterilization. The course concludes with radiation protection, shielding methods, and transport considerations for medical, industrial, and research facilities.</td></tr>
<tr><td>Semester</td><td>8</td><td colspan="2">Credits</td><td></td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td><td>Others</td></tr>
<tr><td>60</td><td colspan="2">0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Describe different sources of radiation and	U	1,

	differentiate the different categories of the same.		
2	Analyze the scientific concept behind the working of different types of accelerators.	U,An,A	1,2
3	Acquire an insight into the interaction between radiations and matter and describe the related scientific terms involved in defining the interaction process.	U,An	1,2,3
4	Describe the different scientific measurement terms used in the measurement related to radiation.	U,A	1,2
5	Describe different experimental setups used in radiation measurement and differentiate them.	U,An	1,2,3
6	Illustrate the biological effects of radiation and the safety measures for radiation exposure on living organisms.	U,An,A	1,3,7,8
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Radiation source**		**14**	
		Types of radiations, ionizing, non ionizing, electromagnetic, particles, neutral -gamma-neutrino-neutron, charged alpha, beta, gamma, and heavy ion sources	7	**1**
		radioactive sources - naturally occurring production of artificial isotopes, accelerators-cyclotrons, nuclear reactors. {Ref 1,2}	7	**2**

2	**Interaction of radiations with matter**		**15**	
		Electrons - classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, specific energy loss, bremsstrahlung, range energy relation, energy and range straggling,	5	**3**
		Heavy charged particles - stopping power, energy loss, range and range energy relations, Bragg curve, specific ionization	**3**	**3**
		Gamma rays Interaction mechanism - Photoelectric absorption, Compton scattering, Pair production, gamma ray attenuation, attenuation coefficients, Elastic and inelastic scattering, Cross sections, linear and mass absorption coefficients, stopping power, LET, Neutrons - General properties, fast neutron interactions, slowing down and moderation. {Ref 1,2}	7	**3**
3	**Radiation quantities, Units and Dosimeters**		**15**	
		Particle flux and fluence, calculation of energy flux and fluence, curie, becquerel, exposure and its measurements, absorbed dose and its relation to exposure, KERMA, Biological effectiveness, wighting factors, (WR and WT), Equivalent dose, Effective dose	8	**4,5**
		, , Dosimeters, Primary and secondary dosimeters, Pocket dosimeter, Films and solid dosimeter (TLD and RPL), Clincal and calorimetric devices, Radiation survey meter for area monitoring. (15 hours) {Ref 2,3}	**7**	**4,5**
4	**Biological effects**		**16**	
		Basic concepts of cell biology, Effects of ionizing radiations at molecular, sub molecular and cellular levels, secondary effects, free radicals, deterministic effects, stochastic effects	**6**	**6**
		Effects on tissues and organs, genetic effects, Mutation and chromosomal aberrations, applications in cancer therapy, food preservation, radiation and sterilization. (12 hours) {Ref 3,4)	**6**	**6**

	Radiation protection, shielding and transport:		4	
		Effective radiation protection, need to safeguard against continuing radiation exposure, justification, and responsibility, ALARA, concept of radiologic practice. time distance and shielding, safety specifications		**6**
5		Teacher Specific content		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations, discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

References:

1. G.F.Knoll: "Radiation detection and measurement", (John Wiley & sons, Newyork, 2000)

2. K.Thayalan :"Basic radiological physics",(Jaypee brothers medical Publishers, New Delhi, 2003)

3. W.J. Meredith and J.B. Masse: "Fundamental Physics of radiology", (Varghese publishing house, Bombay, 1992)

4. M.A.S. Sherer, P.J.Visconti, E.R Ritenour: "Radiation Protection in medical radiography". (Mosbey Elsevier, 2006)

5. Lowenthal G.C and Airey P.L.:" Practical applications of radioactivity and nuclear radiation sources", (Cambridge University Press, 2005)

6. SYLLABUS FOR DISCIPLINE SPECIFIC COURSES - Minor Pathway

DSC -Minor- 01 - 24UPHYDSC101 - Foundations of Physics

The syllabus of the course is included in the DSC major course basket in page number 46

DSC - Minor-02 - 24UPHYDSC102 -Modern Physics

The syllabus of the course is included in the DSC major course basket in page number 51

DSC - Minor-03

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Introduction to Spectroscopy</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC-Minor Pathway</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC205</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a comprehensive exploration of the principles, techniques, and applications of Atomic and Molecular Spectroscopy</td></tr>
<tr><td>Semester</td><td>2</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
<tr><td>Pre-requisite, if any</td><td colspan="5">Basic concepts of Atomic structure and Electronic Transitions</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Illustrates different models of atom and the foundations of Atomic Spectroscopy	U	1, 2
2	Illustrates the importance of understanding Electromagnetic Spectrum and their application in Molecular Spectroscopy	K, U	1, 2
3	Describes principles of Resonance Spectroscopy and its applications	U	1, 2
4	Demonstrate skill in using different soft wares for the analysis of Molecular Spectra	U, A	1, 2
5	Demonstrate skill in spectrum analysis and implications	U, A, An	1, 2
6	Illustrates the utility of Spectrometer in interpreting the spectrum of different light sources	U, A, An	1, 2

Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**Atomic Physics**	**16**	
	1.1	Electromagnetic spectrum. Hydrogen spectrum. Bohr atom model –quantum condition and frequency condition-limitations of the model.	3	1
	1.2	Orbital angular momentum and spin angular momentum. Orbital magnetic moment and spin magnetic moment, gyromagnetic ratio, energy of magnetic moment in a magnetic field.	3	1
	1.3	Vector Atom Model-quantum numbers and term symbols. Spin-orbit interaction -fine structure-fine structure of sodium D lines.	3	1
	1.4	L-S and j-j couplings.	2	1
	1.5	Normal Zeeman effect -experimental arrangement. Anomalous Zeeman effect -Lande g-factor. Paschen-Back effect.	5	1
2		**Molecular Spectroscopy**	**16**	
	2.1	Types of Molecular energies, classification of molecules, rotational spectra of rigid diatomic molecules	4	2
	2.2	Infrared spectroscopy- vibrational energy of a diatomic molecule for harmonic vibrations-vibrational spectrum.	4	2
	2.3	Raman Scattering- Quantum theory of Raman Effect, Stokes and anti- stokes lines Mutual exclusion of IR and Raman spectra	4	2
	2.4	Electronic transitions- UV and Visible spectra Fluorescence and Phosphorescence	4	2

		Resonance Spectroscopy and Activities	**13**	
	3.1	NMR Spectroscopy- Basic principles, resonance condition,	4	3
	3.2	ESR Spectroscopy- Basic principles	4	3
3	3.3	Activity 1. GAMESS/ Gaussview softwares- (a) View molecular vibrations (b) Demonstration of IR, Raman, UV spectra 2. Basic analysis of the spectrum of samples 3. Identify the spectrometers employed in Chandrayaan missions	5	4, 5
4		**Practicals-Minimum 6 to be done**	**30**	
	1	Verification of Beer-Lambert law-dependence of concentration/path length		6
	2	Determination of refractive index of material of prism using spectrometer.		6
	3	Dispersive power of prism using Spectrometer.		6
	4	Dispersive power of grating using Spectrometer.		6
	5	Using a (Quantum chemical) computational software, obtain the vibrational frequencies, bond length, bond angle, dipole moment & Total energy of H2O and CO2 molecules		4
	6	Using a (Quantum chemical) computational software compare the IR and Raman spectra of H2O and CO2 molecules		4
	7	Determination of Planck's constant using LED.		6
	8	Study the V-I characteristics of LEDs emitting different wavelengths and compare their turn-on voltages		6
	9	Determination of wavelength of a laser using diffraction grating		6
	10	Analysis of FTIR/Raman spectrum from given data.		6

5		Teacher specific content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Field Trip,Observation and interactive Session, Group discussion.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbook

1. Aruldhas, G. Rajagopal P. Modern Physics, Prentice- Hall of India 1st Edition 2005

References

1. Beiser, Arthur, Mahajan. Shobhit, Choudhury, S. Rai. Concepts of modern physics. McGraw Hill Education, 2017 7th Edition
2. Banwell C.N., McCash E. M. Fundamentals of Molecular Spectroscopy-4th Edition, McGraw Hill 2017.
3. The Feynman Lectures on Physics, Volume III https://www.feynmanlectures.caltech.edu/III_toc.html
4. G Aruldhas, Molecular Structure and Spectroscopy, Prentice- Hall of India

DSC -Minor- 04

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Basic Electronics and Electricity</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC-Minor</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYDSC206</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course gives an overview of the various circuit parameters and components involved in electricity and enhances the ability to analyse different electrical circuits. This course also provide a comprehension of the fundamentals of Solid state physics for the learner.</td></tr>
<tr><td>Semester</td><td>4</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">30</td><td>75</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Describes various circuit parameters including current, voltage, resistance	U	1, 2
2	Describe various ac circuits and behavior (LR, CR and LCR).	U, A, An	1, 2
3	Demonstrate the practical skill in making rectifiers and voltage regulators (using Zener diode) and graphs	A, An, E, C	1, 2, 3
4	Illustrate the utility of transistor as amplifier and basic ideas of FET	U, An	1, 2, 3
5	Illustrate the utility of Op amp	U, A, An, E	1,2,3
6	Describe the working of Diodes and Transistors and analyse the the circuit parameters for different electronic circuits	U, A, An, E	1, 2, 3, 9
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Basic concepts of Electricity**		18	
	1.1	Modern Electron Theory of electricity- The idea of an electric potential	3	1
	1.2	Resistance, Effect of Temperature on Resistance, Temperature coefficient of Resistance, Thermistor.	3	1
	1.3	Open and Short circuits equivalent resistance, Voltage divider circuits	5	1
	1.4	EMF induced in a coil rotating in a magnetic field	2	2
	1.5	AC applied to resistive, inductive and capacitance circuits - AC applied to LR and RC circuits. Analysis of LCR series circuits - LCR parallel resonant circuit – comparison.	5	2
2	**Applications of Diodes**		12	
	2.1	Rectification - Half wave, - Nature of rectified output, Efficiency & Ripple factor	3	3
	2.2	Full wave, Centre tapped, Bridge rectifier circuits - Nature of rectified output, Efficiency & Ripple factor	3	3
	2.3	Filter Circuits – Capacitor filter	2	3
	2.3	Zener diode and its reverse	4	3

		characteristics. Zener diode as voltage regulator.		
3	**Transistor, FET and Op-Amp**		15	
	3.1	Bipolar junction transistors, Transistor , CE configurations and their characteristics, applications	4	4
	3.2	Current gain β. CE amplifier with voltage biasing	3	4
	3.3	FET (basic idea)	2	4
	3.4	OP-amp- Symbol and terminals. Characteristics of ideal OP-amp, CMRR. Applications -Inverting, Non-inverting and Buffer amplifiers.	6	5
4		**Practicals- Any 6**	30	
	1	Conversion Galvanometer into Voltmeter/Ammeter		6
	2	Diode Characteristics – Forward - Study of dynamic and static properties		6
	3	Zener Diode Characteristics –Reverse – Study of dynamic and static properties		6
	4	Voltage regulator using zener diode – Study of line and load regulations		6
	5	Half wave rectifier – Study of ripple factor and load regulation with and without filter circuit		6
	6	Full wave rectifier – (center tap) – Study of ripple factor and load regulation with and without filter circuit		6
	7	Full wave rectifier – (bridge) – Study of		6

		ripple factor and load regulation with and without filter circuit		
	8	Common Emitter – Input and output characteristics		6
	9	Common Emitter amplifier -study the amplification.		6
	10	Op Amp Inverting amplifier , Non-Inverting amplifier and Buffer amplifier		6
		Simulations using PSpice (any 4)		
5		Teacher specific content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Lecture, Demonstration, Tutorial, Simulations, Practical**
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Theraja B.L., Theraja A. K. A Textbook of Electrical Technology S Chand 1999.
2. Metha V. K. Principles of Electronics S Chand; 7th edition
3. Rashid Muhammad H. Introduction to PSpice Using OrCAD for Circuits and Electronics Pearson; 3rd edition (28 August 2003)

References

1. Malvino, Leach and Saha. Digital principles and applications, (6th Edition) TMH
2. Murugeshan R. Electricity and Magnetism,
3. Salivahanan S., Arivazhagan S. Digital electronics, VPH 2010
4. M Morris Mano, D. Ciletti Michael Digital design 6th edition Visionias 2022

7. MULTIDISCIPLINARY COURSES

MDC - 01

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Physics In Daily Life</td></tr>
<tr><td>Type of Course</td><td colspan="4">MDC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYMDC101</td></tr>
<tr><td>Course Level</td><td colspan="4">100-199</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course, "Physics Around You," provides an engaging exploration of fundamental physics principles manifested in everyday life, trying to connect theoretical concepts and the real-world phenomena that shape our daily experiences. From mastering concepts like units, dimensions, and motion laws to developing expertise in optical phenomena, including reflection and refraction, learners will gain a solid foundation in physics</td></tr>
<tr><td>Semester</td><td>1</td><td colspan="2">Credits - 3</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorilal</td><td>Practical</td></tr>
<tr><td>30</td><td>30</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Describe the concepts of elementary mechanics	U	1, 2
2	Explain the fundamentals of Electricity	U	1, 2
3	Apply optical phenomena in analysing real life situations	A,An	1, 2
4	Describe the basic principle and properties laser and its applications	U	1, 2

5	Demonstrate expertise in the basic electrical and electronic equipments and basic light phenomena	A,An,S	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Elementary mechanics**		**15**	
	1.1	Units and Dimensions, conversions of units, Order of magnitude	2	1
	1.2	Motion in a straight line, velocity, acceleration, laws of motion,	4	1
	1.3	Work, power, efficiency, kinetic energy, potential energy, conservation of energy.	4	1
	1.4	Waves, properties of waves, sound, speed of sound, doppler effect	5	1
2	**Electricity and Light**		**15**	
	2.1	Electric current, voltage, Ohm's law, resistivity, electric power	5	2
	2.2	Electromagnetic waves, reflection, refraction (twinkling of stars), total internal reflection (sparkling of diamonds, Optical fiber), scattering (blue color of sky).	8	3
	2.3	Laser–principle, properties and applications	2	4
3	**Practical (Minimum 6 to be done)**			**30**
	1	Demonstration of Ohm's law		5
	2	Screw gauge to measure radius of wire, volume of sphere and glass piece		5

	3	Vernier caliper to measure volume of cylinder, sphere	5
	4	Familiarization of digital multimeter to, test the diodes, measuring electrical properties like current, voltage, resistance, capacitance	5
	5	Familiarization of CRO by studying waveforms from a function generator (amplitude, frequency time period of sine square and triangular waves)	5
	6	Modelling and review report on advance in space research in India – Chandrayan mission, Adithya L1	5
	7	Demonstration of standing waves using Melde's string experiment.	5
	8	Demonstration of total internal reflection using Laser.	5
	9	Laser triangulation- determination of the height of an object using a laser.	5
	10	Demonstration of refraction of light through a prism	5
4		**Teacher specific content**	**To be evaluated internally**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstrational, Observation , Interactive, Group discussion
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory: Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Beiser, Arthur. Schaum's Easy Outline of Applied Physics, Revised Edition McGraw-Hill Education, 2011
Hewitt, Paul G. Conceptual Physics. Pearson Education, 2002.

References

1. Lewin, Walter, and Warren Goldstein. *For the Love of Physics: From the End of the Rainbow to the Edge of Time-A Journey through the Wonders of Physics*. Simon and Schuster, 2011.

MDC - 02

Discipline	**Physics**			
Course Name	**Observational Astronomy**			
Type of Course	**MDC**			
Course Code	24UPHYMDC102			
Course Level	**100-199**			
Course Summary	The course is structured to spark curiosity among the students, encourage them to explore and appreciate the vastness of the universe using diverse tools of astronomy.The course immerses students in the vast realm of astronomy, imparting a deep understanding of astronomical scales, positional concepts, and the evolution of stars. It further equips learners with the skills to identify celestial objects, constellations, and galaxies, as well as handling tools for observational astronomy.			
Semester	2	Credits	3	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		30	30	60
Pre-requisite, if any	A keen interest in astronomy.			

Course Outcomes

CO No.	**CO Description**	**Domain**	**PO**
1	Describes astronomical scales and basic concepts of positional astronomy	U,A,An	1
2	Demonstrates the utility of telescopes in understanding visible parts of the spectrum and other electromagnetic bands.	U,A,An	1,2
3	Illustrates the different stages in the evolution of star	U,A,An	1,2
4	Describes different galaxies, constellations and the salient features	U,A,An	1,2
5	Categorise the diverse objects in the Solar system	U,A,An	1
6	Demonstrate expertise in handling different tools for observational astronomy	U,A,An	1,2
	Understand (U), Apply (A), Analyse (An)		

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
1		**Observational Astronomy** (15 hours)		
	1.1	Introduction to astronomy, astronomical distances- astronomical unit, light year- scale of the universe	3	1
	1.2	Introduction to constellation- Orion (equitorial), Ursa Major (north circumpolar), Crux (south circumpolar)	5	1,4
	1.3	Electromagnetic spectrum, types of telescopes-optical telescopes-Reflective telescopes, Refractive telescopes - Hubble space telescope, James Webb space telescopes. radio telescopes-GMRT.	7	2
2		**Stars and Galaxies** (15 hours)		
	2.1	Stars-classification of stars based on temperature.	2	3
	2.2	Stellar Masses (Chandrasekhar limit) - birth of stars, nebula, protostar, main sequence star, red giant, death stages- white dwarf, superNova- neutron star- black hole.	4	3
	2.3	Galaxy- classification of galaxies- Milky Way .	2	4
	2.4	Objects in the solar system- Sun, planets, asteroids, comets, meteors. exoplanets	4	5
	2.5	Eclipses- solar eclipses, lunar eclipses, lunar phases	3	5

Lab Sessions

No.	**Experiments** (A minimum of 6 must be done)	Hours	CO
1	Familiarization of telescopes and focusing the objects using a telescope.	2	6
2	Illustration of visible spectrum using prism and telescope.	2	6
3	Virtual observatory exploration.	2	6
4	Making models of astronomical phenomena and objects.	2	6
5	Identifying and documenting planets/stars.	2	6
6	Find the Orion Constellation. Name three stars in the belt and prepare a report of these stars as pointer stars.	2	6
7	Mapping and categorization of constellations.	2	6
8	Observe and sketch the map of constellations observable in any one night.	2	6
9	Moon Phase calendar- Have students create a personalized moon phase calendar for a month. They can sketch the moon’s appearance each night and note the date, enhancing their observational skills.	2	6
10	Starry Night Picnic- Organize a casual evening picnic where students can gaze at the night sky, and identify constellations using a stargazing app.	2	6
11	Learn to use Astronomy software - any two activities of identification.	2	6

12	Astrophotography with a mobile phone.	2	6
13	Telescope making.	2	6
14	Observe and Identify Sunspots.	2	6

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

Text Book:

1. Moché, Dinah L. Astronomy. A self-teaching guide. Seventh Edition, John Wiley and Sons 1993.
2. Basu, Biman Joy of star watching by, National Book Trust, India 2017.

References:

1. Morrison, Ian Introduction to Astronomy and Cosmology , John Wiley & Sons Inc; 1st edition 2008.
2. Moore, Patrick An amateur astronomer 12th edition, Springer 2006.
3. Astronomy, Openstax, Rice University (Free Astronomy book) 2nd Edition 2022

MDC - 03

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Renewable Energy Sources</td></tr>
<tr><td>Type of Course</td><td colspan="4">MDC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYMDC201</td></tr>
<tr><td>Course Level</td><td colspan="4">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course is intended to provide the students with the global energy scenario in the 21st century and the significance of renewable energy sources as an alternative for the other existing energy sources. Exploring the diverse facets of energy, this course provides insights into the global and national energy scenarios, emphasizing sustainability principles. It focuses on renewable energy sources such as solar, wind, ocean, hydro, biomass, and hydrogen, detailing their principles, applications, and environmental implications. Additionally, the course delves into safety measures and effective management practices within the realm of alternative energy, offering a comprehensive understanding of the evolving energy landscape.</td></tr>
<tr><td>Semester</td><td>3</td><td>Credits</td><td>3</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>45</td><td>0</td><td>45</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	PO No
1	Understands the global energy scenario.	U	1,2
2	Understand the significance of solar energy-storage and applications	U	1,2
3	Discuss the principle and working of Wind,Ocean and Hydroelectric power systems.	U	1,2
4	Illustrates biomass conversion technologies	U,An	1,2
5	Describe the process of generation of Biogas	U	1,2
6	Describe the role of Hydrogen as an alternative fuel	U	1,2

7	Display hands on expertise in the novel Energy efficient methods and techniques	A,An	1,2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**1.1 Energy Scenario**		**5**	
	1.1.1	Energy Scenario – Global and National, Energy and sustainable development, Global and Indian Scenario.	2	1
	1.1.2	Principles of Renewable energy, Sources of Renewable energy – an overview, Environmental and Social Implications.	3	1
	1. 2 Solar Energy		**15**	
	1.2.1	Solar Energy -Introduction and Significance, Solar Thermal Energy – (Concentrator, Non-Concentrator).	3	2
	1.2.2	Solar PV systems – Principle and characteristics, Storage of solar energy, Types of Solar Cells. Installation and Maintenance Solar PV systems.	5	2
	1.2.3	Applications – Solar Pond, Solar Cooker, Solar Water Heater, Solar Dryer, Desalination, solar power plant.	7	2
2	**Wind, Ocean and Hydro Energy**		**15**	

	2.1	Wind, Ocean and Hydro Energy: Wind power systems – Principle and Working, Wind turbines – types	5	3
	2.2	Ocean Energy Harvesting – Principle and Working, Types of Ocean Energy: Wave, OTEC and Tidal Energy	5	3
	2.3	Hydroelectric Power Systems – Principle and Working.	5	3
3	**Biomass and Hydrogen Energy**		**10**	
	3.1	Biomass and Hydrogen Energy: Biomass Conversion Technologies: Dry and Wet Processes.	4	4
	3.2	Biogas Generation: Fixed Dome Type and Moving Drum type.	2	5
	3.3	Hydrogen – Production and Storage Hydrogen as Alternative Fuel for Automobiles Safety and Management	4	6
	Suggested Activity - for assessment (Teacher Specific)			
	1	Demonstration of Training modules on Solar energy.		7
	2	Demonstration of Training modules on wind energy.		7
	3	Solar PV systems – Installation and Maintenance - HoT.		7
	4	Solar Energy Harvesting – Estimation of		7

		Efficiency and Fill Factor		
	5	Conversion of thermal energy into voltage (using thermoelectric modules)		7
	6	Hydro energy – Energy Conversion		7
	7	Biofuels – Energy Conversion		7
	8	Energy Audit at your home/college/village		7
	9	Industrial Visit to Renewable energy power Plant		7
	10	Create a wind map of the institute and identify locations with the highest wind speeds.		7
	11	Set up small-scale biogas plant using plastic bottles or containers, and observe the gas production over a period		7
	12	Creating posters to raise awareness about the importance of solar energy.		7
	13	Create a flow chart detailing the steps involved in the generation of hydroelectric power		7
	14	Collect images from magazines or draw pictures to represent biomass materials, conversion processes, and end-use applications.		7
	15	Design and build a solar cooker using materials like cardboard, aluminum foil, and glass		7
4		**Teacher specific content**	**To be evaluated internally**	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Group Discussion, Activities

	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern - from activity listed above Activity: Involvement and record
	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Twidell, John. Renewable energy resources. Routledge, 4th Edition, 2021.
2. Rai G.D., Non-conventional energy sources, Khanna Publishers, 1988.
3. Boyle Godfrey (Editor) , Renewable Energy, Power for a sustainable future, Oxford University Press, 3rd Edition 2012.

8. SKILL ENHANCEMENT COURSES

SEC- 01

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">ELECTRICAL CIRCUITS AND NETWORK SKILLS</td></tr>
<tr><td>Type of Course</td><td colspan="5">SEC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYSEC201</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">In this course we try to understand concepts of basic Electrical systems. We study electrical circuits and elements that are used in an electrical system. After completing the course students will be able to develop skill in constructing and servicing some home appliances.</td></tr>
<tr><td>Semester</td><td>4</td><td colspan="2">Credits</td><td>3</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">0</td><td>45</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	PO No
1	Describes various circuit parameters including current, voltage, resistance	U, A	1, 2
2	Illustrates basic devices used in the measurement of the circuit parameters	U, A	1, 2, 9
3	Demonstrate simple AC and DC sourced electrical circuits	A, An	1, 2, 9
4	Demonstrate the basic models of Transformers and generators	U, A, An	1, 2, 9
5	Describes the response of inductors and capacitors with DC or AC sources	U, A, An	1, 2, 9
6	Illustrate skill in electrical wiring and electrical safety.	A, An, E	

			1, 2, 9

***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**1.1 Basic Electricity Principles**	**5**	
	1.1.1	Voltage, Current, Resistance, and Power.	1	1
	1.1.2	Ohm's law. Series, parallel, and series-parallel combinations.	2	1
	1.1.3	AC and DC Electricity.	1	1
	1.1.4	Familiarization with Galvanometer, multimeter, voltmeter ,ammeter and watt meter	1	1, 2
		1.2 Electrical Circuits	8	
	1.2.1	Basic electric circuit elements and their combination.	1	3
	1.2.2	Rules to analyze DC sourced electrical circuits.	1	3
	1.2.3	Single-phase and three-phase alternating current sources.	2	3
	1.2.4	Rules to analyze AC-sourced electrical circuits.	1	3
	1.2.5	Real, imaginary and complex power components of AC source.	2	3
	1.2.6	Power factor. Saving energy and money	1	3
2		**Generators and Transformers**	9	

	2.1	DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.Isolation Transformer,	3	4
	2.2	Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC	2	4
	2.3	Sources to control heaters and motors. Speed & power of ac motor. Stabilizers	1	4
	2.4	Solid-State Devices: Resistors, inductors and capacitors. Magnets Conductors, Components in Series or in shunt.	2	4
	2.5	Response of inductors and capacitors with DC or AC sources,	1	5
3		**3.1 Electrical Protection:**	8	
	3.1	Relays. Fuses and disconnect switches. Automatic main failure switches Circuit breakers. Overload devices. Relay protection device. IoT based smart Switches	2	6
	3.2	Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection and safety measures.	1	6
	3.3	Electrical Wiring: Basics of wiring-Star and delta connection	3	6
	3.4	Voltage drop and losses across cables and conductors. Insulation.	1	6
	3.5	Types of Cables and its properties, Solid and stranded cable. Preparation of extension board.	1	6
	3.2 Demonstration activities of each module to be conducted in lab		15	6
	1	Familiarise with Galvanometer, multimeter, Ammeter voltmeter and wattmeter .		

	2	Hands on experience on electrical wiring-Basics		
	3	Demonstration of the use of fuses and familiarisation of gauge of fuse wires		
	4	Preparation of an extension board		
	5	Demonstration of MCB's and ELCB's		
	6	Calculation of Power consumption in various Electrical equipment.		
	7	Electrical connections for home appliances		
5		Teacher specific content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Tutorial, Activities, Demonstration
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	B. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Text Book

1. Smith K. C. A. and Alley, R. E. Electrical Circuits, Cambridge University Press, 2014.

References

1. Theraja, B. L. A Textbook of Electrical Technology-Volume I (Basic Electrical Engineering). Vol. 1. S. Chand Publishing, 2005.
2. Theraja, A. K., and R. Sedha. A Textbook of Electrical Technology. 2018.
3. Say, M. G., Performance and design of AC machines. English LB S., 1995.

SEC- 02

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">NUMERICAL METHODS FOR COMPUTATIONAL PHYSICS</td></tr>
<tr><td>Type of Course</td><td colspan="4">SEC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYSEC301</td></tr>
<tr><td>Course Level</td><td colspan="4">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course provides a comprehensive introduction to computational methods in physics, encouraging students to become proficient in using computers as tools to solve real-world physics problems. The emphasis on algorithm development allows students to build a strong foundation for future research or applications in computational physics.</td></tr>
<tr><td>Semester</td><td>5</td><td>Credits</td><td>3</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>30</td><td>30</td><td>60</td></tr>
<tr><td>Pre-requisites, if any</td><td colspan="4">Basic knowledge of Calculus</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Illustrates the need of computational methods in physics.	U	1, 2, 3
2	Create and implement algorithms for solving physics problems	A, S, C	1, 2, 3
3	Illustrates skill in applying numerical methods to a range of physical scenarios.	A	1, 2, 3
4	Demonstrates computational solutions for complex physics problems independently.	C	1, 2, 3
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Algebraic and Transcendental Equations and Curve Fitting**		12	
	1.1	Bisection Method - Newton Raphson method.	3	1
	1.2	Gauss elimination method with pivoting -Gauss-Jordan method for matrix inversion- Gauss-Seidel iterative method	3	1
	1.3	Power method and Jacobi's method to solve eigenvalue problems.	3	1
	1.4	Least squares Regression- fitting a parabola.	3	1
2	**Interpolation and Numerical Calculus and Differential equations.**		18	
	2.1	Finite difference operators - divided difference; - Newton's forward difference and backward difference interpolation formulae.	3	1, 2
	2.2	Newton's divided difference interpolation polynomial; Cubic spline method.	3	1, 2
	2.3	Numerical Differentiation using finite differences.	4	1, 2
	2.4	Newton Cotes general quadrature formula [Concept only] – Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule.	4	1, 2
	2.5	Euler's method – Modified Eulers Method – Runge Kutta method –4th order. Concepts of Stability.	2	1, 2
	2.6	Elementary ideas and basic concepts in finite difference method – Schmidt Method. Five Point Formula.	2	1, 2
4	**Practical- Any 6**		30	
	4.1	Study the Simple Harmonic Motion of a loaded spring using Euler method. Write the algorithm/Computer Programme and execute.		3, 4

	4.2	Solution of Laplace equation - Algorithm and Program.		3, 4
	4.3	Solution of diffusion equation - Algorithm and Program.		3, 4
	4.4	Study the EM oscillations in LC circuit using RK method. Write the algorithm and Programme.		3, 4
	4.5	Find the unknown resistance using Wheatstone bridge arrangement- use Gauss elimination method – write the algorithm and Programme.		3, 4
	4.6	Determine the maximum or minimum values from a given set of data –equal interval- Using interpolation. Write the algorithm and Programme.		3, 4
	4.7	Determine the maximum or minimum values from a given set of data –unequal interval- Using interpolation. Write the algorithm and Programme.		3, 4
	4.8	Find the area common to a circle and an ellipse using trapezoidal rule. Write the algorithm and Programme.		3, 4
	4.9	Determination of the time taken by a particle under non-uniform motion to travel a particular distance using Simpson's rule. Write the algorithm and Programme.		3, 4
	4.10	Fit a parabola to the data connecting the length and period of a simple pendulum. Write the algorithm and Programme.		3, 4
5		Teacher specific content	**To be evaluated internally**	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture Presentations Discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity Practical: Lab Involvement and Record

	A. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Textbooks

1. Sastry, S. S.. Introductory Methods of Numerical Analysis. India, PHI Learning, 2012.
2. Sankara Rao S. Numerical Methods For Scientists And Engineers PHI Learning Pvt. Ltd., 2017.
3. Verma, R. C.. Computational Physics: An Introduction. India, New Age International, 2007.

References

1. Pang, Tao. An Introduction to Computational Physics. Spain, Cambridge University Press, 2006.
2. Sauer Timothy Numerical Analysis, 3rd edition, Pearson, 2017.

SEC- 03

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Essential Electrical Measurements</td></tr>
<tr><td>Type of Course</td><td colspan="4">SEC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYSEC302</td></tr>
<tr><td>Course Level</td><td colspan="4">300</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course aims to describe electrical measurement techniques. Also, students will learn the working principle and applications of digital multimeters, impedance bridges, Q-meters and various transducers.</td></tr>
<tr><td>Semester</td><td>6</td><td>Credits</td><td>3</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td></tr>
<tr><td>30</td><td>30</td><td>60</td></tr>
<tr><td>Pre-requisite, if any</td><td colspan="4">A working knowledge of basic electricity and electronics is desirable.</td></tr>
</table>

Course Outcomes

CO No.	CO Description	Domain	PO
1	Describes what is meant by noise in measurements and need for minimizing it.	U,A,An	1,2
2	Demonstrate skill in using digital multimeter	U,A,An	1,2
3	Demonstrate impedance bridges and q-meter	U,A,An	1,2
4	Describes working and applications of transducers	U,A,An	1,2
5	Illustrate practical skill in handling various electrical measurement devices	U,A,An	1,2
	Understand (U), Apply (A), Analyse (An)		

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
1		**Signals and Systems**: (3 Lectures)		
	1.1	Fluctuations and Noise in measurement system. S/N ratio and Noise figure.	1	1
	1.2	Noise in frequency domain.	1	1
	1.3	Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise	1	1
2		**Digital Multimeter**: (5 Lectures)		
	2.1	Comparison of analog and digital instruments.	1	2
	2.2	Block diagram of digital multimeter,	1	2
	2.3	Principle of measurement of I, V, C.	2	2
	2.4	Accuracy and resolution of measurement.	1	2
3		**Impedance Bridges and Q-meter**: (5 Lectures)		
	3.1	Block diagram and working principles of RLC bridge.	2	3
	3.2	Q-meter and its working operation.	2	3
	3.3	Digital LCR bridge.	1	3
4		**Transducers**: (17 Lectures)		
	4.1	Static and dynamic characteristics of measurement Systems. Generalized performance of systems,	2	4
	4.2	Zero order first order, second order and higher order systems.	2	4
	4.3	Characteristics of Transducers.Transducers as electrical element and their signal conditioning.	2	4
	4.4	Temperature transducers: RTD, Thermistor, Thermocouples,	2	4
	4.5	Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning.	2	4
	4.6	Linear Position transducer: Strain gauge, Piezoelectric.	1	4
	4.7	Inductance change transducer: Linear variable differential transformer (LVDT),	2	4
	4.8	Capacitance change transducers.	2	4
	4.9	Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.	2	4

Lab Sessions

No.	**Experiments** (A minimum of 6 must be done)		CO
1	Determine output characteristics of a LVDT & measure displacement using LVDT		5
2	Measurement of Strain using Strain Gauge.		5

3	Measurement of level using capacitive transducer.		5
4	To study the characteristics of a Thermostat and determine its parameters.		5
5	Study of distance measurement using ultrasonic transducer.		5
6	Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)		5
7	To measure the change in temperature of ambient using Resistance Temperature Device (RTD).		5
8	Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.		5
9	Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.		5
10	To design and study the Sample and Hold Circuit.		5
11	Design and analyze the Clippers and Clampers circuits using junction diode		5
12	To plot the frequency response of a microphone.		5
13	To measure Q of a coil and influence of frequency, using a Q-meter (or equivalent)		5
14	Phase senstive detector / lock-in amplifier		5
15	Software based lock-in amplifier detection		5

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

References:

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
3. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S.Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
5. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer
6. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer

7. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990Mc-Graw Hill

8. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

9. VALUE ADDITION COURSES

VAC- 01

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Science and Society</td></tr>
<tr><td>Type of Course</td><td colspan="4">VAC</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYVAC201</td></tr>
<tr><td>Course Level</td><td colspan="4">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course is meant for students of the humanities/commerce streams, to provide an overview of the nature of S&T and its impact on society. It will also provide a broad introduction to the most significant discoveries and inventions of modern science that have changed our lives and to bring into focus the need for developing a critical appraisal of the issues related to the connection of S&T with society. This course will help to develop scientific temper among the students.</td></tr>
<tr><td>Semester</td><td>3</td><td>Credits</td><td>3</td><td>Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td><td></td></tr>
<tr><td>45</td><td>0</td><td>45</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	To introduce the concepts and practice of Scientific methods with a historical outline	U	1,2
2	To discuss the impact of Modern Science & technology in the Society	U	1
3	To address the Ethical issues related to the practice of Modern Technology	An	2, 8, 10
4	To point out the need of practicing Scientific temper in daily life	U, An	1, 2,10

5	To critically evaluate the distinction between myth and fact in Science by using case studies	E	1, 2, 10
6	To evaluate the errors involved in the measurements	A, E	1, 2
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	1.1	**Science and Scientific methods**	8	
		What is Science? A discussion on Hypothesis, Theories, Laws and Experimentation in Science		1
		Verification of theories (Proving) Corroboration and falsification (Disproving)		1
		Revision of Scientific theories and laws		1
		Open ended nature of the scientific quest		1
	1.2	**Historic Perspectives of universe**	8	
		Concept of flat earth and round earth: Measurement of earth by Eratosthenes and Aristarchus		1
		Geocentric model: Earth is the centre -Ptolemy, Aristotle		1
		Heliocentric model: Sun is the centre –Copernicus		1
		Galileo, his Experiments and Observations		1
2	2.1	**Modern Science and Technology (terminology)**	**14**	
		1. Optics and Photonics 2. Nanotechnology	10	2

		3. Space Science,		
		4. Antibiotics and Vaccination		
		5. Atomic Energy		
		6. Semiconductor Revolution and Telecommunication		
		7.Artificial Intelligence and Data science		
		8. Quantum computing		
	2.2	Ethical issues related to science and technology.	4	2, 3
3	3.1	**Need for scientific temper**	2	4
	3.1.1	Need for an informed public about Science and Technology		4
	3.1.2	Scientific temper in Indian Constitution & Science Policy in India		4
	3.2	**Myths Versus Facts**	8	
	3.2.1	Astronomy and Astrophysics		5
	3.2.2	Eclipse, Origin of Universe		5
	3.2.3	Nuclear Radiation -		5
	3.2.4	Theory of Evolution		5
	3.3	**Addressing Misconceptions in Error Analysis**	5	
	3.3.1	Basic ideas of uncertainty in measurements		6
	3.3.2	Random and systematic errors		6
	3.3.3	Rejection of Spurious measurements		6

4		Teacher Specific content	To be evaluated internally

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Demonstration, Field Trip,Observation and interactive Session, Group discussion.
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern
	B. Semester End examination **For Theory part**: Written examination

Textbooks

1. Russell, Bertrand. The impact of science on society. Routledge, 2016.
2. Bala, Arun, The Dialogue of Civilizations in the Birth of Modern Science, New York, NY: Macmillan 2008.

References

3. Abd-El-Khalick, Fouad. Developing deeper understandings of nature of science: The impact of a philosophy of science course on preservice science teachers' views and instructional planning." *International Journal of Science education* 27.1 2005
4. Basu Biman and Khan Hasan Jawad, Marching Ahead with Science, National Book Trust, 2001.
5. Gopalakrishnan (2006). Inventors who revolutionised our Lives. National Book Trust
6. Stanford Encyclopedia of Philosophy: Helen Longino's "The Social Dimensions of Scientific Knowledge" (HTML) www.http://plato.stanford.edu/entries/scientific-knowledge-social/

VAC- 02

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">ELECTRICAL CIRCUITS AND NETWORK SKILLS</td></tr>
<tr><td>Type of Course</td><td colspan="5">SEC</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYSEC201</td></tr>
<tr><td>Course Level</td><td colspan="5">200-299</td></tr>
<tr><td>Course Summary</td><td colspan="5">In this course we try to understand concepts of basic Electrical systems. We study electrical circuits and elements that are used in an electrical system. After completing the course students will be able to develop skill in constructing and servicing some home appliances.</td></tr>
<tr><td>Semester</td><td>4</td><td colspan="2">Credits</td><td>3</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>45</td><td colspan="2">0</td><td>45</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	PO No
1	Describes various circuit parameters including current, voltage, resistance	U, A	1, 2
2	Illustrates basic devices used in the measurement of the circuit parameters	U, A	1, 2, 9
3	Demonstrate simple AC and DC sourced electrical circuits	A, An	1, 2, 9
4	Demonstrate the basic models of Transformers and generators	U, A, An	1, 2, 9
5	Describes the response of inductors and capacitors with DC or AC sources	U, A, An	1, 2, 9

6	Illustrate skill in electrical wiring and electrical safety.	A, An, E	1, 2, 9
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**1.1 Basic Electricity Principles**	**5**	
	1.1.1	Voltage, Current, Resistance, and Power.	1	1
	1.1.2	Ohm's law. Series, parallel, and series-parallel combinations.	2	1
	1.1.3	AC and DC Electricity.	1	1
	1.1.4	Familiarization with Galvanometer, multimeter, voltmeter ,ammeter and watt meter	1	1, 2
		1.2 Electrical Circuits	8	
	1.2.1	Basic electric circuit elements and their combination.	1	3
	1.2.2	Rules to analyze DC sourced electrical circuits.	1	3
	1.2.3	Single-phase and three-phase alternating current sources.	2	3
	1.2.4	Rules to analyze AC-sourced electrical circuits.	1	3
	1.2.5	Real, imaginary and complex power components of AC source.	2	3

	1.2.6	Power factor. Saving energy and money	1	3
2		**Generators and Transformers**	9	
	2.1	DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.Isolation Transformer,	3	4
	2.2	Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC	2	4
	2.3	Sources to control heaters and motors. Speed & power of ac motor. Stabilizers	1	4
	2.4	Solid-State Devices: Resistors, inductors and capacitors. Magnets Conductors, Components in Series or in shunt.	2	4
	2.5	Response of inductors and capacitors with DC or AC sources,	1	5
3		**3.1 Electrical Protection:**	8	
	3.1	Relays. Fuses and disconnect switches. Automatic main failure switches Circuit breakers. Overload devices. Relay protection device. IoT based smart Switches	2	6
	3.2	Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection and safety measures.	1	6
	3.3	Electrical Wiring: Basics of wiring-Star and delta connection	3	6
	3.4	Voltage drop and losses across cables and conductors. Insulation.	1	6
	3.5	Types of Cables and its properties, Solid and stranded cable. Preparation of extension board.	1	6

	3.2 Demonstration activities of each module to be conducted in lab		15	6
	1	Familiarise with Galvanometer, multimeter, Ammeter voltmeter and wattmeter .		
	2	Hands on experience on electrical wiring-Basics		
	3	Demonstration of the use of fuses and familiarisation of gauge of fuse wires		
	4	Preparation of an extension board		
	5	Demonstration of MCB's and ELCB's		
	6	Calculation of Power consumption in various Electrical equipment.		
	7	Electrical connections for home appliances		
5		Teacher specific content	To be evaluated internally	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lecture, Tutorial, Activities, Demonstration
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment/Quiz/Seminar/Activity/ teacher specific pattern Practical: Lab Involvement and Record
	B. Semester End examination **For Theory part**: Written examination **For Laboratory part**: Practical examination

Text Book

1. Smith K. C. A. and Alley, R. E. Electrical Circuits, Cambridge University Press, 2014.

References

1. Theraja, B. L. A Textbook of Electrical Technology-Volume I (Basic Electrical Engineering). Vol. 1. S. Chand Publishing, 2005.
2. Theraja, A. K., and R. Sedha. A Textbook of Electrical Technology. 2018.
3. Say, M. G., Performance and design of AC machines. English LB S., 1995.

VAC- 03

Discipline	**Physics**
Course Name	**Disaster Management**
Type of Course	**VAC**
Course Code	24UPHYVAC301
Course Level	**300-399**
Course Summary	This course offers a comprehensive overview of disaster management, covering various phases such as preparedness, response, and recovery. It explores both natural disasters beyond human control and environmental hazards induced by human activities. Emphasis is placed on understanding disaster preparedness, response, and recovery strategies. Additionally, the course examines the roles of national and international agencies in disaster mitigation and reduction. Case studies of disasters from India and around the world are also included.

Semester	6	Credits	3	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical	
		45	0	45

Course Outcomes

CO No.	CO Description	Domain	PO
1	Describes the concept of Disaster Management and various approaches aimed at mitigating the impact of disasters	U,A,An	1,2
2	Display practical skill in handling, monitoring and managing disasters	U,A,An	1,2
3	Describe various types of disasters, their origins, causes, and management, as well as the disaster profile of India	U,A,An	1,2
4	Describe the characteristics of major natural disasters that have occurred in the last decade and explore methods to mitigate the risks associated with such disasters.	U,A,An	1,2
5	Apply crisis management skills for facilitating faster response and recovery from disasters.	U,A,An	1,2
	Understand (U), Apply (A), Analyse (An)		

Course Contents & Classroom Transactions

Module	Unit	Description	Hours	CO
1		Natural Disasters (9 hours)		
	1.1	Natural Disasters - Flood Drought, Cyclone,	3	1,3
	1.2	Geographical Disaster, Earthquake, Landslide	2	1,3
	1.3	Climatic Disaster- Heat and Cold Wave, Climate Change	2	1,3
	1.4	Tutorial/lecture/discussion on i) Impacts of Global Warming - Sea level Rise, ii) Ozone Depletion and its impacts on other natural disasters or a related topic.	2	1,3
2		Manmade Disasters (9 hours)		
	2.1	Nuclear Disaster, Chemical Disaster, Biological Disaster,	3	1,3
	2.2	Building Fire, Coal Fire, Oil Fire,	2	1,3
	2.3	Air Pollution, Water Pollution, Industrial Pollution, Deforestation	2	1,3
	2.4	Tutorial/lecture/discussion on Main Air & Sea Accidents in the last decade	2	1,3
3		Disaster Prevention And Control (9 hours)		
	3.1	Disaster preparedness, prevention and mitigation, Community based disaster management (CBDM) and its operation, Disaster Information	5	1,2,4
	3.2	Role of Various Agencies in Disaster Mitigation-	2	1,2,4
	3.3	National level and State levels - National Disaster Response Force (NDRF)	1	1,2,4
	3.4	Tutorial/lecture /discussion on the role and awareness of of national and state level agencies.	1	1,2,4
4		Risk Assessment And Management (9 hours)		
	4.1	Role of the UN, and international agencies in disaster management; United Nations Disaster Relief coordinator (UNDRO), UNDRO Mandate in Disaster Relief and Management, General Assembly, Guiding Principles, Prevention, Preparedness, Stand-By Capacity, Consolidated Appeals; Coordination, Cooperation And Leadership; Continuum From Relief To Rehabilitation And Development, International Decade For Natural Disaster Reduction, Yokohama Conference, Kobe Conference, Plan of Action.	3	2,5
	4.2	National disaster management in India - an overview : National Policy, Historical Framework, National Crisis Management Committee (NCMC), Crisis Management Group, Funding Mechanisms.	2	2,5
	4.3	The Disaster Management Act, 2005, The National Disaster Management Authority (NDMA), State Disaster Management Authorities, District Disaster Management Authority, Role of District Magistrate, National Disaster Response Force (NDRF), Indian Agencies for Disaster Management, Indian Red Cross Society, National Institute of Disaster Management	2	2,5
	4.4	Tutorial/lecture/discussion on the role of various agencies in disaster management	2	2,5
5		Case Studies (9 hours)		

	5.1	Disasters in India: Bhopal gas tragedy of 1984, Orissa cyclone 1999, Kerala Flood 2018 or any other.	3	3,4
	5.2	Disasters across globe: Chernobyl nuclear accident 1986, Tsunami 2004, Brumadinho Dam, Brazil 2019or any other.	3	3,4
	5.3	Tutorial/lecture/discussion on the various disasters and mitigation across globe and in our country	3	3,4

Assessment

Assessments will be based on the options recommended by the SHC-FYUGP regulations as well as in the pattern stipulated by the institution. Assessment details will be provided suring the start of the course.

Teaching & Learning

Class room transactions will comprise of lectures / interactive sessions etc. Lab sessions, intended to give experiential learning will require the students doing experiments on their own and summarizing their results.

References:

1. Introduction to disaster mangement, Satish Modh, Mcmillan Publishers, India Ltd ISBN 13: 978-0230-63979-9
2. DISASTER MANAGEMENT, Uday Singh,VIKAS╠ PUBLISHING HOUSE PVT LTD ISBN : 978-93-5338-045-8
3. (https://ddceutkal.ac.in/Syllabus/MCOM/Disaster_Management.pdf)
4. Natural disaster mitigation – a scientific and practical approach: Science Press, Beijing, 2009
5. Environmental health in emergencies and disasters: A practical guide, B.Wisner & J.Adams (Eds.), WHO, Geneva, 2002 ISBN 92-4 154541-0.
6. Disaster Management in India , Ministry of Human Affairs, Government of India https://asdma.gov.in/pdf/publication/undp/disaster_management_in_india.pdf

10. SIGNATURE COURSES

SIG- 01

<table>
<tr><td>Discipline</td><td colspan="5">Physics</td></tr>
<tr><td>Course Name</td><td colspan="5">Applied Physics – 1</td></tr>
<tr><td>Type of Course</td><td colspan="5">SIG</td></tr>
<tr><td>Course Code</td><td colspan="5">24UPHYSIG301</td></tr>
<tr><td>Course Level</td><td colspan="5">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides a conceptual understanding of the mathematical physics, Electromagnetic Theory, Nuclear and Particle Physics and Electronics. Student learns to apply the theory to solve the problems in the above topics.</td></tr>
<tr><td>Semester</td><td>7</td><td colspan="2">Credits</td><td>4</td><td rowspan="2">Total Hours</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td colspan="2">Practical</td></tr>
<tr><td>60</td><td colspan="2">-</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Apply the theory of Mathematical physics to solve problems in theoretical physics and find their solutions	U, An, A	1,2
2	Acquire skill in applying the Electromagnetic theory to solve problems in Electromagnetics and find their solutions	U, An, A	1,2
3	Apply and analyze the theory of Nuclear and Particle Physics to solve problems in Nuclear and particle physics and find their solutions	U, An, A	1,2,3

4	Apply and analyse the theory of Electronics to solve problems in electronics and find their solutions.	U, An, A	1,2,3,4,5
Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Applied Mathematical Physics: Problems and Solutions**		**15**	
	1.1	Vector calculus:	1	1
	1.2	linear vector space: basis, orthogonality and completeness;	2	1
	1.3	matrices; similarity transformations, diagonalization, eigen values and eigen vectors;	3	1
	1.4	linear differential equations: second order linear differential equations and solutions involving special functions;	3	1
	1.5	complex analysis: Cauchy-Riemann conditions, Cauchy's theorem, singularities, residue theorem and applications	3	1
	1.6	Laplace transform, Fourier analysis	2	1
	1.7	elementary ideas about tensors: covariant and contravariant tensors.	1	1
2	**Applied Electromagnetic Theory: Problems and solutions**		**15**	
	2.1	Solutions of electrostatic problems	2	1,2

	2.2	Solutions of magnetostatic problems	2	1,2
	2.3	boundary value problems; method of images; separation of variables	1	1,2
	2.4	dielectrics and conductors	1	1,2
	2.5	magnetic materials; multipole expansion	1	1,2
	2.6	Maxwell's equations; Scalar and vector potentials; Coulomb and Lorentz gauges	2	1,2
	2.7	Electromagnetic waves in free space, non-conducting and conducting media	1	1,2
	2.8	Reflection and transmission at normal and oblique incidences	1	1,2
	2.9	polarization of electromagnetic waves	1	1,2
	2.10	Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves	1	1,2
	2.11	radiation from a moving charge	2	1,2
3	**Applied Nuclear and Particle Physics: Problems and solutions**		**15**	
	3.1	Nuclear radii and charge distributions, nuclear binding energy	2	1,2, 3
	3.2	electric and magnetic moments; semi-empirical mass formula	2	1,2, 3
	3.3	nuclear models; liquid drop model, nuclear shell model	2	1,3
	3.4	nuclear force and two nucleon problem; alpha decay, beta-decay; electromagnetic transitions in nuclei	2	1,3
	3.5	Rutherford scattering, nuclear reactions, conservation laws	1	1,2, 3

	3.6	fission and fusion; particle accelerators and detectors	2	3
	3.7	elementary particles; photons, baryons, mesons and leptons	2	3
	3.8	quark model; conservation laws, isospin symmetry, charge conjugation, parity and time-reversal invariance.	2	3
4	**Applied Electronics: Problems and solutions**		**15**	
	4.1	Semiconductors in equilibrium: electron and hole statistics in intrinsic and extrinsic semiconductors	1	4
	4.2	metal-semiconductor junctions	1	4
	4.3	Ohmic and rectifying contacts	1	4
	4.4	PN diodes, bipolar junction transistors, field effect transistors	2	4
	4.5	Negative and positive feedback circuits; oscillators	1	4
	4.6	operational amplifiers, active filters	2	4
	4.7	basics of digital logic circuits	2	4
	4.8	combinational and sequential circuits	2	4
	4.9	flip-flops, timers, counters, registers	2	4
	4.10	registers, A/D and D/A conversion.	1	4
5		Teacher Specific content		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations, discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Introductory Nuclear Physics, K. S. Krane JohnWiley
2. Nuclear Physics, S.N. Ghoshal, S. Chand & Company
3. Mathematical methods for Physicists, G.B. Arfken& H.J. Weber 5th edition, Academic Press.
4. Mathematical Physics , V.Balakrishnan, Ane Books Pvt Limited
5. Introduction to Electrodynamics, David J. Griffiths, PHI.
6. Electromagnetics, John D.Kraus, McGraw-Hill International
7. Electronic Devices (Electron Flow Version), 9/E Thomas L. Floyd, Pearson
8. Electronic Principles, Albert Malvino, David J. Bates Patrick E. Hoppe, McGraw Hill Education, 9th edition

SIG- 02

<table>
<tr><td>Discipline</td><td colspan="4">Physics</td></tr>
<tr><td>Course Name</td><td colspan="4">Applied Physics – 2</td></tr>
<tr><td>Type of Course</td><td colspan="4">SIG</td></tr>
<tr><td>Course Code</td><td colspan="4">24UPHYSIG302</td></tr>
<tr><td>Course Level</td><td colspan="4">300-399</td></tr>
<tr><td>Course Summary</td><td colspan="4">This course provides a conceptual understanding of the mathematical physics, Electromagnetic Theory, Nuclear and Particle Physics and Electronics. Student learns to apply the theory to solve the problems in the above topics.</td></tr>
<tr><td>Semester</td><td>8</td><td colspan="2">Credits</td><td>4</td></tr>
<tr><td rowspan="2">Course Details</td><td rowspan="2">Learning Approach</td><td>Lecture/Tutorial</td><td>Practical</td><td>Total Hours</td></tr>
<tr><td>60</td><td>0</td><td>60</td></tr>
</table>

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO No
1	Apply the theory of Classical Mechanics to solve problems and find their solutions	U, An, A	1,2
2	Analyze and apply the theory of Quantum Mechanics to solve problems and find their solutions	U, An, A	1,2
3	Analyze and apply the theory of Thermodynamics and Statistical Physics to solve problems and find their solutions	U, An, A	1,2,3

4	Analyse and apply the theory of Atomic and Molecular Physics to solve problems and find their solutions.	U, An, A	1,2,3,4 5
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	**Applied Classical Mechanics: problems and solutions**		18	
	1.1	Lagrangian formulation: D'Alembert's principle, Euler-Lagrange equation,	2	1
	1.2	Hamilton's principle, calculus of variations; symmetry and conservation laws	2	1
	1.3	central force motion: Kepler problem and Rutherford scattering	3	1
	1.4	small oscillations: coupled oscillations and normal modes	3	1
	1.5	rigid body dynamics: interia tensor, orthogonal transformations, Euler angles, Torque free motion of a symmetric top	3	1
	1.6	Hamiltonian and Hamilton's equations of motion	2	1
	1.7	Liouville's theorem; canonical transformations: action-angle variables, Poisson brackets, Hamilton-Jacobi equation.	1	1
	1.8	Special theory of relativity: Lorentz transformations, relativistic kinematics, mass-energy Equivalence	2	1

2	**Applied Quantum Mechanics: problems and solutions**		**17**	
	2.1	Postulates of quantum mechanics; uncertainty principle;	1	1,2
	2.2	Schrodinger equation; Dirac Bra-Ket notation,	1	1,2
	2.3	linear vectors and operators in Hilbert space	1	1,2
	2.4	one dimensional potential: step potential, finite rectangular well, tunnelling from a potential barrier, particle in a box	3	2
	2.5	harmonic oscillator	1	1,2
	2.6	two- and three-dimensional systems: concept of degeneracy; hydrogen atom; angular momentum and spin; addition of angular momenta;	2	2
	2.7	addition of angular momenta;	1	2
	2.8	variational method and WKB approximation	2	1,2
	2.9	time independent perturbation theory	2	2
	2.10	elementary scattering theory, Born approximation; symmetries in quantum mechanical systems.	3	2
3	**Applied Thermodynamics and Statistical Physics: problems and solutions**		**14**	
	3.1	Laws of thermodynamics	1	3
	3.2	microstates and microstates;	1	3

	3.3	phase space; ensembles; partition function, free energy	1	3
	3.4	calculation of thermodynamic quantities	2	3
	3.5	classical and quantum statistics	2	1,3
	3.6	degenerate Fermi gas	1	3
	3.7	black body radiation and Planck's distribution law;	2	1,3
	3.8	Bose- Einstein condensation	2	3
	3.9	first and second order phase transitions, phase equilibria, critical point	2	3
4	**Applied Atomic and Molecular Physics: problems and solutions**		**11**	
	4.1	Spectra of one-and many-electron atoms	1	2,4
	4.2	spin-orbit interaction: LS and jj couplings	1	2,4
	4.3	fine and hyperfine structures	1	2,4
	4.4	Zeeman and Stark effects	1	2,4
	4.5	electric dipole transitions and selection rules	1	2,4
	4.6	rotational and vibrational spectra of diatomic molecules	2	4
	4.7	Franck-Condon principle; Raman effect; EPR, NMR, ESR, X-ray spectra	2	4
	4.8	Einstein coefficients, population inversion, two and three level systems.	2	4
5		Teacher Specific content		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Demonstrations, Presentations, discussions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

1. Classical Mechanics: Herbert Goldstein , Charles Poole and John Safko, (3/e);Pearson Education.
2. Classical Mechanics: G. Aruldhas, Prentice Hall 2009. Nuclear Physics, S.N. Ghoshal, S. Chand & Company
3. R.K. Pathria, Statistical Mechanics, second edition (1996), Butterworth, Heinemann. (For Modules I, II and III.)
4. R Bowley and M. Sanchez, Introductory Statistical Mechanics, second edition,
5. Modern Quantum Mechanics : J. J. Sakurai, Pearson Education.
6. A Modern Approach to Quantum Mechanics: J S Townsend, Viva Books
7. Fundamentals of molecular spectroscopy, C.N. Banwell and E M McCash, TataMcGraw
8. Spectroscopy, B.P. Straughan& S. Walker, Vol. 1, John Wiley &Sons

SIG- 03

Programme	**Physics**				
Course Name	**General Relativity and Applications**				
Type of Course	**SIG**				
Course Code	**24UPHYSIG401**				
Course Level	**400-499**				
Course Summary	As an introductory course, General Relativity will initiate the learner to understand the description of gravity in terms of curved spaces. The course also serves as an introduction to mathematical techniques of differential geometry that are essential to understand curvature.				
Semester	8	Credits		4	Total Hours
Course Details	Learning Approach	Lecture/Tutorial	Practical		
		60	0		60

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No
1	Equip with techniques of tensor analysis	U An E	1, 2
2	Illustrate the nature of gravity in terms of geometry	An E	1, 2
3	Analyze physical situations involving gravity	U An	1, 2
4	Describe the the pursuit of answers to open questions	An E C	1, 2
***Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT

Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1		**Special relativity and tensor analysis**	**15**	
	1.1	Spacetime diagrams, Construction of another coordinates, Invariance of the interval	2	1

	1.2	Invariant hyperbolae, Time dilation and Length contraction, Lorentz transformation	2	1
	1.3	Definition of a vector, Vector algebra,	2	1
	1.4	The four-velocity, Four-momentum Scalar product	2	1
	1.5	Four-velocity and acceleration, Energy momentum (massive particles and photons)	2	1
	1.6	Metric tensor, Definition of tensors,	1	1
	1.7	(0,1) tensor, (0,2) tensor, Mapping vectors to one forms	2	1
	1.8	(M, N) tensors, Indices, Differentiation of tensors	2	1
2	**Curvature, Curved manifolds**		**15**	
	2.1	Gravitation and curvature	2	2.3
	2.2	Tensor algebra and calculus in polar coordinates	2	2,3
	2.3	Christoffel symbol and metric, Non coordinate basis	2	2,3
	2.4	Differentiable manifolds and tensors, Riemannian manifolds	2	2,3
	2.5	Covariant differentiation, Parallel-transport, geodesics, and curvature	3	2,3
	2.6	The curvature tensor	2	3
	2.7	Bianchi identities: Ricci and Einstein tensors, Curvature in perspective	2	3
3	**Physics in curved spacetime, Einstein equations, Gravitational radiation**		**15**	
	3.1	From differential geometry to gravity	1	3
	3.2	Physics in slightly curved spacetime, Curved intuition, conserved quantities	2	3
	3.3	Purpose of the field equations, Einstein's equations	2	3
	3.4	Einstein's equations for weak gravitational fields, Newtonian gravitational fields	3	3

	3.5	Propagation of gravitational waves	2	3
	3.6	Detection of gravitational waves	2	3,4
	3.6	Generation of gravitational waves, Energy carried away by gravitational waves	3	3,4
4	**Spherical solutions : Stars, Schwarzchild black holes**		**15**	
	4.1	Coordinates for spherically symmetric spacetimes, Static spherically symmetric spacetimes	2	3,4
	4.2	The exterior geometry, The interior structure of the star, Exact interior solutions, Realistic stars and gravitational collapse	3	3,4
	4.3	Trajectories in the Schwarzschild spacetime	3	3,4
	4.4	Nature of the surface r = 2M	3	3,4
	4.5	General black holes Real black holes in astronomy	4	3,4

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Lectures, Tutorials, Seminars/ Presentations Activities, Practical sessions
Assessment Types	MODE OF ASSESSMENT **A. Continuous Comprehensive Assessment (CCA)** Theory:Assignment,Quiz,Seminar,Activity
	A. Semester End examination **For Theory part**: Written examination

Textbook

The first course in general relativity, B. F. Schutz; Cambridge University Press.

Reference

Gravitation and Cosmology: Principles and Applications of General Theory of Relativity, Steven Weinberg; John Wiley & Sons.
Lecture notes on General Relativity, Sean M. Carroll
Classical Theory of Fields, Vol. 2: L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press.
Gravitation, Charles W. Misner, Kip S. Thorne, John A. Wheeler; W. H. Freeman and Company.